Waist circumference and central fatness of Egyptian primary-school children

N.E. Hassan,[1] S.A. El-Masry[1] and A.E. El-Sawaf[1]

محيط الخصر وتراكم الشحوم المركزي لدى الأطفال المصريين في المدارس الابتدائية

نيِّرة المرسي حسن، سحر عبد الرؤف المصري، علي السيد الصواف

الخلاصة: تناولت هذه الدراسة المستعرضة 1283 طفلاً من الأطفال الأصحّاء (681 ذكراً و602 أنثى) تتراوح أعمارهم بين 6 و11 عاماً، لدراسة الترابط بين محيط الخصر وبين السِّمنة المركزية. وقد صُنِّفَ الأطفال وفقاً لمنسب كتلة الجسم إلى طبيعيين ومفرطي الوزن وسِمَان. ولوحظ ترابط إيجابي مرتفع في كلا الجنسين بين محيط الخصر ومنسب كتلة الجسم، والنسبة المئوية للشحمِ في الجسم، وثخانة الطية الجلدية تحت لوح الكتف وفوق الحرقفة، ومجموع قياسات الطيات الجلدية. وكانت السِّمنة المركزية وفرط الوزن بسبب تراكم الشحوم في مركز الجسم من المؤشرات على السِّمنة لدى كل من الأطفال الذكور والإناث الذين يعانون من السِّمنة، باستثناء من كان منهم في الفئة العمرية 6.5 ± 1 سنة. وكان محيط الخصر مؤشراً جيداً على السِّمنة المركزية (فرط الوزن والسِّمنة) في الأعمار التي تتراوح بين 8.5 ± 1 سنة و10.5 ± 1 سنة.

ABSTRACT This cross-sectional study of 1283 healthy children (681 boys, 602 girls) aged 6–11 years tested the degree of correlation between waist circumference measurements and adiposity. The children were classified as normal, overweight or obese according to their body mass index (BMI). For both sexes a highly positive correlation was found between waist circumference and BMI, percentage of body fat, subscapular and suprailiac skinfold thicknesses, and the sum of skinfold measures. Central overweight and obesity were indicators for central fatness for both overweight boys and girls and for obese girls except in age group 6.5 ± 1 years. Waist circumference was a good indicator of central fatness (overweight and obesity) in children aged 8.5 ± years and 10.5 ± 1 years.

Tour de taille et adiposité centrale chez les enfants des écoles primaires en Égypte

RÉSUMÉ Cette étude transversale réalisée auprès de 1283 enfants en bonne santé (681 garçons et 602 filles) âgés de 6 à 11 ans a permis d'évaluer le degré de corrélation entre les mesures du tour de taille et l'adiposité. Les enfants ont été classés comme normaux, en surpoids ou obèses en fonction de leur indice de masse corporelle (IMC). Pour les deux sexes, on a constaté une corrélation très positive entre le tour de taille et l'IMC, le pourcentage de tissu adipeux, l'épaisseur des plis cutanés sous-scapulaire et sus-iliaque, et la somme des mesures des plis cutanés. La surcharge pondérale et l'obésité centrales étaient des indicateurs d'adiposité centrale chez les garçons et les filles en surpoids et chez les filles obèses, sauf dans le groupe d'âge des 6,5 ± 1 ans. Le tour de taille était un bon indicateur d'adiposité centrale (surpoids et obésité) chez les enfants âgés de 8,5 ± 1 ans et de 10,5 ± 1 ans.

[1]*Department of Biological Anthropology, National Research Centre, Dokki, Cairo, Egypt (Correspondence to S.A. El-Masry: masrysa@yahoo.co).*
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Introduction

Central fatness, mostly intra-abdominal fat, is medically more important than subcutaneous fat in the trunk. The accumulation of both types of fat is affected by high food consumption and is therefore a historic novelty for human populations [*1*]. A central fat pattern has adverse health implications in both children and adults. Recent studies in children showed that a greater deposition of central fat correlates with less favourable patterns of serum lipoprotein concentrations, increased blood pressure [*2*], adverse levels of cardiovascular risk [*3*] and increased risk of metabolic complications [*4*].

The ability of simple anthropometric techniques to correctly measure central adiposity needs to be assessed because adiposity tracks from childhood into adulthood [*5*]. Routine evaluation of regional fat distribution on a wide scale requires methods that are simpler than dual-energy X-ray absorptiometry (DXA), computerized tomography (CT) or magnetic resonance imaging (MRI). However, studies on the efficacy of anthropometric techniques for identifying children with high central adiposity are scare. There is a suggestion that waist circumference alone may be a more useful and accurate tool in children than DXA etc. [*6*]. Taylor et al. found that waist circumference performed well in identifying children with high trunk fat as measured with DXA [*5*]. Waist circumference correctly identified > 90% of children as being true positives (high waist circumference and high trunk fat mass) or true negatives (low waist circumference and low trunk fat mass).

The circumference of the waist relates closely to body mass index (BMI) and is also the dominant measure in the waist-to-hip ratio, which reflects the proportion of the body fat located intra-abdominally, as opposed to subcutaneously [*7*]. The waist circumference is a better index of android (abdominal) obesity than waist-to-hip ratio and is the best indicator of changes in the intra-abdominal fat during weight loss [*8*]. Waist circumference independently contributes to the prediction of non-abdominal (total fat – abdominal fat), abdominal subcutaneous and visceral fat in both sexes. It has the ability to act as a surrogate for abdominal fat [*9*]. These observations reinforce the importance of using waist circumference in clinical practice [*10*].

We therefore believed that an examination of waist circumference in a group of primary-school Egyptian children would add valuable comparative data to BMI data in assessment of central fatness in overweight and obese children. BMI is a poor proxy for central fatness [*4*] as it is an expression of weight not adiposity [*11*] and it provides no information on body fat distribution, so it can mask true obesity-related risk in children [*3*].

The aim of our study was to test the degree of correlation between waist circumference measurements of a sample of Egyptian schoolchildren with their adiposity (whether total or central), and to quantify the association of waist circumference measurements with age and degree of BMI (overweight or obese) in the same children.

Methods

Sample

This data were obtained from a cross-sectional survey of a sample of 1283 Egyptian schoolchildren, 681 boys and 602 girls, aged 6–11 years. The pupils were recruited from 2 public schools (El Zahraa primary school and El Orman El-Tagribia school) situated in Giza governorate,

during the period October 2002 to April 2004. Permission to perform the study was granted by the Ministry of Education and the directors of the schools included in the research. Parents were informed about the purpose of the study and their permission (in the form of written consent) was obtained.

Data collection

The following was performed for each child:

- A simple questionnaire was directed to the parents about personal abd socio-economic data (parental education and occupation, crowding index), the presence or absence of consanguinity, the medical history of the child with special emphasis on any chronic condition or long-term systemic treatment. The socioeconomic status of the pupil was characterized by scoring parental education, occupation and crowding index as low (score 3–11), medium (12–16) and high (> 17). Only the medium-level pupils were enrolled in the study (the majority of the pupils in these 2 particular public schools).
- Complete clinical examination to exclude organic and genetic disorders that might interfere with normal growth.
- Anthropometric assessment was then made using standardized equipment, following the recommendations of the International Biological Program [*12*]. Three consecutive measurements were taken and when the difference between the readings was acceptable, the mean was recorded. Body weight was measured with minimal clothing (for which no correction was made) using Seca scales and approximated to the nearest 0.01 kg. Height was measured without shoes using a Holtain portable anthropometer and approximated to the nearest 0.1 cm. Waist circumference was taken midway between the 10th rib and the top of the iliac crest (at the level of the umbilicus) using a flexible nonstretchable plastic tape and approximated to the nearest 0.1 cm. Subscapular and suprailiac skinfold thicknesses were measured on the left side of the body using Harpenden skinfold callipers and approximated to the nearest 0.2 mm. BMI (weight in kg/height^2 in m) and the sum of the subscapular and suprailiac skinfold thicknesses (as an indicator of central adiposity) were calculated.
- Each pupil was also examined by the Holtain Body Composition Analyser using bioelectrical impedance analysis to measure his/her body fat percentage (an estimate of the fraction of the total body mass that is adipose tissue) and percentage of lean using his/her age, weight and height approximated to the nearest unit.

The sample was classified into 3 age groups (6.5 ± 1, 8.5 ± 1 and 10.5 ± 1 years) for boys and girls. The limits proposed by the 2002 standard growth curves for Egyptian children and adolescents [*13*] were applied in reclassifying the sample according to BMI into normal (≥ 15% to < 85%), overweight (≥ 85% to < 95%) or obese (≥ 95%) according to the National Center for Health Statistics criteria [*14*].

Statistical analysis

Mean and standard deviation (SD) for all studied anthropometric measurements, indices and body fat percentage were calculated for each age and sex. Then the percentiles of waist circumference for overweight and obese children were estimated.

The correlation between waist circumference and BMI, subscapular skinfold thickness, suprailiac skinfold thickness, the sum of the 2 skinfold measures and

body fat percentage was investigated using Pearson's correlation test for each age and sex subgroup. Adjustment of age, BMI, percentage body fat, subscapular and suprailiac skinfold thicknesses was done using regression equations to investigate the relation between waist circumference and the sum of subscapular and suprailiac skinfold thicknesses in normal, overweight and obese children.

All the data were analysed using *SPSS*, version 9. The charts were drawn using Microsoft *Excel* software.

Results

The percentage of excess adiposity was nearly equal in girls and boys (12.2% of boys were overweight and 5.4% obese, while 11.8% of girls were overweight and 6.0% obese). Mean and SD for all the studied anthropometric measurements and the percentage of body fat by sex and age are presented in Tables 1 and 2. Waist circumference was nearly equal between boys and girls at all ages, except at age 6.5 ± 1 years when girls recorded higher values than boys with no significant difference ($P > 0.05$).

The correlation between waist circumference and the selected indicators of body fatness for both sexes is presented in Table 3. A highly positive correlation was noticed between waist circumference and BMI, percentage body fat, subscapular skinfold thickness (as an indicator for upper trunk fat), suprailiac skinfold thickness (as an indictor for lower trunk fat), and the sum of subscapular and suprailiac skinfold thick-ness (as an indicator for central adiposity) for both sexes ($P < 0.0001$). After adjustment for age, BMI, percentage body fat, subscapular and suprailiac skinfold thickness (Figures 1 and 2), the sum of subscapular and supra-iliac skinfolds still had a high correlation with waist circumference in normal, overweight and obese pupils (R^2 = 0.43, 0.59 and 0.54 for boys and R^2 = 0.45, 0.50 and 0.69 for girls, respectively).

The means of waist circumference measurement and their corresponding percentiles for overweight and obese pupils are presented in Table 4 for each age and sex. Central overweight was detected with waist circumference percentile ≥ 85th for boys and girls aged 8.5 ± years and 10.5 ± 1 years, while lower values were recorded for those aged 6.5 ± 1 years (75th percentile for boys and 80th percentile for girls) in the overweight group. Central obesity was observed with waist circumference percentile ≥ 95th for boys and girls in all studied age groups, with lower values only for girls aged 6.5 ± 1 years (90th percentile) among obese children.

Discussion

Central fatness in children is correlated with a less favourable metabolic profile [*2*]. Visceral fat or intra-abdominal adipose tissue (IAAT) can only be directly quantified with imaging techniques. IAAT has been detected in children as young as 5 years of age. IAAT generally increases in proportion with general fatness but the relationship between IAAT and total body fat is complex. In children, a major portion of the variance in IAAT is independent of total body fat. Central skinfold and waist circumference alone are highly correlated with IAAT as well as subcutaneous abdominal adipose tissue [*16*].

The definition of child overweight and obesity is arbitrary [*16*]. Comparison of our results regarding prevalence of overweight and obesity with another Egyptian study in Cairo [*17*] shows that they recorded

Table 1 **Descriptive data of the anthropometric measurements for boys by age**

Variable/group	Age 6.5 ± 1 years			Age 8.5 ± 1 years			Age 10.5 ± 1 years		
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
BMI (kg/m²)									
Normal	179	16.57	1.20	232	17.39	1.47	150	17.72	1.79
Overweight	43	19.54	0.73	22	22.25	1.03	18	24.50	0.99
Obese	12	23.32	1.51	13	25.31	1.36	12	28.34	1.32
Total	234	17.47	2.11	267	18.18	2.54	180	19.11	3.62
Waist circumference (cm)									
Normal	177	53.06	3.84	231	57.50	4.67	150	62.10	5.69
Overweight	43	56.56	4.65	22	68.52	8.18	18	75.67	9.61
Obese	12	63.43	6.57	13	76.01	5.60	12	86.03	8.05
Total	232	54.25	4.87	266	59.32	7.02	180	65.05	9.37
Subscapular skinfold (mm)									
Normal	179	5.42	1.29	231	5.95	1.72	150	8.06	3.51
Overweight	43	6.98	2.64	22	12.60	4.68	18	21.12	6.26
Obese	12	8.70	4.69	13	18.22	5.85	12	22.70	6.38
Total	234	5.87	2.09	266	7.10	3.95	180	10.34	6.54
Suprailiac skinfold (mm)									
Normal	179	4.17	1.41	225	4.75	1.78	150	6.01	2.72
Overweight	43	5.21	2.08	22	9.70	3.64	18	13.24	5.87
Obese	12	7.42	3.37	13	13.95	5.48	12	13.90	5.53
Total	234	4.53	1.85	260	5.63	3.28	180	7.26	4.38
Sum of 2 skinfolds (mm)									
Normal	179	9.59	2.09	225	10.71	3.28	150	14.06	5.91
Overweight	43	12.19	3.78	22	22.30	7.56	18	34.36	10.66
Obese	12	16.12	7.05	13	32.17	0.73	12	36.60	9.29
Total	234	10.40	3.32	260	12.76	7.04	180	17.60	10.40
Body fat (%)									
Normal	164	12.72	6.52	211	12.71	7.78	138	15.98	9.75
Overweight	43	17.11	7.44	21	27.01	7.01	18	35.72	9.13
Obese	10	29.27	5.57	13	31.26	8.67	12	38.19	5.26
Total	217	14.35	7.61	245	14.92	9.53	168	19.68	12.33

SD = standard deviation; BMI = body mass index.

higher values than our study (14.3% of boys and 13.8% of girls were overweight while 6.3% of boys and 6.7% of girls were obese). However they used BMI-for-age percentiles according to Hammer et al., not national reference standards, which might overestimate the real prevalence [*18*].

The mean waist circumference and the corresponding percentiles for overweight and obesity were estimated for each age and sex. Mean waist circumference increased with age in both boys and girls. This agrees with other research, for example a study about the development of waist

Table 2 **Descriptive data of the anthropometric measurements for girls by age**

Variable/group	Age 6.5 ± 1 years			Age 8.5 ± 1 years			Age 10.5 ± 1 years		
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
BMI (kg/m²)									
Normal	149	16.64	1.20	186	17.02	1.57	160	17.98	2.17
Overweight	33	19.71	0.64	18	21.82	0.75	20	24.54	0.93
Obese	23	23.14	1.67	7	25.57	1.92	6	28.14	1.07
Total	205	17.86	2.49	211	17.71	2.50	186	19.01	3.33
Waist circumference (cm)									
Normal	147	53.18	4.32	186	57.98	6.51	160	62.34	7.20
Overweight	33	58.78	5.15	18	66.89	5.88	20	77.33	5.47
Obese	23	64.23	8.12	7	73.50	5.89	6	86.32	8.71
Total	203	55.34	6.26	211	59.26	7.37	186	64.72	9.32
Subscapular skinfold (mm)									
Normal	147	6.23	2.20	186	8.07	3.76	160	9.83	4.25
Overweight	33	9.08	2.88	18	14.54	4.52	20	20.39	6.67
Obese	23	11.03	5.06	7	18.80	5.80	6	26.75	7.88
Total	203	7.24	3.25	211	8.98	4.66	186	11.51	6.35
Suprailiac skinfold (mm)									
Normal	148	4.76	1.64	186	5.92	2.93	160	7.61	3.35
Overweight	33	6.61	2.49	18	9.04	4.51	20	14.18	6.45
Obese	23	8.00	2.82	7	12.96	8.62	6	17.47	9.35
Total	204	5.43	2.26	211	6.42	3.68	186	8.63	4.80
Sum of 2 skinfolds (mm)									
Normal	147	10.96	3.26	186	13.99	6.28	160	17.44	7.00
Overweight	33	15.69	5.16	18	23.59	8.04	20	34.57	11.83
Obese	23	19.03	6.99	7	31.76	3.96	6	44.22	12.58
Total	203	12.64	5.05	211	15.40	7.87	186	20.14	10.42
Body fat (%)									
Normal	146	14.66	6.82	179	16.34	7.83	155	19.14	9.22
Overweight	33	25.00	7.74	18	29.71	7.41	19	34.82	9.30
Obese	21	30.98	10.58	7	34.40	3.88	5	42.56	4.93
Total	200	18.08	9.42	204	18.14	9.09	179	21.45	10.91

SD = standard deviation; MBI = body mass index.

circumference percentiles in British children aged 5–16 years [*19*]. Fernandez et al. described waist circumference percentiles of African–American, European–American and Mexican–American children and adolescents, and stated that waist circumference measurements increased in a monotonic fashion across ages but at non-constant rates and in a manner that varied with age and sex [*20*].

Waist circumference was equal between boys and girls in all the studied age intervals except age 6.5 ± 1 years, when girls recorded higher values with no significant difference. However, Fredriks et al. found that mean waist circumference was slightly higher in boys than in girls and this difference was statistically significant from 11 years of age onwards among Dutch children [*21*]. The same was reported by Soar et al. among

Table 3 **Correlation between waist circumference and the selected indicators of body fatness for boys and girls**

Variable	Correlation (*r*) with waist circumference					
	Boys			Girls		
	Age 6.5 ± 1 years (*n* = 233)	Age 8.5 ± 1 years (*n* = 270)	Age 10.5 ± 1 years (*n* = 201)	Age 6.5 ± 1 years (*n* = 206)	Age 8.5 ± 1 years (*n* = 245)	Age 10.5 ± 1 years (*n* = 206)
Body mass index	0.601	0.779	0.818	0.697	0.515	0.801
Subscaplar skinfold	0.518	0.769	0.787	0.733	0.759	0.760
Suprailiac skinfold	0.352	0.739	0.696	0.646	0.567	0.613
Sum of 2 skinfolds	0.523	0.779	0.788	0.759	0.720	0.742
Body fat %	0.354	0.779	0.629	0.571	0.520	0.680

*All correlations were staristically significant (*P *< 0.0001).*
n = *number of participants.*

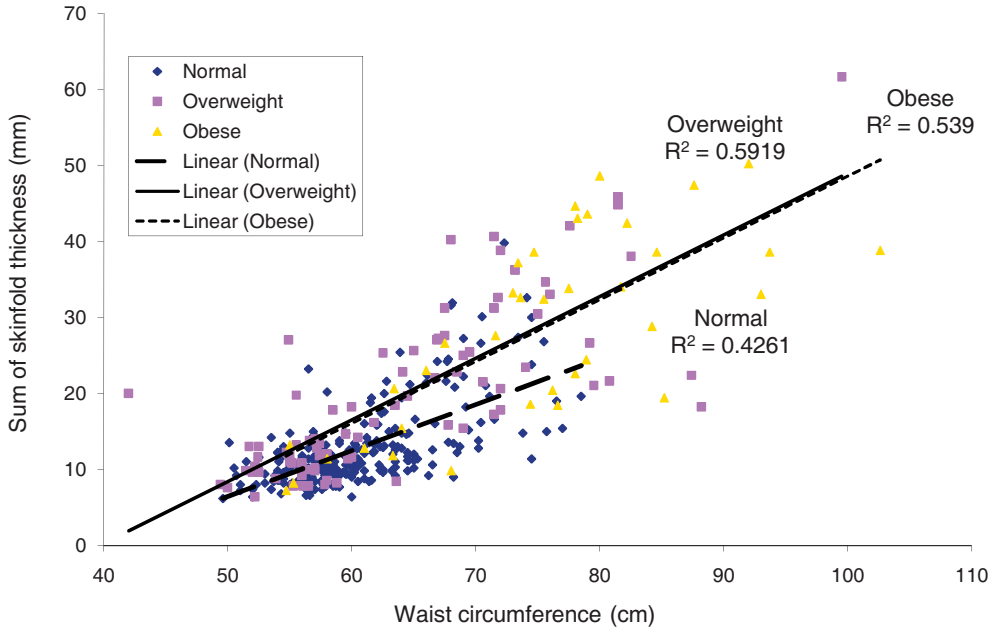

Figure 1 **Regression lines for normal, overweight and obese boys**

schoolchildren aged 7–9 years in Brazil [*22*].

In summary, we have shown that waist circumference correlates with total body fat percentage and BMI, and especially with central adiposity in the trunk region (central subcutaneous fat) in this age group of Egyptian primary-school children of both sexes in the 3 studied categories of BMI. Our results confirm the finding that waist circumference is a convenient measure of abdominal adipose tissue [*23*]

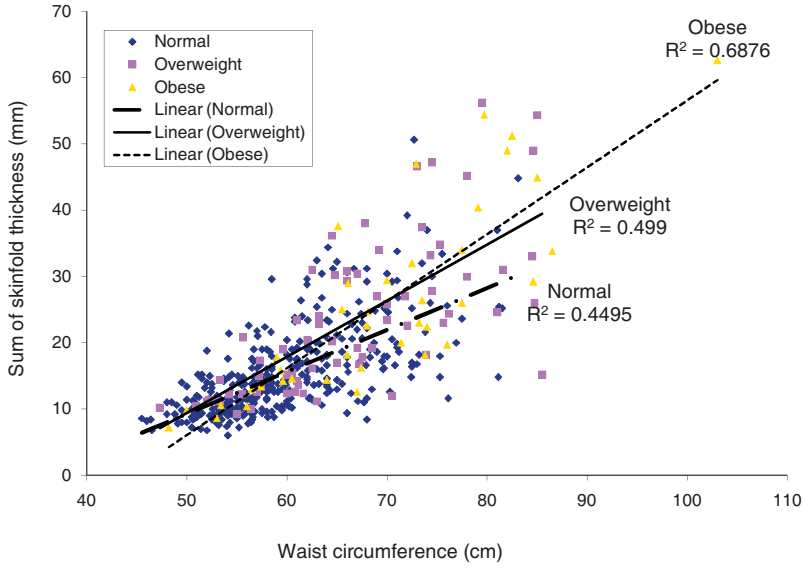

Figure 2 **Regression lines for normal, overweight and obese girls**

Table 4 **Estimated percentiles of waist circumference for overweight and obese boys and girls**

Sex & age (years)	Overweight		Obese	
	Mean	Per-centile	Mean	Per-centile
Boys				
6.5 ± 1	56.56	75	63.43	95
8.5 ± 1	68.52	89	76.01	96
10.5 ± 1	75.67	89	86.03	97
Girls				
6.5 ± 1	58.78	80	64.23	90
8.5 ± 1	66.89	85	73.50	96
10.5 ± 1	77.33	90	86.32	99

and correlates closely with BMI [*8,22*], with centralized or upper body fat in young people [*3,4,24*] and with total body fat [*25*]. Taylor et al. also found in their study in New Zealand children aged 3–19 years that waist circumference performs well as an index of central adiposity in children and adolescents of both sexes over a wide age range [*5*].

A positive correlation was found between waist circumference and the sum of the 2 selected central skinfolds after adjustment for age, BMI, percentage fat and each of these skinfolds, which confirms the advantage of waist circumference as an indicator for central fatness. Our results support Mueller and Kaplowitz, who noted that the sum of subscapular and suprailiac skinfolds was a good indicator for central adiposity [*26*].

Conclusions

Waist circumference is a good indicator for central fatness in children aged 8.5 ± 1 years and 10.5 ± 1 years. Waist

circumference should be routinely measured in schoolchildren. Further work is necessary to examine the link between waist circumference, body fatness and morbidity in young people. National standards for waist circumference are needed to study trends in, and the likely medical and psychological costs of, obesity in young people.

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