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National Prevalence of Obesity

Prevalence of abdominal obesity in adolescents: a systematic review

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Summary

The objectives of this study were to (i) review extant literature on the prevalence of abdominal obesity (AO) in adolescents of both sex (10–19 years old); (ii) analyse the cut-off points used for the diagnosis of AO and (iii) compare its prevalence between developed and developing countries. The search was carried out using online databases (MEDLINE, Web of Science, EMBASE, SPORTDiscus, SCIELO and BioMed Central), references cited by retrieved articles and by contact with the authors, considering articles published from the establishment of the databanks until 19 October 2009. Only original articles and those using waist circumference in the diagnosis were considered. Twenty-nine studies met the inclusion criteria. Fourteen of these studies were performed in developed countries. The prevalence of AO varied from 3.8% to 51.7% in adolescents from developing countries. The range of results was smaller among developed countries; with values from 8.7% to 33.2%. Eighteen different cut-off points were used. It was concluded the AO prevalence is high among adolescents, but is not clear what sex has a higher proportion and it is greater in adolescents from developing countries; however, there is no consensus in the literature about the criteria to be used.

Keywords: Adolescents, cross-sectional study, systematic review, waist circumference.

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Introduction

The paediatric obesity epidemic has increased significantly over the last three decades (1). This increase represents a problem for the healthcare system, seeing that overweight is directly associated with an increased risk for metabolic complications (2).

In epidemiological studies, anthropometry has been considered an efficient method (3,4). Body mass index (BMI) has been used frequently in studies as an indicator of general obesity. Waist circumference (WC) has been used as an indicator of abdominal obesity (AO) with high sensibility and specificity. This indicator has been presenting more accurate positive associations with cardiovascular risk factors than the BMI (5).

Abdominal obesity is a component of the metabolic syndrome according to the criteria of the National Cholesterol Education Program's Adult Treatment Panel III (NCEP-ATP III) (6). Nevertheless, there has been no standardization of abdominal circumference measurement for adolescents (7). So far, no systematic review has been conducted either to verify the prevalence of AO in adolescents

or to analyse the diagnostic criteria established in the literature for this risk factor. Thus, the objective of this study was to systematically review the literature regarding (i) the prevalence of AO in adolescents (10–19 years old) of both sexes (this descriptor has been well described in the guidelines for the diagnosis of metabolic syndrome) (ii) to analyse the cut-off points used for the diagnosis of AO and (iii) to compare the prevalence of AO in the developed and developing countries.

Methods

This study followed the systematic review methodology, which was proposed by Clark & Oxman (8). Searches were carried out using MEDLINE, Web of Science, EMBASE, SPORTDiscus, SCIELO and BioMed Central electronic databases, considering 19 October 2009 the most recent date for the collection of electronic data. Moreover, the references from the articles found in the databases were reviewed and contact with corresponding authors was made in order to find other relevant studies.

The following descriptors were used for the database search: 'abdominal fat', 'abdominal obesity', 'adiposity', 'body composition', 'body fat', 'body fat distribution', 'central adiposity', 'central fat', 'central fatness', 'central obesity', 'centrally-distributed fat', 'centrally-distributed obesity', 'metabolic syndrome', 'metabolic syndrome x', 'plurimetabolic syndrome', 'obesity', 'syndrome x', 'truncal fat', 'truncal obesity', 'trunk adiposity', 'trunk fat', 'trunk obesity', 'waist circumference' and 'anthropometry'. These keywords were combined with 'adolescence', 'adolescents', 'youth', 'teen' and 'teenager'.

Given that the aim of the present review was to verify the prevalence of AO using where only cross-sectional studies were included, for both, the following descriptors were used: 'prevalence studies', 'cross-sectional studies' and 'survey'.

For inclusion, studies were required to conform to the following criteria (i) a sample that included adolescents (10–19 years old); (ii) cross-sectional design; (iii) original studies that presented the AO prevalence for both sexes and (iv) AO was verified by WC. Studies in which the participants were only overweight/obese, diabetics or suffering from another disease were excluded. These criteria were set to increase inter-study comparability.

Potentially relevant papers were selected by (i) screening the titles; (ii) screening the abstracts and (iii) if abstracts were not available or did not provide sufficient data, the entire article was retrieved and screened to determine whether it met the inclusion criteria. The STROBE checklist for cross-sectional studies was used by two researchers to review papers (9,10) and in the case of inter-analysis disagreement, the paper was evaluated by a third researcher (see Fig. 1).

The outcome prevalence and its respective confidence intervals of 95% (95% CI) are presented. The 95% CI was directly extracted from articles (11–22), whenever possible, or calculated using the statistics program States 8.0 using the 'cii' command (95% CI exact for binomial distribution) (23–39). However, in three articles (24,29,31), it was not possible to calculate the 95% CI by sex, as the authors did not separate their findings by sex.

Results

Literature search

The literature search yielded 129 titles of potentially relevant articles (see Fig. 1) and 29 papers were eligible according to the inclusion criteria established for this review (11–40). Figure 2 illustrates the number of included articles according to the year that each article was published. An increased interest in this cardiovascular risk indicator by the scientific community was observed in the last 2 years (2007–08). Table 1 presents a description of the 29 papers included in this study including the lead author, country where it was performed, year of publishing, journal in which it was published, total number of participants in the study, number of adolescents, age range and proportion of girls. All of the articles were published after the year of 2002; however, the first survey was conducted 32 years ago. Fifteen of the studies were in countries of low or middle income, considered developing countries, and fourteen studies were carried out in developed countries. Two articles (15,39) included children (up to 10 years old) as well and another included adults (20 years old or more) (15).

Prevalence and cut-off points

Table 2 presents AO prevalence and the respective 95% CI of AO from each study that was included in the review according to year of survey, study population, classification criteria of AO used, measured place of WC and country development status, along with total data by sex. There were 37 different prevalence levels described in the included articles, because one study presented four criteria for classification (31), two other studies (14,23) were conducted in two different years and one study was conducted over four different years (19). Only in four studies was the total prevalence less than or equal to 10% (11,16,32,37).

It was observed that two of the articles described were repeated in different years, and, in both cases, the authors observed an increase in prevalence. The greatest difference between the first and the second study was observed in McCarthy *et al.* (23). Daratha and Bindler (19) presented a study of trends over four different years, and the totals showed an increase, especially in the last 2 years, with adolescent girls exceeding WC cut-off points at higher rates.

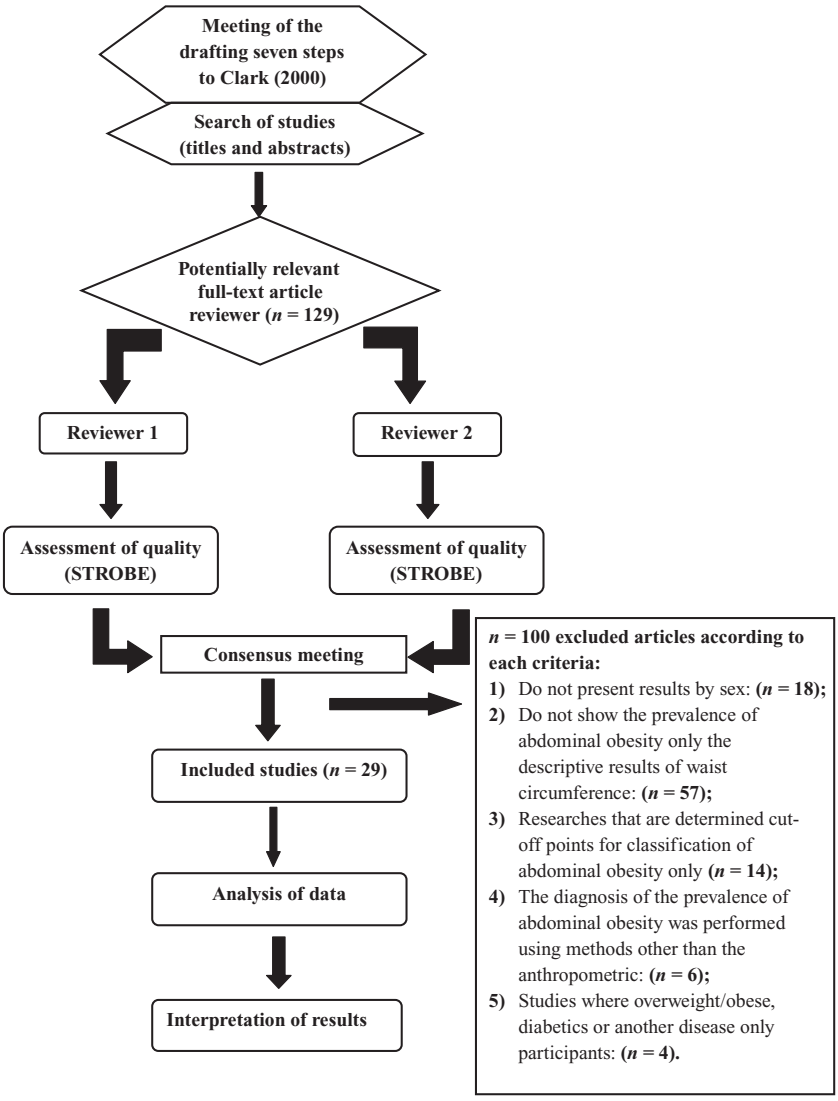

Figure 1 Flowchart of search strategy and results.

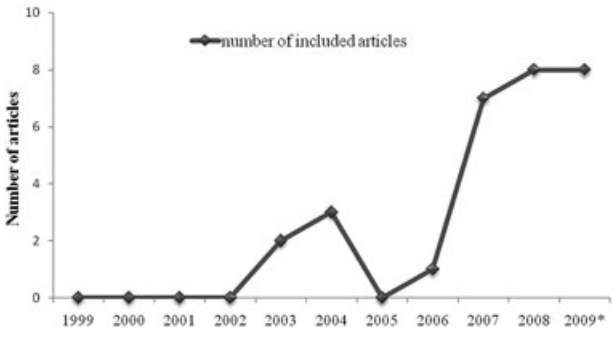

Figure 2 Number of articles included by the year of publication. *Data concerning the 19 October 2009.

With respect to cut-off points for WC, it was verified that there is no current consensus in the literature. Fourteen different cut-off points were used; where the most cited, with seven references, were those proposed by Cook *et al.* (11).

Table 2 describes the anatomical sites for WC measurement used in the studies, which were mostly selected according to WHO guidelines (41); among the 29 studies, 21 researcher used this guideline (11,12,14,17,19,21–24,26,28–36,38,39). Another three studies did not report the specific site of measurement in the paper, only writing *waist circumference*. Upon analysing the agreement between anatomical location utilized in each study and the anatomical locations utilized to determine the cut-off points, we found 90% agreement among the included studies with the references.

Gender differences

According to results presented, AO prevalence was less than 10% for boys in seven of the studies (16,23,25,29,31,32) and less than 10% for girls in eight of the 37 studies (11,16,18,23,29,31,32,34,37). In 15 studies,

Table 1 Descriptive analysis of the studies reviewed

First author	Country	Year published	Journal published*	*n* total study	*n* of adolescents	Age (years)	Proportion of girls
McCarthy HD† (23)	UK	2003	*BMJ*	4 560	4 560	11–16	57.1
Cook S (11)	USA	2003	*Arch Pediatr Adolesc Med*	2 430	2 430	12–19	52.6
de Ferranti SD (24)	USA	2004	*Circulation*	1 960	1 960	12–19	?
Goodman E (25)	USA	2004	*J Pediatr*	1 513	1 513	12–19	50.1
Duncan GE (12)	USA	2004	*Diabetes Care*	991	991	12–19	53.9
Esmaillzadeh A (13)	Iran	2006	*Obesity*	3 036	3 036	10–19	53.4
Fernandes RA (26)	Brazil	2007	*J Pediatr (Rio J)*	811	811	11–17	55.0
Kim HM† (14)	South Korea	2007	*Diabetes Res Clin Pract*	1 317 and 848	1 317 and 848	12–19	50.7 and 49.1
Castillo EH (15)	Mexico	2007	*JAdolesc Health*	1 366	927	07–24	56.6
Bismarck-Nasr EM (27)	Brazil	2007	*Cad Saúde Pública*	287	287	14–23	63.4
Singh R (16)	India	2007	*Diabet Med*	1 083	1 083	12–17	47.0
Ryu SY (28)	South Korea	2007	*J Korean Med Sci*	1 393	1 393	12–13	47.5
Vissers D (29)	Belgium	2007	*Acta Pædiatrica*	506	506	16–19	?
Aounallah-Skhiri H (30)	Tunisia	2008	*Public Health Nutri*	2 872	2 872	15–19	54.9
Cook S (31)	USA	2008	*J Pediatr*	1 826	1 826	12–19	?
Pan Y (17)	USA	2008	*J Am Diet Assoc*	4 450	4 450	12–19	49.0
Pedrozo W (18)	Argentina	2008	*Pan Am J Public Health*	532	532	11–20	60.0
Li Y (18)	China	2008	*Brit J Nutr*	2 761	2 761	15–19	46.4
Guimarães ICB (33)	Brazil	2008	*Arq Bras Cardiol*	536	536	11–18	59.5
Pedrozo WR (35)	Argentina	2008	*Rev Argent Endocrinología y Metab*	532	532	11–20	60.0
Tzotzas T (35)	Greece	2008	*Obesity*	14 456	14 456	14–19	53.9
de Moraes ACF (36)	Brazil	2009	*Rev Assoc Med Bras*	991	991	14–18	54.4
Azizi F (37)	Israel	2009	*Ann Nutr Metab*	1 708	1 708	10–19	53.0
Daratha KB‡ (19)	USA	2009	*Arch Pediatr Adolesc Med*	613	3 176	12–19	47.7
				892			48.7
				857			47.5
				814			47.6
Ekelund U (38)	Estonia, Denmark, and Portugal	2009	*Am J Clin Nutr*	3 193	3 193	10–15	51.8
Johnson WD (20)	USA	2009	*Arch Pediatr Adolesc Med*	2 456	2 456	12–19	48.4
Seki M (21)	Brazil	2009	*Public Health Nutr*	2 170	1 389	06–16	49.1
Valery PC (39)	Australia	2009	*Obes Rev*	158	68	05–17	55.0
Francis DK (22)	Jamaica	2009	*Public Health Nutr*	1 317	1 317	15–19	54.6

*Abbreviated according to the style used by Index Medicus.
†Measurements in two separate years.
‡Measurements in four separate years.
? Information not disponible in the paper.

the prevalence of AO was higher for boys and the magnitude of difference ranged from 0.5% (12) to 14.2% (33). In 19 other cases, a higher proportion of AO was reported for boys, and the difference varied from 0.1% (23) to 57% (37).

Differences between developing countries and developed countries

Abdominal obesity prevalence according to national economic condition is shown in Table 2. The results demonstrated that adolescents from developing countries presented both the highest (33) and the lowest (32) proportion of AO. However, two different studies found that the prevalence of AO among adolescents from developed countries was less than 10% (11,31).

Discussion

The objective of this study was to review the literature on AO among adolescents. Twenty-nine articles that met the inclusion criteria were included in this review. Sixteen of these 29 articles were published in the last 2 years (2008 and 2009) (14–18,26–35). The growing interest in the scientific community about this risk factor can be attributed, partly, to the fact that AO has been included as a criterion in two diagnostic guidelines for the metabolic syndrome: NCEP-ATP III (6) and the International Diabetes Federation (IDF) (40), as well its being directly related to other cardiovascular risk factors, such as dyslipidemias (42,43) and type 2 diabetes (44,45).

The AO prevalence in the included studies ranged widely; in 28 of the 37, values higher than 10% were

Table 2 Description of abdominal obesity (AO) prevalence (%) and the respective confidence intervals 95% (95% CI) along with total data by sex from each study that was included in the review according to year of survey, study population, classification criteria of AO used, measured place of waist circumference and country development status

First author	Year of survey	Study population	Criteria utilized	Measured place (same as writing on paper)	AO in girls % (95% CI)	AO in boys % (95% CI)	AO in total % (95% CI)	Country development status
McCarthy HD* (23)	1977/1987/1997	Population-based study (1977) British Standards Institute (1987) National Diet and Nutrition Survey (1997)	Percentile ≥90 of sample	Midpoint between the lowest rib cage and the top of the iliac crest	8.8 (7.6–10.0)† 38.1 (33.1–43.0)‡	8.7 (7.3–10.1)§ 28.5 (24.1–33.3)‡	33.2 (29.8–36.5)‡	Developed countries
Cook S (11)	1988/1994	NHANES 1988–1994	Percentile ≥90 of sample	Midpoint between the lowest rib cage and the top of the iliac crest	9.4 (6.9–11.8)	10.2 (8.0–12.4)	9.8 (8.2–11.4)	Developed countries
de Ferranti SD (24)	1988/1994	NHANES 1988–1994	Zhu S *et al.*	Midpoint between the lowest rib cage and the top of the iliac crest	26.0	22.0	21.0 (19.2–22.8)	Developed countries
Goodman E (25)	2001/2002	Suburban school-based survey	Cook S *et al.*	Over the umbilicus and the superior iliac crests	22.3 (19.3–25.4)	8.7 (6.8–10.9)	14.5 (12.7–16.3)	Developed countries
Duncan GE (12)	1999/2000	NHANES 1999–2000	Cook S *et al.*	Midpoint between the lowest rib cage and the top of the iliac crest	11.6 (6.5–16.7)	12.1 (7.7–16.5)	11.8 (8.6–15.1)	Developing countries
Esmaillzadeh A (13)	2005	Population-based study of Tehran Lipid and Glucose Study	Percentile ≥90 of sample	At the narrowest waist	10.1 (8.6–11.5)	10.0 (8.4–11.6)	10.0 (9.0–11.1)	Developed countries
Fernandes RA (26)	2006	School-based survey	Taylor *et al.*	Midpoint between the lowest rib cage and the top of the iliac crest	10.3 (7.6–13.5)	21.8 (17.8–26.5)	15.4 (13.0–18.1)	Developing countries
Kim HM*§§ (14)	1998/2001	Korean NHANES 1998–2001	Percentile ≥90 of country	Midpoint between the lowest rib cage and the top of the iliac crest	19.6 (16.6–22.6)¶ 18.5 (14.8–22.2)**	10.3 (8.0–12.7)¶ 16.2 (12.7–19.7)**	15.0 (13.1–17.1)¶ 17.3 (14.8–20.0)**	Developing countries
Castillo EH (15)	2004/2006	Two population-based study	Fernandéz JR *et al.*	Immediately above the iliac crest	30.0 (26.7–33.4)	25.2 (21.7–28.9)	27.9 (25.5–30.4)	Developing countries
Bismarck-Nasr EM (27)	2004	School-based survey	McCarthy HD *et al.*	Not reported specifically place in the paper, only waist circumference	36.8 (29.8–44.3)	22.8 (15.2–32.1)	31.7 (26.3–37.4)	Developing countries
Singh R (16)	?	School-based survey	Cook S *et al.*	Highest point of the iliac crest	3.5 (1.9–5.1)	4.4 (2.7–6.1)	4.0 (2.8–5.2)	Developing countries
Ryu SY (28)	2005	School-based survey	Percentile ≥70 of country	Midpoint between the bottom of the rib cage and the top of the iliac crests	23.4 (20.2–26.8)	24.5 (21.3–27.7)	24.0 (21.7–26.3)	Developing countries
Vissers D (29)	?	School-based survey	Percentile ≥95 of sample	Horizontal plane around the abdomen midway between the iliac crest and the floating ribs	6.0	7.0	11.6 (8.9–14.7)	Developed countries
Aounallah-Skhiri H (30)	2005	Population-based study	Percentile ≥75 of sample	Midpoint between the lowest rib cage and the top of the iliac crest	27.6 (25.4–29.8)	28.4 (25.9–30.9)	28.0 (26.3–29.6)	Developing countries
Cook S (31)	1999/2002	NHANES	Cook *et al.* Ford *et al.* Cruz *et al.* Caprio *et al.*	Midpoint between the lowest rib cage and the top of the iliac crest	15.7 10.8 7.7 18.7	17.2 12.1 10.7 9.6	16.1 (14.4–17.8) 11.5 (10.1–13.0) 9.3 (8.0–10.7) 13.9 (12.3–15.5)	Developed countries
Pan Y (17)	1999/2002	NHANES	Freedman DS *et al.*	Midpoint between the lowest rib cage and the top of the iliac crest	11.4 (8.8–13.9)	10.2 (8.9–11.6)	12.5 (11.5–13.5)	Developed countries

Table 2 *Continued*

First author	Year of survey	Study population	Criteria utilized	Measured place (same as writing on paper)	AO in girls % (95% CI)	AO in boys % (95% CI)	AO in total % (95% CI)	Country development status
Pedrozo W (18)	2005	School-based survey	Cook S *et al.*	Not reported specifically place in the paper, only waist circumference	9.4 (6.9–11.9)	20.7 (17.3–24.1)	13.9 (11.0–16.8)	Developing countries
Li Y (32)	1999/2002	China NHANES	de Ferranti SD *et al.*	Midpoint between the lowest rib cage and the top of the iliac crest	3.6 (2.6–4.7)	4.0 (3.1–5.1)	3.8 (3.1–4.5)	Developing countries
Guimarães ICB (33)	2005/2006	School-based survey	de Ferranti SD *et al.*	Midpoint between the lowest rib cage and the top of the iliac crest	45.7 (40.2–51.4)	59.9 (53.1–66.4)	51.7 (47.3–55.9)	Developing countries
Pedrozo WR (34)	2005	School-based survey	Cook S *et al.*	Midpoint between the lowest rib cage and the top of the iliac crest	9.4 (6.4–13.1)	20.7 (15.4–26.7)	13.9 (11.1–17.1)	Developing countries
Tzotzas T (35)	2003	School-based survey	Freedman DS *et al.*	Midpoint between the lowest rib cage and the top of the iliac crest	21.7 (20.8–22.6)	13.5 (12.6–14.3)	17.9 (17.2–18.5)	Developed countries
de Moraes ACF (36)	2007	School-based survey	Taylor *et al.*	Midpoint between the lowest rib cage and the top of the iliac crest	36.3 (32.2–40.5)	24.8 (24.2–32.8)	32.7 (29.8–35.7)	Developing countries
Azizi F (37)	?	Population-based study of Tehran Lipid and Glucose Study	International Diabetes Federation	Not reported specifically place in the paper, only waist circumference	9.9 (7.9–12.1)	10.2 (8.3–12.3)	10.0 (8.6–11.5)	Developing countries
Daratha KB¶ (19)	1999–2000; 2001–2002; 2003–2004 and 2005–2006	NHANES	Fernandéz JR *et al.*	Midpoint between the bottom of the rib cage and above the top of the iliac crest	15.9 (10.1–24.1)‡; 14.8 (11.2–19.2)**; 18.6 (13.9–24.3)††; 22.1 (16.9–28.4)‡‡	15.1 (10.2–21.8)‡; 13.5 (9.9–18.2)**; 19.2 (14.5–25.0)††; 13.7 (9.8–18.7)‡‡	15.5 (11.5–20.4))‡; 14.1 (11.5–17.2)**; 18.9 (15.5–22.9)††; 17.7 (14.3–21.6)‡‡	Developed countries
Ekelund U (38)	2000	EuropeanYouth HeartStudy	McCarthy HD *et al.*	Midway between the lower rib margin and the iliac crest	19.1 (17.2–21.0)	15.9 (14.1–17.8)	14.4 (13.1–18.8)	Developed countries
Johnson WD (20)	2001–2006	NHANES	Li *et al.*	High point of the iliac crest	20.2 (16.0–24.5)	18.0 (14.6–21.4)	19.1 (16.2–22.0)	Developed countries
Seki M (21)	2005	School-based survey	Cook S *et al.*	Midway between the lowest rib and the superior border of the iliac crest	10.8 (9.0–12.8)	11.5 (9.7–13.6)	11.2 (9.9–12.6)	Developing countries
Valery PC (39)	?	Indigenous Australian youths	Jolliffe *et al.*	Narrowest point between the lower borders of the rib cage and the iliac crest	79.0 (65.5–88.4)	22.0 (11.5–37.8)	15.0 (8.6–23.5)	Developed countries
Francis DK (22)	2006	'YRRBS' nationally representative sample	Han TS *et al.*	Midpoint between the lowest rib and iliac crest	16.2 (13.4–18.9)	1.7 (0.6–2.8)	9.6 (8.0–11.2)	Developed countries

*Measurements in four separate years.
†Measurements performed in 1987.
‡Measurements performed in 1999.
§Measurements performed in 1977.
¶Measurements performed in 2000.
**Measurements performed in 2001.
††Measurements performed in 2003.
‡‡Measurements performed in 2005.
§§Measurements in two separate years.
?Information not available in the paper.
NHANES, National Health and Nutrition Examination Survey; YRRBS, Youth Risk and Resiliency Behaviour Survey.

found, whereas the other nine studies presented a prevalence above 20%, which can be attributed, at least in part, to the diversity of the studied populations.

Three studies included in this review presented results over subsequent years, verifying an increasing prevalence of AO. This phenomenon was also observed for the prevalence of general obesity (46) and metabolic syndrome (14), indicating an alarming problem for public health during adolescence, as this nutritional status tends to remain throughout adulthood (47).

When prevalence was analysed according to the sex, it was observed that in almost half of the studies boys presented a higher proportion. This result is consistent with other epidemiological research investigating general obesity using BMI, where in some studies girls present a higher of proportion obesity than boys (48), and in others boys present a higher prevalence (35). Differences of prevalence among sexes might have been be related to geopolitical and cultural conditions of evaluated countries (1).

When the results were compared by national economic characteristics, wide differences were noted. For example, six of 16 developing countries (37.5%) presented an AO prevalence higher than 20%; however, in studies carried out with adolescents from developed countries, only two of the twenty studies analysed (10.0%) presented values above 20%. Previous studies on developing countries have reported that the obesity is associated with lowest socioeconomic status (49); the burden of nutritional problems is shifting from deficiency to excess energy imbalance. Therefore, urgent strategies for changes lifestyle are necessary with objectives decrease the prevalence and treatment of obesity. Publications such as the World Health Organization (WHO) (50) may be used for interventions which are more to be effective.

Some authors have been investigating the relation between obesity and socioeconomic level (49), and have verified that overweight tends to predominate in low- and middle-income countries, challenging public health and contributing to an increase in health inequity. Thus, obesity greatly impacts not only individual health, but also national health costs in general, through both direct and indirect costs (51).

An important aspect of this issue that should be considered is the criteria used to define AO because 18 different standards were used in these studies. The differences in results can be partly explained by such methodological aspects. Another factor that may have influenced the recorded prevalence is the question of measurement accuracy. Differential or non-differential misclassification effects (error due to disease status or exposure) of AO prevalence are unpredictable, and may have caused the underestimation or overestimation of the true prevalence. In the context of this study, it is likely that the validity of diagnostic criteria and tools used varied for each population characteristic of the adolescents studied (52).

Besides the above-mentioned methodological differences, only one article (52) used an appropriate statistical method (53,54) that showed sensitivity and specificity for determining the cut-off point. In a recent joint scientific statement, several major organizations have attempted to unify criteria (55) and however the defining thresholds for AO are complicated, in part because of several differences among populations and ethnic groups. Thus, population and country-specific cut-off points for WC could be developed (55) and methodology developed by the Multi-Center Study of the WHO can assist in collecting data for setting thresholds in each population and ethnicity (56).

The results of this survey allow the following conclusions (i) knowledge about the subject has increased, especially in the last 2 years (2007–08); (ii) AO prevalence is high; however, it is not clear which sex has a higher proportion of adolescents with AO; (iii) there is no consensus about methodology and criteria to be used for classifying AO in adolescents; (iv) adolescents from developing countries have rates different from those of developed countries and (v) according to the literature, obese adolescents are more likely to develop MS.

Conflict of Interest Statement

No conflict of interest was declared.

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