0021-7557/07/83-02/157
Jornal de Pediatria

ORIGINAL ARTICLE

Evolution of body mass index in two historical series of adolescents

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Abstract

Objective: To verify the evolution of body mass index (BMI) between two studies of adolescent populations.

Methods: Data on the BMI of 8,020 adolescents aged 10 to 15 years living in the city of São Paulo, Brazil, and enrolled on the 2005 study entitled "The nutritional profile of adolescents at public and private schools in São Paulo" were compared with data from the 1989 National Nutrition and Health Census (PNSN - Pesquisa Nacional sobre Saúde e Nutrição). Binomial testing was used to compare proportions once both data sets had been transformed into percentiles.

Results: Comparing the two surveys, significant increases were identified in 85th and 95th percentile BMI values for male adolescents aged 10 to 15 years and for female adolescents aged 10 to 14 years. Analysis of the difference between the 5th and 95th BMI percentiles of the São Paulo and PNSN samples indicates that there was probably an increase in the number of adolescents in the higher BMI ranges in São Paulo in relation to the PNSN survey.

Conclusions: These results demonstrate a tendency for the adolescents' observed mean BMI values to increase during the period between the two surveys, indicating a need for increased monitoring of this measurement as a form of preventing overweight in this population.

J Pediatr (Rio J). 2007;83(2):157-162: Adolescents, body mass index, overweight, obesity.

Introduction

Obesity in children and adolescents has been increasing rapidly in many cities in Brazil and in other countries, indicating that this is no longer just a public health problem for western countries.[1] This being so, the World Health Organization[2] (WHO) has recognized obesity as a major public health epidemic worldwide, indicating a need for practical and viable investigative methods that estimate its prevalence and allow for international comparisons.[3]

In Brazil, a process of nutritional transition took place between 1974/1975 and 1989, with reductions in infant malnutrition and increases in obesity,[4] from which it was projected that there would be an annual increase of 0.5% in the number of obese children.[5] In fact, overweight and obesity already affect 20% of children and adolescents in Brazilian cities, with an observed prevalence in Recife of 35%,[6] and 15.8% in Salvador.[7] In the city of Santos, state of São Paulo, 15.7% of overweight and 18% of obesity were observed.[8,9] While many of these studies may not be

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Manuscript received Jul 10 2006, accepted for publication Nov 01 2006.

Suggested citation: Cintra IP, Passos MA, Fisberg M, Machado HC. Evolution of body mass index in two historical series of adolescents. J Pediatr (Rio J). 2007;83(2):157-162.

doi 10.2223/JPED.1602

representative of their regions, the study in Santos[8,9] stands out as it was populational and not sampled.

Obesity is associated with important health problems in the pediatric population. Body mass index (BMI)[10-12] is an early risk factor for morbidity and mortality, in addition to being a measurement widely correlated with these conditions, both in children and the adult population. Many studies have used BMI values between the 85th and 95th percentiles, by age and sex, to classify overweight, and values equal to or greater than the 95th percentile to classify obesity.[12-14] It is important to point out that overweight is defined as excess total body weight, based on a specific weight cutoff, whereas obesity is excess total or localized body fat.[3]

The objective of this study is to compare the distribution of BMI percentiles among adolescents aged 10 to 15 years recently evaluated in the city of São Paulo with data from the Brazilian Institute of National Statistics and Geography and the National Institute of Food and Nutrition, based on results from the National Nutrition and Health Census (PNSN - Pesquisa Nacional sobre Saúde e Nutrição)[15] and published by Anjos et al.,[16] as a means of monitoring the evolution of overweight and obesity within this population from São Paulo.

Methods

The study enrolled 8,020 adolescents, 55% (4,372) of whom were female and 46% (3,648) of whom were male, students at 43 schools (32 public and 11 private ones) in the North (17%), Midwest (17%), East (37%) and South (29%) zones of São Paulo city.

Information on the number of schools in São Paulo was provided by the *Delegacias Regionais de Ensino* (local educational directorates), which were chosen at random, with the exception of any with less than 200 students enrolled in the 5th to 8th grades. Schools that objected to participation were replaced with others, also selected at random, with the proportion of public and private schools maintained.

Schools participated after authorization from their boards, and adolescents only participated if they provided written consent from their parents or guardians. Exclusion criteria for adolescents were: pregnancy, age less than 10 years or more than 15 years and any physical condition that precluded routine anthropometric assessment.

This study is part of the Adolescent Obesity Early Diagnosis and Lifestyle Project which aims to delineate the nutritional profile of students at public and private schools. The project was coordinated by the Adolescent Care and Support Center (CAAA - Centro de Atendimento e Apoio ao Adolescente) at the UNIFESP Pediatrics Department and by the Physical Activity and Weight Control Task Force (Força Tarefa de Atividade Física e Controle de Peso - ILSI Brazil).

This study conforms to ethical principals for research involving human beings, in accordance with resolution CNS 196/96, and was approved by the Research Ethics Committee at the Universidade Federal de São Paulo (CEP nº 0977/03).

Anthropometric assessment was performed by a team of 20 interns and five coordinators, trained in advance in the techniques and standardization of the methods employed.

Subjects were weighed using a Seca® portable digital scale with a 150 kg capacity, standing on the base plate, unshod, wearing light clothing and with their arms aligned with their bodies. Height was measured using a Seca® wall stadiometer at 90º to the floor, in accordance with parameters defined by Jelliffe[17] and the WHO.[18] These measurements were used to calculate BMI, by dividing weight in kg by the square of stature in m, and nutritional status was assessed according to the criteria proposed by the Centers for Disease Control and Prevention.[19]

In order to describe the profile of the sample, according to the various study variables, frequency tables were constructed for categorical variables and descriptive statistics (mean, standard deviation, minimum and maximum values) were used for continuous variables (age, height, weight and BMI).

The BMI data were put in order from the least value (minimum) to the greatest (maximum) and subdivided into 100 equal sized parts, known as percentiles, adopting the values at P5, P15, P25, P50, P75, P85 and P95, by sex and age group.

In order that the BMI percentiles for the two studies could be compared, the figures obtained in the National Nutrition and Health Census were fixed and compared to those from the São Paulo sample. Analysis was by age and sex, using binomial testing to compare proportions between the studies.

Results

The female (n = 4,372) and male (n = 3,648) adolescents exhibited very similar mean values for age (13.03 and 13.06 years), weight (49.48 and 50.55 kg), height (155.77 and 157.75 cm) and BMI (20.26 and 20.07 kgm^2).

The distribution of BMI across percentiles of 10 to 15 year-old female and male adolescents from the city of São Paulo are presented in Table 1, and the equivalent data for adolescents from the same age group, as published by Anjos et al.,[16] according to the PNSN data (1989) are in Table 2.

Comparative analyses will now be presented of the BMI percentiles for the adolescents from São Paulo city (n = 8,020) and the 1989 PNSN values (n = 8,701), broken

down by age and sex. Taking the P85 and P95 values from the PNSN as fixed points, the corresponding percentage of adolescents in the São Paulo sample whose BMI was within those limits was calculated. The binomial test was then used to compare proportions in order to detect significant differences between the values expected for P85 and P95. Table 3 shows that there were significant differences in the values at P85 and P95 for all age and sex combinations, with the exception of P85 for 15-year-old females.

The results shown in Table 4 demonstrate that there was a significant difference between the samples in the values for

Table 1 - Distribution of adolescents in the city of São Paulo by age and sex (2005) according to body mass index percentile

Sex/Age (years)	P5	P15	P25	P50	P75	P85	P95
Female							
10 (n = 180)	14.69	15.61	16.42	18.18	20.80	22.17	25.41
11 (n = 891)	15.09	15.99	16.78	18.69	21.15	22.66	25.84
12 (n = 999)	15.16	16.43	17.27	19.22	21.56	23.39	26.89
13 (n = 1,106)	16.28	17.34	18.15	20.00	22.24	23.95	27.49
14 (n = 962)	16.61	17.89	18.83	20.81	22.95	24.59	27.63
15 (n = 234)	17.40	18.53	19.31	20.65	22.50	24.11	27.79
Male							
10 (n = 134)	15.16	15.92	16.48	17.77	20.63	22.55	25.93
11 (n = 765)	15.22	16.01	16.70	18.49	21.45	23.24	26.15
12 (n = 816)	15.06	16.18	16.88	18.71	21.64	23.64	27.02
13 (n = 904)	15.55	16.89	17.70	19.50	22.31	24.26	28.30
14 (n = 787)	16.44	17.57	18.27	19.71	22.22	23.86	27.70
15 (n = 242)	16.61	17.67	18.65	20.36	22.47	24.00	29.84

Table 2 - Distribution of adolescents by age and sex according to body mass index percentile, 1989 National Nutrition and Health Census

Sex/Age (years)	P5	P15	P25	P50	P75	P85	P95
Female							
10 (n = 776)	13.50	14.60	15.10	16.30	17.60	18.60	21.00
11 (n = 768)	14.10	15.10	15.60	16.80	18.60	19.80	22.80
12 (n = 757)	14.70	15.70	16.40	17.90	19.60	20.90	23.40
13 (n = 713)	15.40	16.70	17.40	19.00	21.10	22.20	24.30
14 (n = 699)	16.10	17.30	18.30	20.00	21.90	23.30	26.00
15 (n = 615)	17.10	18.30	19.00	20.60	22.50	23.60	26.00
Male							
10 (n = 780)	14.10	14.80	15.20	16.10	17.10	18.00	20.00
11 (n = 782)	14.30	15.10	15.60	16.50	17.60	18.70	21.30
12 (n = 721)	14.50	15.40	15.90	16.90	18.20	19.10	22.00
13 (n = 732)	15.10	16.00	16.50	17.70	19.20	20.10	21.90
14 (n = 742)	15.40	16.40	17.10	18.30	19.80	20.80	22.40
15 (n = 616)	15.70	17.20	17.80	19.10	20.70	21.70	23.80

Table 3 - Comparative analysis of the 85th and 95th percentiles for body mass index for the São Paulo and National Nutrition and Health Census (PNSN) samples

Sex/Age (years)	BMI value at P85 in the PNSN	Percentile in São Paulo*	p†	BMI value at P95 in the PNSN	Percentile in São Paulo‡	p§
Female						
10	18.6	P59	p < 0.001	21.0	P77	p < 0.001
11	19.8	P64	p < 0.001	22.8	P86	p < 0.001
12	20.9	P70	p < 0.001	23.4	P85	p < 0.001
13	22.2	P75	p < 0.001	24.3	P87	p < 0.001
14	23.3	P78	p < 0.001	26.0	P91	p < 0.001
15	23.6	P82	p = 0.207	26.0	P91	p = 0.013
Male						
10	18.0	P51	p < 0.001	20.0	P69	p < 0.001
11	18.7	P51	p < 0.001	21.3	P73	p < 0.001
12	19.1	P54	p < 0.001	22.0	P77	p < 0.001
13	20.1	P59	p < 0.001	21.9	P73	p < 0.001
14	20.8	P63	p < 0.001	22.4	P76	p < 0.001
15	21.7	P65	p < 0.001	23.8	P84	p < 0.001

* Percentile or percentage of adolescents in the São Paulo sample whose BMI is below P85 for the PNSN sample, by age and sex.
† p value from the binomial test when the value from the São Paulo population is compared with P85 of the PNSN sample.
‡ Percentile or percentage of adolescents in the São Paulo sample whose BMI is below P95 for the PNSN sample, by age and sex.
§ p value from the binomial test when the value from the São Paulo population is compared with P95 of the PNSN sample.

Table 4 - Comparative analysis of the P5 to P95 range of body mass index from the National Nutrition and Health Census (PNSN) with the sample

Sex/Age (years)	BMI value at P5 in the PNSN	BMI value at P95 in the PNSN	Percentage for São Paulo*	p†
Female				
10	13.8	21.0	75.0	p < 0.001
11	14.1	22.8	84.5	p < 0.001
12	14.7	23.4	82.4	p < 0.001
13	15.4	24.3	85.3	p < 0.001
14	16.1	26.0	87.6	p = 0.014
15	17.1	26.0	87.6	p = 0.222
Male				
10	14.1	20.0	68.7	p < 0.001
11	14.3	21.3	71.9	p < 0.001
12	14.5	22.0	75.4	p < 0.001
13	15.1	21.9	70.1	p < 0.001
14	15.4	22.4	74.8	p < 0.001
15	15.7	23.8	82.6	p < 0.001

* Percentage of adolescents from the São Paulo sample whose BMI falls within P5 to P95 in the PNSN sample, by age and sex.
† p value when binomial testing is used to compare the actual percentage in the São Paulo population with the expected percentage of 90% (P95-P5 from the PNSN).

the difference between P5 and P95, for each age and sex combination with the exception of 15-year-old females. In each case the percentage of adolescents from the 2005 sample falling within this range is lower than the expected 90%, indicating a probable increase in the number of adolescents in the upper BMI bands.

Discussion

Anthropometric measurements are widely used for evaluation of the nutritional status of individuals and populations, since they are more practical and of lower cost, but, in common with any assessment method, they have their limitations.[20-22]

This study has demonstrated that the adolescents of São Paulo, from 10 to 15 years of age, are exhibiting a significant increase in BMI at the different percentiles, indicating that, as the years pass, there is an ever increasing tendency towards gaining body weight, particularly among males.

A study comparing national surveys from 1975 and 1997 observed that, among girls, there was an increase of around 5 units of BMI at the 95th percentile for ages 10 to 12 years and of around 3 units for those aged 13 years or more, with the greatest increases occurring at the upper limits of the distribution.[22] Over a shorter period we also identified significant increases among females, and the greatest increases also occurred among the younger girls and at the upper limits of BMI.

Another study compared data on British adolescents aged 11 to 16 years from the National Diet and Nutrition Survey with figures from the British Standards Institute,[23] using standard deviation scores, and found a mean increase in BMI of 0.47 and 0.53 units, for males and females respectively. Although our study did not use scores to analyze BMI, it will be noted that while the British study observed the greatest increases among females, here the opposite was true. One important point is that our study assessed males and females simultaneously, which was not the case with the British Standards Institute data, and so there was no temporal interference, which we now know has a significant impact, not only on the increasing prevalence of obesity, but also on its severity.

Data from the PNSN were used to calculate recently published cutoff points for the assessment of nutritional status in Brazilian children and adolescents, and the BMI values used for overweight and obesity[24] were lower than those at the 85th and 95th percentiles for the 10 to 15-year-old adolescents from São Paulo. These data reaffirm the tendency for body weight to increase in this population.

Passos[25] compared BMI data for adolescents from São Paulo city at varying percentiles with data published by Must et al.,[26] the CDC[27] and Cole et al.,[19] and also found that these adolescents exhibited cutoff points that were higher than the international parameters, being closer to the cutoff points established by Cole, demonstrating that the values observed in this population are well above those considered appropriate. The principal differences occurred at the upper extremities (P85 and P95) and among the younger adolescents of both sexes.

With the objective of arresting this increase in the prevalence of obesity among young Brazilians,[14,28,29] we suggest that the more rigid evaluation criteria be adopted, such as the cutoff points recently proposed for the Brazilian population,[24] which, in addition to being defended by international authors,[3] are a closer approximation to the reality in our country, allowing for overweight to be diagnosed earlier, so that interventions aimed at impacting juvenile obesity can be established, as a means of achieving better quality of life.[1,3,24,25,30]

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