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The use of BMI and Abdominal Circumference in the Diagnosis of Obesity in Schools: a Systematic Review

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Abstract*— *To verify body composition or body weight distribution in a more traditional way, isolated body weight or height adjusted weight has been used. In the last 5 years, evaluations have been used to verify the distribution of this fat, where these measures are more preventive to health.The objective of the study was to analyze the studies that indicate the use of BMI and waist circumference as a tool to diagnose obesity. The current study is a systematic review, where it followed the criteria of a systematized review and meta-analysis proposed by the PRISMA protocol. The criteria adopted for the selection of articles were the use of the following variables for obesity: BMI, Circumference of abdomen, relation of C.A with stature and C.A and body weight. After consulting the databases selected to search for articles, 1,846 articles were identified on the topic of interest with the descriptors (obesity in schoolchildren). 410 articles were found on the Scielo platform, 150 articles were found on the Bireme platform. In the Pubmed platform 1,236 articles and finally in the Scopus platform a total of 50 articles. After the exclusion, 16 articles were used for the analysis. The majority of the studies in the area of collective health are concluded, but only the BMI isolated for the diagnosis are indicated as evaluation measures. More recent studies indicate an evolution in the way of evaluating. As can be seen in the sixteen articles analyzed.

Keywords*— *BMI; abdominal circumference; schooling; obesity.

I. INTRODUCTION

The etiology of obesity is profoundly complex and multicausal, where assessments should verify associations, interactions, and relationships of genes, environments, lifestyles, and psychological variables [1]. For Gallwitz et al. [2], the modern environment may contribute greatly to the development of obesity. According to the author, there has been a decrease in levels of physical activity and an increase in caloric intake, where such combination are very strong environmental determinants.

The highest rate of increase in obesity, according to a study by Gong et al. [3], has been occurring in populations with higher levels of poverty and lower educational level. According to his study, there is a dangerous inversion, where about 20 years the poorest population suffered from hunger and malnutrition. This can be explained by the association of higher palatability and the low cost of high energy density foods.

Studies have warned of increased obesity in children, pointing to the possibility that obese children may become obese adults. Childhood obesity has been increasing in a disorderly way in the world, so it is inevitable to talk about it [4,5,6].

In the treatment of the obese patient in general, it is first necessary to be recognized the state of the body weight and this be accepted by the patient. It is important to have an interaction between the patient and health specialists, in this case with obesity in schoolchildren, the closest contact is the Physical Education Teacher. This professional will verify if there is really excess weight and if the patient really needs to have a deepening in their evaluation [7].

To verify body composition or body weight distribution in a more traditional way, isolated body weight or height adjusted weight has been used. In the last 5 years, we have used evaluations to verify the

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distribution of this fat, where these measures are more preventive to health [8].

The combination of an assessment with body mass and body fat distribution has been considered the best option to meet a need for clinical evaluation, however, since all assessments for the diagnosis of obesity present ethnic and genetic limitations [5].

Thus, the association of BMI measurement with abdominal circumference at the present time is the most reliable means to diagnose obesity in a primary intervention [9].

Abdominal obesity is a key part of the constellation of risk factors for Metabolic Syndrome (MS) and is strongly associated with the risk of Type 2 Diabetes Mellitus (DM2). An analysis of the associations between risk factors for MS in 2,735 participants in the Dallas Heart Study showed that the highest BMI was significantly associated with MS in diabetic and non-diabetic patients. In a prospective cohort study that examined the association between MS and type 2 diabetes among 4,022 patients with atherosclerosis, abdominal obesity was the component most strongly associated with the risk of type 2 diabetes.

Data from nine European studies were examined to determine the association between MS and abdominal adiposity in more than 15,000 men and women. Weight reduction, alone or in combination with lifestyle intervention, leads to a significant reduction in the prevalence of MS [10]. With this, the objective of the research was to analyze the studies that point out the use of BMI and abdominal circumference as a tool to diagnose obesity.

II. METHODS

The current study is a systematic review, where it followed the criteria of a systematic review and meta-analysis proposed by the protocol (PRISMA) [11].

Eligibility criteria

The studies that verified the epidemiology of obesity and ways of evaluating obesity in schoolchildren in Brazil were considered eligible, with no restriction or limitation in the year of publication and the language that were written. The criteria adopted for the selection of articles were the use of the following variables for obesity: BMI, Circumference of abdomen, relation of C.A with stature and C.A and body weight. In this review, we also included cross-sectional and case-control studies, where the data came from primary and secondary sources. Were excluded from the review: a) did not use BMI and abdominal circumference for obesity, b) presented insufficient data, c) complete texts not available, d) summaries, book chapters, comments.

The methodological quality of the studies was evaluated by the GRADE system proposed by the *Grades of Recommendation, Assessment, Development and Evaluation group* [12]. In addition, after the selection of the studies, a checklist containing questions (Table 2) was applied to verify their scientific inference.

Search sources

In the current review, detailed and individualized research strategies were performed in the databases: PubMed/MEDLINE, Scopus, LILACS and Scielo. The studies were separated into a list, where they were manually revised in order to verify whether or not the need to include additional references. The descriptors were searched between 10/10/2017 to 04/20/2018.

Methodology of search and collection of articles

The research began in the selection of articles individually, where the inclusion criterion was followed and according to the title and the summary of the selected references, just as in each selected article the criteria for its selection were checked. After this screening, the articles were read in their entirety excluding those that did not meet the established criteria. After reading the selected articles, the information collected from each one were: author and year of publication, state of study, type of study, sample number and prevalence of obesity. Finally, it was decided that the meta-analysis in the study would not be included, because the studies presented a very great heterogeneity, as well as the analyzes and statistical methods used are very discrepant.

Table 1: Studies used for final analysis according to author and year, study characteristic, sample, variables used and results achieved.

Author/Year	Kind of study	Sample	Variables	Results
Gong et al., (2014)[3]	Control Case	7-11 years old; 114 Fem.212 Masc.254	BMI, abdomen circumference, level of physical activity	BMI = 25.4 kg/m² (masc.), 28.5 kg/m² (fem) C.A = 89 cm Obesity = 8% Cardiac Risk = 10%
Schafiee et al., (2018)[4]	Descriptive	14,880 students, age = 6-18 years	Abdominal circumference, BMI, wrist circumference.	Excess abdominal weight = 85 cm, 12% cardiac risk. BMI = 27.3 kg/m², 10%

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				obese
Neamat-Allah et al., (2014)[5]	Epidemiológico	Sample = 1.192 Age = 12-18 years old	BMI, circumference of abdomen, triceps skinfolds.	BMI = 25.3 kg/m² Obesity = 7% Abdominal circumference = 78 cm Cardiac risk = 5%
Goluch-Koniuszy and Kuchlewska (2017)[6]	Longitudinal	Sample = 1,738, masc. 882, feminine 856 Age = 13 years	BMI, waist circumference,	BMI: Female (20.2 kg/m² ± 3.3). Masc (20.1 kg/m² ± 3.5) Obesity: 12.9% Female. 6.6% men. Abdominal circumference: Female. (70.3 ± 8.2), m. (72.2 ± 9.3)
El-Serag et al., (2014)[8]	Control Case	Sample = 426 Age = 12-18 years old	BMI, abdomen circumference, height/circumference of abdomen.	BMI = 28.6 kg/m² Obesity = 7% Abdominal circumference = 87 cm Cardiac risk = 6.3%
Castro-Correia (2018) [13]	Descriptive	Sample = 44 (feminine) Age = 14-18 years	BMI, abdominal circumference, blood pressure, glycated hemoglobin	BMI = 26.3 kg/m² Obesity = 8.2% Abdominal circumference = 79 cm Cardiac risk 9.4%
Patel et al., (2017)[14]	Transversal	Sample = 737 Ages = 10-16 years	BMI, abdominal circumference, biochemical analyzes	Obesity = 10% BMI = 26.3 kg/m² Abdominal circumference = 87 cm Cardiac risk = 8%
Turconi et al., (2006)[15]	Transversal	Sample: 532 (254 males and 278 females, aged 15.4 ± 0.7) years.	BMI, waist circumference, skinfolds	Obesity masc. 4.7% Female obesity. 1.1%.
Mihrshahi et al., (2018)[16]	Longitudinal	Sample: 7.555. (3,100 men, 4,455 fem.) Age: 10.5 years.	BMI, abdomen circumference, abdomen/height circumference.	BMI masc. 11.5% obese (29.3 kg/m²) BMI femin. 12.2% obese (29.8kg/m²) Abdomen Circumference Masc. 76.2 cm (21% cardiac risk) Circumference of abdomen femin. 77.4 cm (21.4% cardiac risk)

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Continuation Table 1: Studies used for final analysis according to author and year, study characteristic, sample, variables used and results achieved.

Ramirez-Velez et al., (2017)[17]	Transversal	Sample: 7954 (3460 males and 4494 females) Age: 12.8 (± 2.3) years].	BMI, Circumference of abdomen,	BMI Masc.19.4 kg/m² (obesity 3.3%) Abdominal circumference: 6.6.0 cm (cardiac risk 8.1%) BMI female.20.0 kg/m² (obesity 3.5%) Abdominal Circumference 64.8 cm (8.0% cardiac risk)
Suder, Gomula e Koziel (2017)[18]	Transversal	Sample: 34,005 male and 34,008 female. Age: 13.5 years (± 2.3)	BMI, Circumference of abdomen,	Female BMI. 23.4 kg/m² (8% obese) Abdominal circumference 56 cm (9% cardiac risk) BMI masc. 22.3 kg/m² (7% obese) Abdominal circumference 60 cm (8% cardiac risk)
Zhang et al., (2017)[19]	Transversal	Sample: 72,755 Age: 7 to 18 years old	BMI, Circumference of abdomen,	Obesity: 20.37% (boys) and 11.61% (girls).
Romanholo et al., (2018)[20]	Transversal	Sample: 482 230 male and 252 female. Age: 9.4 years	BMI, Circumference of abdomen,	BMI: 21% obese male. 19% obese women. Abdominal circumference: 9.3% male. 15% female.
Teixeira et al., (2017)[21]	Transversal	Sample: 505 students (female 284) and male 221) Age: 7,8 years	BMI, Circumference of abdomen,	BMI female.17.7 kg/m² ± 3.4 (10.3% obese) BMI masc. 17.6 kg/m² ± 3.3 (11.6% obese) Female abdominal circumference.61.2 ± 8.8 (10.6% risk factor) Abdominal circumference male. 61.5 cm ± 9.5 (12.7% risk factor)
Jensen, Camargo and Bergamaschi (2016)[22]	Transversal	Sample: 217 school children (n = 111 boys and n = 106 girls) Age of 9.2 years (dp 1.0 year)	Sum of skinfolds, BMI and abdominal circumference	BMI masc. 18.4 kg/m² ± 3.9 (8% obese) BMI female.18.5 kg/m² ± 3.8 (7.6% obese) C.A men. 54cm ± 3.4 (9% risk) C.A. female. 53 cm± 3.1 (8.3% risk)
Zanella, Souza e Valentini (2018)[23]	Transversal	Sample: 48 children (5 to 7 years),	BMI and Abdominal Circumference	Abdominal Circumference = 63.3 cm (± 9.2 cm) BMI = 20.8 kg/m² (± 12.8 kg/m²)

Legend: A.C. = abdominal circumference.
Source: Own authors, 2018.

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Table 2: Methodological evaluation according to GRADE criteria.

Evaluated parameters	**Gong et al., (2014) [3]**	**Schafiee et al., (2018) [4]**	**Casto-Correia (2018) [13]**	**El-Serag et al., (2014) [8]**	**Neamat-Allah et al., (2014) [5]**	**Patel et al., (2017) [14]**	**Goluch-Koniuszy e Kuchlewska (2017) [6]**	**Turconi et al., (2006) [15]**	**Mihrshahi et al., (2018) [16]**	**Ramirez-Velez et al., (2017) [17]**	**Suder, Gomula, Koziel (2017) [18]**	**Zhang et al., (2017) [19]**	**Romanholo et al., (2018) [20]**	**Teixeira et al., (2017) [21]**	**Jensen, Camargo, Bergamaschi (2016) [22]**	**Zanella, Souza e Valentini (2018) [23]**
1. Are the outcomes presented scientifically relevant?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Is the methodology clearly and accurately described as the main outcome?	N	Y	Y	Y	N	Y	Y	N	N	Y	N	Y	Y	Y	Y	Y
3. As a primary outcome, do they use intervention applied to childhood obesity?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Is there another association with childhood obesity?	Y	Y	N	Y	N	Y	Y	Y	N	N	N	N	Y	Y	N	N
5. Is there a control group to compare the main outcome?	N	N	Y	Y	N	N	N	Y	N	N	N	Y	N	N	Y	N
6. Is the sample statistically significant?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
7. Do the authors clearly state the results?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. Do the results meet the hypothesis?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9. Do the authors express the limitations of the study?	N	Y	N	Y	Y	N	N	Y	Y	Y	Y	N	Y	Y	Y	Y
10. Does the conclusion bring any scientific inference?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11. Are potential conflicts of interest declared?	Y	NA	Y	Y	NA	NA	NA	NA	NA	Y	NA	S	NA	NA	NA	NA

Legend: Y: Yes; N: No; NA: Not applicable.

Source: Own authors, 2018

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III. RESULTS

Selection of study using the databases selected to search for articles, 1,846 articles were identified on the topic of interest with the descriptors (obesity in schoolchildren). 410 articles were found on the Scielo platform, 150 articles were found on the Bireme platform. In the Pubmed platform 1,236 articles and finally in the Scopus platform a total of 50 articles.

After the removal of 220 duplicate articles, 1,624 articles in English, Portuguese and Spanish were obtained for the analysis. A comprehensive review of the title and abstract eliminated 1,578 articles (did not contain all the variables required for the study, or different variables), resulting in 46 articles in the first stage of the study.

In the second step, all 46 articles were included and read in full, reading ops were excluded from the final analysis; 15 of them due to lack of data for the classification of nutritional status, 10 because the articles evaluated another outcome totaling 16 articles used in the study. The diagram showing the process of identification, inclusion and exclusion of studies is shown in figure 1.

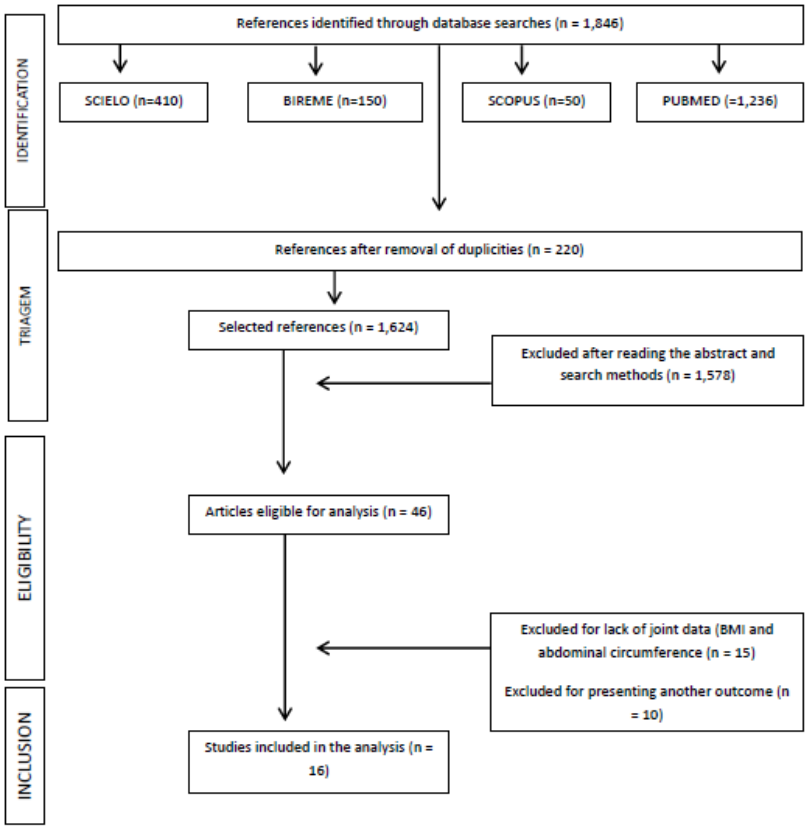

Fig.1: Diagram of bibliographic research adapted from PRISMA.

IV. DISCUSSION

The global data on obesity according to Costa, Brito and Lessa [24], show an increasing number of children and adults being overweight or really obese. The prevalence of obese individuals and overweight individuals may vary with age, sex, social classes and ethnicity. According to Sichieri et al. [25], about 50% of adults in the United States, Canada and some Western European countries have a BMI of 25 kg/m² or more.

Weight and height are essential for the evaluation of nutritional status, identifying a possible need or excess of calories and having to be analyzed according to age and sex [26].

An important feature of this method, according to Dos Anjos et al. [27], is that in individual conditions it is not necessarily associated with the amount of visceral fat, since it does not provide information on body composition. People with the same BMI may present different amounts of body fat, and consequently different risks of morbidities [28].

According to research conducted by Dos Anjos et al. [27], Berria et al. [31] found similar BMI values in prepubertal children (before puberty) of both sexes, but with a higher percentage of fats between them compared to BMI.

BMI is the most widely used method for verifying and validating obesity. This test is known as the Quetelet index, and its result comes from the weight divided by the height squared. This test according to Guedes and Guedes [26] and Pollock [32], is a way to establish the thresholds

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between malnutrition, healthy weight and different types of obesity.

However, there are some criticisms regarding the BMI test, according to authors such as Guedes and Guedes [26], Bouchard et al. [33] and Wipke-Tevis et al. [34], BMI is not able to distinguish central peripheral fat, nor does it differentiate lean mass from fat mass, thus overestimating obesity in athletic individuals. Therefore, according to Wipke-Tevis et al. [34], BMI is a means and not the end to diagnose obesity, that is, it is an important tool if associated with waist circumference.

Still, Guedes and Guedes [26] say that the information between weight and height are very useful in terms of growth and body composition, but should not be evaluated in isolation, since they are not enough data to answer questions about obesity and possible chronic diseases.

For Da Silva Pinto et al. [35] and Heremann et al. [36], affirm that in order to associate BMI with obesity, knowledge about the distribution and factors associated with obesity, especially the one located in the abdominal region, should be used, in order to contribute to the planning of interventions in order to prevent obesity and the associated factors.

A study on the abdominal obesity analysis of children and adolescents was developed in the municipality of Cascavel, Paraná. This study carried out several evaluations, among them BMI and waist circumference. In this study, the prevalence of abdominal obesity is close to 10%, and the factors associated with the outcome were school grade and nutritional status. Educational actions should be emphasized among school children, with special attention to those of Elementary School and with excess body weight [36].

In a study conducted by Dias et al. [37], evaluated abdominal fat and blood pressure in low-income students in the city of Santo André/SP. The waist measurement was directly related to the anthropometric indexes commonly used and did not work in the preschool age group as a predictor of cardiovascular risk, but was associated with obesity.

In a study by Teixeira et al. [21] evaluated the risk factors for the metabolic syndrome in schoolchildren aged 6 to 10 years. In the study they checked the circumference of the abdomen and BMI and verified that at least one risk factor was present in 61% (n = 308) of the sample.

Mihrshahi et al. [16], evaluated the obesity of Australian children and adolescents aged 5 to 16 years in the anthropometric variables BMI and waist circumference. In this study it can be verified that 15% of the evaluated ones were with the BMI classified as obese, and of these 80% were with the abdominal circumference classified as risk in developing cardiopathies.

The WHO points to obesity as one of the biggest public health problems in the world. It projected that, by 2025, about 2.3 billion adults would be overweight; and more than 700 million obese [38].

The Brazilian Association of Obesity (ABESO) warns about the number of overweight and obese children, according to their projections, in the world could reach 75 million if nothing is done. In Brazil, the values of obesity have been increasing in the population in a general way. Some surveys conducted by the Research Institutions (VIGITEL and ABESO) indicate that more than 50% of the population is overweight in the next 20 years. Among children, it would be around 15%. In the last official survey conducted by the IBGE between 2008/2009, we already noticed the growing movement of obesity [38].

V. CONCLUSION

According to the proposed objective, a total of 1,846 articles were initially collected with the proposed theme. However, when analyzing these studies it can be seen that some still use outdated or unreliable variables for the diagnosis of obesity and distribution of body fat in the school population.

Therefore, most of the studies are located in the area of collective health and indicate only the BMI isolated for diagnosis as evaluation measures. More recent studies indicate an evolution in the way of evaluating. Thus, it can be seen in the sixteen articles analyzed and in these studies the BMI is always related and compared to the waist circumference, to verify the nutritional aspects and possible cardiovascular risks.

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