AMERICAN JOURNAL OF HUMAN BIOLOGY 14:15 20 (2002)

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

BETTY PÉREZ,[1]* MARITZA LANDAETA-JIMÉNEZ,[2] AND MAURA VÁSQUEZ[3]
[1]*Instituto de Investigaciones Económics y Sociales, Facultad de Economía, Universidad Central de Venezuela, Caracas, Venezuela*
[2]*División de Investigaciones Biológicas, Fundacredesa, Caracas, Venezuela*
[3]*Escuela de Estadística, Facultad de Economía, Universidad Central de Venezuela, Caracas, Venezuela*

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

---

Contract grant sponsor: The National Council of Scientific and Technological Research (CONICIT).

*Correspondence to: Betty M. Pérez, Apartado de Correos 78162, la Urbina, Caracas 1074, Venezuela.

Received 28 June 2000; Revision received 22 May 2001; Accepted 19 June 2001

DOI 10.1002/ajhb.10002

retardation, a meaningful deficit in other physical characteristics, especially in those that measure bone structure was founded (Ledezma et al., 1995; Perez 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 anteriorally. 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:

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

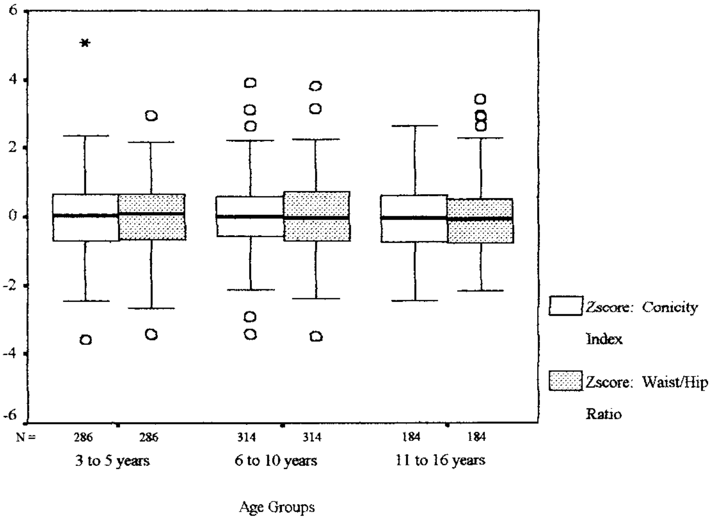
Statistical analysis

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	$\bar{X}$	s	CV	$\bar{X}$	s	CV	$\bar{X}$	s	CV	$\bar{X}$	s	CV	$\bar{X}$	s	CV	$\bar{X}$	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/m^2)	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

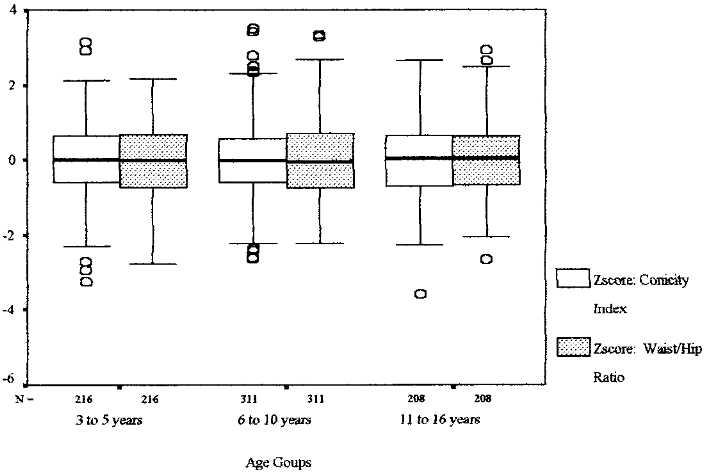


Fig. 1. Box-plot diagram for conicity index and waist hip ratio boys.

between age groups, and the Scheffe 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:

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

where:

WHR = Waist hip ratio

$C =$ Conicity index

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

	Boys						Girls					
	Levene	Analysis of variance	Scheffe				Levene	Analysis of variance	Scheffe			
	0.205	0.000		G1	G2	G3	0.580	0.000		G1	G2	G3
Conicity index			G1			*			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:

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

$$\varepsilon = \text{Random error vector}$$

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:

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

where:

$$Y = \text{WHR}$$

$$= \text{conicity}$$

$i = 1, 2, \ldots, n_j;$
subjects of the sample in each group

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

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

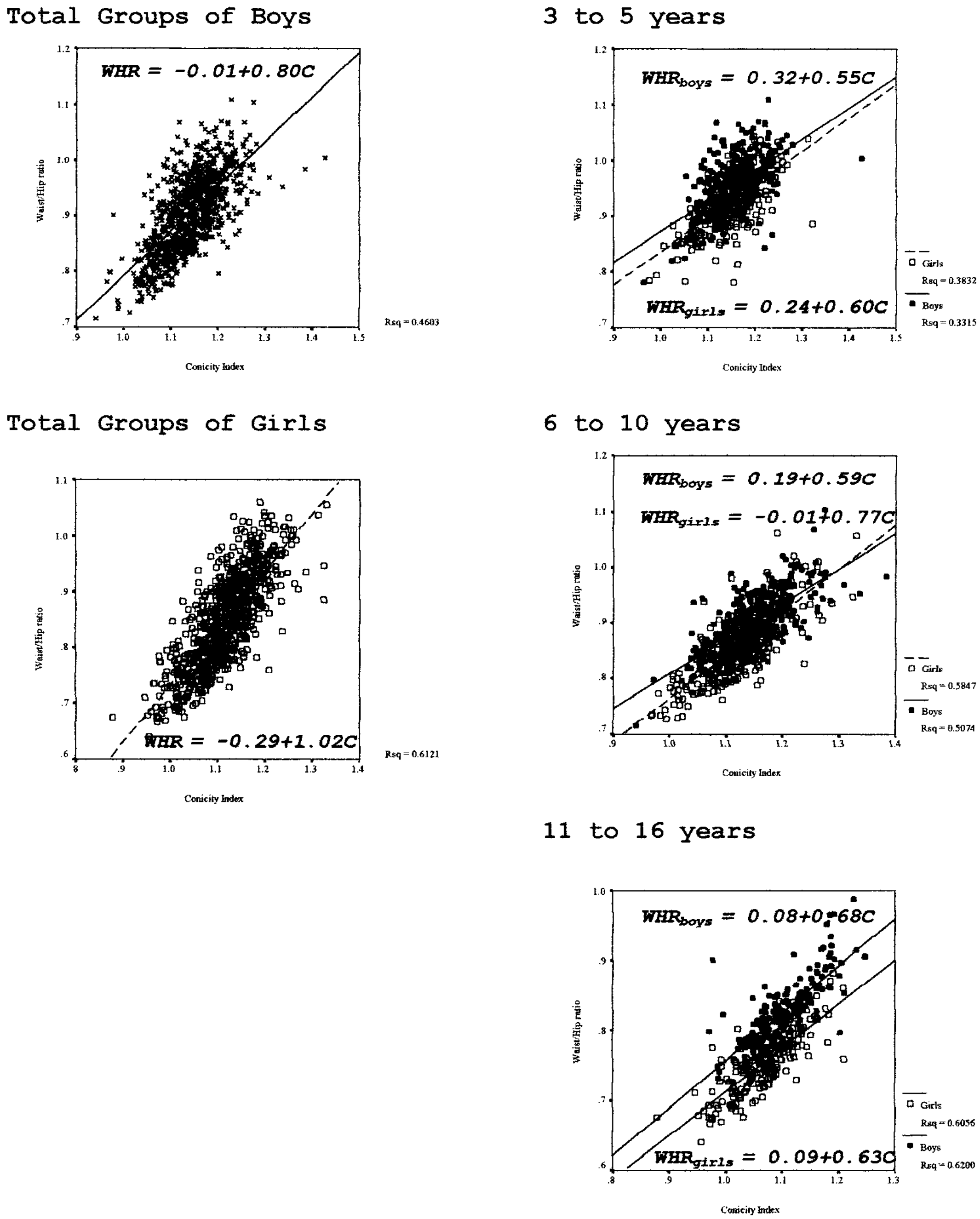


Fig. 2. Scatter diagrams for the total sample and by age groups of the variables involved.

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 (Perez et al., 2000c). On the other hand, high values of *C* were associated with high values of weight on female adolescents (Perez 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

We thank all children and youths who participated in the study, Dr. Robert M. Malina for his editorial assistance, and to the referees for their constructive suggestions.

LITERATURE CITED

Baumgartner RN, Roche AF, Chumlea WC, Siervogel RM, Glueck CJ.1987. Fatness and fat patterns: associations with plasma lipids and blood pressures in adults, 18 to 57 years of age. Am J Epidemiol 126:614–628.

Larsson B, Svardsudd K, Welin L, Wilhelmsen L, Björntorp P, Tibblin G.1984. Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in.1913. Br Med J 288:1401–1404.

Lean MEJ, Han TS, Morrison CE. 1995. Waist circumference as a measure for indicating need for weight management. Br Med J 311:158–161.

Ledezma T, Perez B, Landaeta-Jimenez M. 1995. Pobreza y desnutrición: factores limitantes del desarrollo humano. Antropol Fısica Latinoam 1:19–29.

Lemieux S, Prud'homme D, Bouchard C, Tremblay A, Despres JP. 1996. A single threshold value of waist girth identifies normal-weight and overweight subjects with excess visceral adipose tissue. Am J Clin Nutr 64:685–693.

Mendez-Castellano H, Mendez MC. 1994. Sociedad y Estratificacion Social. Caracas: Fundacredesa.

Mueller WH, Meininger J, Lienr P, Chang W, Chandler P. 1996. Conicity: a new index of body fat distribution—What does it tell us? Am J Hum Biol 8: 489–496.

Must A, Jaques PF, Dallal GE, Bajema CJ, Dietz WH. 1992. Long-term morbidity and mortality of overweight adolescents: a follow-up of the Harvard Growth Study of 1922 to 1935. N Engl J Med 327:1350–1355.

Ohlson L-O, Larsson B, Svardsuudd K, Welin L, Eriksson H, Wilhelmsen L, Bjorntorp P, Tibblin G.1985. The influence of body fat distribution on the incidence of diabetes mellitus. Diabetes 34:1055–1058.

Perez B, Landaeta-Jimenez M, Ledezma T. 1996. Social and biological profiles of children at risk in a Venezuelan community. In: Sidhu LS, Sidhu SP, editors. Human biology: global developments. Patiala, India. Ludhiana.

Perez B, Landaeta-Jimenez M, Vasquez M. 2000a. Distribucion de 1a adiposidad en adolescentes venezolanos mediante el ındice de coincidad. Acta Cient Venezolana 51:244–251.

Perez B, Landaeta-Jimenez M, Ledezma T, Mancera A. 2000b. Adiposidad, distribucion de grasa y lipidos sericos en adolescentes venezolanos. In: Varela TA, editor. Investigaciones en Biodiversidad Humana. Universidad de Santiago de Compostela Press Santiago de Compostela: 539–546.

Perez B, Landaeta-Jimenez M, Valdez R. 2000c. Relationship of weight and height with waist circumference, body mass index and conicity index in Venezuelan adolescents. Acta Med Auxol 32:60 (Abstract).

Pouliot M, Despres JP, Lemmeux SL. 1994 Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. Am J Cardiol 73:460–468.

Rolland-Cachera M, Bellisle F, Deheeger M, Pequignot F, Sempe M. 1990. Influence of body fat distribution during childhood on body fat distribution in adulthood: a two-decade follow-up study. Int J Obes 14:473–481.

Ross, WB, Marfell-Jones MJ. 1991. Kinanthropometry., MacDougall JD, Wenger HA, Green HJ, editors. Physiological testing of the high-performance athlete. Champion IL: Human Kinetics, pp 432.

Valdez R, Seidell JC, Ahn YI, Weiss KM. 1992. A new index of abdominal adiposity as an indicator of risk for cardiovascular disease: a cross-population study. Int J Obes 16:77–82.

Van Loan MD. 1996. Body fat distribution from subcutaneous to intra-abdominal: a perspective. Am J Clin Nutr 64:787–788.