

# Body mass index of Kuwaiti adolescents aged 10–14 years: reference percentiles and curves

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مَنَسَبَ كتلة الجسم لدى المراهقين الكويتيين بين 10 – 14 عاماً: الشرائح المئوية والمنحنيات المرجعية  
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**الخلاصة:** استهدفت هذه الدراسة السكانية المرتكز، إعداد معايير مرجعية لمنسب كتلة الجسم BMI لدى المراهقين الكويتيين، لاستخدامها في الكويت وسائر بلدان الخليج. ولقد تم قياس الوزن والطول في تلامذة المدارس المتوسطة الذين تتراوح أعمارهم بين 10 و 14 عاماً (32 624 من الذكور، و 30 209 من الإناث). واستخدمت أساليب تسليس smoothing التحوُّف المتعدِّد الحدود، للحصول على أفضل منحنيات اللياقة في الشرائح المئوية لمؤشر كتلة الجسم. وكان منسب كتلة الجسم لدى الذكور في الشرائح المئوية المنخفضة والأعمار المنخفضة أعلى على الدوام مما هي عليه لدى الإناث، وأما في الشرائح المئوية التي هي أعلى، فقد كان منسب كتلة الجسم لدى الإناث أعلى على الدوام مما هو عليه لدى الذكور. وقد قورنت المعطيات مع معطيات المركز الوطني للولايات المتحدة المعني بالمعايير الإحصائية الصحية ومع معطيات من المراهقين السعوديين والإيرانيين.

**ABSTRACT** The aim of this population-based study was to develop body mass index (BMI) reference standards for Kuwaiti adolescents for use in Kuwait and other Gulf countries. All available intermediate school students aged 10–14 years (32 624 males and 30 209 females) were measured for weight and height. Polynomial regression smoothing techniques were used to obtain the best-fitting curves for BMI percentiles. The BMI of boys at lower centiles and ages was almost always higher than girls. At higher centiles, the BMI of girls was almost always higher than boys. The data were compared with the United States National Center for Health Statistics standards and data from Saudi Arabian and Iranian adolescents.

## Indice de masse corporelle des adolescents koweïtiens âgés de 10 à 14 ans : percentiles et courbes de référence

**RÉSUMÉ** Cette étude en population avait pour objectif de mettre au point des normes de référence en matière d'indice de masse corporelle (IMC) concernant les adolescents koweïtiens, en vue de leur utilisation au Koweït et dans d'autres pays du Golfe. On a ainsi relevé la taille et le poids de tous les élèves des collèges âgés de 10 à 14 ans disponibles (32 624 garçons et 30 209 filles). Des techniques de lissage par régression polynomiale ont été utilisées pour obtenir les meilleures courbes d'ajustement des percentiles de l'IMC. L'IMC des garçons dans les centiles et aux âges les plus bas était presque toujours supérieur à celui des filles. Dans les centiles les plus élevés, l'IMC des filles était presque toujours supérieur à celui des garçons. Ces données ont été comparées aux normes du *United States National Center for Health Statistics* et aux données relatives aux adolescents saoudiens et iraniens.

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## Introduction

The stage of adolescence has been defined as ages 10 to 19 years [1], a group that represents about 20% of the general population [2]. During adolescence, the highest weight gain is concurrent with the greatest height gain [3]. As a consequence, the rate of rise of body mass index (BMI) accelerates not long after puberty. It has been suggested that this increase in BMI is related less to chronologic age than to pubertal development [3,4].

Although BMI has been recommended for assessing overweight and obesity among adolescents, an acceptable universal BMI reference standard for international use has not yet been developed [5–7]. Research about the suitability of reference standards for different populations is limited as references may over- or underestimate the levels of obesity among different populations. Moreover, some populations in developing countries may mature later than in developed countries [6,8]. Therefore, it is difficult to make comparisons between countries during this stage of development [9,10]. BMI levels have been shown to vary in adolescence according to age and sex [5].

Although the creation of standard BMI levels by age and sex based on local data have been advocated [11], it may be unnecessary for each country to develop its own standards. A more practical alternative is for a series of references to be developed so that the one that most closely matches the study population can be chosen [12]. At present there are no reference standards for use in Kuwait or other Gulf Arab populations. The purpose of this study was to develop reference BMI centile curves for Kuwaiti adolescents aged 10–14 years, for use in Kuwait and possibly neighbouring Gulf countries.

## Methods

### Sample

This population-based study was conducted with the collaboration of the Ministry of Education and the Ministry of Health in Kuwait, under the control of the first author, to develop BMI reference standards and curves for local use, especially for Kuwaiti adolescents aged 10–14 years. No financial support was required. The data collection period was October 1997–May 1999.

Pre-university public education in Kuwait of 14 years includes 2 years of kindergarten, and 4 years each of elementary, intermediate and secondary education. A list of intermediate schools was obtained from the Ministry of Education, and all of them were included in the study since they are attended by the majority of the target population aged 10–14 years. The total number of intermediate public schools was 158 at the time of the study. Males and females attend separate schools at intermediate level. The sample comprised 62 833 intermediate school students (32 624 males and 30 209 females), representing 84% of the target population (Kuwaiti pupils enrolled in intermediate schools). The schools were distributed over all geographical areas of the country and therefore students represented all socioeconomic strata of the population.

### Measurements

The data collected for the study were sex, age, weight and height. The data collection process included quality control checks and crosschecks. Each school had a nurse who measured the students' weights and heights every year as part of his/her responsibilities. So each nurse was experienced in these measurements. The first author selected and further trained the 10 most experienced

school nurses on how to use the scale and stadiometer.

Age was ascertained to the nearest month from the pupil's civil identification card which contained his/her date of birth and was kept in the school file.

The measurements of weight and height were taken by the nurses. A team of 2 nurses visited each school. One measured weight and the other height. Weight was measured to the nearest 0.1 kg with the participant standing and wearing light clothes, using a pre-calibrated digital Seca scale, which was recalibrated at each different location. Height was measured to the nearest 0.1 cm while the participant was standing without shoes, using a specially designed portable stadiometer with a spirit level to ensure that it was parallel to the floor during measurement. Measurements were recorded 3 times and the mean reading was recorded by a school teacher or a secretary against the name of the students on the class list obtained from the school.

BMI, weight in kilograms divided by height in metres squared ( $\text{kg}/\text{m}^2$ ), was used as an index of overweight and obesity and was calculated for each age and sex. The BMI curves were then compared with the United States National Center for Health Statistics (NCHS) population reference data from the National Health and Nutrition Examination Survey (NHANES-1) [11]. We also reviewed 2 other similar studies that compared the BMI of Saudi Arabian and Iranian adolescents with that of the Americans [13,14]. These 2 studies were chosen not only for the proximity of their populations to Kuwait but because the majority of the original settlers of Kuwait came from Saudi Arabia and the Islamic Republic of Iran.

#### Data analysis

SPSS for Windows, version 11 was used for data analysis. Children were grouped into

year groups of 10–14 years based on their age and the 5th, 15th, 25th, 50th, 75th, 85th and 95th percentiles, which were empirically calculated for each group. Percentile curves were then constructed and smoothed using best-fitting polynomials. The best-fitting model was selected using  $R^2$  criteria. Linear, quadratic cubic, exponential and inverse polynomials were assessed prior to selecting the best-fitting method, which was the cubic polynomial in most cases. Then centile curves were visually compared between groups (i.e. between males and females and between countries).

## Results

### BMI centiles for Kuwaiti adolescents

Table 1 shows the BMI centiles of Kuwaiti children aged 10–14 years. At the 5th centile and up to the age of 12 years, the BMI of boys was higher than that of girls. At the 15th centile and up to the age of 11 years, the BMI of boys was higher than girls. At the 25th centile, the BMI of boys was higher than girls at age 11 years. Thereafter, with 2 exceptions, at ages 10 and 14 years for the 95th centile, the BMI of girls exceeded that of boys at every age and centile category. This was reflected also in the smoothed centile curves comparing male and female BMI values (Figure 1).

### Comparison with other countries

Figure 2 compares the smoothed percentile BMI curves of Kuwaiti males aged 10–14 years with their American counterparts from the NCHS data. At the lowest centile (5th), the BMI of the Americans was higher than that of Kuwaitis in every age category. At the 25th centile, the BMI of Kuwaitis was higher than that of the Americans except at ages > 13 years. At higher centiles, the BMI of Kuwaitis was higher than that of the Americans.

Table 1 Body mass index (BMI) percentiles of Kuwaiti male (M) and female (F) children aged 10–14 years

Age group (years)	n	BMI percentiles (kg/m <sup>2</sup> )														
		5th		15th		25th		50th		75th		85th		95th		
	M	F	M	F	M	F	M	F	M	F	M	F	M	F		
10– < 11	9307	8473	14.1	13.4	15.2	14.8	16.0	15.7	17.9	18.0	21.0	21.3	23.4	23.5	27.7	27.8
11– < 12	8053	7778	14.4	14.0	15.6	15.5	16.4	16.5	18.6	19.2	22.5	23.0	25.0	25.2	29.6	29.5
12– < 13	7339	6871	14.7	14.6	16.0	16.2	17.1	17.4	19.5	20.2	23.5	23.9	25.8	26.4	30.1	30.8
13– < 14	6016	5243	15.0	15.3	16.3	17.1	17.3	18.2	19.7	20.8	23.5	24.6	26.1	27.3	31.2	32.3
14– < 15	1909	1844	15.0	16.2	16.4	17.8	17.3	19.0	19.6	21.5	23.7	25.3	26.7	27.9	31.8	31.6

n = total number of participants.

Figure 3 compares the smoothed percentile BMI curves of Kuwaiti females aged 10–14 years with their NCHS American counterparts. A very similar pattern was noted as for boys, but at the lowest centile the BMI of Kuwaiti girls at ages > 13 years began to exceed that of the Americans. At the 25th centile, a reverse trend was noted, the BMI of the Americans being higher than the youngest age group of Kuwaitis (10 years). Thereafter, the BMI of Kuwaiti girls was higher than that of the Americans, except that the gap between the 2 groups at the 50th and 75th centiles was narrower among girls than among boys. At the 95th centile, the gap between Kuwaiti and American males was wider than between Kuwaiti and American females.

Figures 4 and 5 compare the BMI curves for Saudi Arabian and Iranian adolescents with those of the Kuwaitis and Americans. At the 5th centile for males, the BMI of Americans was higher than all the other nationalities, especially at older ages (Figure 4). The BMI of Iranians was the lowest, followed by the Saudi Arabians and Kuwaitis. At the 50th centile, the BMI of Saudi Arabians and Iranians was very close but consistently lower than the Americans, but the pattern of change was similar to the Americans. At the 95th centile, which is usually used as an index of adiposity, the BMI of Saudi Arabians and the Americans almost overlapped, except at age > 13 years. The BMI of Iranians was far below both the Saudi Arabians and the Americans and the BMI of the Kuwaitis was the highest (Figure 4).

For girls, a similar pattern was noted, although with some variations (Figure 5). At the 5th centile, the BMI of Kuwaiti girls was lower at age > 13 years than American girls. The lowest group was the Iranians followed by the Saudi Arabians. At the 50th centile, the BMI of Kuwaitis was consist-

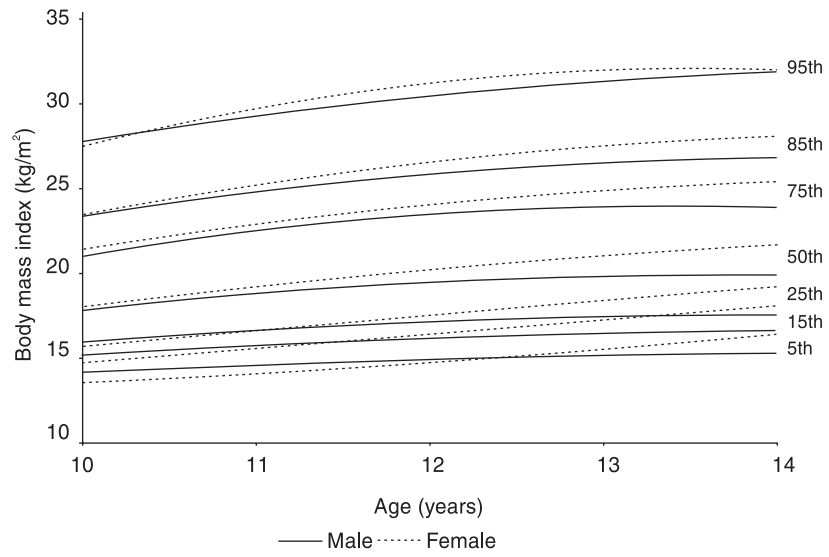


Figure 1 Body mass index percentiles of Kuwaiti children aged 10–14 years

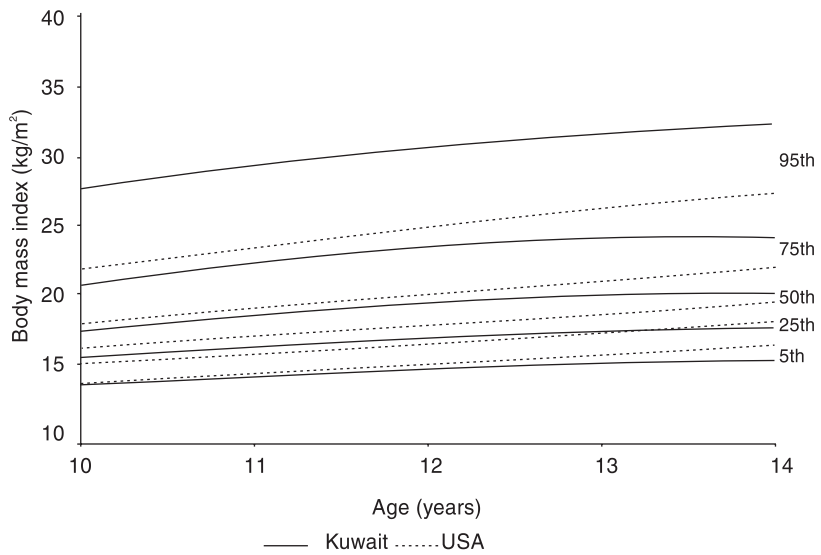


Figure 2 Body mass index percentiles of Kuwaiti male children aged 10–14 years: comparison with their American counterparts (United States National Center for Health Statistics population reference data) [11]

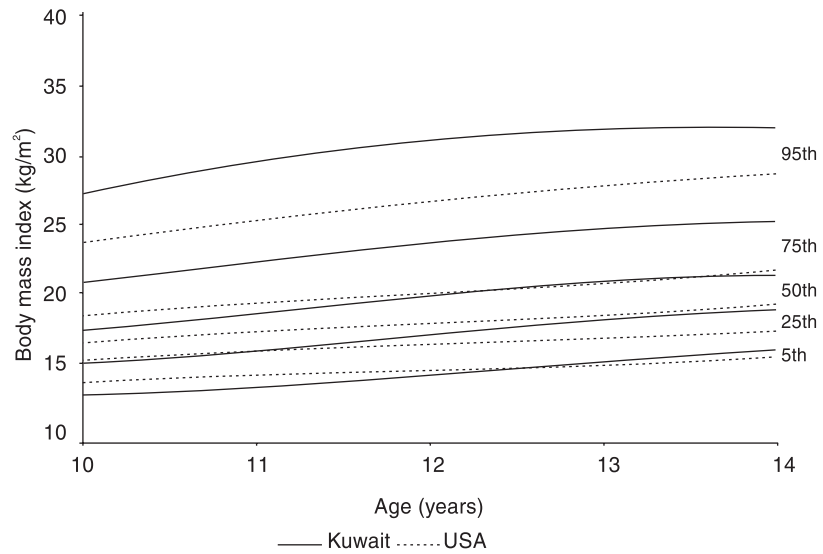


Figure 3 **Body mass index percentiles of Kuwaiti female children aged 10–14 years: comparison with their American counterparts (United States National Center for Health Statistics population reference data) [11]**

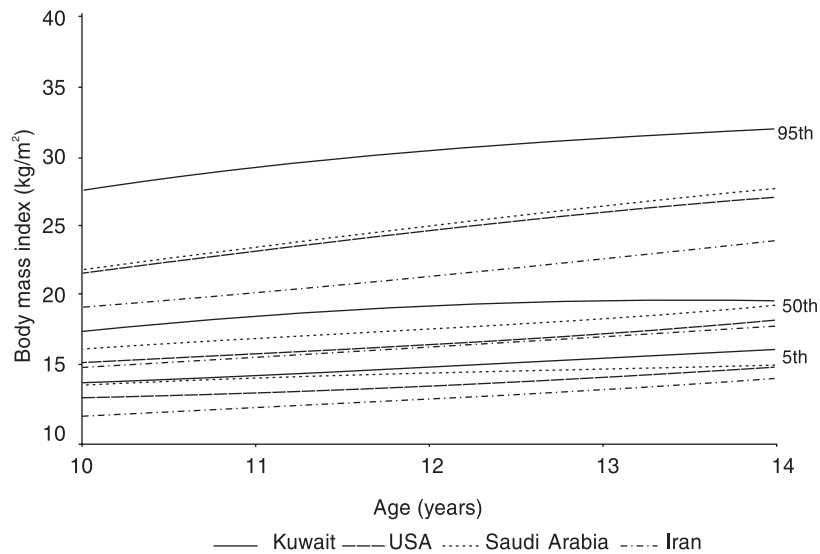


Figure 4 **Body mass index percentiles of male children aged 10–14 years: comparison of Kuwaiti children with American [11], Saudi Arabian [13] and Iranian [14] children**

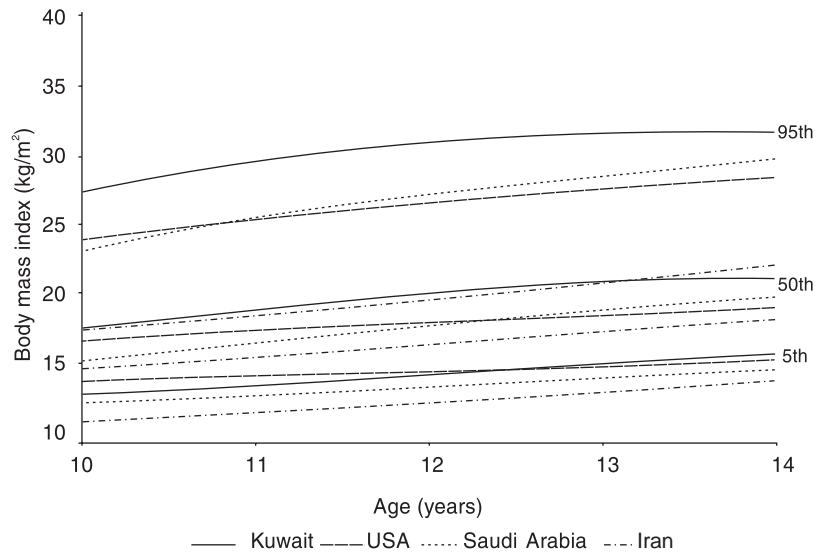


Figure 5 Body mass index percentiles of female children aged 10–14 years: comparison of Kuwaiti children with American [11], Saudi Arabian [13] and Iranian [14] children

ently higher than the Americans and the BMI gap widened at higher ages. The BMI of Saudi Arabians at this centile was lower than the Americans up to the age of 12 years. Thereafter, it increased slightly over the Americans and the gap between them widened at > 13 years. The BMI of Iranians was consistently lower than the Americans and the gap was narrower at both ends of the age range, at 10 and 14 years. At the 95th centile, the BMI of Kuwaitis surpassed all others and the widest gap was between it and the Iranians. The BMI of Saudi Arabians was closest to the Americans, being lower at age 11 years and higher at all other ages, especially at > 13 years of age. At ages 11 to 13 years, the BMI of Saudi Arabians was consistently higher than the Americans (Figure 5).

## Discussion

Our data for BMI shows that, on average, Kuwaiti children were heavier and shorter than their American counterparts, which may overestimate their level of obesity and also their underweight, as the Americans seem to be better nourished. These differences may be attributed to genetic rather than nutritional deficiencies [15–17]. This is confirmed, with regard to nutritional status, by the Saudi Arabian and the Iranian studies, which concluded that the differences between the BMI of Saudi Arabians, Iranians and Americans may be attributed to genetic rather than environmental factors [13,14]. The Iranian study further suggested that if serious malnutrition existed among Iranians in proportion to the general popu-

lation, then the pattern of upper centiles would follow that of the Americans and lower centiles would be much lower than anticipated. The shift in the Iranian centiles may suggest that either the Iranian diet does not promote growth as does the American or that the shift may be due to genetic differences [14]. This may be true for Kuwaitis and Saudi Arabians at the lowest centile.

Nonetheless, the shared issue is the genetic factor. It has been reported that the genetic influence on BMI seen in adulthood may have already been expressed at age 7 years and its influences supersedes that of environmental factors [18]. These findings suggest that the central issue for the differences between the BMI of Americans compared with the cited nationalities, including the present study, may be genetic in nature, which also suggest that the NCHS reference centiles are too high for identifying underweight and nutritional status in the compared nationalities.

Recently BMI standards have been recommended for determining overweight and obesity among adolescents. Well-nourished adolescents could be used to develop local BMI reference standards and compare studies of the same ethnicity with these standards [19], but the creation of such references would be a difficult undertaking. Moreover, it is unlikely that each country needs to develop its own standards. As an alternative, a series of references can be developed for ethnic, national or regional groups of similar genetic composition and the reference that closely matches the study population can be chosen. A measure of body shape, the Cormic index (CI)—sitting height divided by standing height—may be useful in this context. For example, if a study shows an average CI of 0.5, authors of a given study would use a reference set of data with a value close to the CI. However, this may make the data collection procedures more

cumbersome since it would require weight, height, BMI and CI to be measured [12]. A solution for this controversy has been provided by producing BMI cut-off points for various nationalities which are age and sex specific [7]. This method may eliminate the bias occurring from using the relatively overweight American population as the reference, as in the case of NCHS data. However, this method requires exact age values and it may not be suitable for Nilotic Africans and Australian Aborigines [12].

A major problem that faces the development of international reference standards for adolescents is that sexual development differs between populations [20]. As an illustration, comparing a study population of prepubertal adolescents with a reference population of postpubertal adolescents would be invalid because the normal BMI for the 2 groups would also be different. Nutritional status, especially undernutrition, may play a role in the sexual development of adolescents of various populations and consequently growth spurts [20–22]. Early maturing adolescents of the same age face a greater increase in weight than their late maturing counterparts and this increase in weight has long-term effects [23]. Anthropometric values of adolescents vary noticeably between countries and so does maturation status. It has been recommended that the BMI of adolescents should be interpreted based on sex, age and maturation [6]. The unadjusted prevalence used chronological age-matched BMI cut-offs, while the adjusted prevalence made certain adjustments, such as population adjustment (for an individual's nutritional status), thus taking into consideration maturational differences between populations [8].

To solve part of this problem, BMI data collection should be carried out during the age at which certain maturational landmarks occur, such as the age of menarche among



girls. Equivalent markers of sexual development for boys have not been established. One possibility might be self-assessment of genital stage development, for example using illustrations of various stages of development and comparing them with physical examination findings. Axillary hair, for example, could be considered as a marker of sexual development. This method, however, has not been fully validated [4,22,24–29] and in addition these developmental stages may be difficult to apply in the Gulf region due to cultural taboos.

Nevertheless, in less developed countries, BMI should be further explored in adolescents. This may require longitudinal studies to ascertain whether adolescents falling below certain cut-off points for BMI have raised levels of morbidity and mortality. However, it was felt from the overall, average-based analysis that any changes in slopes in the smoothed curves could most plausibly be explained only by pubertal changes. The use of BMI, therefore, should be continued until other indices of adiposity have been thoroughly explored. It is

well known that BMI is age-dependent. The use of American NCHS references for adolescents should be discouraged. Instead, multinational references should be encouraged such as described recently in a pooled analysis of 6 large, nationally representative, cross-sectional growth studies (in Brazil, Great Britain, Hong Kong, the Netherlands, Singapore and the United States of America) [7]. These may as yet be the best references currently available, especially for developing countries. However, for populations composed predominantly of ethnic groups not included in the multinational reference population, the appropriateness of the reference data should be carefully evaluated before utilizing it [12,30,31].

While we do not necessarily recommend that our study findings be applied to the population of Saudi Arabia or the Islamic Republic of Iran, we suggest, as others have, that the use of the American reference standards may not be entirely valid for ascertaining the degree of adiposity in Kuwait or elsewhere in the Eastern Mediterranean Region.

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### **Obesity and overweight**

World Health Organization projections indicate that globally in 2005, approximately 1.6 billion adults (over 15 years) were overweight and at least 400 million were obese. It is further projected that by 2015, approximately 2.3 billion adults will be overweight and more than 700 million obese.

Once considered a problem only in high-income countries, overweight and obesity are now dramatically on the rise in low- and middle-income countries, particularly in urban settings. Many of these countries are now facing a “double burden” of disease: while they continue to deal with the problems of infectious disease and under-nutrition, they are experiencing a rapid upsurge in chronic disease risk factors such as obesity and overweight. It is, moreover, not uncommon to find under-nutrition and obesity existing side-by-side within the same country, the same community and even the same household.

Source: WHO Fact sheet No. 311  
(<http://www.who.int/mediacentre/factsheets/fs311/en/index.html>.)