# Central adiposity in Brazilian schoolchildren aged 7–10 years

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Waist circumference (WC) is a measure of central adiposity related to elevated risk factor levels in children and adolescents. The aim of the present study was to describe WC percentiles in 7- to 10-year-old Brazilian children and to compare frequencies of obesity and overweight as defined by BMI and frequencies of excess and at risk of abdominal adiposity as defined by WC to the corresponding age and sex data from British references. A representative sample of 2919 schoolchildren of the city of Florianopolis (southern Brazil) was examined. Smoothed WC percentiles were derived using the least mean square method. Frequencies of overweight and obesity and of excess and at risk of abdominal adiposity were assessed using the 91st and 98th centiles of the British references as cut-off points. WC increased with age in both boys and girls, with higher values for boys at every age and percentile level. Nutritional status categories of children assessed by the 91st and 98th British BMI and WC centiles showed moderate agreement (weighted κ = 0·58). Overweight was more frequent in Brazilian than British children: 15·1 % of girls and 20·1 % of boys were above the 91st percentile of the 1990 BMI for age British references. About one-quarter (22·0 % of girls and 26·9 % of boys) exceeded the 91st percentile of WC British references. The present data could be used to compare WC in children in other populations and may serve as a baseline for future studies of temporal trends in WC in Brazil.

**Central adiposity: Waist circumference percentiles: Childhood: Obesity prevalence: Brazil**

Recent studies have shown that waist circumference (WC) increased much faster than BMI in children and adolescents over the past 10–20 years (McCarthy *et al.* 2003, 2005; Moreno *et al.* 2005).

While the BMI is generally accepted and used to classify children as overweight or obese in population studies, it is recognised that the BMI cannot distinguish between muscle and fat masses and gives no indication about body adiposity distribution (Reilly *et al.* 2000). The BMI therefore seems a poor proxy for central adiposity. The WC is a highly sensitive and specific measure of trunk adiposity (Taylor *et al.* 2000) and a strong predictor of visceral adiposity in the paediatric population (Brambilla *et al.* 2006; Lee *et al.* 2006). Further, WC is related to metabolic complications of obesity, including poor lipid profile, increased blood pressure and insulin resistance in children and adolescents (Freedman *et al.* 1999; Savva *et al.* 2000; Maffeis *et al.* 2001; Moreno *et al.* 2002).

It has therefore been recommended that WC should be used to identify young individuals at risk of morbidity associated with central body adiposity and could be adopted as an alternative or additional measurement to BMI (McCarthy *et al.* 2003). However, there are no commonly accepted WC cut-offs for classifying children with high central adiposity.

The prevalence of overweight based on BMI has tripled in Brazilian children and adolescents over the past two decades (Wang *et al.* 2002); however, there are no data on WC values and the level of central adiposity in Brazilian children and adolescents.

The aim of the present study was to: (a) describe WC centiles in 7- to 10-year-old Brazilian children derived from 2919 schoolchildren living in Florianopolis; (b) describe the prevalence of overweight and obesity as defined by BMI and the prevalence of at-risk abdominal adiposity and excess abdominal adiposity as defined by WC, using British reference data in

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the same population; (c) examine the agreement between two measures of adiposity, based on BMI and WC.

These data are important to allow valuable comparisons with other studies and to monitor the prevalence of (central) adiposity over time.

## Methods

### Subjects

The present study was conducted in the city of Florianopolis, from September to November 2002. Florianopolis is the capital of the province of Santa Catarina, in the south of Brazil.

The study design has been described elsewhere (de Assis *et al.* 2005). Briefly, a representative sample of 7- to 10-year-old schoolchildren attending the first four grades of elementary schools of the city was selected, using a stratified multistage cluster-sampling design. Information included anthropometric data (height, weight, skinfolds and circumferences) and socio-economic status (SES) of the family. Parents completed a questionnaire with sociodemographic information, including monthly family income. Tertiles of monthly family income were used to indicate low, medium and high SES.

Of the 3313 eligible children, 377 had missing anthropometric data (child absent or ill; child refused to participate). In the present article 2926 children (1502 boys and 1424 girls), with complete information on age, sex, school level, SES and all anthropometric measurements were included (88·3 %). Participation rate did not significantly differ according to sex and age. However, SES differed between participants and non-participants: more participants were categorised in the low and medium SES and fewer in the high SES compared with non-participants (low SES, 48·8 *v.* 38·6 %; medium SES, 21·7 *v.* 14·6 %; high SES, 29·5 *v.* 46·7 %; *P*<0·01).

Santa Catarina's population is predominantly of European origin; specific information on ethnicity was not available in the present study.

Parents gave written informed consent to their child's participation in the study, which received approval from the Committee on Human Studies of the Federal University of Santa Catarina.

### Anthropometric measurements

The administrative department of each school provided information on age, based on birth certificates. Anthropometric measurements of participants were taken by trained technicians, according to the procedures recommended by Lohman *et al.* (1988).

Anthropometric measurements were performed in lightly dressed children, without shoes. Weight was measured with a digital-solar 180 kg scale (Marte® model PP; Marte Scale and Precision Equipment, Minas Gerais, Brazil). Height was measured using a metric tape fixed to a wall without a baseboard, with the child standing up, weight being equally distributed on both feet, with the head held in the Frankfort plane and head back and buttocks on the vertical land on the height gauge. The triceps and subscapular skinfold thicknesses were measured to the nearest mm with a skinfold caliper (Cescorf®; Scientific Sports Equipment, Porto Alegre, RGS,

Brazil). Triceps skinfold was measured at the midpoint between the acromion and olecranon process. Subscapular skinfold was measured about 20 mm below the tip of the scapula, at a 45° angle to the lateral side of the body. The mean of triplicate records was used in the analysis. The WC was measured to the nearest mm with a flexible non-elastic tape, midway between the tenth rib and the iliac crest. The BMI was computed as weight in kg divided by height in $m^2$. Two other indicators of central adiposity were also examined: the waist:height ratio (WHtR) as an index of abdominal adiposity; the subscapular:triceps skinfold ratio (STR) as an index of trunk adiposity.

### Data analysis

The data were first examined for outliers, and those with WC values exceeding ± 5 age-standardised SD scores were eliminated (six girls and one boy). The final analytical population contained 2919 children (1501 boys and 1418 girls).

Weight, height, WC, BMI, WHtR and STR are presented as medians and ranges by sex and age. Because anthropometric variables were not normally distributed (Kolmogorov–Smirnov test), non-parametric tests were used. Differences between sexes in each age group were assessed using the Mann–Whitney *U* test. Differences across ages for each sex were assessed using the Kruskal–Wallis *H* test. Regression analysis with the Pearson coefficient was used to examine the relationship of WC and WHtR to height in each age group and sex. The association was controlled by age as a continuous variable to take into account even small differences.

Smoothed percentiles for WC were constructed from the raw data using the 'COLELMS' command in STATA® to calculate the crude least mean square (LMS) values. The LMS method enables normalised growth centile standards to be developed, and deals with skewness which might be present in the distribution of the measurements. The LMS method summarises the changing distributions by three independent curves representing the median, CV and skewness, the latter expressed as a Box-Cox power (Cole, 1990). The 50th and the 90th centiles values of WC were compared with data from the UK (McCarthy *et al.* 2001) and with data from the USA for American-European children (Fernández *et al.* 2004).

Overweight and obesity were estimated using cut-off points corresponding to the 91st and 98th centiles (SD scores of 1·33 and 2, respectively) of the British reference populations based on BMI (Cole *et al.* 1995); at risk of abdominal adiposity and excess of abdominal adiposity were estimated using cut-off points corresponding to the 91st and 98th centiles of the WC British reference, respectively (McCarthy *et al.* 2001). Similar cut-off points allow prevalence of at risk and excess abdominal adiposity (defined by WC) to be compared with that of overweight or obesity (defined by BMI), using the British reference populations, as described by McCarthy *et al.* (2003). The 91st and 98th centiles for BMI are similar to the cut-off points based on adult BMI health-risk-related outcomes for overweight and obesity defined by the International Obesity Task Force (Cole *et al.* 2000).

Overall frequencies of total overweight or obesity and at risk or excess of abdominal adiposity were computed by using direct standardisation on age and sex. Comparisons of frequencies between sexes were performed using the $\chi^2$ test.

The agreement between the two measures of adiposity was analysed by the weighted κ statistic. Discordant subgroups of children classified as non-overweight according to the BMI cut-off, but as at risk and with an excess of abdominal adiposity according to the WC cut-off (WC-only group), were compared with those classified as without abdominal adiposity according to the WC cut-off, but overweight and obese according to the BMI cut-off (BMI-only group), for the ancillary anthropometric variables: height, WHtR and STR.

The significance level was set at $P < 0.05$. Statistical analyses were performed with SPSS version 10.0 and STATA® version 8.0 (Statistical Analysis System software, version 8.0, 1989; SAS Institute, Cary, NC, USA).

## Results

Table 1 presents medians and ranges for anthropometric characteristics by age and sex. Weight, height, BMI, WC and STR increased with age in both boys and girls, while WHtR decreased with age in both sexes. Boys tended to have higher values for BMI than girls; however, significant sex differences occurred only at age 8 years. Between sexes, boys presented higher WC ($P < 0.001$) and WHtR ($P$ ranging between 0.01 and 0.001) than girls in all age groups.

WC was moderately correlated with height in all age groups, for both sexes ($P < 0.001$). In the analysis of the entire sample, the Pearson correlation coefficients between WC and height, after controlling for age, were $r$ 0.57 ($P < 0.001$) for boys and $r$ 0.54 ($P < 0.001$) for girls. In contrast, a weaker correlation was seen between WHtR and height, for both boys ($r$ 0.11; $P < 0.04$) and girls ($r$ 0.16; $P < 0.3$).

Table 2 presents the smoothed sex- and age-specific WC values at the 5th, 10th, 15th, 25th, 50th, 75th, 85th, 90th and 95th percentiles. Boys had higher values than girls at every age and percentile point. The difference between boys and girls on the 95th percentile at age 10 years was 4·4 cm.

Fig. 1 compares the WC data of Florianopolis school children with the British (McCarthy *et al.* 2001) and US (Fernández *et al.* 2004) reference populations. Compared with the British reference, Florianopolis children had higher levels of WC at the 50th and 90th percentiles, in the same age range. At the 90th percentile differences increased substantially, ranging from 6·1 to 8·7 cm for boys and from 5·3 to 7·5 cm for girls. Compared with the US data, Florianopolis children had slightly lower 50th percentile WC values, but the difference was much larger between 90th percentiles. At the 90th percentile, differences between Florianopolis and US children ranged from 1·8 to 3·7 cm for boys and from 2·8 to 5·0 cm for girls.

Age-standardised frequencies of obesity and overweight (non-obese), using the BMI cut-offs (Cole *et al.* 1995) and excess abdominal adiposity and at-risk abdominal adiposity, using the WC cut-offs (McCarthy *et al.* 2001), estimated in boys and girls separately, are presented in Table 3. Using British reference values, 5·6 % of girls and 8·3 % of boys were above the 98th percentile for BMI-for-age, and 15·1 % of girls and 20·1 % of boys were above the 91st percentile. The corresponding values for WC were 10·1 % of girls and 13·4 % of boys exceeding the 98th percentile and 22·0 % of girls and 26·9 % of boys exceeding the 91st percentile of British WC references. In all age groups total and centrally

distributed adiposity prevalences were significantly higher than expected on the basis of British reference data ($P < 0.001$), except for BMI-overweight and obesity prevalence in 10-year-old girls.

Between sexes, a difference was observed in frequency of overweight (non-obese) according to the BMI British reference in 10-year-old children (13·5 % for boys *v.* 5·9 % for girls; $P = 0.001$). Frequencies of obesity (BMI) did not differ significantly between boys and girls, whatever the age group. Using British WC references, 8- and 9-year-old boys presented higher frequencies of excess abdominal adiposity compared with girls in the same age groups ($P = 0.003$).

Nutritional status categories of children assessed by BMI (non-overweight, overweight and obese) and assessed by WC (without abdominal adiposity, at risk of abdominal adiposity and excess of abdominal adiposity) showed 84·9 % agreement. When analysis was stratified by sex, the agreement was slightly higher for girls compared with boys (86·2 *v.* 83·6 %; $P = 0.046$). The amount of agreement beyond that explained by chance as described by the κ statistic showed a moderate agreement for both boys (κ 0·58) and girls (κ 0·57). Table 4 presents mean values and standard deviations for the ancillary anthropometric variables in subgroups of children only detected by the WC cut-off for abdominal fat (WC-only group) and the group only detected by the BMI cut-off for overweight and obesity (BMI-only group). Overall, 252 of the 2403 children (10·5 %) were classified as non-overweight according to BMI but at risk of abdominal adiposity according to WC cut-offs. By contrast, the BMI cut-off identified fifty-two children (2·4 % of 2203) as overweight or obese, which were not identified as at risk of abdominal adiposity by the WC cut-off. In subgroups of children where BMI and WC percentiles were discordant, an elevated WC preferentially identified children who were taller and also had higher WHtR. There was no mean age difference between children detected by the WC-only group and children detected by the BMI-only group (9·2 (SD 1·1) *v.* 9·0 (SD 1·1) years; $P = 0.2$).

## Discussion

In the present article we compared the estimated frequencies of centrally distributed adiposity (as defined by WC) and total adiposity (as defined by BMI) in 7- to 10-year-old schoolchildren living in a city located in the south of Brazil to the corresponding age and sex data from British references. We also presented age- and sex-specific WC percentiles for these children in order to allow valuable comparisons with other populations.

Some limitations of the present study have to be considered. The data were not representative for the whole country, but to the best of our knowledge this is the most up-to-date large set of data on WC in 7- to 10-year-old Brazilian children. Santa Catarina's population is predominantly of European origin; however, specific information on ethnicity was not available in the present study. Due to a high degree of miscegenation in the Brazilian population, it might be advisable to develop standards in the national context, with representative samples of children from all ethnic backgrounds.

A difficulty in this type of research is the absence of commonly accepted cut-offs for classifying children with high WC. This is in contrast with the BMI, for which the

**Table 1.** Anthropometric characteristics of 2919 schoolchildren by age and sex

(Medians and ranges)

| Age (years) | Boys | | | | Significance of difference across age | Girls | | | | Significance of difference across age |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7 | 8 | 9 | 10 | | 7 | 8 | 9 | 10 | |
| *n* | 337 | 385 | 423 | 356 | | 323 | 384 | 373 | 338 | |
| Weight (kg) | | | | | | | | | | |
| Median | 26·3* | 29·2* | 31·2 | 34·9 | $P < 0.05$ | 25·2 | 27·9 | 31·7 | 34·6 | $P < 0.05$ |
| Range | 17·8−47·2 | 17·6−59·0 | 20·2−62·2 | 17·6−73·1 | | 17·3−47·4 | 16·8−52·1 | 18·2−64·7 | 19·1−73·7 | |
| Height (cm) | | | | | | | | | | |
| Median | 126·5* | 131·3* | 136·4 | 141·4 | $P < 0.05$ | 125·3 | 130·1 | 136·2 | 141·2 | $P < 0.05$ |
| Range | 112·0−152·8 | 112·0−152·0 | 116·8−159·9 | 113·0−160·0 | | 111·0−142·0 | 111·7−156·7 | 112·2−160·0 | 119·8−160·0 | |
| BMI (kg/m²) | | | | | | | | | | |
| Median | 16·3 | 16·8* | 16·7 | 17·4 | $P < 0.05$ | 16·1 | 16·5 | 17·0 | 17·1 | $P < 0.05$ |
| Range | 12·6−25·9 | 13·3−30·0 | 12·6−29·7 | 12·8−28·7 | | 13·2−27·5 | 12·6−25·5 | 13·0−30·8 | 12·6−31·7 | |
| WC (cm) | | | | | | | | | | |
| Median | 56·0* | 58·0* | 59·1* | 60·5* | $P < 0.05$ | 54·5 | 55·5 | 58·0 | 59·0 | $P < 0.05$ |
| Range | 47·5−79·6 | 48·6−89·6 | 49·0−89·0 | 49·5−89·5 | | 47·0−78·0 | 47·0−79·0 | 48·5−88·5 | 48·0−89·0 | |
| WHtR | | | | | | | | | | |
| Median | 0·446* | 0·441* | 0·438* | 0·431* | $P < 0.05$ | 0·439 | 0·430 | 0·428 | 0·418 | $P < 0.05$ |
| Range | 0·38−0·60 | 0·38−0·67 | 0·35−0·62 | 0·36−0·63 | | 0·36−0·60 | 0·36−0·59 | 0·34−0·59 | 0·34−0·58 | |
| STR | | | | | | | | | | |
| Median | 0·56 | 0·57 | 0·59 | 0·59 | $P < 0.05$ | 0·56 | 0·56 | 0·57 | 0·61 | $P < 0.05$ |
| Range | 0·31−6·47 | 0·23−1·74 | 0·26−1·99 | 0·28−3·03 | | 0·28−2·93 | 0·05−1·59 | 0·26−6·38 | 0·28−3·88 | |

WC, waist circumference; WHtR, waist:height ratio; STR, subscapular:triceps skinfold ratio.

* Median value was significantly different from that of the girls in a given age group ($P < 0.05$).

**Table 2.** Values of percentiles of waist circumference (cm) by age and sex

| Age (years) | Percentiles | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5th | 10th | 15th | 25th | 50th | 75th | 85th | 90th | 95th |
| Boys | | | | | | | | | |
| 7 | 51·2 | 52·3 | 53·1 | 54·4 | 57·3 | 60·8 | 63·1 | 64·9 | 68·0 |
| 8 | 52·2 | 53·5 | 54·4 | 56·0 | 59·4 | 63·8 | 66·8 | 69·2 | 73·4 |
| 9 | 53·4 | 54·8 | 55·8 | 57·5 | 61·2 | 66·0 | 69·3 | 71·9 | 76·8 |
| 10 | 54·9 | 56·3 | 57·3 | 59·0 | 62·8 | 67·7 | 71·2 | 74·0 | 79·1 |
| Girls | | | | | | | | | |
| 7 | 50·5 | 51·5 | 52·3 | 53·5 | 56·2 | 59·8 | 62·1 | 64·0 | 67·3 |
| 8 | 49·9 | 51·2 | 52·1 | 53·7 | 57·0 | 61·4 | 64·3 | 66·6 | 70·7 |
| 9 | 51·3 | 52·8 | 53·8 | 55·5 | 59·2 | 63·9 | 67·0 | 69·5 | 73·8 |
| 10 | 52·4 | 53·8 | 54·9 | 56·6 | 60·3 | 65·0 | 68·1 | 70·5 | 74·7 |

International Obesity Task Force cut-offs are now widely accepted. Using this reference, the frequencies of obesity and overweight (including obesity) in the same sample of the present study were 5·5 and 22·1 % respectively (de Assis *et al.* 2005). For WC, some studies have derived WC cut-offs on the basis of the relationship with metabolic risk factors (Freedman *et al.* 1999; Maffeis *et al.* 2001; Moreno *et al.* 2002; Katzmarzyk *et al.* 2004). The optimal threshold differed markedly between these studies, depending on the number and type of metabolic risk factors and probably due to ethnic and environmental differences between populations. Others have developed thresholds on the basis of the correlation of WC



**Fig. 1.** Comparisons of the 50th and 90th percentiles for waist circumference obtained from the UK, the USA and Brazil (Florianopolis city) for boys (A) and girls (B) aged 7–10 years. (●), USA 90th; (■), Brazil 90th; (◆), UK 90th; (○), USA 50th; (□), Brazil 50th; (◇), UK 50th.

with high trunk fat mass (Taylor *et al.* 2000), or based on the distribution of WC data from reference populations (McCarthy *et al.* 2003; Fredriks *et al.* 2005). In the absence of Brazilian WC reference data, we chose the criterion proposed by McCarthy *et al.* (2003), based on British reference data, to compare frequencies of nutritional status categories as defined by BMI and WC.

The results of the present study showed that, using BMI or WC, there were higher frequencies of Brazilian children with total and central adiposity compared with the corresponding age and sex data from the British references, except for BMI-defined overweight prevalence in 10-year-old girls. According to the cut-off points corresponding to the 91st and 98th centiles to define central adiposity based on WC (McCarthy *et al.* 2001) and overall adiposity based on BMI (Cole *et al.* 1995), we found higher frequencies of children with centrally distributed adiposity than total overweight and obesity. The prevalence rates recorded in the present study agree with those reported in British adolescents aged 11–16 years (McCarthy *et al.* 2003), using the same British references for WC and BMI, regardless of the different age ranges between the two studies. In the British study centrally distributed adiposity affected a higher percentage of youth than total obesity (McCarthy *et al.* 2003). In Australian children aged 7–8 years, the WC identified a greater number of boys over the cut-off point (as defined by the 91st percentile) compared with the BMI cut-off points (as defined by International Obesity Task Force references). However, more girls were identified by BMI cut-offs as overweight or obese compared with the WC cut-off points (Garnett *et al.* 2005).

In the present study, we analysed indirect associations among measures of adiposity and physical growth. The correlation between WC and height suggests that the increase in WC in childhood is due in part to linear growth, as stated by others (McCarthy & Ashwell, 2006). In fact, children identified by the WC cut-off as at risk of abdominal adiposity but not by BMI cut-off were 7 cm taller, suggesting that the magnitude in the WC can be in part explained by the difference in height. Although children classified as at risk of abdominal adiposity according to the WC cut-offs (WC-only group) presented a significantly higher WHtR compared with children classified only by the BMI cut-offs (BMI-only group), the clinical significance of this increase ($P < 0.01$) may be irrelevant. It is important, however, to examine the WHtR, as this index takes height into account.
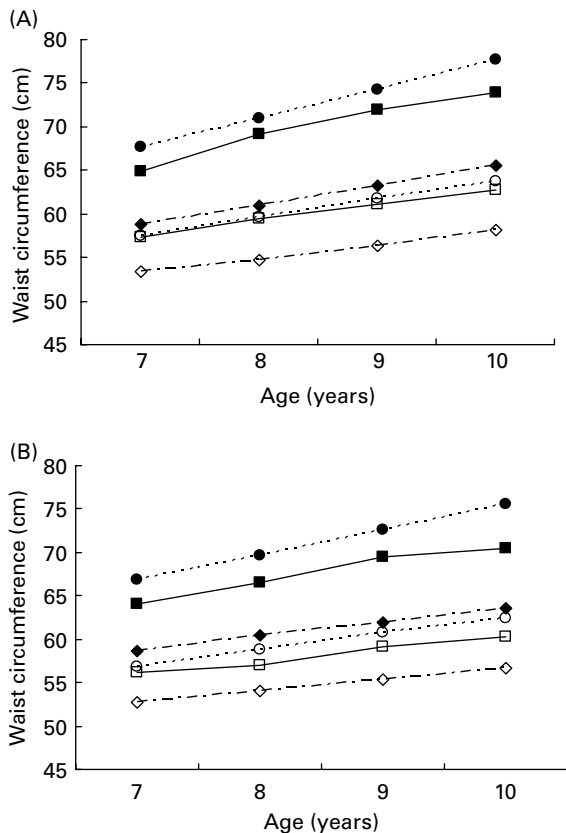
**Table 3.** Frequencies (%) of overweight and obese 7- to 10-year-old boys and girls defined according to body mass index (1990 British reference data; Cole *et al.* 1995) and frequencies (%) of excess and at-risk abdominal adiposity defined according to waist circumference (WC) (McCarthy *et al.* 2001)

| | BMI | | | | WC | | | |
|---|---|---|---|---|---|---|---|---|
| | Obese | | Overweight | | Excess | | At risk | |
| Age (years) | Boys | Girls | Boys | Girls | Boys | Girls | Boys | Girls |
| 7 | 8·3 | 5·6 | 10·4 | 9·6 | 11·3 | 7·7 | 14·5 | 12·1 |
| 8 | 10·4 | 6·5 | 12·2 | 12·2 | 18·2* | 10·7 | 13·5 | 10·2 |
| 9 | 8·3 | 6·4 | 11·1 | 9·7 | 13·7* | 12·3 | 13·0 | 11·3 |
| 10 | 6·2 | 3·8 | 13·5* | 5·9 | 9·8 | 9·2 | 13·2 | 14·5 |
| Total | 8·3 | 5·6 | 11·8 | 9·4 | 13·4 | 10·1 | 13·5 | 11·9 |

* Frequency was significantly different from that of the girls ($P < 0·01$).

The WHtR has recently been proposed as an index to assess central adiposity in children and adolescents, based on evidence that it is a better predictor of CVD risk factors than the BMI (Savva *et al.* 2000; Kahn *et al.* 2005; McCarthy & Ashwell, 2006). Although WC measurement cannot differentiate between visceral and subcutaneous adiposity stores, it has been shown that WC is a good predictor of visceral fat, linked to increased risk of metabolic diseases in children and adolescents (Hirschler *et al.* 2005; Lee *et al.* 2006).

Values of WC at the 90th percentile in Florianopolis children were higher than those from British data (1977–87) (McCarthy *et al.* 2001) but lower than those found in European-American children (Fernández *et al.* 2004), in the same age range. Indeed, the 75th percentile in boys and girls of Florianopolis approached or exceeded the 95th percentiles in British children (McCarthy *et al.* 2001). These comparisons should be interpreted considering several important differences between the studies, such as the site of waist measurement, the date of data collection, the method of derivation of the percentile values and the genetic, ethnic and socio-economic characteristics of the populations. Data from the UK and in the present study were measured midway between the tenth rib and the iliac crest and the derivation of percentile values were developed using the LMS method. The USA study used the site just above the uppermost lateral border of the right ilium for measurement of the WC and percentile

regression to model centiles. These issues have been discussed elsewhere (McCarthy *et al.* 2001; Eisenmann, 2005).

These data add to the existing WC percentile distributions developed for children and youth in Italy (Zannolli & Morgese, 1996), Spain (Moreno *et al.* 1999), the UK (McCarthy *et al.* 2001), Cyprus (Savva *et al.* 2001), Australia (Eisenmann, 2005) and the USA (Fernández *et al.* 2004). There are important differences in mean values of WC for age between countries, with the highest values for the USA and Cyprus and the lowest for the UK, with intermediate values for Australia, Italy, and Spain. Unmeasured factors such as socio-economic, dietary and physical activity patterns, and ethnic characteristics might explain some of the variation in the WC values between studies. In a representative sample of US children and adolescents (NHANES III), the distribution of WC differed according to ethnic origins in boys and girls (Fernández *et al.* 2004). An inverse association among high cardiorespiratory fitness and central obesity (defined by the subscapular skinfold and sum of trunk skinfolds), BMI and percentage body fat was showed in Greek children aged 6–13 years (Nassis *et al.* 2005).

In conclusion, WC percentile distributions of Florianopolis schoolchildren aged 7–10 years showed higher values than British reference data and lower values than American data. Compared with British children, the schoolchildren from Florianopolis were heavier and had a more marked central distribution of body fat. Using British references for WC and BMI, centrally distributed adiposity was more prevalent than total overweight and obesity.

Taking these data as baseline, regular and frequent monitoring of childhood WC values would be advisable. Even if the gold standard to define centrally distributed adiposity prevalence remains uncertain, valid within-population comparisons of relative changes can be made against the same standard over time. More research is required to identify optimal WC cut-offs related to elevated risk factor levels in children and to establish international reference data for WC.

**Table 4.** Ancillary anthropometric variables among subgroups of children with discordant status (above cut-offs) defined according to the body mass index and waist circumference (WC) cut-offs

(Mean values and standard deviations)

| | Subgroups of children above cut-offs according to | | | | |
|---|---|---|---|---|---|
| | WC only* (n 252) | | BMI only† (n 52) | | |
| | Mean | SD | Mean | SD | P |
| Height (cm) | 138·9 | 8·4 | 131·5 | 7·6 | 0·000 |
| WHtR | 0·47 | 0·03 | 0·46 | 0·03 | 0·01 |
| STR | 0·67 | 0·33 | 0·61 | 0·18 | 0·3 |

WHtR, waist:height ratio; STR, subscapular:triceps skinfold ratio.
* Children classified as at risk of abdominal adiposity according to the WC cut-off, but not as overweight and obese according to the BMI cut-off.
† Children classified as overweight and obese according to the BMI cut-off, but not as at risk of abdominal adiposity by the WC cut-off.

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