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The Development of Reference Values for Waist Circumference, Waist Hip and Waist Height Ratios in Egyptian Adolescents.

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Abstract

Background: Egypt represents one of highest prevalence African countries regarding obesity among school students.

Objective: The development of accurate anthropometric measures of central fat accumulation in Egyptian adolescents as an urgent need for both clinical and research

purposes.

Methods: This was a cross sectional study involving 800 adolescents aged 12-17.99 years using a multistage cluster sampling design to get a representative sample of students for whom the following anthropometric measures were assessed: weight, height, waist circumference (WC), hip circumference. Then waist hip ratio (WHR) and waist height ratio (WHTR) were calculated. These data were analysed to get the mean, standard deviation and percentiles for the WC, WHR and WHTR distributed according to age and sex.

Results: Mean, standard deviation and percentiles (5th, 10th, 15th, 25th, 50th, 75th, 90th, and 95th) were created for the WC, WHR and WHTR for Egyptian adolescents according to age and sex. Egyptian adolescents had higher values for the waist circumference than other ethnic groups.

Conclusions: Egyptian mean, standard deviation and percentiles values are better to be used for evaluation of Egyptian adolescents with obesity for clinical and research purposes.

Keywords: Waist circumference, waist hip ratio, waist height ratio

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Introduction

Adolescent obesity has fuelled scientific concerns recently in the developing world due to its recognition as a problem of increasing magnitude and significant morbidities. It has been estimated that 11% of African children will be overweight by 2025. A recent survey showed that school students in Egypt had the highest rates of overweight and obesity [31.4 and 9.3% respectively] among 7 African countries [1].

Using the Body Mass Index [BMI] alone to assess adiposity is inaccurate and non-indicative of body fat distribution [2].

Waist Circumference [WC] percentiles demonstrated high sensitivity and specificity for detection of trunk fat mass when compared to dual-energy X-ray absorptiometry [3]. Therefore, WC measurement is vital in the evaluation of obese adolescents. The pattern of body fat distribution is inherited and determined by certain gene loci which are strongly associated with other loci that control the occurrence of adverse metabolic outcomes [4].

The Waist Height Ratio [WHTR] is used recently as it compensates for the allowable accumulation of some fat in taller individuals and at the same time correlates with intra-abdominal fat mass and consequently with cardiovascular risk factors [2,5]. Furthermore, it is a good measure of adiposity in adolescents [6]. WHTR proved to be more indicative of adiposity than the waist circumference and the BMI [5,7].

To the best of our knowledge, no studies have been done in Egypt to set the norms for the anthropometric measures related to body fat distribution which have important relations to cardiovascular risk factors related to obesity; namely the waist circumference, waist hip ratio as well as the recently described waist height ratio [8-10]. Therefore, this study aimed at measuring the waist circumference, hip circumference, waist hip ratio and waist height ratio in a statistically sound sample of Egyptian adolescents living in

Cairo which contains inhabitants originating from all-over Egypt. Determination of the national standard reference values of these measurements is of utmost importance to the anthropometric assessment of obese Egyptian adolescents.

Subjects and Methods

A cross section study was conducted in the period from January to June 2015 including 800 adolescents [12-18 years old] chosen randomly from preparatory and secondary schools in eastern, western, southern and northern parts of Cairo, the capital of Egypt.

Sampling technique: Multistage cluster sampling design was used to get a representative sample of students in these 4 areas. In the first stage, the sample was stratified according to school types [governmental and private] then schools were selected randomly from the list of schools that were obtained from the Ministry of Education. In the second stage, inside each school, school grades were stratified into [1st, 2nd and 3rd] then classes were randomly selected from each grade and all students in selected classes were eligible to participate.

Table 1: *Distribution of the studied adolescents according to the type of school.*

Type of school	Males N (%)	Females N (%)	Total
Governmental	200 (25.7%)	204 (26.3%)	404 (52%)
Private	165 (21.2%)	208 (26.7%)	373 (48%)
Total	365 (47%)	412 (53%)	777 (100%)

Sample size justification

It was calculated as a cluster sample using the following formula:

Sample size for a cluster sample = Simple Random Sample size × Design effect.

Where the design effect = [1+ [m-1] p], m= size of the cluster and p = Intra-Cluster Correlation Coefficient [ICC]. Assumed that the proportion to be evaluated=0.21 and a confidence interval of width=0.2, at 95% confidence interval. The sample size for a simple random sample=72. For correction for design [the cluster design] we had to estimate the ICC = 0.010 and the average cluster size [average number of respondents of each type in every cluster [type of school]]. The average cluster size was 40 and ICC was 0.01, we had a design effect of 1.39. So, the sample size of each group after correction was approximately 100 individuals. By multiplication of 100 by 2 types of schools in 4 districts, the whole sample was calculated as 800 students.

All participants had the weight measured in kilograms

Table 2: *Anthropometric data of the study sample.*

Age †		N	Weight (Kg)	Height (cm)	BMI	WC (cm)	HC (cm)	WHR	WHTR
Males	**12**	49	58±17	150.8±8.9	23.4±6	78.2±14.7	89.7±14.6	0.87±0.04*	0.52±0.08
	13	72	58.6±15	156.1±8	24±5.5	79.5±13.5*	92.9±12.7	0.85±0.06*	0.51±0.09*
	14	72	60.6±14	161.±8.7	23.2±4.6*	78.3±11.6	92.8±11	0.84±0.06	0.49±0.07
	15	62	68±15.7	167.5±8*	24±5	78.5±11	95.8±9.6*	0.82±0.06*	0.47±0.06
	16	65	74±17*	170.4±9*	25.4±5.9	80.3±12	98.4±10.8	0.81±0.05*	0.47±0.07
	17	45	75.7±15*	173±7*	25.2±5	80.5±11	99.2±9.8	0.8±0.04	0.46±0.06
Females	**12**	52	57.9±16.2	151.7±7	24.9±5.7	77.9±13	93.8±16.2	0.83±0.1	0.51±0.07
	13	103	57.4±14.6	156±6	23.5±5.4	75±12	93.4±12.3	0.8±0.07	0.48±0.07
	14	81	64.2±14.2	159.2±6	25.3±5	79.6±11.7	98.7±10.3	0.8±0.07	0.5±0.07
	15	47	66.7±14	162±6.5	25.3±4.6	78.2±11	99.7±9.9	0.78±0.07	0.48±0.06
	16	82	64.6±14	160.2±6	25±5	77.9±10	98.8±9	0.78±0.06	0.48±0.05
	17	47	66.2±18.8	161.7±7.2	25.2±6.2	79.3±12.7	99.5±13	0.79±0.07	0.49±0.07

† Indicates whole year age group, i.e., 12 = 12.0-12.99 years.
*There is a statistically significant difference between males and females (student t test)
WC = waist circumference, HC = hip circumference, WHR = waist hip ratio, WHTR = waist height ratio.

Table 3: *BMI percentiles of the studied sample.*

		Percentile							
		5th	**10th**	**15th**	**25th**	**50th**	**75th**	**90th**	**95th**
Males	**12**	15.4	17	17.6	19.5	23	26	32	33.3
	13	16.6	17.9	18.4	19.2	23.5	27.4	32.1	33.6
	14	17.1	17.7	18	19.9	22.4	26.5	30.7	32.4
	15	17.8	18.4	18.9	20.2	22.6	27.3	32.6	35.5
	16	17.4	19.6	20.4	21.6	23.8	28	35.6	38.8
	17	18.1	19.6	20	21	24.5	29	33.3	34.2
Females	**12**	17	17.8	18	20	23.8	29.5	33.2	34.2
	13	16.6	17.5	18.4	19.8	22.8	25.6	30.5	34.5
	14	18.7	19.3	20.1	21.3	23.3	29	33.6	36.2
	15	18.9	19.6	20.5	21.7	24.6	28.2	32.2	34.4
	16	18.8	19.5	19.9	21	24.7	28.4	32	33
	17	18.5	19	20	22	25	28.5	33.2	37.4

Table 4: *Waist circumference in cm of the studied sample.*

		Percentile							
		5th	10th	15th	25th	50th	75th	90th	95th
Males	**12**	51.5	57	62	69.5	76	90.5	100	102
	13	59.6	63.3	66	70.2	78	90	95.4	103.7
	14	60.9	64.3	67	71	76.5	85.7	96.8	100.3
	15	62	64.3	66.4	70.7	76	87	95.7	98.8
	16	61.3	66.6	69	73	78	89	101.4	104.7
	17	65.6	68.6	71	74	77	89.5	98.4	101.8
Females	**12**	55.6	60.3	64.3	69.2	76	86.5	96.8	103.3
	13	58	61	65	68	73	83	91.6	102.2
	14	63	65	67	71	78	88	97	101.9
	15	62.4	63.8	66.2	68	78	85	92.4	102.4
	16	62	66	67	70	78	85	93	97.8
	17	60.4	65.6	66	69	80	85	96.2	106.8

Table 5: *Waist/hip ratio of the studied sample.*

		Percentile							
		5th	10th	15th	25th	50th	75th	90th	95th
Males	**12**	0.79	0.8	0.82	0.83	0.88	0.9	0.92	0.94
	13	0.74	0.76	0.68	0.82	0.86	0.89	0.9	0.93
	14	0.75	0.76	0.78	0.8	0.84	0.89	0.92	0.94
	15	0.71	0.74	0.76	0.78	0.81	0.85	0.89	0.92
	16	0.72	0.74	0.76	0.78	0.81	0.85	0.9	0.92
	17	0.74	0.75	0.76	0.77	0.8	0.84	0.87	0.9
Females	**12**	0.72	0.78	0.8	0.8	0.85	0.87	0.89	0.9
	13	0.7	0.72	0.73	0.75	0.81	0.86	0.89	0.9
	14	0.7	0.71	0.72	0.75	0.81	0.86	0.9	0.93
	15	0.7	0.71	0.72	0.73	0.78	0.82	0.9	0.93
	16	0.7	0.72	0.73	0.75	0.78	0.83	0.9	0.92
	17	0.7	0.72	0.73	0.74	0.79	0.84	0.9	0.95

Table 6: *Waist/height ratio of the studied sample.*

		Percentile							
		5th	10th	15th	25th	50th	75th	90th	95th
Males	**12**	0.35	0.39	0.42	0.46	0.5	0.58	0.63	0.66
	13	0.38	0.4	0.42	0.44	0.5	0.57	0.63	0.65
	14	0.38	0.4	0.42	0.43	0.48	0.54	0.59	0.62
	15	0.38	0.39	0.4	0.42	0.46	0.52	0.56	0.57
	16	0.37	0.39	0.4	0.42	0.45	0.52	0.59	0.6
	17	0.38	0.4	0.41	0.42	0.45	0.49	0.57	0.61
Females	**12**	0.39	0.41	0.45	0.46	0.5	0.56	0.64	0.65
	13	0.38	0.4	0.42	0.43	0.47	0.52	0.57	0.64
	14	0.39	0.41	0.42	0.44	0.49	0.55	0.61	0.64
	15	0.39	0.4	0.41	0.43	0.48	0.52	0.56	0.62
	16	0.38	0.41	0.43	0.45	0.48	0.53	0.57	0.6
	17	0.38	0.4	0.42	0.43	0.49	0.55	0.58	0.62

with a digital scale with minimal clothing. Height was measured to the nearest 0.1 cm on a portable stadiometer [Seca stadiometer 213]. The Body Mass Index [BMI] was calculated as weight (kg)/height (m^2) [11]. Measurement of the Waist Circumference [WC] was done in the standing position in expiration midway between the lowest rib and the top of the iliac crest with a non-stretchable tape [12]. Hip Circumference (HC) was measured at the maximum dimension of the gluteal region [13]. All measurements were done between 9am to 12pm for all the included subjects.

Data analysis was done using "SPSS version 18" after exclusion of outliers (23 subjects) that were defined as BMI ≥ 3SD Z score. Continuous variables [weight, height, BMI, WC, HC, Waist Hip Ratio (WHR), and WHTR] were given as mean ± Standard Deviation (SD), and categorical variables as numbers and percentages. WC, WHR and WHTR were distributed by percentiles (5^{th}, 10^{th}, 15^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 95^{th}) according to age and sex. To compare the difference between males and females with regards to the means of the anthropometric measures (continuous variables), the Student's t-test for independent samples was used. A value of $p < 0.05$ was considered statistically significant.

The study was approved by the local ethics committee of Ain Shams University and the Egyptian Ministry of Education as well as the administrative departments of the involved schools.

Results

This study involved 777 school attending adolescents including 365 males (46.98%) and 412 females (53.02%) aged 12-17.99 years. They were recruited from governmental as well as private schools (Table 1). The male to female ratio was the same as that in the studied schools. Their anthropometric data are listed in Table 2 which also shows that there were some significant anthropometric differences between males and females particularly in height between males and females from 15 to 17 years and in WHR. WHTR showed significant differences between males and females only in studied subjects at the age of 13 years. Their BMI percentiles, WC, WHR percentiles and WHTR percentiles are shown in Tables 3-6 respectively. Boys aged 12 and 13 years had higher mean WHTR than girls; but, later on girls' WHTR exceeded that of boys till the age of 17 years. The cutoff of 0.5 was reached at the 50th centile in our study group (Table 6).

Discussion

Developing national reference ranges, percentiles and standard deviation scores for the WC, WHR, and WHTR became an urgent research and clinical need in Egypt with the reported high prevalence of overweight and obesity. This enables clinicians to compare patients' anthropometric measurements with reference values and consequently determine their cardiovascular risk.

The height of the included males exceeded that of females significantly at 15-17 years which corresponds to the higher height gain at the completion of puberty [11]. Significant differences existed in the WHR which reflected the smaller waist circumference and the larger hip circumference in female adolescents compared to males due to the difference in gender related body fat distribution [12].

Comparing the WC percentiles of Egyptian adolescents to Venezuelans revealed higher values for Egyptians across all percentile lines [13]. These differences were less along the lower percentiles e.g. 3rd and increased towards the 50th percentiles and were maximum at the 97th percentiles indicating more central adiposity in Egyptian adolescents. Comparison of the WHR in Egyptians to Venezuelans revealed striking similarities along the percentile lines with some typical values e.g. 95th percentile of WHR at 12 years in males =0.94 in both. This indicates larger body built in Egyptian adolescents. Similarly, Egyptian adolescents had higher values for the waist circumference when compared with British adolescents and the differences were more marked in females [14]. A study of Spanish adolescents including males and females from 6.5-14.5 years showed that Egyptian adolescents had higher mean WC in the corresponding age groups [15].

The mean WHTR in Egyptian adolescents was higher than that of British adolescents in the corresponding age groups despite nearly similar heights indicating greater central adiposity in Egyptian adolescents as evidenced by the increased weight in Egyptian compared to British adolescents [14]. In both Egyptians and British, the WHTR decreased as age advanced which is expected with the increase in height coincident with the adolescent growth spurt. The fiftieth centile for the Egyptian WHTR remained though at or below the 0.5 cutoff value except in males aged 12 years. Our study subjects showed higher WHTR in boys than girls at the age of 12-13.99 years which was similar to Brazilian children at 10-15 years [16]. We observed that the mean values of the WHTR were higher in Egyptian adolescents than their Brazilian counterparts. A WHTR of 0.5 was reached at the 50th centile in our studied subjects which is less than that of Greek adolescents who reached 0.5 at the 90th centile [5]. This value was reached earlier by Egyptian adolescents compared to Pakistani adolescents at the age of 12 years who hit the cutoff of 0.5 at the 85th percentile indicating more central adiposity in Egyptian adolescents [17].

A study in American children declared a WHTR <0.5 to be associated with cardiovascular risk similar to that of the general population but this has not been evaluated in Egyptian children and adolescents whose 50th centiles reached the 0.5 values in some age groups [18]. These findings invite further research on the appropriate cutoff in Egyptian adolescents and the inference of this cutoff on the metabolic profile as it has been shown that the detrimental effects of insulin resistance can differ in different races [19,20].

In conclusion, this study was the first to establish the normal ranges for WC, WHR and WHTR in Egyptian adolescents. It demonstrates that Egyptian adolescents have higher WC percentiles than the available data for other ethnic groups. Therefore, we recommend the use of the Egyptian percentiles in the evaluation of obese Egyptian adolescents and the implementation of these percentiles in further research to evaluate their relationship to the well-identified cardiovascular risk factors and adverse metabolic outcomes of obesity rather than using the available ethnically different percentiles.

References

1. Manyanga T, El SH, Doku DT, et al. The prevalence of underweight, overweight, obesity and associated risk factors among school-going adolescents in seven African countries. BMC Public Health 2014; 14: 887.
2. McCarthy HD, Ashwell M. A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message--'keep your waist circumference to less than half your height. Int J Obes 2006; 30: 988-992.
3. Taylor RW, Jones IE, Williams SM, et al. Evaluation of waist

circumference, waist-to-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 Nutr 2000; 72: 490-495.

4. Shungin D, Winkler TW, Croteau DC, et al. New genetic loci link adipose and insulin biology to body fat distribution. Nature 2015; 518: 187-196.

5. Bacopoulou F, Efthymiou V, Landis G, et al. Waist circumference, waist-to-hip ratio and waist-to-height ratio reference percentiles for abdominal obesity among Greek adolescents. BMC Pediatr 2015; 15: 50.

6. Lewitt MS, Baker JS, Mooney GP, et al. Pubertal stage and measures of adiposity in British schoolchildren. Ann Hum Biol 2012; 39: 440-447.

7. Rivera Soto WT, Rodríguez-Figueroa L. Is Waist-to-Height Ratio a Better Obesity Risk-Factor Indicator for Puerto Rican Children than is BMI or Waist Circumference? P R Health Sci J 2016; 35: 20-25.

8. Rizk NM, Yousef M. Association of lipid profile and waist circumference as cardiovascular risk factors for overweight and obesity among school children in Qatar Diabetes Metab Syndr Obes 2012; 5: 425-432.

9. Moore LM, Fals AM, Jennelle PJ, et al. Analysis of Pediatric Waist to Hip Ratio Relationship to Metabolic Syndrome Markers. J Pediatr Health Care 2015; 29: 319-324.

10. Srinivasan SR, Wang R, Chen W, et al. Utility of waist-to-height ratio in detecting central obesity and related adverse cardiovascular risk profile among normal weight younger adults [from the Bogalusa Heart Study] Am J Cardiol 2009; 104: 721-724.

11. Rogol AD, Clark PA, Roemmich JN. Growth and pubertal development in children and adolescents: effects of diet and physical activity. Am J Clin Nutr 2000; 72: 521S-528S.

12. Hochberg Z, Belsky J. Evo-devo of human adolescence: beyond disease models of early puberty. BMC Med 2013; 11: 113.

13. Mederico M, Paoli M, Zerpa Y, et al. Reference values of waist circumference and waist/hip ratio in children and adolescents of Mérida, Venezuela: comparison with international references. Endocrinol Nutr 2013; 60: 235-242.

14. Cole TJ, Freeman JV, Preece MA. Body mass index reference curves for the UK, 1990. Arch Dis Child 1995; 73: 25-29.

15. Moreno LA, Fleta J, Mur L, et al. Waist circumference values in Spanish children--gender related differences. Eur J Clin Nutr 1999; 53: 429-433.

16. Padua Cintra I, Zanetti Passos MA, Dos Santos LC, et al. Waist-to-height ratio percentiles and cutoffs for obesity: a cross-sectional study in Brazilian adolescents. J Health Popul Nutr 2014; 32: 411-419.

17. Mushtaq MU, Gull S, Abdullah HM, et al. Waist circumference, waist-hip ratio and waist-height ratio percentiles and central obesity among Pakistani children aged five to twelve years. BMC Pediatr. 2011; 11: 105.

18. Khoury M, Manlhiot C, McCrindle BW. Role of the waist/height ratio in the cardiometabolic risk assessment of children classified by body mass index. J Am Coll Cardiol 2013; 62: 742-751.

19. Guo F, Garvey WT. Development of a Weighted Cardiometabolic Disease Staging [CMDS] System for the Prediction of Future Diabetes. J Clin Endocrinol Metab 2015; 100: 3871-3877.

20. Wahi G, Anand SS. Race/Ethnicity, Obesity, and Related Cardio-Metabolic Risk Factors: A Life-Course Perspective. Curr Cardiovasc Risk Rep 2013; 7: 326-335.

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