Childhood Overweight, Obesity, and the Metabolic Syndrome in Developing Countries

Roya Kelishadi

From the Department of Preventive Pediatric Cardiology, Isfahan Cardiovascular Research Center (WHO Collaborating Center), Isfahan University of Medical Sciences, Isfahan, Iran.

Accepted for publication February 19, 2007.

The incidence of chronic disease is escalating much more rapidly in developing countries than in industrialized countries. A potential emerging public health issue may be the increasing incidence of childhood obesity in developing countries and the resulting socioeconomic and public health burden faced by these countries in the near future. In a systematic review carried out through an electronic search of the literature from 1950–2007, the author compared data from surveys on the prevalence of overweight, obesity, and the metabolic syndrome 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. The few studies conducted in developing countries showed a considerably high prevalence of the metabolic syndrome among youth. These findings provide alarming data for health professionals and policy-makers about the extent of these problems in developing countries, many of which are still grappling with malnutrition and micronutrient deficiencies. Time trends in childhood obesity and its metabolic consequences, defined by uniform criteria, should be monitored in developing countries in order to obtain useful insights for primordial and primary prevention of the upcoming chronic disease epidemic in such communities.

child; developing countries; metabolic syndrome X; obesity; overweight

Abbreviations: ATP III, Adult Treatment Panel III; CASPIAN, Childhood and Adolescence Surveillance and Prevention of Adult Non-Communicable Disease; CDC, Centers for Disease Control and Prevention; HDL-C, high density lipoprotein cholesterol; IOTF, International Obesity Task Force.

INTRODUCTION

The prevalence of chronic or noncommunicable disease is escalating much more rapidly in developing countries than in industrialized countries. According to World Health Organization estimates, by the year 2020, noncommunicable diseases will account for approximately three quarters of all deaths in the developing world (1). Obesity is a major risk factor for chronic diseases and plays a central role in the “insulin resistance” or “metabolic” syndrome, which includes hyperinsulinemia, hypertension, hyperlipidemia, type 2 diabetes mellitus, and an increased risk of atherosclerotic cardiovascular disease. The metabolic syndrome is a common pathophysiologic condition with implications for the development of many chronic diseases. Obesity beginning in childhood often precedes the hyperinsulinemic state (2).

In this regard, a potential emerging public health issue for developing countries may be the increasing incidence of childhood obesity and, as a result, new cases of metabolic syndrome among children, which in turn is likely to create an enormous socioeconomic and public health burden for poorer nations in the near future (3). However, little is known about the prevalence of childhood obesity and the pediatric metabolic syndrome because of the limited number of studies, the various definitions used, and the different age groups studied, which makes comparisons difficult.

The metabolic syndrome is highly prevalent in the adult population worldwide, with a suggested ethnic predisposition in Asians (4). Genetic predisposition or early-life adverse
events may contribute to the insulin resistance and adverse body-fat patterning seen in the metabolic syndrome and its related complications, notably in non-European populations (5). It is now well documented that the metabolic syndrome can be detected as early as childhood and is highly prevalent in the pediatric populations of Western communities (6). As a major risk factor for chronic disease, the metabolic syndrome is rapidly increasing in prevalence with rising childhood obesity and sedentary lifestyles worldwide. In Western countries, the incidence of childhood obesity has more than doubled over the past generation; as a consequence, the prevalence of metabolic syndrome and type 2 diabetes mellitus is rapidly increasing in the pediatric population (7, 8). Although chronic diseases are now well recognized as a growing problem for low- and middle-income countries, limited data are available for these countries, and the developing world has been largely ignored in health strategies.

Until now, most national public health programs and policies, as well as national-level research on children of low- and middle-income countries, have focused on undernutrition and its effects on the survival and mortality of mothers and children. However, based on current knowledge and extrapolation from studies carried out in adults and high-income countries, the appropriate practice of evidence-based health promotion in developing countries might require consideration of childhood overweight and its complications, in addition to nutritional deficiencies. Given that childhood obesity and related comorbidity, notably the metabolic syndrome, will increase the impact of a number of risk factors for adult diseases, it is reasonable to increase our knowledge about the prevalence of these disorders in developing countries, many of which are still grappling with the public health effects of malnutrition and micronutrient deficiencies.

This article reviews the prevalence of overweight, obesity, and the metabolic syndrome in the pediatric populations of developing countries. These data will help national policy-makers to design programs for primordial and primary prevention, as well as for control of factors associated with adult chronic disease.

METHODS
Search of the literature


Definition of childhood overweight and obesity

There is no universal consensus on a cutoff point for defining overweight or obesity in children and adolescents. Usually, for clinical practice and epidemiologic studies, child overweight and obesity are assessed by means of indicators based on weight and height measurements, such as weight-for-height measures or body mass index (weight (kg)/height (m)^2) (9). For children and teens, body mass index ranges above a normal weight have different labels (“at risk of overweight” and “overweight”). Additionally, body mass index ranges for children and teens are defined so that they take into account normal differences in body fat between boys and girls and differences in body fat at various ages. The US Centers for Disease Control and Prevention (CDC) defines “overweight” as being at or above the 95th percentile of body mass index for age and “at risk of overweight” as being between the 85th and 95th percentiles of body mass index for age (10). The European Childhood Obesity Group classifies overweight as being at or above the 85th percentile of body mass index and obesity as being at or above the 95th percentile of body mass index (11). The International Obesity Task Force (IOTF), in their definition, used data from six national studies conducted in different countries and provided centile curves that passed through the widely used cutoff points of 25 kg/m^2 and 30 kg/m^2 for adult overweight and obesity (12). These body mass index cutoff points are reported to be more internationally based than other definitions (12).

However, as an overall index of obesity, body mass index cannot distinguish fat mass from muscle mass, nor can it represent the fat distribution; hence, it may not be the most appropriate measure for predicting risk of noncommunicable diseases (13). Population-based studies concerning the correlation between anthropometric indices and risk factors for chronic disease in children and adolescents, though limited, have documented that in children, as in adults, abdominal or upper body fat confers increased risk of metabolic complications such as dyslipidemia and high fasting glucose, as well as high blood pressure (14, 15). There is no universal cutoff for waist circumference, but in some studies abdominal obesity has been defined as a waist circumference above the 75th percentile for age and sex in the population studied (8, 16, 17).

Definition of pediatric metabolic syndrome

In adults, the definition of metabolic syndrome varies in terms of the indicators and cutpoints used. The definitions of the World Health Organization (18) and the European Group for the Study of Insulin Resistance (19) include measures of insulin resistance, but the definition used by the US National Cholesterol Education Program (20) includes abnormalities in any three of the following factors: glucose level, triglyceride level, high density lipoprotein cholesterol (HDL-C) level, systolic blood pressure, and waist circumference (insulin is not included). The new definition used by the International Diabetes Federation requires central obesity plus two of the following four additional factors: raised triglyceride level, reduced HDL-C level, raised blood pressure,
and raised fasting plasma glucose level. Sex- and, for the first time, ethnicity-specific cutoffs for central obesity as measured by waist circumference are included (21).

Definitions accepted for pediatric metabolic syndrome include the use of adult cutoffs or a single set of cutoffs for all ages of childhood. However, neither insulin concentration nor central obesity is defined in the pediatric age group. Population-based studies of children and adolescents have used various definitions (15, 22, 23). Lambert et al. (22) considered fasting insulin in the components of the metabolic syndrome and used the 75th percentiles from a Canadian community-based sample of children as cutoff points for each indicator, except for body mass index and systolic blood pressure, for which the 85th and 95th percentiles, respectively, were used. In a study in Hungary, Csábi et al. (24) considered hyperinsulinemia, hypertension, impaired glucose tolerance, and dyslipidemia (high cholesterol and/or high triglycerides and/or low HDL-C) as the components of pediatric metabolic syndrome.

Two studies carried out in the United States used the Adult Treatment Panel III (ATP III) definition (20) with modified cutoff values for youths. The two studies were similar in defining a high triglyceride level as ≥110 mg/dl, a low HDL-C level as ≤40 mg/dl, a high blood pressure as ≥90th percentile, and a high fasting blood glucose level as ≥110 mg/dl, but Cook et al. (7) defined abdominal obesity as waist circumference ≥90th percentile and de Ferranti et al. (8) used the cutoff of the 75th percentile. In another US study, Cruz et al. (25) defined the pediatric metabolic syndrome as the presence of at least three of the following: abdominal obesity (waist circumference ≥90th percentile), low HDL-C level (≤40 mg/dl), hypertriglyceridemia (≥90th percentile), hypertension (≥90th percentile), and/or impaired glucose tolerance.

In a non-Western study conducted in a large sample of children aged 6–18 years (26), my colleagues and I employed the definitions used by de Ferranti et al. (8) and Cruz et al. (25); the only difference was that, according to the recent recommendation of the American Diabetes Association (27), we defined a high fasting blood glucose level as ≥100 mg/dl.

In a recent national study of Korean adolescents aged 12–19 years, Park et al. (28) defined the metabolic syndrome as having at least three of the following risk factors: waist circumference ≥90th percentile, systolic or diastolic blood pressure ≥90th percentile, triglyceride level ≥110 mg/dl, HDL-C level ≤40 mg/dl, and fasting glucose level ≥110 mg/dl.

As Goodman et al. (29) have noted, important demographic and clinical differences exist in the typology of metabolic syndrome, depending on the definition. Such discrepancies suggest that the concept of a common pathologic syndrome or etiologic mechanism underlying metabolic syndrome as defined by these guidelines may be flawed (29).

RESULTS

Lower- to middle-income nations face the double burden of having both malnourished and overnourished populations, with most overweight and obese children being concentrated in urban areas. In developing countries, the rapid progress of urbanization and demographic trends is associated with a cluster of noncommunicable diseases and unhealthy lifestyles described as the “lifestyle syndrome” or the “New World syndrome.” This is suggested as the most important etiology for the very high rates of obesity and its consequent morbidity and mortality in developing nations. In addition, in such communities, childhood obesity is still considered a sign of healthiness and high social class.

A recent review by Wang and Lobstein (30) confirmed that children in lower- and middle-income countries, especially those growing up in urban environments and following a Western lifestyle, are facing a significant and rapidly growing epidemic of childhood obesity. Based on the secular trends observed in different countries, they estimated that by 2010, approximately 41 percent of children in the Eastern Mediterranean region, 38 percent in the European region (including the countries of the former Soviet Union), 27 percent in the Western Pacific region, and 22 percent in the Southeast Asian region will be obese (IOTF criteria (12)). In other words, it is estimated that during the next 3–4 years, approximately one in every 10 children in the Eastern Mediterranean and European regions will be overweight; the corresponding figure for the Americas is estimated to be one in seven children (30).

Prevalence of childhood overweight and obesity

The prevalence of childhood overweight and obesity in some developing countries is depicted in figure 1. A brief description of these studies is presented below.

Prevalence by age group. Children of preschool age. Based on the CDC cutoff values (10), an estimated 22 million children under age 5 years are estimated to be overweight or at risk of becoming overweight worldwide. There is strong evidence that childhood obesity is becoming increasingly prevalent in low- and middle-income countries (31, 32). Malnutrition and obesity coexist in many developing nations. According to a review conducted by Martorell et al. (33) in 2000, obesity does not appear to be a public health problem among preschool-age children in Asia and sub-Saharan Africa. However, in a number of countries in Latin America and the Caribbean, the Middle East and North Africa, and Central/Eastern Europe and the Commonwealth of Independent States, levels are as high as they are in the United States (33).

An analysis of 160 nationally representative surveys from 94 developing countries (34) showed an increasing prevalence of overweight and obesity from childhood to adulthood, although rates of early childhood malnutrition remained relatively high. This review found rapidly increasing prevalences of overweight and obesity among preschool-age children in developing countries. However, certain countries demonstrated high prevalences of overweight in conjunction with high frequencies of malnutrition—for instance, in northern Africa, where the percentage of overweight children exceeded 8 percent and the percentage of children with wasting exceeded 7 percent. Similarly, in eastern Asia, 4.3 percent of preschool-age children were overweight and 3.4 percent suffered from wasting. In Latin
America, where malnutrition and underweight were once predominant, the percentage of overweight preschool-age children was close to 5 percent but the percentage of wasted children was 1.8 percent. In a number of countries, such as Egypt, Argentina, Malawi, Nigeria, Uzbekistan, Peru, Qatar, and Jamaica, the percentage of overweight children exceeded that of the United States. In 38 countries for which secular data were available, 16 showed a rising trend in obesity prevalence over time, 14 were static, and only eight showed falling rates in obesity prevalence (34). Rates of increase seemed most marked in the countries of northern Africa, such as Morocco and Egypt, as well as in some countries of the Caribbean and Latin America.

In a recent review, Khor (35) reported that approximately half of the preschool-age children in Asia are malnourished; prevalence ranges from 16.0 percent in China to 64.0 percent in Bangladesh. Prevalences of stunting and underweight are also high, especially in southern Asia, where one in every two preschool children is stunted (35).

These findings highlight that concurrence of overweight/obesity and stunting is an important public health issue in low- and middle-income countries, beginning in early childhood. Maternal undernutrition and its associated intranatal growth retardation and compromised lactation and infant feeding lead to stunting in early life. This pattern is usually followed by overfeeding of stunted children with diets of poor nutritional quality, characterized by high-calorie foods of low density and diversity, which in turn leads to rapid weight gain later in childhood. This growth pattern may lead to a disproportionately high fat mass accompanied by a central fat deposition and its consequences. It is therefore necessary to implement vigorous efforts to optimize infantile and childhood growth and to modify prenatal and perinatal determinants of adverse adult health outcomes.

Children and adolescents aged 6–18 years. In developing countries, the prevalence of overweight/obesity in older children is reported to be much higher than in preschoolers. However, considering the large differences in the sociocultural contexts of these countries and the rapidity of the epidemiologic transition, the extent of childhood overweight largely differs across countries. Among developing countries, the prevalence of childhood obesity is highest in the Middle East and in Central and Eastern Europe (36). A cross-sectional survey of a representative sample of 2,104 persons was performed in Lebanon. Overweight and obesity (classes I–III) were defined according to IOTF cutoffs (12). The prevalences of childhood overweight and obesity were higher overall for boys than for girls (22.5 percent vs. 16.1 percent for overweight and 7.5 percent vs. 3.2 percent for obesity, respectively) (37).
Prevalence by region. Latin American countries. In a study conducted in southern Brazil in 2001–2002, 21 percent of adolescents aged 15–18 years were overweight and 5 percent were obese (38). In a nationwide study carried out among Brazilian adolescents aged 10–19 years, the prevalence of overweight and obesity according to the CDC cutoff values (10) was 7.7 percent, reaching 10.6 percent within the female group and 4.8 percent within the male group (39).

In 2001, the prevalences of overweight and obesity among Argentine adolescents with a mean age of 15 years were reportedly 10.9 percent and 2.2 percent, respectively, with a higher prevalence in boys than in girls (40). A previous study conducted in the same population in 1988 had shown a prevalence of 19.9 percent underweight and 6.4 percent overweight (41). In Chilean 6-year-olds, the prevalence of overweight increased from 0.7 percent in 1987 to 2.2 percent in 2003, but obesity has not increased since the year 2000 (42). Among Mexican adolescents, based on the CDC cutoffs (10), the prevalences of overweight and obesity were 19.8 percent and 7.9 percent, respectively; 18 percent of boys and 21 percent of girls were overweight, and 11 percent of boys and 9 percent of girls were obese (43).

African countries. Although malnutrition is prevalent in African countries, childhood obesity is increasing in some of these countries. In a study in Tunisia, 9.1 percent of adolescent girls are reportedly at risk for becoming overweight (body mass index ≥85th percentile) (44). Another study in Tunisia showed higher rates among adolescents; 16 percent of girls and 11 percent of boys were overweight (45).

In a study among female adolescents in Egypt, 35 percent of the girls were overweight and 13 percent were obese. 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 (46). In a recent study using the CDC cutoffs for body mass index (10), 12.1 percent of Egyptian adolescents (7 percent of boys and 18 percent of girls) were overweight, and 6.2 percent (6 percent of boys and 8 percent of girls) were obese (43).

The prevalence of obesity within South African children aged 3–16 years was found to be 3.2 percent for boys and 4.9 percent for girls, whereas the prevalence of overweight was 14.0 percent for boys and 17.9 percent for girls (47). Another study in a population in the transitional phase in the North West Province of South Africa showed that according to IOTF standards (12), 7.8 percent of schoolchildren aged 10–15 years were overweight or obese (48). Similar to many other developing countries, shifts in dietary intakes and activity patterns toward higher fat intakes and lower physical activity are contributing to the escalating trend of obesity in South Africa (49).

Eastern European countries. In a study in Poland, 4.9 percent of adolescents aged 14–15 years (5.5 percent of girls and 4.4 percent of boys) were obese (50). In a study in Bosnia, Jusupovic et al. (51) reported a high prevalence of obesity in adolescents; in seventh-grade students (ages 12–13 years), obesity was present in 48.4 percent of boys and 30.8 percent of girls. A nationwide anthropologic survey of children and adolescents was carried out in the Czech Republic in 2001 (52) to continue a series of surveys that have been repeated at 10-year intervals since 1951 (with the participation of the Slovak Republic until 1991). No increase in mean body weight has been recorded in pubescent girls since the 1970s, and no increase has been reported in pubescent and postpubescent boys since 1991. Nevertheless, the younger age groups, namely those of primary-school children, continued to show an increase in mean body weight. The secular trend in body weight has been less pronounced compared with the trend in body height. In 2001, rates of overweight and obesity had risen in most age groups of schoolchildren compared with those reported in 1991. In contrast, a slight decrease in the rate of overweight was seen in boys starting from the age of 16 years and in girls starting from the age of 13 years. The prevalence of obesity was significantly higher in boys than in girls (52).

Mediterranean countries. Secular trends in childhood obesity in Greece were assessed by Krasas et al. (53). In the younger group (ages 6–10 years), the prevalences of overweight and obesity were 25.3 percent and 5.6 percent, respectively, while for adolescents (ages 11–17 years) they were 19.0 percent and 2.6 percent, respectively (53). Prevalences of overweight and obesity were 25.9 percent and 5.1 percent for all males and 19.1 percent and 3.2 percent for all females. With regard to trends, an increase in body mass index was found among males when the results of our survey were compared with those of the previous three. However, the trends for girls were different. An increase was found when the results of this study were compared with those of 1942. A decrease in body mass index at most ages was found when the results of this study were compared with those of the 1982 survey, while an increase was recorded only for younger girls below age 13 years in comparison with the 1984–1985 study. This study demonstrates that the prevalences of overweight and obesity among schoolchildren are 22.2 percent and 4.1 percent, respectively, and have been increasing in the last several decades, especially among boys (53).

Another study, which was part of the Health Behavior in School-Aged Children Study, provided national estimates for overweight and obesity in Greek school-aged children and adolescents; self-reported weight and height data were used (54). According to the IOTF cutoff points (12), 9.1 percent of girls and 21.7 percent of boys were classified as overweight, and 1.2 percent of girls and 2.5 percent of boys were classified as obese. Corresponding values obtained using CDC growth charts (11) were 8.1 percent of girls and 18.8 percent of boys for overweight and 1.7 percent of girls and 5.8 percent of boys for obesity. In comparison with most other Western countries, the prevalence of obesity is lower in Greek children aged 11–16 years (54).

In a study in Edrine, Turkey, based on the IOTF cutoff values (12), the prevalences of overweight and obesity among adolescent girls were 10.6 percent and 2.1 percent, respectively, while they were 11.3 percent and 1.6 percent for adolescent boys (55). In the urban area, the prevalences of overweight and obesity among adolescent girls were 10.3 percent and 2.1 percent, respectively, while they were 11.6 percent and 1.6 percent for boys. In the rural area, the prevalences of overweight and obesity among adolescent girls were 12.4 percent and 2.2 percent, respectively, while they were 9.6 percent and 1.2 percent for boys (55).
Asian and Middle Eastern countries. Asia. A paradox of childhood underweight/overweight exists among children and adolescents living in Asian countries. Approximately 70 percent of the world’s malnourished children live in Asia, resulting in that region’s having the highest concentration of childhood malnutrition. However, the global problem of childhood overweight increasingly extends into the developing world. In Thailand, the prevalence of obesity among children aged 6–12 years rose from 12.2 percent to 15.6 percent in just 2 years (56). In Japan, the prevalence of obesity among schoolchildren aged 6–14 years increased from 5 percent to 10 percent between 1974 and 1993, and the prevalence of extreme obesity increased from 1 percent to 2 percent (57). In Iran, we found that the prevalence of overweight among youths aged 6–18 years doubled from 4.2 percent to 8.3 percent between 1993 and 1999 (58).

In a cross-national comparative study using the IOTF cutoffs (12), the prevalences of childhood overweight and obesity were reported to be 15.7 percent and 15.6 percent, respectively, in Russia and 6.4 percent and 6.5 percent, respectively, in China (59). However, large differences exist between different parts of China; in a study of children aged 9–16 years in Dalian, 22.9 percent of boys and 10.4 percent of girls were overweight, which was a higher prevalence than that indicated in Chinese national surveys of recent decades (60).

Although the rate of malnutrition in India remains high, weight increases have been observed in some areas undergoing rapid economic and epidemiologic transition. In one study, based on the CDC cutoffs (10), 9.9 percent of boys aged 10–15 years and 12.0 percent of girls aged 10–15 years were overweight, and 5.0 percent of the boys and 6.3 percent of the girls were obese (61). In a larger study among adolescents aged 13–18 years, the age-adjusted prevalence of overweight was 17.8 percent for boys and 15.8 percent for girls (62).

In a recent report from Sri Lanka, the prevalences of underweight, stunting, and overweight in adolescents aged 10–15 years were reported to be 47.2 percent, 28.5 percent, and 2.2 percent, respectively (63).

Hakeem et al. (64) evaluated the prevalence of certain noncommunicable disease risk factors in schoolchildren aged 10–12 years living at different levels of urbanization. They compared Pakistani, British Pakistani, British Indian, and British Caucasian children and found that the proportion of children at high risk of noncommunicable disease increased with urbanization. They suggested that in addition to genetic predisposition, environmental factors like undernourishment in early life, adoption of an urbanized lifestyle, or a combination of both factors could be major determinants of this high risk of noncommunicable disease (64). A study by Baddrudin et al. (65) in Pakistan found a high prevalence of noncommunicable disease risk factors among schoolchildren from low- and middle-income families.

As Tee (66) has mentioned, the sustained economic growth and increasing economic stability in the Asian region over the last three decades has been accompanied by changing lifestyles, leading to significant changes in the food and nutrition issues facing Asian countries. The chronic diseases associated with excessive consumption of nutrients, especially fat, are becoming increasingly apparent. Effective data collection and analysis are essential to formulate and implement intervention programs to address the changing nutrition problems in Asia (66).

The Middle East. There have been few reviews on the prevalence of childhood obesity in Middle Eastern countries (67). Because the Middle East has the highest dietary energy surplus of the developing countries and because of rapid changes in the demographic characteristics of the region, with large shifts in dietary and physical activity patterns, a rapid rise in noncommunicable disease risk factors, especially obesity, is occurring (68). Most of the surveys in this region have been performed in adult populations; in addition, the cutoffs used and age groups evaluated have differed between studies, making comparison difficult. However, the few studies evaluating obesity among youth living in these countries have shown considerably high prevalences, especially among adolescents.

The prevalence of obesity in Kuwait is among the highest in the Arab Peninsula (69). A recent study performed among adolescents aged 10–14 years in Kuwait revealed very high prevalences of overweight (31.8 percent of girls and 30.0 percent of boys) and obesity (13.1 percent of girls and 14.7 percent of boys) (70). In Bahrain, a review of data extracted from the Ministry of Health annual health report and the 1981 and 1991 censuses revealed a high prevalence of obesity among different age groups (71). A recent study among Bahraini school students found that according to the IOTF criteria, the overall prevalence of obesity was 15 percent in boys and 18 percent in girls (72). A study among 898 adolescent girls in the United Arab Emirates revealed that 14 percent of subjects were overweight and 9 percent were obese, according to the CDC criteria (73). A survey of Saudi Arabian male schoolchildren aged 6–18 years showed a prevalence of overweight of 11.2 percent and a prevalence of obesity of 15.8 percent (74). This finding of a higher prevalence of obesity than of overweight is contrary to the findings of most other studies. In a study among prepubescent children (ages 6–8 years) in Lebanon, the prevalences of overweight and obesity based on the IOTF cutoff points were 26 percent and 7 percent, respectively, in boys and 25 percent and 6 percent, respectively, in girls (75).

In a study in Saudi Arabia (76), the overall prevalence of childhood overweight was 10.7 percent and 12.7 percent in body and girls, respectively, and the prevalence of obesity was 6.0 percent and 6.7 percent in boys and girls, respectively. In the different provinces, the prevalence of overweight ranged from 8.8 percent to 27.4 percent in boys and from 9.3 percent to 27.6 percent in girls, and obesity ranged from 4.7 percent to 10.4 percent in boys and from 4.3 percent to 13.8 percent in girls. In general, girls had a higher prevalence of both overweight and obesity compared with boys (76). Another study in Saudi Arabia found an overall prevalence of 11.7 percent for overweight and 15.8 percent for obesity in children aged 6–18 years (77). A study of Saudi Arabian youths over 12 years of age found that based on the CDC cutoff values (10), 13.8 percent of subjects were overweight and 20.5 percent were obese (78).

Among adolescents aged 10–14 years in Kuwait, based on the CDC cutoffs (10), the overall prevalences of

overweight and being at risk of overweight among males were 14.7 percent and 30.0 percent, respectively; the corresponding figures among females were 13.1 percent and 31.8 percent, respectively. There was no consistent rise or decline in overweight and obesity in both sexes with respect to age. However, the overall prevalence of overweight was lower in males than in females, but the overall prevalence of obesity was higher in males than in females. When compared with the US National Center for Health Statistics reference population, the body mass index of Kuwaiti adolescents exceeded that of American adolescents in each centile category at or above the 50th percentile (79).

In a study in Bahrain, among adolescents aged 12–17 years, the overall prevalence of obesity was highest (21 percent in males and 35 percent in females) when the World Health Organization-recommended criteria of body mass index for age and skinfolds for age percentiles (9) were applied, and the prevalence was lowest (15 percent in boys and 18 percent in girls) when the IOTF cutoffs (12) were used. This study revealed a much higher prevalence of obesity in the Bahraini adolescent population than was previously reported, especially among girls (80).

In a recent population-based study in Qatar, based on the IOTF cutoffs (12), the prevalences of overweight and obesity were 28.6 percent and 7.9 percent, respectively, among adolescent boys and 18.9 percent and 4.7 percent, respectively, among girls. The prevalence of overweight was highest at 16 years of age among boys (10.5 percent) and at 17 years among girls (8.9 percent). The prevalence of obesity was highest at 12 years of age among boys (11.7 percent) and at 13 years among girls (6.4 percent) (81).

A study in the United Arab Emirates showed that based on the CDC cutoff values (10), 10-year-old male children had 1.7 times the rate of overweight compared with international standards and 1.9 times the rate at age 18 years. Similarly, female children had 1.8 times the rate of overweight compared with international standards at 10 and 18 years of age. Obesity was 2.3-fold higher among males at age 14 years compared with international standards, and it increased to 3.6 times the rate at 18 years of age. Among female children, obesity was the same as that of males at age 14 years: 2.3 times the international standards. At 18 years of age, female obesity was 1.9-fold higher than the international standard, nearly one half the rate of obesity among males at the same age. The frequency of obesity among youth was 2–3 times greater than the recently published international standard (82).

Similarly to many other developing countries, Iran is rapidly moving along lines of epidemiologic, demographic, and nutrition transition that are suggested to be secondary to rapid changes in fertility and mortality patterns and to urbanization. These changes have led to a considerable imbalance in food consumption, with low nutrient density characterizing diets and overconsumption being evident among more than a third of households (83, 84). The other suggested underlying factor for the increasing rate of childhood obesity in Iran is that plumpness is still considered a sign of child healthiness in that country. A limited number of local studies have been performed in Iran. A study performed among 1,000 female high school students aged 14–21 years in Kerman (southeastern Iran) found a prevalence of 4.6 percent for overweight and 0.7 percent for obesity (85). A study among female students aged 14–20 years in Tabriz (northwestern Iran) showed that 10.1 percent and 3.9 percent of the subjects were overweight and obese, respectively (86). A study performed in children and adolescents aged 3–18 years in Tehran (the capital city) showed that 5.1 percent of school-aged children were obese (87). Another study among 2,321 students aged 11–16 years in Tehran showed that according to the CDC criteria (10), 21.1 percent of subjects were overweight and 7.8 percent were obese (88). Our previous study of 2,000 students aged 11–18 years living in three counties in central Iran (89) showed that according to CDC cutoffs, 10.7 percent of girls and 7.4 percent of boys were overweight and 2.9 percent of girls and 1.9 percent of boys were obese.

The differences between the age groups studied, the subjects’ living areas (urban/rural), and the body mass index cutoffs used made comparisons between these studies difficult. In general, these studies show that the prevalence of childhood obesity in Iran is much lower than in other Arab countries in the region, which is suggested to be due to both genetic and lifestyle differences between Iran and other Arab nations. The only national survey performed for assessment of risk behaviors and risk factors for chronic disease among Iranian children and adolescents was performed from 2003–2004 as the baseline survey of a study entitled “Childhood and Adolescence Surveillance and Prevention of Adult Non-Communicable Disease” (CASPIAN). This multicenter study was performed among 21,111 school students aged 6–18 years living in urban and rural areas of 23 (out of 28) provinces in Iran. The prevalence of overweight was 13.9 percent (8.1 percent of boys and 5.7 percent of girls) according to the CDC percentiles (10) and 5 percent (2.6 percent of boys and 2.4 percent of girls) according to the obtained percentiles. According to the CDC (10), IOTF (12), and national cutoffs, the prevalences of overweight were 8.82 percent, 11.3 percent, and 10.1 percent, respectively, and the prevalences of obesity were 4.5 percent, 2.9 percent, and 4.79 percent, respectively. Significant differences were found between various counties, with the lowest prevalences (according to CDC criteria) being observed in Zahedan (3.1 percent overweight and 0.6 percent obesity) and Shahrekord (6.2 percent overweight and 2.3 percent obesity) and the highest prevalences being observed in Rasht (18.8 percent overweight and 7.4 percent obesity) and Qom (18.4 percent overweight and 7.3 percent obesity) (90).

The above studies show that childhood obesity is becoming an emerging health problem in the Eastern Mediterranean; however, until now, most national public health programs and policies, as well as national-level research on children and adolescents in this region, have focused on undernutrition and its effects on survival, mortality, and development in mothers and children.

**Prevalence of the pediatric metabolic syndrome**

There is still no clear understanding of the clinical importance of the metabolic syndrome and the way in which its components relate to one another. Some investigators who
have used factor analysis to examine the metabolic syndrome among adolescents and adults have not found a single factor contributing to this syndrome (91–96). A number of common findings have emerged from previous studies among adults, including the identification of 2–4 factors; the loading of insulin on more than one factor, i.e., those that have been interpreted as glycemia, obesity, and dyslipidemia; and the presence of a separate factor for blood pressure (97). It is suggested that the shared features might be responsible for the clustering of these risk factors in the same individual more commonly than can be explained by chance alone.

Although the numbers of factors and the factor loading patterns have differed depending on the baseline characteristics of the population studied and the variables included in the analysis, none of the previous studies have reduced the metabolic syndrome to fewer than two factors. In the study by Lambert et al. (92) among Canadian youth, factor analysis revealed three factors (body mass index/insulin/lipids, body mass index/insulin/glucose, and diastolic/systolic blood pressure). The factors suggested that these three physiologic domains, with a unifying role for markers of insulin resistance and adiposity, underlie the metabolic syndrome (11). The study by Goodman et al. (93) among US adolescents found three factors with similar factor loadings: an adiposity factor, which accounted for the initial and largest proportion of the total variance; a cholesterol factor; and a carbohydrate/metabolic factor. Together, they accounted for 67 percent of the variance in the measured variables. In that study, body mass index and obesity were associated with every risk factor measured, and obesity was the predominant correlate of coronary artery disease risk factors among adolescents (92, 93). Because Meigs (97) found similar factor pattering among adolescents and adults, they suggested that the interrelations between physiologic variables might be established from early life.

In our factor analysis (98), which to our knowledge was the first of its kind in a non-Western pediatric population and the first to compare children with and without the metabolic syndrome, we found that in all age groups (6–9.9, 10–13.9, and 14–18 years), three similar factors were loaded: lipids, adiposity, and blood pressure. These three factors accounted for 87.4–90.8 percent of the variance (98). Three factors were loaded in persons with the metabolic syndrome—cholesterol/triglycerides, metabolic factors/adiposity, and blood pressure (65.9 percent of variance)—and four factors were loaded among persons without the metabolic syndrome—cholesterol, metabolic factors, adiposity, and blood pressure (75.6 percent of variance). We did not find a central feature that underlay all three factors among children with the metabolic syndrome; however, waist circumference was the only variable that was loaded for two factors (98).

Overall, these findings support a change in the concept of the metabolic syndrome from that of a single entity causally associated with insulin resistance (4) to one in which the syndrome represents several distinct but intercorrelated entities.

As table 1 shows, diverse definitions of pediatric metabolic syndrome have been used in various populations, making comparisons difficult. Based on modified ATP III criteria, Cook et al. (7) found a prevalence of 4.2 percent for the metabolic syndrome in American adolescents of different ethnicities. Using a definition based on the ATP III criteria with a cutoff at the 75th percentile for waist circumference, de Ferranti et al. (8) found a much higher prevalence of the metabolic syndrome than did Cook et al. (7), who documented that the metabolic syndrome occurs in nearly 10 percent of US children aged 12–19 years. Lambert et al. (22), who in their Canadian study defined metabolic syndrome as hyperinsulinemia combined with at least two additional risk factors, reported a prevalence of 11.5 percent, with no age- or sex-specific difference being observed.

On the basis of the available data, the review by Molnar (99) suggested that the prevalence of the metabolic syndrome and type 2 diabetes mellitus in European children (24) is not as high as it is in North America.

Such research has been very limited in developing countries. In a study in Turkey that adapted the ATP III criteria for metabolic syndrome to children and adolescents, 2.2 percent of adolescents had metabolic syndrome (100). The syndrome was nearly 10 times more common among overweight and obese students (21 percent) than among lean students. In a study conducted in Tehran in which the metabolic syndrome was defined according to modified ATP III criteria (7), Esmaillzadeh et al. (101) reported a prevalence of 10.1 percent in adolescents aged 10–19 years (10.3 percent in boys and 9.9 percent in girls). In a recent study, Kim et al. (102) compared prevalences of the metabolic syndrome among South Korean adolescents in 1998 and 2001. The numbers of subjects aged 12–19 years were 1,317 in 1998 and 848 in 2001. The overall prevalence of the metabolic syndrome increased significantly from 6.8 percent in 1998 to 9.2 percent in 2001. Based on this study, approximately 500,000 out of 5.4 million South Korean adolescents aged 12–19 years might have the metabolic syndrome (102).

In the first study of a non-Western population conducted in a large, representative national sample (n = 4,811), which included not only adolescents but also children as young as age 6 years, we found that, on the basis of the two definitions used for metabolic syndrome (8, 25), 2–14 percent of Iranian children and adolescents studied had the syndrome (103). Based on extrapolation of our findings, it can be estimated that among the approximately 16 million students in Iran, 320,000–2,240,000 children and adolescents currently may have metabolic syndrome (103).

DISCUSSION

Findings

The dramatic rise in childhood obesity in developing countries is considered a major driving force behind the high prevalence of the pediatric metabolic syndrome in those countries.

In studies conducted among children and adults in Iran and Turkey, the most frequent components of the metabolic syndrome were high triglyceride levels and low HDL-C levels (5, 100, 103–107). This can reflect an ethnic predisposition toward this type of dyslipidemia in this region. The
TABLE 1. Prevalence and definitions of the metabolic syndrome among children and adolescents in developed and developing countries

<table>
<thead>
<tr>
<th>Study</th>
<th>Country and population</th>
<th>Criteria</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Developed countries</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cook et al. (7)</td>
<td>United States; representative sample aged 12–19 years (White, Black, Mexican-American) (n = 2,430)</td>
<td>ATP III* criteria (20) with modified cutoff values; i.e., three or more of the following: triglycerides &gt; 110 mg/dl, HDL-C* ≤ 40 mg/dl, systolic or diastolic blood pressure &gt; 90th percentile, fasting blood glucose ≥ 110 mg/dl, waist circumference &gt; 90th percentile</td>
<td>The prevalence of the metabolic syndrome was 4.2% (6.1% in males, 2.1% in females). The syndrome was present in 28.7% of overweight adolescents.</td>
</tr>
<tr>
<td>de Ferranti et al. (8)</td>
<td>United States; adolescents aged ≥ 12 years (n = 1,960)</td>
<td>ATP III criteria with modified cutoff values; i.e., three or more of the following: triglycerides &gt; 110 mg/dl, HDL-C &lt; 40 mg/dl, systolic or diastolic blood pressure &gt; 90th percentile, fasting blood glucose ≥ 110 mg/dl, waist circumference &gt; 75th percentile</td>
<td>Two thirds had at least one metabolic abnormality, and nearly one in 10 had metabolic syndrome.</td>
</tr>
<tr>
<td>Lambert et al. (22)</td>
<td>Canada; children and adolescents aged 9, 13, and 16 years (n = 2,244)</td>
<td>Hyperinsulinemia combined with &gt; 2 risk factors including overweight, high systolic blood pressure (&gt; 90th percentile), impaired fasting blood glucose, high triglycerides (&gt; 75th percentile), and low HDL-C (&lt; 25th percentile)</td>
<td>A prevalence of 11.5%, with no age- or sex-specific difference.</td>
</tr>
<tr>
<td>Cruz et al. (25)</td>
<td>United States; obese Hispanic children aged 8–13 years (n = 126)</td>
<td>Presence of three or more of the following: abdominal obesity (waist circumference &gt; 90th percentile for age, sex, and Hispanic ethnicity), low HDL-C (&lt; 10th percentile for age and sex (138)), hypertriglyceridemia (triglycerides &gt; 90th percentile for age and sex (138)), hypertension (systolic or diastolic blood pressure ≥ 90th percentile adjusted for height, age, and sex), and/or impaired glucose tolerance (139))</td>
<td>The metabolic syndrome was present in 30% of obese children.</td>
</tr>
<tr>
<td><strong>Developing countries</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Csábi et al. (24)</td>
<td>Hungary; obese (77 female, 103 male) and control (84 female, 155 male) Caucasian children aged 8–18 years</td>
<td>Presence of hyperinsulinemia, hypertension (systolic or diastolic blood pressure &gt; 90th percentile adjusted for height, age, and sex), impaired glucose tolerance (139), and dyslipidemia (high cholesterol (&gt; 90th percentile) and/or high triglycerides (&gt; 90th percentile) and/or low HDL-C (&lt; 10th percentile) (140))</td>
<td>The metabolic syndrome was detected in 8.9% of obese children and 0.4% of controls.</td>
</tr>
<tr>
<td>Kim et al. (102)</td>
<td>South Korean adolescents in 1998 and 2001; numbers of subjects aged 12–19 years were 1,317 in 1998 and 848 in 2001</td>
<td>Presence of at least three of the following risk factors: waist circumference ≥ 90th percentile, systolic or diastolic blood pressure ≥ 90th percentile, triglycerides ≥ 110 mg/dl, HDL-C ≤ 40 mg/dl, and fasting blood glucose ≥ 110 mg/dl</td>
<td>The overall prevalence of the metabolic syndrome increased significantly from 6.8% in 1998 to 9.2% in 2001.</td>
</tr>
<tr>
<td>Agirbasli et al. (100)</td>
<td>Turkey; adolescents aged 10–17 years (n = 1,385)</td>
<td>ATP III criteria (20) for metabolic syndrome in children and adolescents: high blood pressure, high triglycerides, low HDL-C, fasting glucose ≥ 100 mg/dl, and elevated body mass index corresponding to overweight or obesity</td>
<td>2.2% of adolescents had metabolic syndrome. The syndrome was nearly 10 times more common among overweight and obese students (21%) than among lean students.</td>
</tr>
<tr>
<td>Esmailzadeh et al. (101)</td>
<td>Tehran, Iran; adolescents aged 10–19 years (n = 3,036)</td>
<td>Modified ATP III definition. Being overweight (&gt; 95th percentile) and being at risk for overweight (≥ 95th–&lt; 95th percentile) were defined on the basis of standardized percentiles curves of body mass index suggested for Iranian adolescents.</td>
<td>The prevalence of the metabolic syndrome was 10.1% (95% CI*: 9.0, 11.1) among Iranian adolescents (boys: 10.3%, 95% CI: 8.6, 11.8; girls: 9.9%, 95% CI: 8.4, 11.3).</td>
</tr>
<tr>
<td>Kelishadi et al. (103)</td>
<td>Iran; national survey; children and adolescents aged 6–18 years (n = 4,811)</td>
<td>a. Modified ATP III criteria (8), but fasting blood glucose ≥ 100 mg/dl</td>
<td>The prevalence of the metabolic syndrome was 14.1%, without a difference between boys and girls, except in the age group 14–18 years, where it was higher in boys than in girls (15% vs. 11%).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Criteria based on those of the Third National Health and Nutrition Examination Survey (25), but fasting blood glucose ≥ 100 mg/dl</td>
<td>The prevalence of the metabolic syndrome was 2.1%, without a difference between boys and girls, except in the age group 14–18 years, where it was higher in boys than in girls (3% vs. 1%).</td>
</tr>
</tbody>
</table>

* ATP III, Adult Treatment Panel III; HDL-C, high density lipoprotein cholesterol; CI, confidence interval.
prevalences of high total and low density lipoprotein cholesterol are reported to be considerably higher in Western countries than in Iran and Turkey. A study in the United States revealed that 26 percent and 20 percent of rural children had high total and low density lipoprotein cholesterol levels, respectively (108); however, in our study, among Iranian children and adolescents, the prevalences of hypertriglyceridemia and low HDL-C (i.e., the components of the metabolic syndrome) were higher than those reported from Western countries. In our population, the mean value and percentiles for triglycerides were higher and those for HDL-C were lower than in Western countries (109). The high prevalence of the metabolic syndrome among the adult populations of Iran and neighboring countries (5, 104, 105, 110, 111) confirms the supposed ethnic predisposition toward this type of dyslipidemia among Asians (4). In addition, a gene-environment interaction might explain differences between communities and may require further study. Diets high in trans-unsaturated fat may lower HDL-C levels, increase triglyceride levels, and interfere with fatty acid metabolism; our previous study indicated that the poor quality of the fat consumed, being rich in saturated and trans-fatty acids, correlated with the high prevalence of dyslipidemia among Iranian youths (112).

A complex interaction of genetic, environmental, and behavioral factors has been suggested as the underlying cause of the metabolic syndrome. However, findings on the roles of dietary patterns and physical activity rates in this global health problem are inconclusive. Some lifestyle behaviors, including physical inactivity, smoking, and unhealthy dietary habits, particularly high carbohydrate and fat intakes, are associated with the metabolic syndrome in adults (113, 114). Such findings regarding the metabolic syndrome among youth are limited, and major effort is needed to better understand the factors associated with this complex disorder in the pediatric population. There is no report in the current literature regarding the association between lifestyle factors and the metabolic syndrome in the pediatric population of developing countries. In our study, which to our knowledge was the first to determine such an association, we found that the risk of the metabolic syndrome among children and adolescents rose with the consumption of solid hydrogenated fat and white-flour bread (115). While the frequency of intake of sweets/candies increased the risk of the metabolic syndrome in both sexes, the frequency of eating fast foods and the frequency of eating carbohydrates increased this risk in boys and girls, respectively. In both sexes, the frequency of consumption of fruits and vegetables, as well as dairy products, decreased the risk of having the metabolic syndrome (115). Our findings are in line with the results of a study among young adult Americans which showed that low fruit and vegetable consumption and high sweetened beverage consumption were independently associated with the prevalence of the metabolic syndrome in some ethnic groups (116). In addition, consistent with some previous studies in developed countries (117, 118), we found that low levels of physical activity significantly increased the risk of the metabolic syndrome in youths (119).

Some studies have shown that fetal growth and size at birth may be associated with the development of the metabolic syndrome in later life (120). Birth weight reflects the pattern of intrauterine growth, and being born either large or small for gestational age might have long-term effects on risk of chronic diseases in adulthood (121, 122). In our study, among boys, being born large for gestational age and, among girls, being born small for gestational age increased the risk of having the metabolic syndrome (115). While some studies showed that lower birth weight increased the risk for having the metabolic syndrome in adulthood (123, 124), a longitudinal study showed that large-for-gestational-age newborns were at higher risk of developing metabolic syndrome in childhood (125). A recent study revealed a U-shaped relation between birth weight and several components of the metabolic syndrome, but postnatal weight gain was the dominant factor associated with the high-risk cluster (126). Additional research is needed to find the mechanisms through which environmental changes lead to the programmed effects of fetal growth. As Ong (127) concluded in a recent review, increasing trends towards childhood overweight and its metabolic consequences and their epidemiologic associations with lower birth weight have led to critical assessments of the benefits and disadvantages of rapid early growth. Current nutritional strategies that promote catch-up growth should include some monitoring of weight-for-length and adiposity, and the concept of “healthy catch-up growth” should be the goal of future research (127).

Evidence is growing that factors operating early in life influence people’s risk of chronic disease later in life. Consistent with a recent meta-analysis (128), our findings from the CASPIAN Study population confirmed the protective role of breastfeeding with regard to high blood pressure (129). In addition, we found an inverse association between breastfeeding and overweight (90). However, we did not find a protective effect of breastfeeding against the metabolic syndrome (115). It has been suggested that the association of breastfeeding with some components of the metabolic syndrome, but not with their cluster, may be due to an interaction with age (130).

Childhood socioeconomic status can affect adult health (131, 132). As an indicator of socioeconomic status, educational level is reported to be negatively correlated with the relative risk of the metabolic syndrome among adults (133, 134). In our study, a lower educational level of parents increased the odds of having the metabolic syndrome in children (115). A lower educational level of parents seems to be associated with the adoption of harmful habits, such as an unhealthy diet and physical inactivity among family members.

Different studies of adults have shown that among the various risk factors examined, a positive family history of chronic diseases is related to the metabolic syndrome (133, 135, 136). In our study, a positive family history of obesity and/or hypertension in parents increased the risk of the metabolic syndrome in both sexes, and a history of premature cardiovascular disease increased it in boys. A positive history of diabetes in parents and/or other relatives increased the odds of having the metabolic syndrome in the youths studied (115). Our findings suggest that genetic and/or non-genetic familial influences play a role in the development of the metabolic syndrome in the pediatric population.
Hence, encouraging physical activity and healthy dietary habits, such as increasing fiber intake, reducing the consumption of junk foods and saturated fat, and increasing levels of physical activity starting in childhood, may have important effects on public health. This is of special concern for low- and middle-income countries faced with an epidemic of chronic diseases in the near future. Those children with a positive family history of chronic disease need special attention in this regard (137). Given the possible link between birth weight and the metabolic syndrome, as well as the possible impact of environmental factors on fetal maturation and metabolism, public health approaches should be directed towards primordial and primary prevention of chronic diseases and related risk factors.

Conclusion

This review of findings from developing countries provides alarming evidence-based data on the considerable prevalence of childhood overweight and its metabolic consequences in countries still grappling with the public health effects of malnutrition and micronutrient deficiencies. Strategies aimed at reducing caloric intake and increasing caloric expenditure through regular exercise, early and aggressively, are necessary to meet the challenges these changes impose. Establishment of a uniform and universally accepted set of criteria for defining overweight, obesity, and the metabolic syndrome in children and adolescents would be the foundation for addressing this emerging public health concern.

Health professionals and policy-makers should focus on primary prevention of childhood obesity and the metabolic syndrome, especially in low- and middle-income countries, which are facing an epidemic of chronic diseases in the near future. The limited number of comparable nationally representative data from developing countries in the current literature emphasizes the importance of monitoring time trends in child obesity in different countries. Doing so would enable policy-makers to obtain useful insights for evidence-based health promotion programs, as well as for proactive prevention and control of this growing epidemic.

ACKNOWLEDGMENTS

Conflict of interest: none declared.

REFERENCES


117. Brage S, Wedderkopp N, Ekelund U, et al. Features of the metabolic syndrome are associated with objectively mea-


