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Waist circumference percentiles for Kuwaiti children and adolescents

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Abstract

Objective: Abdominal obesity is a major risk factor for chronic diseases. Yet there are no waist circumference (WC) cut-offs for children in the Arabian Gulf. We developed smoothed WC percentiles for 5–19-year-old Kuwaiti children and adolescents, which could be used in clinical and public health practice. We also examined the percentages of children who had WC ≥ 90th percentile, a value commonly associated with an elevated risk of CVD.
Design: This is a cross-sectional study that was conducted by the Kuwait National Nutrition Surveillance System.
Setting: Data were collected from representative primary-, intermediate- and secondary-school children as part of the yearly nutrition and health monitoring. Least mean square regression was used to develop smoothed WC curves.
Subjects: A total of 9593 healthy 5·0–18·9-year-old children of both sexes were studied from all areas of Kuwait. Age, gender, residency, education level, weight, height and WC were collected for all participants.
Results: We developed the first smoothed WC curves for Kuwaiti children. Male children had higher WC than female children. WC increased with age in both genders, but larger percentages of male children had WC ≥ 90th percentile. Male children aged >10 years have higher WC percentiles than do female children at the 50th, 75th, 90th and 97th percentiles.
Conclusions: Male children (especially those aged >10 years) are at higher risk than female children. Few health-care professionals routinely measure WC. WC measurement should be promoted as an important tool in paediatric primary care practice. The use of these age- and gender-specific percentiles can impact public health recommendations for Kuwaiti and other Arab children from the Gulf.

Keywords
Waist circumference percentiles
Cut-offs
Children
Adolescents
Kuwait
Epidemiology

Obesity is a major risk factor for several serious chronic diseases, including CVD and type 2 diabetes mellitus (T2DM)[1]. In addition, obesity is associated with some cancers, gallbladder disease, hypertension and osteoarthritis[1–8]. The measurement of obesity in children and adolescents, as in adults, is an important first step in the recognition and reduction of CVD and T2DM and their potential consequences[1–8], as obesity has been shown to track into adulthood[5].

Simple reliable methods for measuring overall obesity exist and include measuring weight (kg) and dividing it by the square of the height (m^2) to obtain the BMI. An alternative and increasingly used measure of obesity is waist circumference (WC), which reflects abdominal fat accumulation. Recent studies show that WC in adults[2,3] and children[4–8] may be a more sensitive indicator of future cardiovascular risk than BMI. Consequently, most researchers and expert organizations now assert that WC should be used in screening for metabolic syndrome (MS). Two such organizations, the National Cholesterol Education Program (NCEP) of the USA and the International Diabetes Federation (IDF), both use WC as one of the five indicators of MS, a condition that is associated with increased risk of CVD and T2DM[3,4]. The five indicators that indicate high risk for MS are elevated blood pressure, large WC, hyperglycaemia, high TAG levels and low levels of HDL cholesterol.

In the IDF definition, a large WC (along with any two additional indicators) is central to the diagnosis of MS, while with the NCEP definition, possession by an individual of any three of the five indicators constitutes the presence of MS[4,7].

On account of lifestyle changes associated with the transition in nutrition in the Arabian Gulf, resulting principally from rising incomes associated with the discovery and production of oil over the past few decades, obesity has increased dramatically[9,10]. El Bayoumy *et al.*[11] found that the overall prevalence of overweight and

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obesity among men was 29·3 % and 14·9 %, respectively, ($P < 0·001$) and the prevalence of overweight and obesity among women was 32·1 % and 14·2 %, respectively ($P < 0·001$). Studies have shown that with new affluence has come increased availability of fast-food restaurants and ready availability of other semi-fast food establishments in all Gulf countries, including Kuwait[9,12]. In addition to the ready availability of energy-dense fast foods, many Kuwaiti citizens are less physically active than their predecessors[12]. Of the over 2·6 million total population of Kuwait, about one-half of the population is of 'migrant' workers who perform much of the manual labour done in Kuwait. The increased availability of energy-dense foods and the concomitant decrease in activity has been documented in the Gulf (which includes Kuwait) and is believed to be the main reason why diseases such as T2DM and CVD[11–14] have increased dramatically over the past several years. Of great concern is the finding that chronic diseases are also increasing among children and adolescents[11,15].

Virtually all studies of obesity in adults and children in Kuwait have measured BMI[10,16–18] as the yardstick to measure obesity. No large-scale epidemiological studies have examined WC, despite the fact that WC is thought to be more reliably related to MS than is BMI[2,3,7,19].

The objective of the present study was to develop smoothed WC percentiles for Kuwaiti children and adolescents between 5·0 and 18·9 years of age that could be used to inform public health practice. We also sought to examine the percentages of Kuwaiti children, at each age, who had WC that exceeded the 90th percentile, a value that is commonly said to indicate elevated risk for MS[6,8]. Finally, we sought to examine the correlation between overall obesity (defined by BMI values) and abdominal obesity (measured by WC values) in this child and adolescent population.

Subjects and methods

The study included 9593 healthy male and female students who were interviewed and measured in primary, intermediate and secondary schools in Kuwait. The sample included 5014 children (5·0–9·9 years) and 4579 adolescents (10·0–18·9 years). The data were collected as part of the Kuwait National Nutrition Surveillance System (KNNS). The KNNS system has been described elsewhere[10,20]; however, in brief, it includes children and adults from all geographical locations (governorates) of Kuwait. It includes measurements of weight and height, WC and cholesterol values in some subgroups. It also includes several sociodemographic variables. It is designed to continuously monitor the nutritional health status of different Kuwaiti population groups and to provide data as an instrument of policy formulation and health intervention evaluation for health workers and decision makers. In the present study, adolescents are children who are between 10 and 19 years of age.

A structured questionnaire was used to elicit a variety of information including age, gender, location of residence and school grade level of pupils.

Non-fasting cholesterol levels were measured in a subsample of 1497 children who were more than 10 years of age. Cholesterol was measured from capillary blood taken from the finger in adolescents who were in a sitting position. Cholesterol was analysed using a Reflotron (Boehringer Mannheim, Germany); this device meets the performance standards of the American NCEP Laboratory Standardization Panel.

Weight, height and WC were also measured. Weight was measured to the nearest 0·1 kg and height was measured to the nearest 0·1 cm. WC was measured to the nearest 0·1 cm mid-way between the inferior margin of the lower rib and the top of the iliac crest. BMI was calculated as the weight (kg) divided by the square of height (m^2). We used WC ≥90th percentile as evidence of elevated risk for obesity-related cardiovascular disorders[6,8]. Thus, we dichotomized the population into those children and adolescents who were <90th percentile (lower risk) and those who were ≥90th percentile (higher risk). The basic prevalence estimates of higher risk were generated by examining the number of children with WC ≥ 90th least median square (LMS) regression percentile values for each age and sex category (see Tables 2 and 3). LMS regression resulted in cut-off values at each selected percentile (e.g. 75th, 90th, etc.). We then found the percentage of children in each age and sex category whose WC value was same or more.

Statistical analysis was carried out using descriptive statistics, including means and frequencies and inferential statistics that included correlation coefficients and independent sample *t* tests. To produce smoothed WC percentile graphs and tables, the software program Chartmaker Pro (Institute of Child Health, London, UK) was used to carry out LMS regression using the method developed by Cole and Green[21]. The LMS procedure resulted in a WC cut-off for male children and another for female children at each percentile (3rd, 10th, 25th, 50th, 75th, 90th and 97th percentiles) for each age category. Graph and table percentiles calculated were the 3rd, 10th, 25th, 50th, 75th, 90th and 97th percentiles. The LMS method involved summarizing the percentiles at each age (separately for male and female children in the present study) on the basis of the Box–Cox power transformations, which are used to normalize the data. The final percentile curves were the result of smoothing three age-specific curves, termed lambda (L), mu (M) and sigma (S). The L, M and S curves describe the skewness, median and CV of the distribution of WC at each age[21]. Statistical analyses were carried out with the Statistical Package for Social Sciences statistical software package version 17·0 (SPSS Inc., Chicago, IL, USA). Significance was defined as $P \leq 0·05$.

Results

The sample of 9593 included 4843 (50·5 %) male and 4750 (49·5 %) female children. The overall age range of the sample was 5·0–18·9 years. The mean (SD) age of male children was 11·0 (SD 3·9) years, whereas it was 10·9 (SD 3·9) years for female children.

Table 1 shows the number, mean and SD of WC and BMI values of Kuwaiti children and adolescents aged 5·0–18·9 years by sex. The mean WC generally increased with age for both male and female children. The BMI values of male and female children also generally increase with age. However, the BMI means for ages 8, 9 and 10 years are higher than at other ages. From the age of 10 years, male children have higher WC values than do female children, as is evident from Table 1. The mean BMI values of male children are generally higher than those of female children at most ages.

Tables 2 and 3 show the smoothed WC percentile values for male and female children at various percentiles (3rd, 10th, 25th, 50th, 75th, 90th and 97th), respectively. They also show that waist percentiles increase with age for both male and female children. The tables also show the percentage of male and female children at each age who had WC ≥ 90th percentile. The tables indicate that between 7·9–16·7 % and 1·8–13·4 % of male and female children, respectively, had a WC ≥ 90th percentile, a value frequently considered to be evidence of elevated risk for MS[6,8]. As can be seen from Table 1, the percentage of male children exceeding the 90th percentile was larger than the percentage of female children exceeding that value at every age ≥6 years. The smoothed percentile curves for female and male children are shown in Figs 1 and 2, respectively.

Above the age of 7 years, male children have higher WC percentiles than female children at the 50th, 75th, 90th and 97th percentiles. Thus, it seems that the dramatic increase in WC is established in male children starting as early as at the age of 7 years. Before the 7th year, female children have higher WC percentiles at these four percentile levels (50th, 75th, 90th and 97th).

Table 1 Mean WC and BMI of Kuwait children aged 5·0–18·9 years by sex

	WC (cm)							BMI (kg/m^2)					
	Male				Female			Male			Female		
Age (years)	Mean	SD	*n*	≥90th*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*
5	54·2	7·3	219	10·0	52·8	7·0	213	22·0	5·5	219	20·9	4·9	213
6	54·3	6·6	624	10·1	54·6	7·3	590	22·6	5·0	624	22·9	5·9	590
7	58·2	9·4	598	16·7	57·0	8·1	642	27·0	8·1	598	26·2	7·1	642
8	60·1	10·4	580	15·0	60·5	9·6	567	31·0	9·3	580	30·5	8·4	567
9	63·1	11·1	496	13·9	63·3	11·0	483	33·7	10·2	496	34·5	10·3	483
10	67·5	12·8	172	13·4	66·8	10·7	190	39·4	12·1	172	39·6	11·5	190
11	72·1	12·8	178	12·4	69·9	11·5	214	21·4	5·8	178	22·1	5·8	214
12	74·5	13·6	232	12·9	71·7	10·9	254	22·4	5·9	232	22·7	5·3	254
13	75·7	13·9	277	10·5	72·5	10·9	263	22·7	6·4	277	23·4	5·5	263
14	78·9	15·2	363	12·7	75·3	11·7	320	23·8	6·6	363	24·7	6·3	320
15	82·2	16·1	283	13·4	73·7	12·0	282	25·2	7·0	283	24·3	5·9	282
16	82·3	16·1	363	11·0	73·6	11·6	272	24·9	7·1	363	23·8	5·5	272
17	83·6	15·9	316	10·8	73·0	12·6	291	25·9	7·5	316	24·3	5·5	291
18	81·8	15·7	142	7·9	74·0	12·7	167	25·0	7·0	142	24·6	6·2	167

WC, waist circumference.
*Percentage with WC values ≥90th percentile.

Table 2 Smoothed WC percentiles (in cm) for Kuwaiti male children

Age (years)	3rd	10th	25th	50th	75th	90th	97th	≥90th*
5	43·5	45·5	47·8	50·7	54·6	60·0	68·5	10·0
6	44·5	46·6	49·3	52·6	56·9	62·9	72·3	10·1
7	45·5	48·0	51·0	54·8	59·9	67·0	78·2	16·7
8	46·3	49·2	52·7	57·2	63·2	71·7	85·4	15·0
9	47·5	50·8	54·9	60·0	66·9	76·8	92·7	13·9
10	49·2	52·9	57·5	63·3	71·0	82·1	99·5	13·4
11	51·2	55·2	60·3	66·7	75·1	87·1	105·6	12·4
12	53·1	57·5	62·9	69·8	78·9	91·5	110·7	12·9
13	54·9	59·5	65·3	72·5	82·1	95·3	115·0	10·5
14	56·4	61·3	67·3	74·9	84·8	98·5	118·8	12·7
15	57·8	62·8	69·0	76·8	87·1	101·1	121·9	13·4
16	59·0	64·2	70·5	78·5	89·0	103·3	124·5	11·0
17	60·0	65·3	71·7	79·9	90·6	105·2	126·6	10·8
18	60·8	66·2	72·8	81·1	91·9	106·7	128·4	7·9

WC, waist circumference.
*Percentage with WC values ≥90th percentile.

Table 3 Smoothed WC percentiles (in cm) for Kuwaiti female children

Age (years)	3rd	10th	25th	50th	75th	90th	97th	≥90th*
5	43·8	45·7	48·0	50·9	54·6	59·6	67·4	11·3
6	44·4	46·6	49·3	52·6	56·9	63·0	72·4	12·9
7	45·4	47·9	51·0	54·9	60·0	67·2	78·8	11·4
8	46·3	49·2	52·7	57·2	63·2	71·7	85·4	13·4
9	47·6	50·8	54·8	60·0	66·7	76·5	92·1	11·8
10	49·3	52·9	57·4	63·1	70·7	81·6	98·7	11·6
11	51·4	55·4	60·3	66·6	74·9	86·7	104·9	9·3
12	53·3	57·7	63·0	69·8	78·7	91·3	110·4	5·1
13	55·0	59·7	65·3	72·5	82·0	95·2	114·9	3·8
14	56·6	61·4	67·4	74·9	84·8	98·5	118·8	5·3
15	57·9	62·9	69·1	76·9	87·2	101·3	122·1	2·1
16	58·9	64·1	70·5	78·6	89·1	103·6	124·8	1·8
17	59·8	65·1	71·7	80·0	90·7	105·4	127·0	2·7
18	60·5	66·0	72·7	81·1	92·1	107·0	128·7	3·6

WC, waist circumference.
*Percentage with WC values ≥90th percentile.

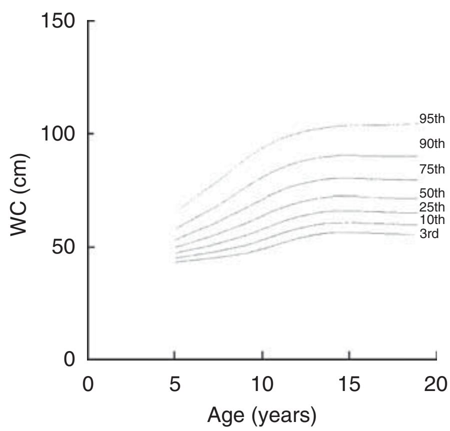

Fig. 1 Smoothed waist circumference (WC) percentiles for female Kuwaiti children aged 5–19 years

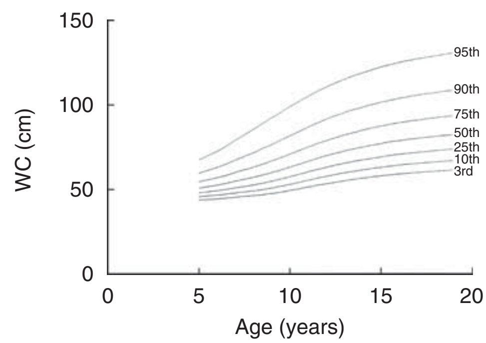

Fig. 2 Smoothed waist circumference (WC) percentiles for male Kuwaiti children aged 5–19 years

For primary school-aged children the mean BMI of female (n 2497) and male children (n 2517) was 27·6 (SD 9·1) kg/m^2 and 27·7 (SD 9·1) kg/m^2, respectively. The mean WC of female children was 58·1 (SD 9·6) cm, whereas the mean WC of male children was 58·4 (SD 9·8) cm.

The mean BMI of female (n 2253) and male adolescents (n 2326) was 25·2 (SD 8·1) kg/m^2 and 25·3 (SD 8·7) kg/m^2, respectively. The mean WC of female adolescents was 72·6 (SD 11·9) cm, whereas the mean WC of male adolescents was 78·5 (SD 15·7) cm. Male adolescents maintained a slightly higher mean BMI than did female adolescents. However, the mean WC of male adolescents was significantly higher ($P < 0·01$) than that of female adolescents.

A WC ≥ 90th percentile is thought to confer increased risk of developing MS[6,8]. When we dichotomized our sample by gender into those with WC ≥ 90th percentile and those with WC < 90th percentile, we found that the mean BMI of male and female children, whose WC was ≥90th percentile, was significantly greater ($P < 0·01$) at every age than those who had WC <90th percentile.

The Pearson correlation (r) of WC and BMI in primary school-aged female children was 0·879 (n 2497, $P < 0·01$), whereas the correlation in primary school-aged male children was slightly higher ($r = 0·896$, n 2517, $P \leq 0·01$). The correlation of WC and BMI in female adolescents was 0·595 (n 2253, $P < 0·01$), whereas it was slightly higher in male adolescents ($r = 0·656$, n 2326, $P \leq 0·01$).

For male children, the partial correlations (controlling for age) between cholesterol values and WC ($r = 0·218$, n 761, $P = 0·001$) and between cholesterol and BMI ($r = 0·217$, n 761, $P = 0·001$) were both highly significant. For female children, the correlations between cholesterol values and WC ($r = 0·099$, n 728, $P = 0·007$) and between cholesterol and BMI ($r = 0·080$, n 728, $P = 0·030$) were also significant.

Discussion

Obesity is increasing worldwide among adults and among children and adolescents[1–8,22]. There is growing evidence that abdominal obesity is associated with increased risk for T2DM, dyslipidaemia (elevated TAG and lowered HDL cholesterol levels), hypertension and CVD[23]. WC is a sensitive measure of abdominal fat[2,3,7]. Several experts recommend that WC should be used for children and adults when screening for potential CVD and T2DM risk[6–8,15,19,23].

WC cut-off values have been proposed for children and adolescents of several Western countries (e.g. Italy[19], Spain[24], Britain[25], USA[26], Canada[27], etc.); however, waist cut-off values do not exist for Kuwaitis or for most other Gulf Arab children and adolescents. We know from adult studies that body fat distributions vary across ethnic groups, leading NCEP and IDF to call for the application of different WC cut-offs for some non-Western populations. Given the high rate and growing trend towards obesity worldwide[22], including in Kuwait and other Gulf countries, the development of age- and gender-specific WC cut-offs is needed.

These are the first age- and gender-specific comprehensive smoothed WC growth curves developed for Kuwaiti children and adolescents. Given the precipitous increase in overweight and obesity in Kuwait[15–18], the use of these curves and tables can provide early identification of children who may be at higher risk for future CVD and T2DM[6,8].

We found that male children had higher WC percentiles than female children at most of the ages that were studied. These results are similar to those found from other adolescent populations, in which e.g. Fernandez *et al.*[26] in Americans and Katzmarzyk[27] in Canadians also found that male children had higher WC percentiles than female children for most of the ages they studied. Thus, our Kuwait results can be seen as a part of a larger worldwide trend towards greater overall and abdominal obesity, particularly among male children.

The 90th percentile is commonly suggested[6,8] as a cut-off percentile at and above which the risk for MS and CVD increases substantially. Of male children 8·0–16·7 % (for an average of 12 %) over the entire 5·0–18·9-year age range in our study had WC percentiles ≥90th percentile. In female children, between 2·0 % and 13·0 % (for an average of 7·6 %) over the entire age range had values ≥90th percentile. In fact, male children had a greater percentage of individuals above the 90th percentile at nearly every age (>6 years of age) in our study.

The percentage of male children who exceed the 90th percentile was more or less constant (averaging about 12 %) over the 5·0–18·9-year age range. However, the percentage of girls exceeding the 90th percentile declined after the age of 10 years. Thus, for this sample, the age of 11 years seems to be a transition age, with ages ≥11 years showing substantial decreases in the percentage of girls with WC ≥90th percentile. Our cross-sectional study cannot answer why this observed difference occurs or what causes it. Additional studies are needed to ascertain why this dramatic gender-related decrement occurs in percentages exceeding the 90th percentile in female children. It may be related to gender-related maturational or possibly to cultural differences in exercise patterns between male and female children.

The age of 10 years is the age that represents the transition age between primary and intermediate schools in Kuwait. The mean BMI values at the age of 9 and 10 years were inexplicably high. Perhaps, the diet or exercise regimes differ between the two school levels. In 2003, Al Isa[17] reported that obesity increased in Kuwaiti men and women between 1980–1981 and 1993–1994, but that the increase in obesity was slightly greater in men than in women. In a later study, in adolescents, Al Isa and Thalib[16] studied BMI in 10–14-year-old Kuwait children and found that the percentage of obesity was higher in male children, particularly at the higher percentiles (75th through the 95th) of the BMI distribution. Therefore, these studies using BMI as a measure of overall fatness show that male adolescents and adults have greater obesity than do female adolescents. Al Isa[17] pointed to changes in the levels of affluence, excessive food consumption and sedentary behaviour to explain the increasing obesity rates and gender differences in obesity in this age group. Mabry *et al.*[12] also indicate that changing exercise patterns may account for the increases in obesity in Gulf countries[12].

In a later study, Al Isa and Thalib[18] found that the BMI values of Kuwaiti boys aged 3–9 years exceeded those of girls at those ages. Those results are similar to the results that we found for the WC values of boys and girls. In our study, there was no consistent pattern in the mean BMI between male and female children at 5–14 years of age. However, the mean BMI values of older male adolescents (15–18 years) were larger than those of older female adolescents. The correlation between WC and cholesterol values was stronger and more highly significant in male than in female children. This supports the finding that men are at greater risk due to their larger WC values.

Thus, our results show clearly that males are at greater risk and that intervention in this group is urgently required to understand and reverse this finding. Child and adolescent overweight and obesity have been shown to track into adulthood[5,28], thus increasing the risk for later development of CVD and T2DM.

Above the age of 10 years, male children have higher WC percentiles than female children at the 50th, 75th, 90th and 97th percentiles. Further research is needed to explain why this clear trend towards bigger WC occurs in male children between 11·0 and 18·9 years of age and why this age seems to be the transition age. However, this suggests that starting at the age of 10 years, WC should be measured in male and female children as after this age the correlation of BMI and WC is low and expert groups[4] have found WC to be a better indicator of CVD risk than BMI. Moreover, the correlation of WC with cholesterol values was more significant than that of BMI and cholesterol values, indicating that WC is more highly related to metabolic risk than is the current measure of obesity and BMI.

As relatively few health-care professionals routinely measure WC, efforts are needed to promote the measurement of this anthropometric indicator as an important tool in paediatric primary care practice. It is clear that these age- and gender-specific WC percentiles can be used as a tool to impact public health recommendations and practice *vis-à-vis* children and adolescents in Kuwait and other Gulf countries.

These are the first age- and gender-specific comprehensive smoothed WC growth curves developed for Kuwaiti children and adolescents. Owing to the genetic and ethnic similarities of Gulf Arab children[18], these WC percentiles might be able to be used in other Gulf populations where WC percentiles do not currently exist. The comparison of observed values of other Gulf children and adolescents to the 90th or 95th percentiles of these tables may be particularly helpful. Second, this is a large representative study of both sexes over a wide age range. Thus, the present study can be used as a basis for comparison for children of similar ages performed in different countries outside the Arabian Gulf.

The cross-sectional nature precludes us drawing conclusions about the associations we observed in the present study. Only longitudinal studies that track anthropometric indicators and other metabolic indicators of risk can definitively answer questions about the relationship of WC to proven cardiovascular risk. Other indicators of the MS (e.g. blood lipids, blood glucose and blood pressure) were not measured in the present study. The direct correlation of these indicators with WC would have given a stronger indication of risk.

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