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Nutritional evaluation of adolescents: usefulness of anthropometric indicators in the diagnosis of obesity

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The results of body measurements and several anthropometric indices in the detection of obesity of 351 adolescents aged 15 to 19 years attending the preuniversities in Havana are presented. Body weight and height values were between the 50th and 75th percentiles of the Cuban national norms while those of the triceps and subscapular skinfolds were between the 90th and 97th percentiles. The high correlation between the two relative body weight indices and the sum of the three skinfolds evidenced the value of these indices in field studies. The study showed that determining the incidence of obesity remained a problem as it depended on the anthropometric indicators and the cutoff points that were used and which resulted in values ranging from 9.6% to 53.7%.

Adolescence is a stage of growth and development accompanied by complex morphological and physiological changes in which nutrition plays an important role. Physical activity also has a profound influence on body dimensions and is an important factor in the accumulation of excess adipose tissue when energy output is less than energy input. The comparison of body dimensions using national references in order to assess the nutritional status of a given population, is more appropriate than when compared to international references as the former reflects the interaction between genetic and environmental factors.

The measurement of fat folds, especially the triceps skinfold, has been used repeatedly in nutritional studies; values considered "normal" suggest an adequate energy intake [3, 9]. Other authors [8, 11], however, reported that the subscapular skinfold was a better indicator of nutritional status. The use of the triceps skinfold is not adequate because it is supposedly under genetic control while the subscapular skinfold is more responsive to nutritional factors and consistently shows a higher correlation with weight [7]. The need to relate body measurements or an index of relative weight to medical problems has been the purpose of many investigations [2, 18]. Various indices of relative body weight have been used in the past years among which the body mass index proposed by Quetelet in 1832 continues to be used in epidemiological studies [14, 15, 16]. Comparison of actual weight with that expected for age and height, using national or international references, has also been used in these studies. In this paper body measurements and the use of several anthropometric indices in the detection of obesity in a group of adolescent boys and girls are presented.

Materials and Methods

From two preuniversities in the City of Havana 438 students were randomly selected. Of these, 132 boys and 219 girls aged 15 to 19 years volunteered for the study. Weight, height, triceps, subscapular and suprailiac skinfolds were measured following the techniques described by the International Biological Program [25]. The Harpenden caliper was used and the measurements recorded to the nearest 0.1 mm on the left side of the body. The Cuban national norms [13] were used as reference for height, weight and skinfolds, and to calculate an index of relative weight by comparing actual weight with that expected for age and height. The percentage of body weight (%$\overline{W}$) was calculated as follows [22].

$$\frac{\text{Actual weight (Kg) of subject at present age}}{\text{Actual length (cm) of subject at present age}} = A$$

$$\frac{\text{50th P expected weight (Kg) for corresponding age}}{\text{50th P expected length (cm) for corresponding age}} = B$$

$A/B \times 100$ = Index for surveyed subject.

A percentage equal or greater than 120 indicates obesity, 110–119 overweight, 90–109 normal weight and less than 90 underweight.

The body mass index ($W: H^2$) was also used as another index of relative weight. The 97th percentile of the national norms for skinfolds was defined as obesity, as well as the value proposed by Seltzer and Mayer [21] for the triceps skinfold.

Log transformation of weight and skinfolds were used for comparison and simple linear correlations. Student's *t*-test was used for comparison between sexes and the chi square test to determine significant difference for the indices used to define obesity. The level of statistical significance was chosen at p of less than 0.05.

Results

Body weight, height, and skinfold measurements in boys and girls are presented in Tables I and II. As expected the boys were significantly taller and heavier than the girls ($P < < 0.05$) and in both sexes these values were between the 50th and 75th percentiles of the Cuban national norms, whereas the triceps and subscapular skinfolds were between the 90th and 97th percentiles. The subscapular skinfold showed a tendency to increase with age in both sexes.

Figure 1 presents the distribution of heights, weights and three skinfolds compared to the antional norms with a greater skewness to the right of all the body measurements, particularly the suprailiac skinfold.

The linear coefficient correlations between height, weight and the sum of the three skinfolds with the relative weight indices are shown in Table III. The body mass index showed a low correlation with height while the

TABLE I

Height and weight (mean ± S.D.)

	Boys				Girls			
Age	No.	Height (cm)	Weight(1)	(Kg)	No.	Height (cm)	Weight(1)	(Kg)
15.0—15.9	37	168.6* ±7.1	1.748* ±0.062	(56.0)	53	159.5 ±6.4	1.716 ±0.078	(52.0)
16.0—16.9	46	170.1* ±6.7	1.774* ±0.067	(59.5)	93	160.5 ±6.1	1.737 ±0.060	(54.6)
17.0—17.9	36	172.5* ±5.7	1.793* ±0.053	(62.1)	48	158.0 ±5.9	1.727 ±0.062	(53.4)
18.0—19.9	13	172.4* ±6.7	1.782* ±0.052	(60.2)	25	160.5 ±5.3	1.730 ±0.042	(53.7)

(1) Log_{10} transformed data
The numbers in parentheses indicate the antilogarithm of weight.
* Values significantly greater than the mean for girls $p < 0.05$.

TABLE II

Skinfold thicknesses (mean ± S.D.)

Age	No.	Triceps(1)	Subscapular(1)	Suprailiac(1)	Total(1) Skinfold
15.0—15.9	37	0.993 ±0.152 (9.8)	0.983 ±0.231 (9.6)	1.125 ±0.218 (13.3)	1.575 ±0.159 (37.6)
16.0—16.9	46	0.996 ±0.162 (9.9)	0.992 ±0.144 (9.8)	1.157 ±0.228 (14.3)	1.605 ±0.161 (40.3)
17.0—17.9	36	0.988 ±0.146 (9.7)	1.026 ±0.112 (10.5)	1.206 ±0.201 (16.1)	1.626 ±0.138 (42.2)
18.0—19.9	13	0.976 ±0.145 (9.5)	1.058 ±0.141 (11.4)	1.102 ±0.217 (12.6)	1.589 ±0.145 (38.8)

(1) Log_{10} transformed data
The numbers in parentheses indicate the antilogarithm of skinfold.

Age	No.	Triceps(1)	Subscapular(1)	Suprailiac(1)	Total(1) Skinfold
15.0—15.9	53	1.259 ±0.158 (18.1)	1.168 ±0.157 (14.7)	1.419 ±0.148 (26.2)	1.843 ±0.129 (69.7)
16.0—16.9	93	1.291 ±0.131 (19.5)	1.233 ±0.126 (17.1)	1.439 ±0.172 (27.5)	1.877 ±0.138 (75.4)
17.0—17.9	48	1.267 ±0.092 (18.5)	1.205 ±0.135 (16.0)	1.416 ±0.161 (26.1)	1.859 ±0.109 (72.3)
18.0—19.9	25	1.273 ±0.915 (18.7)	1.212 ±0.011 (16.3)	1.432 ±0.151 (27.0)	1.863 ±0.105 (72.91)

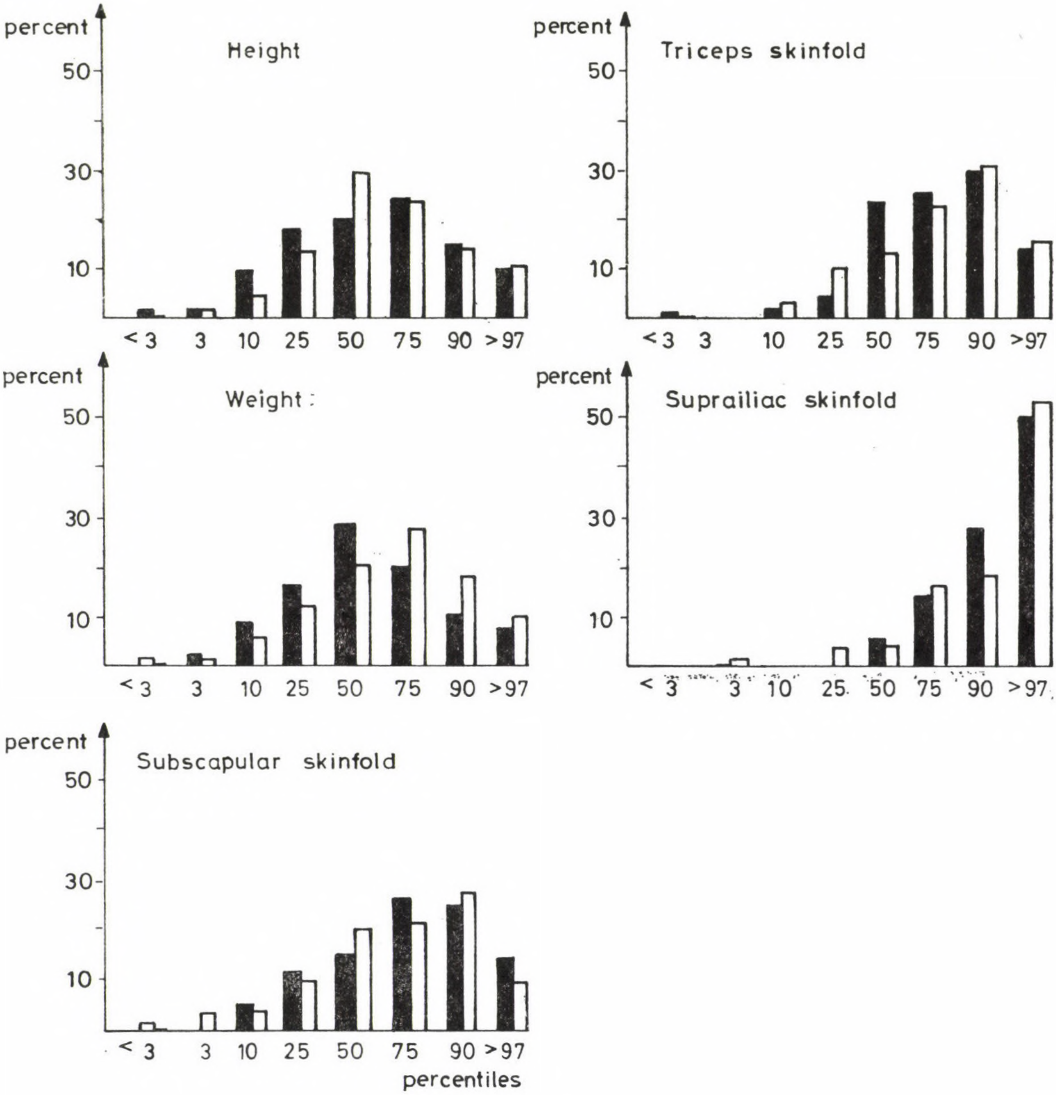

FIG. 1.

percentage of body weight was significantly high ($p < 0.05$), which indicates a degree of dependency with respect to height. The rest of the correlation coefficients was high ($p < < 0.05$).

Table IV provides the linear coefficient correlations describing the relationship between weight, three skinfold thicknesses, and the sum of two and three skinfolds. The correlation coefficients between weight and subscapular skinfolds were the highest while the sum of two and three skin-

TABLE III

Correlation coefficients for height, weight[1] and total skinfolds[1] vs relative weight indices

	%W		W : H²	
	Boys	Girls	Boys	Girls
Height	0.29*	0.29*	0.05	0.04
Weight	0.85*	0.85*	0.79*	0.85*
Summed fat folds	0.67*	0.70*	0.68*	0.73*

[1] Log_{10} transformed data
* $p < 0.05$

TABLE IV

Correlation coefficients between weight (a) and skinfolds (a)

Skinfold	Boys	Girls
Triceps	0.47	0.61
Subscapular	0.64	0.65
Suprailiac	0.58	0.54
Triceps + subscapular	0.59	0.70
Triceps + subscapular + suprailiac	0.63	0.54

(a) Log_{10} transformed data

TABLE V

Comparison of incidence of obesity using several indices

	Boys		Girls	
	No.	per cent	No.	per cent
$\%\overline{W} \geq 120$	40	30.3 a	45	20.5 a
Suprailiac skinfold (1)	67	50.7 b	118	53.7 b
Triceps skinfold (1)	22	16.7 c	37	16.9 c
Triceps skinfold (2)	19	14.4 c	36	16.5 c
Subscapular skinfold (1)	12	9.6 d	32	14.5 c

Different letters differ significantly $p < 0.05$
(1) 97th percentile based on Cuban national norms.
(2) Based on Seltzer and Mayer (21)

folds did not contribute to a higher correlation with weight than just the subscapular skinfold.

Table V presents the incidence of overweight using different criteria. The percentages of relative weight and suprailiac skinfold evidenced the highest incidence of obesity and were statistically different from each other and from the other skinfold percentages. The incidence of obesity between boys and girls derived from the various indices was not significantly different.

Discussion

Body weight and height values were between the 50th and 75th percentiles of the Cuban national norms and similar to those reported in another school in the City of Havana [23]. The three skinfold's values were also in the higher percentiles. The national norm's include urban and rural children from all the provinces some of which are less developed. This probably explains the higher values, although the percentage of boys and girls with skinfold thicknesses, especially the suprailiac in the 97th percentile, suggests an excess amount of adipose tissue. The triceps and subscapular values are slightly higher than those reported by Jenicek and Demerjian in Franco-canadian adolescents [10] and by the Health Examination Survey [11]. The triceps skinfolds were similar to those reported by Clarke et al. [1] in high-school children from Vermont. The technique involved when measuring the suprailiac skinfold is difficult [11] and should only be undertaken in specific studies. Nevertheless we were interested in this skinfold because of the tendency to deposit excess adipose tissue in this area. Two decades ago, Laska-Mierzejwska [17] reported in a study done in the schools of the City of Havana that the abdominal skinfold was large in both sexes regardless of race. We are faced with the problem of deciding which skinfold or combination of skinfolds would best assess the nutritional status of various population groups.

Garn et al. [7] found that the subscapular skinfold was more adequate in this assessment because it uniformly showed higher correlations with weight in Michigan children and adolescents aged 3 to 19 years. The sum of the subscapular plus triceps skinfold did not improve the predictive efficiency. In our study the results were similar not only with the sum of two folds but with the sum of three folds (triceps, subscapular plus suprailiac) as well. The problem of which anthropometric indicator should be used in the assessment of obesity became apparent (Table V). The incidence of obesity as determined by percentage of relative weight and the three skinfolds ranged from 9.6%—53.7%. The highest percentages corresponded to the suprailiac skinfold, which were significantly different from the other indices. The use of one skinfold by itself, does not take into account the individual differences in fat distribution as well as those due to age, sex and ethnic factors.

The exceptionally large accumulation of adipose tissue in the suprailiac area warrants more further studies of the possible factors that contribute to it. The other question is whether or not these adolescents are obese. Evidently the value of a single skinfold is not sufficient for the diagnosis [6]. Probably more than one skinfold should be taken which would be more representative of the fat distribution at different ages, and which would also take into account sex and ethnic factors. Jolliffe [12] advocated the sum of three skinfold thicknesses giving values of 60 mm and over in men, and 75 mm and over in women as indicative of obesity. It seemed that more precision could be obtained if a selection of skinfolds were made on the basis of correlations not with weight but with total body fat, as determined by ^{40}K or other techniques [8, 24]. Actually this is what is done when regression equations are derived from anthropometry. Roche [20] in a review concerning the measurement of skinfold thickness and the difficulties posed by the selection of sites, the validity of the data obtained, and its transformation to estimated areas of adipose tissues, concluded that there was still much to be done, including the answer as to the normal level of fatness in terms of function and survival.

The results of our study have confirmed these difficulties. The suprailiac fold seemed to overestimate the incidence of obesity, whereas the triceps and subscapular skinfolds may have underestimated it. The results of the linear correlations between the relative body weight indices (percentage of weight for height and body mass index) and the sum of the three skinfolds were high, 0.67 and 0.70 respectively, which indicates their usefulness as a measure of obesity. Womersley and Durnin [25] especially recommended the $W: H^2$ which in our study showed a high correlation with weight and the sum of the three skinfold thicknesses, but a low correlation with height; this was not the case for the percentage of weight for height index which showed a positive correlation with height. Still, the use of the $W : H^2$ index as an indicator to be applied in population studies of different ethnic origins assumes that the relation between weight and height remains invariable. This probably is not completely true as these proportions vary with age, sex and with ethnic origin. The latter has great significance in the American populations due to the high percentage of racial mixture. Jordan [13] reported on a greater length of the lower extremities and a shorter length of the trunk in the Cuban population as compared to the English population of the same height. Also, the biacromial and bitrochanteric diameters are smaller in the Cuban than in the English population. This would mean that the difference in weight for each body segment would entail a change in the proportion between height and total body weight which probably should be taken into account when values for the diagnosis of obesity are to be established with different populations. The above facts point to the necessity of values for the body mass index which are specific for specific populations if epidemiological studies of obesity are to be performed with this index.

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References

1. Clarke RP, Merrow SB, Morse EH, Keyser DE: Interrelationships between plasma lipids, physical measurements, and body fatness of adolescents in Burlington, Vermont. Am J Clin Nutr 23: 754, 1970
2. Criqui MH, Klauber MR, Barret-Connor E, Holbrook MG, Suárez L, Wingard DL: Adjustment for obesity in studies of cardiovascular disease. Am J Epidemiol 116: 685, 1982
3. Dugdale AE, Chen ST, Hewitt G: Patterns of growth and nutrition in childhood. Am J Clin Nutr 23: 1280, 1970
4. Durnin JVGA, Rahaman MM: The assessment of the amount of fat in the human body from measurements of skinfold thickness. Br J Nutr 21: 681, 1967
5. Durnin JVGA, Womersley J: Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutr 32: 77, 1974
6. Esquivel M, Vasallo J: Grasa subcutánea y estado nutricional (I). Rev Cub Pediatr 53: 274, 1981
7. Garn SM, Rosem NN, McCarn MB: Relative values of different fat-folds in a nutritional survey. Am J Clin Nutr 24: 1380, 1971
8. Harsha DW, Frerichs RR, Berenson GS: Densitometry and anthropometry of black and white children. Hum Biol 50: 261, 1978
9. Jelliffe DB: Evaluation of the nutritional status of a community. WHO Monograph No. 53, Geneva 1968
10. Jenicek M, Demirjian A: Triceps and subscapular skin-fold thickness in French-Canadian school-age children in Montreal. Am J Clin Nutr 25: 576, 1972
11. Johnston FE, Hamill PVV, Lemeshow S: Skinfold thickness of youths 12–17 years, United States. National Center for Health Statistics, Washington DC 1974
12. Jolliffe N: Obesity. In: Clinical Nutrition ed Jolliffe N Harper and Brothers Publishers, New York 1962, p 820
13. Jordán J: Desarrollo humano en Cuba. Editorial Cientifico Técnica. La Habana 1979
14. Keys A, Fidanza F, Karvonen MJ, Kimura N, Taylor HL: Indices of relative weight and obesity. J Chron Dis 25: 329, 1972
15. Keys A: Overweight, obesity, coronary heart disease and mortality. Nutr Rev 38: 297, 1980
16. Khosla T, Lowe CR: Indices of obesity derived from body weight and height. Br J Prev Soc Med 21: 122, 1967
17. Laska-Mierzejwska T: Desarrollo y maduración de los miöos y jóvenes de La Habana (Cuba): Rev Cub Pediatr 39: 385, 1967
18. Noppa H, Bengtsson C, Wedel H, Wilhemsen L: Obesity in relation to morbidity and mortality from cardiovascular disease. Am J Epidemiol 3: 682, 1980
19. Rauh JL, Schumsky DA: An evaluation of triceps skinfold measures from urban school children. Hum Biol 40: 363, 1968
20. Roche AF: Postnatal growth of adipose tissue in man. Studies in Physical Anthropology. 5: 53, 1979
21. Seltzer CC, Mayer GA: A simple criterion of obesity. Postgrad Med 38: A101, 1965
22. Sveger T: Does overnutrition or obesity during the first year affect at age four? Acta Paediatr Scand 67: 465, 1978
23. Suárez A, Jiménez JM, Mesa DM: unpublished results
24. Ward GM, Krzwicki HJ, Rahman DP, Quaas RL, Nelson RA, Consolazio CF: Relationship of anthropometric measurements to body fat as determined by densitometry, potassium-40, and body water. Am J Clin Nutr 28: 162, 1975
25. Weiner JS, Lourie JA: Human Biology: A Guide to Field Methods. Blackwell Scientific Publications, Oxford 1969
26. Womersley J, Durnin JVGA: A comparison of the skinfold method with extent of 'overweight' and various weight-height relationships in the assessment of obesity. Br J Nutr 38: 271, 1977

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