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Relationship between body composition and blood pressure in Bahraini adolescents

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The objective of the present study was to examine the relationship between body composition and blood pressure (BP) in Bahraini adolescents. A sample of 504 Bahraini schoolchildren aged 12–17 years (249 boys and 255 girls) was selected using a multi-stage stratified sampling procedure. BP measurements were performed on the students. Anthropometric data including weight, height, waist circumference (WC), hip circumference, and triceps, subscapular and medial calf skinfold thicknesses were also collected. BMI, percentage body fat, waist:hip (WHR), and subscapular:triceps skinfold ratio were calculated. Mean systolic BP and mean diastolic BP were higher in males than in females. Weight and height in boys and weight only in girls were significantly associated with systolic BP independent of age or percentage fat. Nearly 14 % of the adolescents were classified as having high BP. BMI and percentage body fat were significantly and positively associated with the risk of having high BP in the boys and girls. Adolescents with high WHR or WC, as indicators for central obesity, tended to have higher BP values. The results from the present study indicate that obesity influences the BP of Bahraini adolescents and that simple anthropometric measurements such as WHR and WC are useful in identifying children at risk of developing high BP. These findings together with the known tracking of BP from adolescence into adulthood underline the importance of establishing intervention programmes in order to prevent the development of childhood and adolescent obesity.

Obesity: Blood pressure: Adolescents: Bahrain

Increase in body fat is a serious and widespread problem in the world. Statistics from developed and many developing countries suggest that the prevalence of childhood and adolescent obesity has increased substantially in the last few decades and it is probable that this trend will continue (World Health Organization, 1998). This is a cause of concern as obesity at this age is associated with a wide variety of conditions and metabolic abnormalities, including elevated blood pressure (BP) (Williams *et al.* 1992*a*,*b*; Freedman *et al.* 1999*a*). The effects of obesity present in adolescence on BP levels may be related to the accumulation of abdominal fat that occurs around the time of puberty (Daniels *et al.* 1999; Goran & Gower, 1999). Although several anthropometric indicators such as subscapular skinfold thickness (SSKF), waist:hip (WHR) and waist circumference (WC) (Shear *et al.* 1987; Freedman *et al.* 1999*b*; Lurbe *et al.* 2001) have been shown to be associated with cardiovascular disease risk factors, controversy still exists regarding the best anthropometric marker for assessing the relationship between body-fat distribution and the risk of elevated BP.

Studies from the Arab Gulf countries have documented an increase in the prevalence of overweight and obesity among adolescents (Al-Mousa & Parkash, 2000; Musaiger *et al.* 2000). However, little is known about the adverse health impact of obesity during childhood and adolescence. In the United Arab Emirates, Moussa *et al.* (1994) found that there was a significant difference in systolic BP (SBP) and diastolic BP (DBP) means between obese and non-obese schoolchildren (7–18 years). In Kuwait, Moussa *et al.* (1999) showed that both SBP and DBP mean values were significantly higher in obese than in non-obese children (6–13 years) in both males and females. The aim of the present study, therefore, was to investigate the relationship between body composition and BP in a representative sample of Bahraini 12- to 17-year-old schoolchildren.

Subjects and methods

Sampling

A cross-sectional survey was conducted in September–December 2000 on Bahraini male and female adolescents between the ages of 12 and 17 years. The sample, which comprised 504 students (249 males and 255 females),

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Abbreviations: BP, blood pressure; DBP, diastolic blood pressure; FFM, fat-free mass; FM, fat mass; OR, odds ratio; SBP, systolic blood pressure; SSKF, subscapular skinfold thickness; STR, subscapular:triceps skinfold ratio; TSKF, triceps skinfold thickness; WC, waist circumference; WHR, waist:hip.

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was selected using a multi-stage stratified random sampling technique. Bahrain was divided into four governorates, and elementary and secondary schools were selected randomly from each governorate. A total of twenty-four schools were included. The number of students was selected proportionally to the total number of students in each school using the schools' records. A systematic random sample of students was drawn from each school. Only Bahraini students were included in the survey, and a replacement sample was selected to substitute for the non-Bahraini in each educational level. Students' reported age and date of birth were verified against the schools' records, which in turn were based on the students' birth certificates.

Blood pressure measurement

SBP and DBP were measured under standardised conditions (Task Force on Blood Pressure Control in Children, 1987) using an Accoson mercury sphygmomanometer (Acuson, Mountain View, CA, USA) of appropriate cuff size (covering 80 to 100 % of the arm circumference) and a Littman stethoscope (Littmann Master Cardiology, 3M Littmann, USA). The same sphygmomanometer was used on all the students. Each student was asked to sit quietly for 5 min, to relieve any possible tension, before BP was measured. A qualified female nurse took the BP measurements for all the students. The measurement was repeated after 3 min and the average of the two readings was used in the analysis.

The definition of high BP was based on the recommendations of the WHO Expert Committee on Hypertension Control (World Health Organization, 1994). High BP status was defined as SBP and/or DBP $\geq$ 95th percentile for age; normal BP status was defined as SBP and/or DBP $<$ 95th percentile for age.

Anthropometric measurements

Anthropometric measurements including weight and height, triceps skinfold thickness (TSKF) and SSKF were taken from the adolescents according to standardised methods (Fidanza, 1991). Weight and height measurements were taken by a single researcher, while the skinfold thickness and circumference measurements were performed by one of two trained observers (one for each sex) whose quality of performance was evaluated before the study. Height and weight measurements were taken twice and the mean of the two measurements was used to calculate BMI (body weight divided by body height squared, expressed in kg/m^2).

Skinfold thickness was measured to the nearest 0·2 mm, on the left side and at the two anatomical locations, namely triceps and sub-scapular. Skinfold measurements were made using a Holtain calliper (range 0–40 mm × 0·2 mm; CMS Weighing Equipment Ltd, London, UK) or a Lange skinfold calliper (range 0–60 mm × 1 mm; Cambridge Scientific Industries Inc, Cambridge, MA, USA). The Lange calliper was only used for those with skinfold thickness $>$ 40 mm (i.e. above the measuring range of the Holtain callipers). Three readings were taken at each of the three anatomical sites and the average of these readings was included in the analysis. Body diameters were measured to the nearest 1 mm, using a flexible non-stretchable tape (range 0–1·45 m × 1 mm; CMS Weighing Equipment Ltd). Circumferences measured were mid-upper-arm circumference, WC and hip circumference.

BMI and percentage body fat were used to assess the fat composition in the surveyed adolescents. There are no equations for calculating body-fat composition in the Arab countries. Most of the equations available in Western countries are focused on estimating body fatness among adults, and a few of them are specific to adolescents. The equations of Slaughter *et al.* (1988) are among those commonly used for adolescents, because they are based on the multi-compartmental model of body composition and thus take into account variation in fat-free-mass (FFM) density with age and sex that occurs during childhood. Percentage body fat was calculated from the age- and sex-specific equations of Slaughter *et al.* (1988).

For all boys:
Percentage body fat $= 0{\cdot}735$ (TSKF + calf skinfold thickness) $+ 1{\cdot}0$.
For girls with (TSKF + SSKF) $\leq$ 35 mm:
Percentage body fat $= 1{\cdot}33$ (TSKF + SSKF) $- 0{\cdot}013$ $(\text{TSKF} + \text{SSKF})^2 - 2{\cdot}5$.
For girls with (TSKF + SSKF) $>$ 35 mm:
Percentage body fat $= 0{\cdot}546$ (TSKF + SSKF) $+ 9{\cdot}7$.
Total body fat mass (FM) and FFM were calculated as follows and as reported by Gibson (1990):
FM (kg) = (percentage body fat/100) × body weight (kg);
FFM (kg) = body weight (kg) − body FM (kg).

Regional fat distribution was assessed by calculating the WHR and the subscapular:triceps skinfold ratio (STR). The WC was also used to assess central obesity.

Statistical analysis

Data were entered and analysed using the SPSS version 10 statistical package. Mean values and standard deviations for SBP and DBP were calculated. Correlation coefficients between BP and other anthropometric indicators were also determined. The designated level of statistical significance was $P < 0{\cdot}05$.

Linear regression analysis was carried out on males and females separately, to examine the independent effects of various anthropometric variables (percentage body fat, STR and weight and height) on SBP.

Using the BMI reference data of Must *et al.* (1991*a*,*b*), participants were classified into three groups according to their BMI percentile category: underweight, normal and overweight ($<$ 85th, 85th to $<$ 95th and $\geq$ 95th respectively). Percentage body fat categories were based on the classification system proposed by Ellis (1996) ($<$ 25 %, 25–35 % and $>$ 35 %). WHR and WC were categorised using internal cut-off points (tertiles). Chi-square for trend was used to determine the presence of association between the variables.

The association between BMI, percentage body fat, WHR, WC and the outcome variable (BP status) was examined using contingency tables. Risk was estimated using odds ratios (OR) and 95 % CI. Logistic regression analysis was used to calculate the age-adjusted OR.

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Results

The means for the anthropometric characteristics of the sample studied are illustrated in Table 1. In general, girls have higher mean values of BMI and skinfold measurements. Mean values for weight and height increased with age in both sexes, except at age 17 years where height in both boys and girls, and weight in girls only dropped slightly from their mean values at age 16 years. Boys have higher means of WC than girls at ages 13, 14 and 17 years, while girls have higher WC at ages 12, 15 and 16 years.

The mean values of SBP in the male and female participants were 122·9 (SD 16·5) and 118·6 (SD 14·1) mmHg and those of DBP were 72·1 (SD 12·1) and 70·1 (SD 11·7) mmHg, respectively. Mean SBP was significantly higher in boys than in girls ($P=0·002$), but no statistically significant difference in mean DBP between the two sexes was observed ($P=0·057$). The correlation between BP and age in the adolescents, investigated by the Spearman rank correlation, was found to be significant for SBP and was stronger in males (r 0·44; $P<0·001$) than in females (r 0·21; $P=0·001$). No significant correlation was found between DBP and age in boys (r −0·02; $P=0·818$) or in girls (r 0·07; $P=0·295$).

Relationship between blood pressure and anthropometric indicators

The age-adjusted correlation coefficients between BP and the anthropometric indicators are presented in Table 2. Height, weight, BMI, TSKF, SSKF, percentage body fat and FM were all significantly related to SBP and to DBP in both sexes. In girls the correlation between SBP and fat indices (percentage body fat and FM) was stronger than in boys. FFM was significantly correlated with SBP and DBP in boys but not in girls. The strongest correlation observed for SBP was with weight. Of the fat-patterning indices, WC showed the strongest correlation with SBP and DBP.

The results of the multiple regression analysis of SBP conducted on the independent variables of age, percentage fat, STR and weight and height are shown in Table 3. Because of the difficulty in separating the effects of these variables, as they were highly correlated with each other, the selected independent variables were entered in three steps. Age was entered into the first step, followed by percentage body fat and STR and both height and weight were entered in the last step. Age was significantly associated with SBP, especially in boys, accounting for 18 % of the SBP variation. Percentage fat but not STR was significantly associated with SBP in both boys and girls ($P<0·001$). The increment in the R^2 value, when these two variables were entered, ranged from 7 % in boys to 25·5 % in girls. Weight and height in males and weight only in females were significantly associated with SBP, independent of age, percentage fat or STR. The value of R^2 in the final model was 0·37 and 0·29 in boys and girls, respectively. When weight and height were tested along with percentage fat and STR, by entering them together in step 2, and after adjusting for age, only weight in females and weight and height in males remained in the final model. These findings indicate that body size is more important than either body fat or STR in explaining differences in SBP among the adolescents.

Association between blood pressure and obesity

The mean values with their standard errors of SBP and DBP of the adolescent participants by their age and obesity status are presented in Figs. 1 and 2. Mean SBP was significantly higher ($P<0·001$) among adolescents with BMI≥85th percentile than in those with BMI <85th percentile of the BMI reference (Must *et al.* 1991*a*,*b*). A statistically significant difference between the obese and non-obese group was also found for DBP in both boys ($P=0·005$) and girls ($P<0·001$).

Of the total sample (n 504), seventy participants (14 %) were found to have SBP and/or DBP at or above the 95th percentile of the reference values, which put them in

Table 1. Anthropometric measurements of Bahraini adolescents by age and sex (Mean values)

		Age (years)					
	Sex	12–	13–	14–	15–	16–	17–
Subjects (n)	M	41	46	48	37	43	34
	F	50	43	40	41	40	43
Weight (kg)	M	40·7	52·1	59·0	59·1	65·9	70·4
	F	50·4	52·5	53·1	61·3	63·5	62·1
Height (m)	M	1·478	1·554	1·622	1·672	1·707	1·701
	F	1·515	1·545	1·548	1·569	1·582	1·575
Triceps skinfold thickness (mm)	M	12·2	15·6	15·2	12·2	14·0	18·1
	F	25·7	25·8	26·7	33·0	33·8	32·3
Subscapular skinfold thickness (mm)	M	9·8	13·2	13·4	10·9	12·7	17·1
	F	19·8	17·7	19·5	25·3	26·5	25·1
Waist circumference (mm)	M	651	727	761	743	772	813
	F	702	707	712	762	784	774
BMI (kg/m^2)	M	18·5	21·2	22·3	21·0	22·5	24·4
	F	21·5	21·8	22·0	24·7	25·3	25·0

M, male; F, female.

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Table 2. Associations between systolic blood pressure (SBP) and diastolic blood pressure (DBP) and selected anthropometric indicators in male and female adolescents aged 12–17 years

(Age-adjusted correlation coefficients)

	Sex			
	Males (*n* 249)		Females (*n* 255)	
Anthropometric indicator	SBP	DBP	SBP	DBP
Height	0·399***	0·413***	0·286***	0·302***
Weight	0·434***	0·303***	0·519***	0·411***
BMI	0·358***	0·210**	0·504***	0·376***
Triceps skinfold thickness	0·285***	0·184**	0·433***	0·370***
Subscapular skinfold thickness	0·302***	0·188**	0·483***	0·373***
Percentage body fat	0·279***	0·176**	0·468***	0·381***
Fat mass	0·304***	0·196**	0·490***	0·392***
Fat-free mass	0·422***	0·332***	0·093 NS	0·061 NS
Waist : hip	0·210**	0·144*	0·305***	0·142*
Subscapular : triceps skinfold ratio	0·081 NS	0·029 NS	0·201**	0·105 NS
Waist circumference	0·379***	0·266***	0·513***	0·374***

$^{*}P<0·05$, $^{**}P<0·01$, $^{***}P<0·001$.

Table 3. Multivariate analysis of systolic blood pressure on age and selected anthropometric variables

	Standardised coefficient of anthropometric variables†					
	Age	Percentage fat	STR	Weight	Height	Adjusted R^2
Males						
Step: 1	0·43***	–	–	–	–	0·18
2	0·39***	0·27***	0·11	–	–	0·25
3	0·04	−0·15	0·02	0·49**	0·23*	0·37
Females						
Step: 1	0·23***	–	–	–	–	0·05
2	0·12*	0·44***	0·09	–	–	0·26
3	0·07	0·08	0·06	0·41**	0·06	0·29

STR, subscapular : triceps skinfold ratio.
$^{*}P<0·05$, $^{**}P<0·01$, $^{***}P<0·001$.
† Estimated by stepwise linear regression.

the high BP category. Of these, forty-five were males (18 % of total boys) and twenty-five were females (10 % of total girls).

WC, a measure of central obesity, showed a significant association with the risk of having high BP in both sexes. Boys and girls in the uppermost tertile of WC were approximately seven times as likely as those in the lowest tertile of this measurement to have elevated BP. In contrast, WHR showed a statistically significant relationship with risk of high BP status in the female subjects only ($P=0·006$; OR 4·3; 95 % CI 1·4, 13·3). Adjusting for age did not affect the OR of anthropometric variables (BMI percentile category, percentage body fat and WC) and risk of having elevated BP (Table 4).

Discussion

Although the relationship between childhood and adolescent BMI and BP has been extensively studied, to our knowledge the present study is the first to examine this relationship in Bahraini adolescents. The present findings demonstrate age and sex differences in the BP of adolescents. As was previously reported (Leccia *et al.* 1999; Okasha *et al.* 2000), sex differences were marked for SBP, with boys having higher values than girls, but not for DBP. The finding that the correlation between age and SBP was greater in boys (r 0·44; $P<0·001$) than in girls (r 0·21; $P=0·001$) appears to be due to sex-related differences in the pattern of growth and increase in height with age. The present study revealed several anthropometric variables that were significantly correlated with SBP in the adolescents, including height, weight, BMI, percentage body fat, FM, WC and WHR. In general the means for all anthropometric measurements were found to be statistically higher among adolescents with high BP compared with those with normal BP. Because of the difficulty in separating the effects of these anthropometric variables on SBP, since they were highly correlated with each other, attempts were made to evaluate the independent influence of these variables by multiple stepwise regression analysis. This was done on those variables that showed the strongest correlation with SBP or have been previously shown to be important in explaining variations in SBP in adolescents.

The close relationship between increased body weight and elevated BP has been described in both adults (Berkey *et al.* 1998) and children and adolescents (Wilson *et al.* 1985; Horswill & Zipf, 1991). The present findings

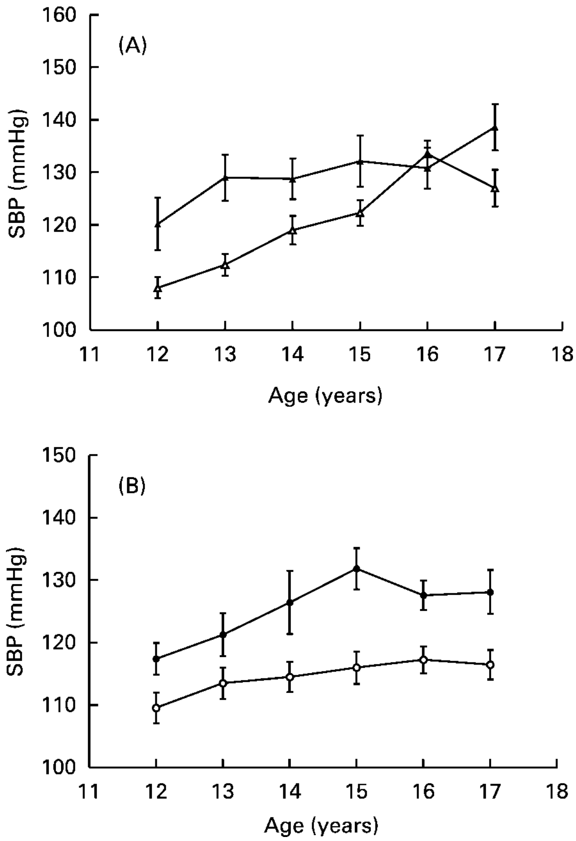

Fig. 1. Systolic blood pressure (SBP) by age in obese (≥85th percentile; -▴-, -•-) and non-obese (<85th percentile; -▵-, -○-) male (A) and female (B) Bahraini adolescents aged 12–17 years. Values are means, with their standard errors represented by verical bars.

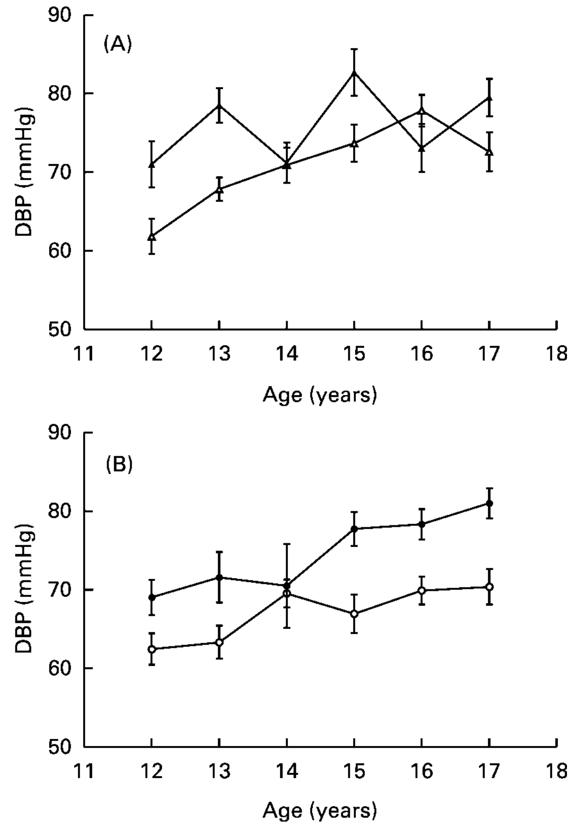

Fig. 2. Diastolic blood pressure (DBP) by age in obese (≥85th percentile; -▴-, -•-) and non-obese (<85th percentile; -▵-, -○-) male (A) and female (B) Bahraini adolescents aged 12–17 years. Values are means, with their standard errors represented by verical bars.

indicate that weight and height in boys and weight in girls were the most important predictors of SBP in Bahraini adolescents. The observation that, in boys, age and body size account for a greater proportion of SBP variations than percentage body fat was consistent with previous work (Stallones *et al.* 1982; Leccia *et al.* 1999). This suggests that body composition components other than body fat (such as muscle and bone mass) may be

Table 4. Risk of high blood pressure status for selected anthropometric variables
(Age-adjusted odds ratios; OR)

	Males (*n* 249)			Females (*n* 255)		
Variable	*P* value*	OR†	95 % CI†	*P* value*	OR†	95 % CI†
BMI percentile						
<85th	0·001	1·0‡		0·000	1·0‡	
85th–95th	0·009	3·30	1·4, 8·1	0·466	1·71	0·4, 7·1
≥95th	0·001	3·85	1·7, 8·6	0·000	11·26	4·1, 30·9
Percentage body fat						
<25	0·004	1·0‡		0·007	1·0‡	
25–35	0·223	1·76	0·7, 4·4	0·562	1·67	0·3, 9·5
>35	0·001	3·82	1·7, 8·4	0·016	6·45	1·4, 29·3
WHR tertiles						
1	0·215	1·0‡		0·027	1·0‡	
2	0·860	1·10	0·4, 3·2	0·035	3·11	1·1, 8·7
3	0·190	1·9	0·7, 5·2	0·010	4·38	1·4, 13·5
WC tertiles						
1	0·002	1·0‡		0·000	1·0‡	
2	0·077	2·72	0·9, 8·2	0·957	1·05	0·2, 5·4
3	0·001	6·10	2·1, 17·5	0·002	7·33	2·1, 26·3

WHR, waist : hip; WC, waist circumference.
* Wald's test.
† Odds ratios and 95 % CI calculated using logistic regression, adjusted for age.
‡ Reference category.

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involved in mediating the relationship between BP and body mass. This is supported by the relatively strong correlation observed between SBP and FFM in boys (*r* 0·59; *P*=0·000). The STR, a widely used indicator of fat patterning, has been shown to be associated with the occurrence of hypertension in adults (Gillum *et al.* 1998). However, no significant association was found between STR and SBP, suggesting that STR may not be a useful indicator of fat distribution in this age group. Similar results were reported in US adolescents (Stallones *et al.* 1982).

The adverse impact of childhood and adolescent obesity on BP and other cardiovascular disease risk factors is well known (Srinivasan *et al.* 1996; Freedman *et al.* 1999*a*). The present results showed that obese adolescents had significantly higher SBP and DBP than the non-obese, confirming previous observations that greater BMI in adolescence is associated with raised BP (Wilson *et al.* 1985; Moussa *et al.* 1994; Berkey *et al.* 1998). In addition to correlations and linear regression coefficients, OR have been used to examine the relationship between adolescent obesity and BP. The BP status of the adolescents was defined according to the recommendations of the WHO Expert Committee of Hypertension Control (World Health Organization, 1994), which were based on the sex- and age-specific guidelines of the Second Task Force of Blood Pressure Control in Children (Task Force on Blood Pressure Control in Children, 1987). Using the 85th and 95th sex- and age-specific BMI cut-off points, it was found that obese adolescents have a substantially greater risk of having high BP; obese boys and girls were 3·8 and eleven times more likely to have elevated BP than the non-obese, respectively. These OR were comparable with those reported by Freedman *et al.* (1999*a*) among 5- to 17-year-old children of the Bogalusa Heart Study (OR 4·5; 95 % CI 3·6, 5·8). The risk of having elevated BP also increased with increasing levels of percentage body fat. These findings were in accordance with the results of earlier studies in which increased TSKF (Gortmaker *et al.* 1987) or excess percentage body fat (Williams *et al.* 1992*a*,*b*) were used to examine the relationship between BP and adiposity in children and adolescents.

Unless extremely elevated, BP levels in children and adolescents do not appear to be related to disease outcomes. However, available data indicate a role for high BP and obesity at this age in increasing the risk for cardiovascular disease in adulthood (Lauer & Clarke, 1989). Must *et al.* (1992) found that being overweight in adolescence was associated with an increased risk of morbidity from CHD and atherosclerosis in adulthood, independent of adult obesity. The effects of obesity in adolescence on adult morbidity and mortality may be related to the accumulation of intra-abdominal fat that occurs around the time of puberty. Studies on children and adolescents showed that increased central body fatness was significantly associated with a variety of metabolic and cardiovascular abnormalities that cluster with obesity, including elevated BP and lipoprotein profile disturbances (Daniels *et al.* 1999; Gillum, 1999). Caprio *et al.* (1996) found that visceral fat, assessed using magnetic resonance imaging, was significantly associated with basal insulin, triacylglycerols and HDL-cholesterol in obese adolescent girls. Although these studies and many others have linked regional fat distribution to cardiovascular disease risk factors in children and adolescents, controversy still exists regarding the best anthropometric indicator of central obesity in this age group.

Relying on skinfold thickness to distinguish central from peripheral adiposity, Shear *et al.* (1987) showed that centrally located body fat (measured by the subscapular skinfold) was strongly and directly related to SBP in children and young adults and that such a relationship was independent of peripheral fat (as measured by TSKF). In a case–control study on 6- to 17-year-old schoolchildren from the United Arab Emirates, Moussa *et al.* (1994) found that BMI but not WHR was associated with BP and concluded that WHR may not be a reliable indicator of body-fat patterning in this group of children. In contrast, Lurbe *et al.* (2001) found that excess accumulation of fat in the abdominal region in children and adolescents, quantified using WHR or WC, was positively related to the average of 24 h SBP monitoring, independent of weight, height, sex and age. The use of WC rather than WHR for estimating central obesity has been emphasised in recent years. The WC can express abdominal fat accumulation better than the WHR does (Taylor *et al.* 2000). This may be because in growing children the hip may reflect changes in bones and muscles more than changes in fat. The present finding that WC in both boys and girls and WHR in girls only were significantly and positively associated with risk of having high BP supports the concept that fat distribution is related to cardiovascular risks, of which elevated BP is an important factor, in adolescents. The age-adjusted OR showed that boys and girls in the uppermost tertile of WC were six and seven times, respectively, more likely to have high BP than those in the lowest tertiles of this measurement. These results and the observation that among anthropometric indicators of body-fat distribution, WC showed the strongest correlation with SBP suggest that, as in adults (Pouliot *et al.* 1994), WC may serve as a good index of central (abdominal) obesity in adolescents. This is particularly important in epidemiological studies, given the ease with which this measurement can be obtained.

The mechanism by which central fat deposition influences BP in adolescents appears to be through changes in insulin sensitivity and its compensatory hyperinsulinaemia. Increased insulin secretion has been shown to be present in adolescent obesity and to be related to the amount of intra-abdominal fat (Caprio & Tamborlane, 1999). Excessive insulin secretion leads to Na and water retention and stimulation of sympathetic activity, which may in turn lead to hypertension.

High intake of Na by obese adolescents may be another confounding factor for high BP. There are no studies on Na intake by adolescents in this region. However, indicators show that the intake of Na in the Arab Gulf countries exceeds the daily requirements. Data from food composition tables for the region show that the Na content in local dishes and meals is high. This is due to several reasons: the high use of table salt; spices and pickles in food preparation; high intake of fast foods; the salinity of water used in cooking (Musaiger, 2002). Some studies

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suggest that fast foods such as beef burgers, fried chicken and French fries are more likely to be consumed by obese than non-obese adolescents (AO Musaiger, unpublished results). It is probable that obese adolescents have a greater salt intake than non-obese adolescents. In spite of that, such a conclusion needs further investigation, as the present study did not aim to look into the relationship between food intake and BP.

One limitation of the present study is that the BP reading was recorded as the average of two measurements, which were taken after 5 min rest, but on one occasion only. Thus the possibility that errors may have occurred in classifying adolescents as having high BP or normal BP cannot be ruled out. However, the purpose of using BP categories in the analysis was to obtain a general idea of the extent of elevated BP in the studied adolescents rather than to diagnose the presence of hypertension among them. In addition, treating BP as a dichotomous variable allowed us to estimate risk using OR, which are easier to interpret than regression coefficients.

The recognition of obesity (whether assessed by BMI or percentage body fat) and central obesity (assessed by WC or WHR) in the present study as important factors associated with increased risk of developing elevated BP among Bahraini adolescents may help target prevention towards high-risk individuals in this age group. This is especially important in the light of evidence linking adolescent obesity with metabolic abnormalities and risk of cardiovascular diseases in adulthood.

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