JECA

The Study Of Conicity Index And Waist Hip Ratio In Nigerian Children And Adolescents

B. DANBORNO AND A. OYEWALE
Department of Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria 810261, Nigeria **Email:** danborno@scientist.com

ABSTRACT

Since the introduction of the conicity index by Valdez et al, (1992) the conicity index has been applied to assess the central distribution of fat as a risk of cardiovascular diseases. This study was conducted to apply this index to investigate the fat distribution pattern of Nigerian children (n = 240 boys and n = 211 girls) 3 to 15 years of age, grouped as 3-5 years, 6-10 years and 11-15 years. Anthropometric variables increase from 3-5 years age group to 11-15 years age group, with a significant difference ($P<0.001$) in both boys and girls, only the triceps skin fold fails to show significant difference. The means of conicity index and the waist-hip ratio decrease with the increase in age of the subjects with the 3-5 years age group having higher means and 11-15 years having lower means with statistical significance ($P<0.001$). Correlation and regression analyses were used to establish relationship between conicity index, waist hip ratio and other anthropometric variables. The study shows that central fat distribution decreases as an individual ages and becomes peripherally distributed, explaining the decrease in conicity index and waist-hip ratio, which is more pronounced in the girls.

Keywords: Conicity index, Waist-hip ratio, BMI, Fat distribution, boys, girls, Nigeria.

Epidemiological studies which concern the relationship of fat distribution have found that a centripetal fat distribution (trunk and upper body) is associated with a high incident of coronary heart disease, high serum triglyceride concentration and diabetes (Albrink and Meigs, 1964; Baumgartnet et al. 1987; Bjorntorp, 1999; Ribeiro et al, 2004). These studies suggest that in addition to total body fat, body shape and regional fat distribution is important indicator of cardiovascular health in adult (Ohlson et al; 1985; Baumgartner et al., 1987 Ribeiro et al., 2004), which is now the leading cause of death (WHO, 2002). As a result, there is interest in the development in these indicators in children and adolescence and their potential relevance for latter health outcome (Garn and Bailey, 1978; Rolland-Cachera, et al. 1990, Must et al; 1992). Centralized pattern of fat is greater in males than female in all ethnic group so far studied (Cameron et al, 1994).

In industrialized and rich countries, obesity and overweight are the most frequent nutritional disorder in children and adolescence, and there is a continuing increase in their prevalence (Freedman et al., 1997; Al-Hadded et al., 2000; WHO, 2000; Al-Hourani et al., 2003; Henry et al., 2004). Overweight children have a high risk of being overweight in adulthood (Gan and Bailey, 1978; Salbe et al., 2002) and therefore are also at risk associated health complications as hypertension and coronary heart disease (Power et al., 1997; Ribeiro et al., 2004). The risk and consequences of accumulation of fat in childhood and adolescence requires an aggressive approach for prevention and treatment. Early intervention including increased activity and reduction in high fat, high calorie food, is important and some success has been shown in such a programme (Togashi et al., 2002; Al-Hourani et al., 2003; Henry et al., 2004).

The waist-to-hip (WHR) to estimate adipose tissue distribution is risk factor of cardiovascular disease and diabetes (Larsson et al; 1984, Ohlson et al; 1985; Daniel et al., 1999).

In adolescents the conicity index has been used as an alternative (Valdez et al; 1992, Perez et al; 2000). There is also a positive link between over weight measured by the body mass index and high conicity values, as well as between high conicity value and high level of triglycerides (Perez et al., 2000).

Hence, an excessive amount of fat in the body is a better criterion for the diagnosis of obesity during childhood which may seriously affect the child's development of emotional maturity, his success in sports and other physical activities, and his attainment of physical fitness at maturity (Togashi et al., 2002; Smith and

Rinderknecht, 2003).

The scope of this study will entail a survey of primary school age children in Nigeria, to compare the conicity index with the WHR to estimate abdominal adipose tissues distribution.

MATERIAL AND METHODS

This study was based upon a cross sectional sample of 241 boys and 210 girls, 3 to 15 years of age, from two primary schools in Zaria, North West Nigeria. The schools are Brilliant Nursery and Primary School and Ar Rayyan Nursery and Primary School, Sabon Gari, Zaria.

The method involved an assessment of the children's growth, nutritional status and body composition. The demographic information of interest included the age and sex of the children, the sample was divided into three groups: 3 to 5 years, 6 to 10 years and 11 to 15 years, which is to approximate early childhood, middle childhood and adolescence respectively.

Measurements were taken as described by Lohman et al. (1988). Body weight was measured to the nearest 0.1kg with a balance scale with minimal clothing. Height was measured to the nearest centimetre (0.1cm) with the subject in bear feet. Circumferences were measured with the subject standing. Waist circumference was measured at the maximal abdominal girth, approximately midway between xiphoid process and the umbilicus. Hip circumference was measured at the level of the greatest protrusion of the gluteal muscle approximately at symphysium interiorly using a flexible tape measure.

The conicity index was calculated using the formula developed by Valdez et al., (1992), as

$$\textit{Conicity index} = \frac{\textit{Waist circumference (m)}}{0.109 \quad \sqrt{wt(kg)/ht(m)}}$$

The waist hip ratio was also calculated as:

$$WHR = Waist\ (cm)\ /Hip\ (cm)$$

A larger value of conicity index indicates a more central fat distribution. Skinfold thickness (triceps, subscapular and calf-midway between the knee and the ankle) were measured with Harpenden's calipers and recorded to the nearest 0.1mm.

Data were expressed as mean $\pm$ standard deviation (SD). One way analysis of variance was used to test for significant difference between age group within the same sex, correlation and regression analysis were used to examine the relationship between WHR and conicity index for age and sex. Sigma Stat 2.0 for Windows (San Rafael, CA) was used for the statistical analysis.

RESULTS

The descriptive statistics for weight, height, circumferences, conicity index, waist hip ratio (WHR) and body mass index (BMI), in the three age groups by sex are given in Table 1.

The mean weight increase with the increase in age of the subjects with girls (6-10, 11-15 years) having higher means than the boys with statistical significance $P<0.001$. The mean height of the subjects increases as the subject's age increases showing significant difference of $P<0.001$. The means of waist circumference and the hip circumference increase with the increase in the age of the subjects with the 11-15 years age group having higher mean and 3-5 years having lower means with the statistical significance ($P<0.001$) higher in girls than boys.

Considering the skinfolds thickness, the subscapular skin fold increases with the increase in age in both sexes except in age 6-10 years of boys ($P<0.001$). The means of triceps skin fold in boys decrease with increase in age of the subjects while the decrease in girls rises with 11-15 years. The calf skin fold decreases with increase in age except 11-15 years of age in both sexes, which rise above with statistical difference ($P<0.001$). The means of the sum of the three skinfolds increase in age of both sexes except 6-10 years.

The means of arm, forearm, and thigh circumferences increases with increase in the age of the subjects with significant difference of $P<0.001$. The averages of conicity index and the waist hip ratio decrease with the increase in the age of the subjects with the 3-5 years age having higher means and 11-15 years lower means with increase in age of the subjects.

Boys in age group 3-5 years attain higher mean than girls in the same age group in all variables except thigh circumference. In general, both boys and girls show increase variance with age especially for weight and height. Additionally, a tendency toward diminishing mean values with age was observed for C and WHR.

Table 2 shows the correlation matrix of anthropometric variables indicating relationship among the variables in boys and girls. The statistical significance for a ($P < 0.05$) is about 1.3 % which is the lowest compare to b ($P < 0.01$) about 7.7% and the highest statistical significance c ($P < 0.01$) about 66.7%. The correlation of variables depends on the relationship that exists among the parameters. Height correlates to all variables except triceps skinfold, conicity index and body mass index.

Correlation exists between weight and other variables except the triceps skinfold. Waist circumference does not correlate with triceps skinfolds and conicity index while the hip circumference is related to other variables except the triceps skinfold.

The sum of three skinfolds (subscapular, triceps and calf) correlates to other except to conicity and WHR. Though triceps and calf skinfolds are not correlated to forearm circumference. The thigh circumference is related to other variables except the WHR. The conicity index shows no correlation between the height, waist circumference and the sum of three skinfolds while the WHR shows no relationship between the three skinfolds and the circumferences of the body. The correlation of BMI can be shown in all the variables except the height and WHR.

The regression of conicity index and WHR within the sex and age group are shown in Table 3. This table could be used to predict the relationship of conicity index and WHR. Conicity index explained a significant portion of variability in WHR in all groups. Boys tend to increase in values (from, $r = 0.34\text{-}0.50$, $r^2 = 0.11\text{-}0.25$, $F = 12.36\text{-}31.12$) and statistically significant with increase in age having a wide range as they move towards the adolescence stage while the girls decrease in values ($r = 0.34$ 0.30, $r^2 = 0.12\text{-}0.09$, $F = 14.06\text{-}3.16$). Conicity index explained a significant portion of variability in WHR in all groups with r^2 ranging from 0.07 (3-5 years) to 0.25 (11-15 years). The influence was stronger in male during adolescence $r^2 = 0.25$ ($P < 0.001$).

Table 1: The Mean ± Standard Deviations Of The Anthropometric Variables Measured In Boys And Girls.

Variables	Boys			Girls		
	3 –5 yrs (n = 99)	6–10 yrs (n = 92)	11-15 yrs (n = 49)	3 – 5 yrs (n = 60)	6–10 yrs (n = 118)	11-15yrs (n = 33)
Weight (kg)	17.18 ± 3.51^a	21.29 ± 3.98^b	31.21 ± 5.81^c	16.63 ± 3.58^a	22.78 ± 4.92^b	33.68 ± 6.20^c
Height (cm)	112.13 ± 15.74^a	119.84 ± 9.04^b	139.98 ± 7.65^c	107.81 ± 11.23^a	122.95 ± 9.41^b	141.53 ± 7.74^c
Waist Cir.(cm)	53.58 ± 3.96^a	55.12 ± 3.97^b	60.11 ± 3.96^c	52.39 ± 3.46^a	54.97 ± 3.40^b	59.02 ± 6.14^c
Hip Circ. (cm)	51.88 ± 4.01^a	54.57 ± 3.97^b	60.70 ± 4.15^c	51.48 ± 3.61^a	55.78 ± 3.58^b	62.21 ± 8.11^c
Subscapular SF(mm)	3.99 ± 0.97^a	3.83 ± 0.60^a	4.06 ± 0.75^a	3.83 ± 0.72^a	4.04 ± 0.92^b	7.03 ± 0.87^c
Triceps SF(mm)	6.77 ± 1.75^a	6.17 ± 4.09^a	5.98 ± 1.58^a	6.56 ± 1.66^a	6.37 ± 1.98^a	7.23 ± 2.11^a
Calf SF(mm)	10.79 ± 2.32^a	9.13 ± 1.97^a	12.28 ± 9.36^a	9.97 ± 2.00^a	9.93 ± 2.43^b	12.16 ± 2.18^c
Sum of three SF(mm)	21.55 ± 4.09^a	19.12 ± 4.90^b	22.32 ± 9.34^a	20.36 ± 3.66^a	20.33 ± 4.72^a	26.42 ± 10.96^b
Thigh Cir.(cm)	30.12 ± 2.38^a	32.28 ± 2.98^b	38.03 ± 3.75^c	30.14 ± 2.10^a	33.31 ± 3.30^b	39.15 ± 4.78^c
Conicity Index	1.27 ± 0.13^a	1.21 ± 0.07^b	1.18 ± 0.05^b	1.23 ± 0.09^a	1.18 ± 0.07^b	1.12 ± 0.12^c
WHR	1.03 ± 0.05^a	1.01 ± 0.05^b	0.99 ± 0.04^c	1.02 ± 0.05^a	0.99 ± 0.05^b	0.98 ± 0.27^c
BMI(kg/m^2)	10.84 ± 3.97^a	14.81 ± 2.14^b	15.83 ± 1.96^b	11.88 ± 3.85^a	14.95 ± 1.90^b	17.02 ± 4.61

Circ. = Circumference *SF =Skinfold* *WHR = Waist-Hip Ratio.*

Means with similar superscripts indicate that they are similar and means with different superscripts are significantly different between age groups within the same sex at P<0.001.

Table 2: Correlation Matrix Of Anthropometric Variables Studied In Boys And Girls (n = 451).

Variables	HT	WT	WC	HC	SS	TS	CS	AC	FC	TC	CI	WHR	BMI
HT	-	0.75[C]	0.53[C]	0.62[C]	0.27[C]	-0.01	0.14[b]	0.46[c]	0.32[c]	0.65[c]	-0.08[c]	-0.16[c]	-0.06
WT		-	0.72[c]	0.78[c]	0.40[c]	0.07	0.20[c]	0.63[c]	0.45[c]	0.89[c]	-0.49[c]	-0.14[b]	-0.14[b]
WC			-	0.72[c]	0.36[c]	0.09	0.16[c]	0.55[c]	0.35[c]	0.69[c]	0.09	0.18[c]	0.18[c]
HC				-	0.42[c]	0.07	0.14[b]	0.53[c]	0.36[c]	0.75[c]	-0.23[c]	-0.52[c]	0.44[c]
SS					-	0.38[C]	0.25[c]	0.37[c]	0.24[c]	0.46[c]	-0.03	-0.08	0.30[c]
TS						-	0.20[c]	0.16[c]	0.06	0.11[a]	0.02	0.04	0.13[b]
CS							-	0.18[c]	0.07	0.18[c]	-0.047	0.01	0.14[b]
AC								-	0.39[c]	0.63[c]	-0.20[c]	-0.02	0.39[c]
FC									-	0.46[c]	-0.19[c]	-0.04	0.29[c]
TC										-	-0.34[c]	-0.09	0.51[c]
CI											-	0.31[c]	-0.64[c]
W/HR												-	-0.01
BMI													-

HT = Height WT = WeightWC = Waist Circumference SS = Subscapular Skinfold TS = Triceps Skinfold CS = Calf Skinfold AC = Arm Circumference FC = Forearm Circumference TC = Thigh Circumference CI = Conicity Index WHR = Waist-Hip Ratio BMI = Body Mass Index. P<0.05 bP<0.01.

Table 3: Regression Coefficients of Conicity Index and WHR within the sex groups

	n	Regression Equation	r	r^2	P
Boys and Girls	451	WHR=0.68+0.27xC	0.31	0.10	<0.001
Boys	245	WHR=0.55+0.37xC	0.29	0.10	<0.001
3 –5 years	99	WHR=0.89+0.12xC	0.34	0.11	<0.001
6 – 10 years	92	WHR=0.75+0.22xC	0.34	0.11	<0.001
11 – 15 yrs	49	WHR=0.73+0.24xC	0.50	0.25	<0.001
Girl's	206	WHR=1.12- 0.08xC	0.27	0.07	<0.001
3 – 5 yrs	60	WHR=0.83+0.15xC	0.27	0.07	<0.05
6 – 10yrs	118	WHR=0.66+0.28xC	0.34	0.12	<0.001
11 – 15yrs	33	WHR=0.22+0.67xC	0.30	0.09	>0.05

C = Conicity Index WHR = Waist-hip ratio

DISCUSSIONS

The results obtained have revealed that conicity index can be used as an alternative method to estimate relative body fat distribution on the basis of measurements that do not require elaborate equipment. 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 and its relation to chronic diseases (Taylor et al., 2000; Perez, et al., 2002).

In a similar study by Perez, et al. (2002) the results obtained were closely related to present sample results especially when considering the values obtained for weight, height and waist circumference. The values obtained by Perez et al. (2002) in Venezuelan children for hip circumference and BMI are higher than the one obtained in this present study, but when compared to reports for United States, United Arab Emirates and other Gulf States both the Venezuelan and the present study are lower due to the effect of increasing prosperity in the gulf region (Al-Hadda et al. 2000; Al-Hourani et al., 2003; Smith and Rinderknecht, 2003). The calculated means of conicity index and waist hip ratio in this present sample were higher than the one obtained in recent work in Venezuelan children (Perez et al., 2002), but similar to the ones reported by Taylor et al., (2002) in New Zealand children and adolescents.

Though, the conicity index and WHR decrease with increase in age of the subjects in both sexes, the result obtained in this study for conicity index and WHR in Nigerian children are higher than the Venezuelan children (Perez et al., 2002). The association between conicity and WHR was more apparent in females than males and tended to be stronger in the older age groups. A similar trend was observed in a study conducted by Mueller et al. (1996) among boys and girls 15-16 years of age, correlations between conicity index and WHR were 0.83 and 0.87 for boys and girls respectively. In the present sample, the relationship indicated by r^2 were slightly lower (0.07-0.25).

The three skinfolds (triceps, subscapular and calf) studied showed lower values than the one obtained in the United States and agrees with that study in showing very low significant difference when the three age groups were compared (Smith and Rinderknecht, 2003). Skinfold showed the least level of difference, even though the adolescent girls showed a higher value compared their male counterparts. This higher value is due to the role of female sex hormones preparing for reproductive life (Frisch, 1990; Bjorntorp, 1991). The sum of three skinfolds indicates distinct patterns of fat distribution on both the trunk and the extremities and the centripetal trend difference between early and late maturer becomes evident during adolescence (Cameron et al., 1994).

The correlations among the anthropometric variables studied in boys and girls indicate about 75% relationship with $P<0.001$ statistical significant difference. Considering the regression coefficients table of conicity index and WHR within the sex and age groups which indicates a prediction of relationship between conicity index and WHR. This explained the statistical insignificant difference ($P>0.05$) for 11-15 years in girls which is insignificant. This was due to the girls moving toward adolescence and development of secondary sexual characteristics in girls (Bjorntorp, 1991; Danubio et al., 2004), and the provision for the development of center of body a must for successful reproductive life (Pawlowski et al., 2003).

CONCLUSION

This study shows that some anthropometric variables increase with increase in age of the subjects while others decrease with increase in age. The variables, weight, height, waist circumference and hip circumference increase with increase in age of the subjects. Sum of three skinfolds, the thigh circumference and body mass index of both sexes increases with the increase in age subjects.

The conicity index and waist hip ratio decrease with increase in age of the subjects with statistical significance ($P<0.001$). Conicity index show a somewhat better capacity than waist hip-ratio to detect central and peripheral fat pattern distribution. The relationship indicated by r^2 coefficient of determination were slightly lower and this shows that central fat distribution decrease as an individual ages and becomes peripherally distributed, explaining the decrease in conicity index and waist-hip ratio and the increase in the body mass index of the subjects.

Conicity explained a major part of the variation in fat distribution as indicated by the WHR, especially in adolescent males. On the other hand, high value of conicity was associated with high value WHR in female adolescents (Perez et al., 2000).

WHR decrease with increase in the age of the subjects. The waist circumference of 3 5 years of age of both sexes are high than the hip circumference of the same age. The fat distribution tends towards the girth as the age increase in both sexes but is more pronounced in the girls. Hence, decrease in WHR as the age increases are more pronounced in the girls as the fat are more distributed towards the hip and buttocks (gluteofemoral region) in girls but the waist circumference of the boys continue to increase.

The conicity index which is related to waist circumference also decrease as the age increases, hence, decrease in the value of conicity index obtained. In girls, apart from peripheral distribution of fat, there are evidences of development secondary sexual characteristics which showed a decrease in conicity index and WHR with increase in age. In lower age, 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. Therefore, the risk of cardiovascular disease and diabetes may be more in male than female. Conicity can be used as an alternative method to estimate body fat distribution in children adolescents, but continue research is needed to confirm this observation.

ACKNOWLEDGEMENTS

The authors wish to thank the proprietors and teachers of Ar Rayyan and Brilliant Nursery and Primary Schools for their contribution to the success of this study and to the pupils who graciously participated in the study.

REFERENCES

Albrink MJ and Meigs JW (1964). Interrelationship between skinfold thickness, serum lipids and blood sugar in normal men. *Am J Clin. Nutr. 15:255-261.*

Al-Haddad F, Al-Nuaimi, Little BB, Thabit M (2000). Prevalence of obesity among school children in the United Arab Emirates. *Am J. Hum Biol 12:498 -502.*

Al-Hourani HM, Henry CJK, Lightowler HJ (2003). Prevalence of overweight among females in the United Arab Emirates. *Am J Hum Biol 15:758-764.*

Baumgartner RN, Roch AF, Chumlea WC, Siervogel RM, Glueck CJ (1987). Fatness and fat patterns: association with plasma lipids and blood pressure in adults, 18-57 years of age. *Am. J. Epidemiol. 126: 614-628.*

Bjorntorp P. (1991). Adipose tissue distribution and function. *Int. J. Obes 15:67-81.*

Bjorntorp P. (1999). Abdominal fat distribution and disease: and overview of epidemiological data. *Am Med. 24:15-18.*

Cameron N, Gordon-Larsen P, Wrchota EM (1994). Longitudinal analysis of adolescent growth in height, fatness, and fat patterning in rural South African black children. *Am. J. Phys. Anthropol 93: 307-321.*

Daniel M, Marion SA, Sheps SB, Hertzman C, Diane Gamble (1999). Variation by body mass index and age in waist-to-hip ratio associations with glycemic status in an aboriginal population at risk for type 2 diabetes in British Columbia, Canada. *Am. J. Clin. Nutr. 69:455-600.*

Danubio ME, De Simione M, Vecchi F, Amicone E, Altobelli E, Gruppioni G (2004). Age at menarche and age of onset of pubertal characteristics in 6 14 year-old girls from the province of L'Aquila (Abruzzo, Italy). *Am J. Hum Biol 16:470-478.*

Frisch RE (1990). Body fat, menarche, fitness and fertility. In Adipose tissue and reproduction R.E. Frisch (Ed). Basil: Karger, 1990, pp 66-72.

Garn, S.M and Bailey, SM (1978). Genetics of maturational processes. *In Human Growth, Falkner, F and Tanner, J.M. (eds) Plenum New York, pp 307-330.*

Henry CJK, Lightowler HJ, Al-Hourani HM (2004). Physical activity and levels of inactivity in adolescent females age 11 16 years in the United Arab Emirates. *Am. J. Hum. Biol 16:346-353.*

Larsson B, Svardsudd K, Welin L, Wilhemsen L, Bjorntorp P, Tibblin G (1984). Abdominal adipose distribution, Obesity and risk of cardiovascular disease and death: 13 years follow up of participant in the study of men born in 1913. *Brit. Med. J. 288: 1401-1404.*

Lohman T, Roche, A, Martorell R. (1988). Anthropometric standardization reference manual Champaign, IL: Human Kinetics.

Meuller WH, Meininger J, Lienr P, Chang W, and Chandler P (1996). Conicity: A new index of body fat distribution what does it tell us? *Am. J. Hum. Biol. 8: 486-496.*

Must A, Jacques 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 1992 1935. *N Engl. J. Med. 327: 1350-1355.*

Ohlson, LO, Larsson B, Svarduudd 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.*

Pawlowski B and Grabarczyk M (2003). Center of body mass and the evolution of female body shape. *Am J. Hum Biol. 15: 144 -150.*

Perez B, Landaeta, J. M and Vasquez M (2002). Fat distribution in Venezuelan children and adolescents estimated by the conicity index and waist/hip ratio. *Am J. Hum Biol. 14: 15-20.*

Perez B, Landaeta, JM, Valdez, R (2000). Relationship of weight and height with waist circumference body mass index and conicity index in Venezuelan Adolescent. *Acta. Med. Auxol. 32-60. (Abstract).*

Power C, Lake JK, Cole TJ (1997). Measurement and long-term health risks of child and adolescent fatness. *Int. J. Obes Relat. Metab Discord 21: 507-26.*

Ribeiro JC, Guerra S, Oliveira J, Andersen LB, Duarte JA, Jorge Mota (2004). Body fatness and clustering of cardiovascular disease risk factors in Portuguese children and adolescents. *Am. J. Hum. Biol. 16:556-562.*

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.*

Salbe AD, Weyer C, Harper I, Lindsay RS, Ravussin E, Tataranni PA (2002). Assessing risk factors for obesity between childhood and adolescence: I. Birth weight, childhood adiposity, parental obesity, insulin, and leptin. *Pediatrics 110: 299-306.*

Smith C, Rinderknecht K (2003). Obesity correlates with increased blood pressure in urban native American youths. *Am. J. Hum. Biol 15:79-90.*

Taylor RW, Keil D, Gold EJ, Williams SM, Goulding A (2000). Evaluation of waist circumference, waist-hip ratio, and the conicity index as screening tools for high trunk fat mass, as measured by dual energy X-ray absorptiometry, in children aged 3 19 y. *Am. J. Clin. Nut. 72: 490-5.*

Togashi K, Masuda H, Rankinen T, Tanaka S, Bouchard C, Kiyama H (2002). A 12-year follow-up study of treated obese children in Japan. *Int. J. Obes. Relat Meta. Disord. 26:770-777.*

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.*

WHO (2000). Obesity: preventing and managing the global epidemic. Technical report series 894. Geneva: World Health Organization.

WHO (2002). Global cardiovascular InfoBse: WHO collaborating center on surveillance of cardiovascular diseases. World Health Organization.