Fat Distribution in Venezuelan Children and Adolescents Estimated by the Conicity Index and Waist/Hip Ratio

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ABSTRACT   This study compares the conicity index (C) with the waist/hip ratio (WHR) in a cross-sectional sample of Venezuelan children (n = 784 boys and n = 735 girls), 3 to 16 years of age. Distributions of C and WHR were compared in Box-plot diagrams. Regression analysis was used to examine the relationship between indices by age and sex. Conicity captured more outliers in the distribution than WHR and explained 33% to 62% of the variability in WHR in three age groups. The influence was stronger in females during adolescence (R^2 = 0.60, P < 0.05). According to the principle of C, most children presented a bi-conical shape, which was more pronounced in boys than girls and which was indicative of a more central distribution of adiposity. These results are related, in part, to age and sex differences in body composition and to the earlier onset of the adolescent growth spurt in Venezuelan children. Am. J. Hum. Biol. 14:15–20, 2002.   © 2002 Wiley-Liss, Inc.

Epidemiological studies suggest that in addition to total body fat, body shape and regional fat distribution are important indicators of cardiovascular health in adults (Baumgartner et al., 1987; Ohlson et al., 1985). As a result, there is interest in the development of these indicators in children and adolescents and their potential relevance for later health outcomes (Rolland-Cachera et al., 1990; Must et al., 1992). The waist-to-hip ratio (WHR) is used to estimate abdominal adipose tissue distribution and is a risk factor of cardiovascular disease and diabetes (Larsson et al., 1984; Ohlson et al., 1985). More recently, however, its validity as a measure of abdominal visceral adipose tissue deposition has been questioned (Pouliot et al., 1994; Lemieux et al., 1996). Accumulation of intra-abdominal fat is of most concern for long-term health consequences (Van Loan, 1996). The waist circumference by itself has also been proposed as a measured of abdominal fat (Lean et al., 1995).

In adolescents the conicity index (C) has been used as an alternative to analyze fat distribution (Valdez et al., 1992; Pérez et al., 2000a). There is also a positive link between overweight measured by the body mass index and high conicity values, as well as between high conicity values and high levels of tryglicerides (Pérez et al., 2000b). This study considers age and sex differences in C among Venezuelan children and examines its relationship with the WHR.

MATERIALS AND METHODS

Sample

The data are a cross-sectional sample of 784 boys and 735 girls, 3 to 16 years of age, from a marginal area of the city of Caracas. Some of the children were drawn from a fee-paying school according to parental income as a part of a local nutritional intervention program. Using the Graffar method modified by Méndez Castellano (Méndez-Castellano and Méndez, 1994), which is based on father's occupation, mother's level of education, number of children in the family, housing conditions, and crowding, among other environmental, cultural, and social conditions of the families of the children, the sample was classified as one of low income.
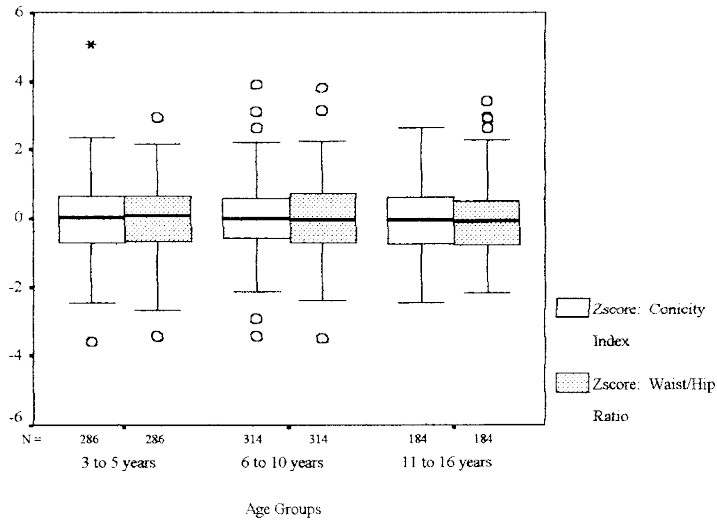
The growth, nutritional status, and body composition of the sample has been previously reported in which the weight of evidence suggests that coupled with growth

retardation, a meaningful deficit in other physical characteristics, especially in those that measure bone structure was founded (Ledezma et al., 1995; Pérez et al., 1996). The sample was partitioned into three ages groups: 3 to 5 (Gl), 6 to 10 (G2), and 11 to 16 (G3), to approximate early childhood, middle childhood, and adolescence.

Anthropometry

Measurements were taken by an experienced team. The measurements were made in the morning following standard procedures (Ross and Marfell-Jones, 1991). They included body weight with minimal clothing (0.01 Kg), height (0.1 cm) with the subjects in bare feet, and waist and hip circumferences (0.1 cm). Circumferences were measured with the subject standing, and landmarks were indicated on the skin. Waist circumference was measured at the minimal abdominal girth, approximately midway between the xiphoid process and the umbilicus. Hip circumference was measured, at the level of the greatest protrusion of the gluteal muscles, approximately at symphysion anteriorily. A flexible steel tape (Hoechst mass, West Germany) was used. Based on replicate measurements technical errors between and within technicians, for specific measurements were as follows: weight (0.5–0.6 kg), height (0.1–0.1cm), waist circumference (0.1–0.2 cm), hip circumference (0.2–0.3 cm).

The conicity index was calculated after Valdez et al. (1992):

$$C = \frac{\text{waist circ}}{0.109\sqrt{\text{wt(kg)}/\text{ht(m)}}}$$

A higher value of C indicates a more central fat distribution. The WHR was also calculated:

$$\text{WHR} = \text{waist(cm)}/\text{hip(cm)}$$

Statistical analysis

Box-plot diagrams were used to compare distributions of the two ratios. Dispersion of the data was explored by the coefficient of variation. Both indices were standardized as Z scores to allow for comparisons. Analysis of variance was used to test for differences

TABLE 1. Mean and standard deviations of anthropometric variables and derived indices by age group and sex

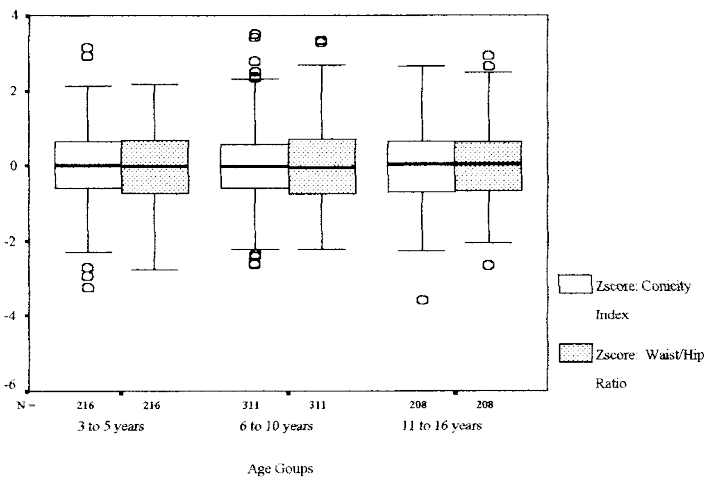| | Boys | | | | | | | | | Girls | | | | | | | | |
| | Age groups (years) | | | | | | | | | Age groups (years) | | | | | | | | |
| | < 3 to 5 (n = 286) > | | | < 6 to 10 (n = 314) > | | | < 11 to 16 (n = 184) > | | | < 3 to 5 (n = 216) > | | | < 6 to 10 (n = 311) > | | | < 11 to 16 (n = 208) > | | |
Variables	X̄	s	CV	X̄	s	CV	X̄	s	CV	X̄	s	CV	X̄	s	CV	X̄	s	CV
Weight (Kg)	16.51	2.90	0.18	23.92	5.78	0.24	44.36	12.54	0.28	16.06	2.74	0.17	23.97	5.44	0.23	45.22	10.18	0.23
Height (cm)	102.72	7.89	0.08	122.81	9.38	0.08	153.40	13.18	0.09	102.18	7.90	0.08	123.07	9.67	0.08	151.35	8.02	0.05
Waist circumference (cm)	50.26	3.84	0.08	54.80	5.53	0.10	63.86	7.26	0.11	49.60	3.66	0.07	53.55	4.76	0.09	63.11	6.66	0.11
Hip circumference	52.57	4.36	0.08	60.93	6.62	0.11	77.35	9.12	0.12	53.58	4.56	0.09	62.50	6.56	0.10	83.73	9.16	0.11
Body mass index (Kg/m²)	15.58	1.49	0.10	15.65	1.85	0.12	18.47	2.90	0.16	15.33	1.45	0.09	15.64	1.80	0.11	19.53	3.10	0.16
Conicity Index	1.15	0.05	0.05	1.15	0.06	0.05	1.10	0.05	0.05	1.15	0.05	0.05	1.12	0.06	0.05	1.06	0.05	0.05
Waist hip ratio	0.96	0.05	0.05	0.90	0.05	0.06	0.83	0.05	0.06	0.93	0.05	0.06	0.86	0.06	0.07	0.76	0.04	0.06

Boys

Girls

Fig. 1. Box-plot diagram for conicity index and waist hip ratio boys.

between age groups, and the Scheffé post hoc test was used to identify which pair(s) differed significantly. Regression analysis was used to examine the relationship between WHR and C for age and sex. A model was fitted separately by sex to describe WHR as a function of C by age:

$$WHR = \beta_0 + \beta_1 \times C + \alpha_0 I_{(G1)} + \alpha_1 I_{(G1)} \times C + \gamma_0 I_{(G2)} + \gamma_1 I_{(G2)} \times C + \varepsilon$$

where:

WHR = Waist hip ratio

C = Conicity index

TABLE 2. Differences among age groups within each sex (ANOVA)

	Boys						Girls					
	Levene	Analysis of variance		Scheffé			Levene	Analysis of variance		Scheffé		
				G1	G2	G3				G1	G2	G3
Conicity index	0.205	0.000	G1			*	0.580	0.000	G1		*	*
			G2			*			G2	*		*
			G3	*	*				G3	*	*	
	0.042	0.000					0.000					
				G1	G2	G3						
Waist/hip ratio			G1		*	*						
			G2	*		*						
			G3	*	*							

*Denotes differences between groups, $P < 0.05$.

$I_{(G1)}$ = Functional term of the model:

$$\begin{cases} 1, & \text{if individual belongs to G1} \\ 0, & \text{all sites} \end{cases}$$

$I_{(G2)}$ = Functional term of the model:

$$\begin{cases} 1, & \text{individual belongs to G2} \\ 0, & \text{all sites} \end{cases}$$

ε = Random error vector

These models were compared with another model that did not take age into account (Chow's test). This was done to estimate age effect on WHR as a function of C.

After applying Chow's test of structural change, the regression was fixed by age groups as follows:

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + \varepsilon; \ i = 1, 2, \ldots, n_j$$
$$j = 1, 2, 3$$

where:

$$Y = \text{WHR}$$

$$X = \text{conicity}$$

$i = 1, 2, \ldots, n_j$;

subjects of the sample in each group

$j = 1$ (3 to 5 yr.), 2 (6 to 10 yr.), 3 (11 to 16 yr.).

The analyses were performed with the SPSS package, version 7.5.

RESULTS

Descriptive statistics for weight, height, circumferences, C, and WHR in the three age groups by sex are given in Table 1. Boys attained higher means than girls in all variables, except for hip circumferences in each age group. The differences were statistically significant for hip and waist circumferences for all ages except for waist circumference in 6 to 10 year olds. In general, both boys and girls showed increased variance with age, especially for weight and height. Additionally, a tendency towards diminishing mean values with age was observed for C and WHR.
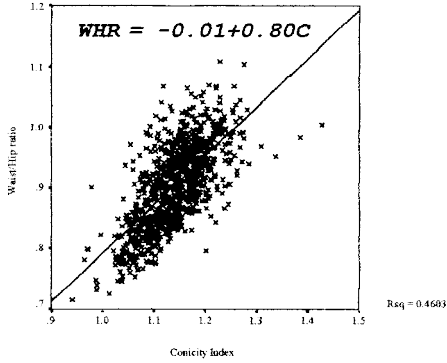
Box-plot diagrams depicted similar patterns for C and WHR, in boys and girls (Fig. 1). ANOVA after the Levene homogeneity test showed significant age differences ($P < 0.05$) for C and WHR by age group in both sexes except in boys, where the differences was only between G3 and G1/G2 ($P < 0.05$). It was not possible to run ANOVA test due to a non-homogeneous variance pattern in girls (Table 2).

The relation of WHR to C in the total sample and by age groups is shown in Figure 2. C explained a significant portion of variability in WHR in all groups with R^2 ranging from 0.33 (G1) to 0.62 (G3). The influence was stronger in males during adolescence ($R^2 = 0.62$, ($P < 0.05$).
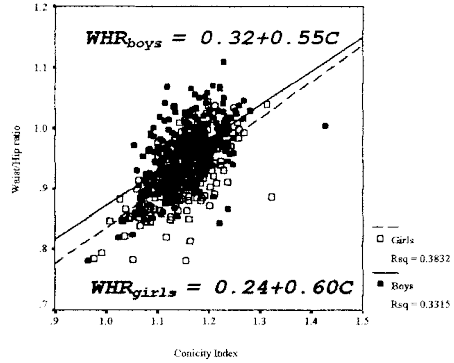
DISCUSSION

Different methods for the study of the amount and distribution of subcutaneous fat have been used in the context of several health issues. Technological advances, including computed tomography and magnetic resonance imaging, have provided major insights into the study of fat distribution
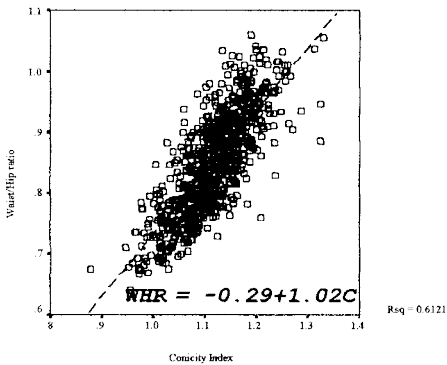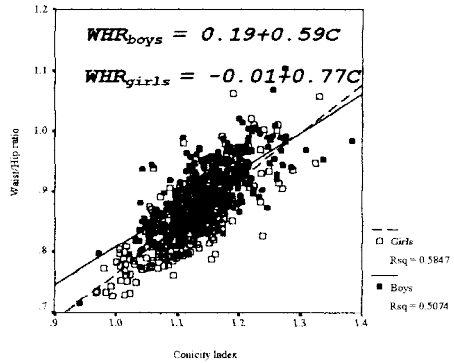
Total Groups of Boys

$WHR = -0.01+0.80C$

Rsq = 0.4603

3 to 5 years

$WHR_{boys} = 0.32+0.55C$

$WHR_{girls} = 0.24+0.60C$

□ Girls
Rsq = 0.3832
■ Boys
Rsq = 0.3315

Total Groups of Girls

$WHR = -0.29+1.02C$

Rsq = 0.6121

6 to 10 years

$WHR_{boys} = 0.19+0.59C$

$WHR_{girls} = -0.01+0.77C$

□ Girls
Rsq = 0.5847
■ Boys
Rsq = 0.5074

11 to 16 years

$WHR_{boys} = 0.08+0.68C$

$WHR_{girls} = 0.09+0.63C$

□ Girls
Rsq = 0.6056
■ Boys
Rsq = 0.6200
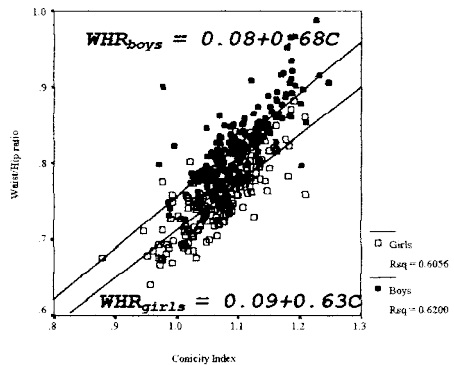
Fig. 2.   Scatter diagrams for the total sample and by age groups of the variables involved.

and its relation to chronic diseases. However, the relative ease of anthropometry in the field setting and in large surveys makes it an important tool. The present report illustrates that C can be used as an alternative method to estimate relative body-fat distribution on the basis of measurements that do not require elaborate equipment.

The association between C and WHR was more apparent in females than males and tended to be stronger in the older age groups. In a study of boys and girls 15 to 16 years of age, correlations between C and WHR were 0.83 to 0.87 for boys and girls, respectively (Mueller et al., 1996). In the present sample, the relationships indicated by the adjusted R^2 were slightly lower.

Both C and WHR decrease with age. C showed a somewhat better capacity than WHR to detect central and peripheral fat pattern distribution as indicated by outliers points.

Conicity explained a major part of the variation in fat distribution as indicated by WHR, specially in adolescent males. A recent cross-sectional analysis done with same sample reported confounding effects of height and body mass index on abdominal adiposity measured by conicity index in male adolescents (Pérez et al., 2000c). On the other hand, high values of C were associated with high values of weight on female adolescents (Pérez et al., 2000a).

Conicity can be used as an alternative method to estimate body fat distribution in adolescents in field surveys, but continued research is needed to confirm these observations.

ACKNOWLEDGMENTS

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