Prevalence of Metabolic Syndrome in Brazilian Adults: A Systematic Review and Meta-Analysis of Published Studies

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Abstract

Background
A cluster of interconnected cardiometabolic risk factors characterizes metabolic Syndrome (MetS). The prevalence of MetS is increasing worldwide, but there is not a meta-analysis of this prevalence in the Brazilian population. We aimed to determine the prevalence of metabolic syndrome among adult general population in Brazil through a meta-analysis study.

Methods
Original research studies were searched at PubMed, Scopus, Web of Science, and SciELO databases, from 2011 to 2021. We used the Joanna Briggs Institute tool to assess the quality of included studies. The random effect model was used to estimate the pooled prevalence of MetS. Subgroup and meta-regression analysis were conducted for explored heterogeneity and used the Funnel Plot to assess publication bias. The study was performed based on the criteria of Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA).

Results
The search in electronic databases identified 1598 records. From this total, 26 studies were eligible to be included in the final analysis. The overall pooled prevalence among the general population of Brazil was 33% with high heterogeneity observed. By gender, the prevalences were 26% in males and 38% in females. By criteria that was used to define MetS, the prevalence were 31% in NCEP ATP III, 25% in JIS, 37% in IDF/NHLBI/AHA/WHF/IAS/IASO and 33% in IDF criteria. The prevalence in different habitat was 34% in urban, 15% in rural, 28% in quilombola and 37% in indigenous. In different regions was 37% in the South, 30% in Southeast, 38% in North, 31% in Northeast and 39% in Midwest. The pooled prevalence of MetS with age was <45 years: 43% and ≥45 years: 42% and the prevalence based on year of study implementation was 31% in 2015-2019, 35% in 2010-2014 and 28% in 2005-2009. There were no statistically significant differences between subgroups. Most of the studies showed high quality assessment criteria’s except adequate sample size criteria and many studies participants were not sampled in an appropriate way.

Conclusions
Our review indicates a high prevalence of MetS in the healthy Brazilian adult population, when compared to others countries and with a world estimate.

Background
Metabolic syndrome (MetS) is a complex disorder characterized by the association of cardiovascular risk factors and insulin resistance (1). The components that define MetS include hyperglycemia, hypertension, high triglyceride levels, low high density lipoprotein (HDL) cholesterol levels and abdominal obesity (2).

Most of these components are used as diagnostic criteria by some guidelines, such as the International Diabetes Federation (IDF) (3) and the National Cholesterol Education Program (Adult Treatment Panel III) (NCEP-ATPIII) (4), in addition to the World Health Organization (WHO) (5). Generally, studies that used more than one guideline to define the prevalence of MetS, observed a discrepancy in the results found (6, 7). This difference occurs because there are divergent points between the assessment factors used by each of the definitions (8). In the case of the WHO and the NCEP-ATPIII, for example, the main difference is that the former considers microalbuminuria and obesity to be diagnostic factors for the metabolic syndrome, and the NCEP-ATPIII requires that, among the components used for diagnosis, for a confirmation of a case of MetS, at least three are altered (9). Unlike the NCEP-ATPIII and IDF criteria, the WHO also considers the presence of type 2 diabetes mellitus (DM2) a mandatory factor for diagnosis which, probably, when compared with the other two methods, makes this one find a smaller number of MetS patients (10).

Regardless of the criteria used for diagnosis, it is well accepted that the prevalence of MetS is increasing at epidemic proportions in developed and developing countries (11). The global prevalence of this condition in the adult population is estimated at around 20 to 25% (12). In relation to Latin America, the general prevalence found was similar, around 24.9%, with a greater predominance of women and in the age group above 50 years old (13). In Brazil, the prevalence was estimated in 2013, in the adult population at around 28.9 and 29.6% (14).

MetS demands high expenses of the health system, in addition to causing considerable damage to the quality of life of patients, and is therefore considered a serious public health problem worldwide (15, 16). Thus, it emphasizes the importance of studies on the prevalence of the syndrome to assist in designing and directing measures to prevent the development of this condition. Several systematic reviews and meta-analyses on the prevalence of MetS have been published in various parts of the world (17–19). However, to date, no meta-analysis has evaluated this prevalence in Brazil. Therefore, our objective was to develop a systematic review and meta-analysis summarizing available epidemiological data on the prevalence of MetS among adults in the Brazilian population.

Methods
Data sources and searches
The present systematic review and meta-analysis was performed in accordance with the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) guidelines (20). The review has been registered at PROSPERO (www.crd.york.ac.uk/prospero/), registration number CRD42021241890. A literature search was carried out to identify prevalence of MetS in Brazilian adults. The studies were identified through systematically search at PubMed, Scopus, Web of Science, and SciELO, for relevant studies published before april 2021. The following keywords were used in combination: “metabolic syndrome” or
Syndrome X or MetS, and "prevalence," and "Brazil." No language restrictions were imposed. A manual review of the reference lists in each identified study was also conducted.

Study selection

The search was performed independently by three authors (LTSV, LSBS, and VASJ). This reviewers independently identified potentially eligible articles by performing an initial screen of titles and abstracts. All potentially relevant titles and abstracts were selected for full text examination. Any discrepancies among the reviewers were resolved through consensus. Then, the following inclusion criteria were applied: (1) original type studies (e.g., cohort study, cross sectional studies); (2) studies that were conducted among 18 years of age or older and reportedly healthy individuals of both sexes; (3) There were no restrictions geographic region (urban, rural) and (4) to define MetS, studies that used any defined criteria to determine the prevalence of MetS.

The exclusion criteria for our study were as follows: (1) the reviews and letters to the editors, (2) studies that used animal models or in vitro, (3) studies performed outside of Brazil, (4) the study population comprising individuals who were reported to have other health complications, (5) studies with incomplete information (6) or in a specific population.

Data extraction

The three investigators extracted the data independently. The following information collected from each study was: first author’s name, year of publication, gender, age range, city and region of study and area in which the study was carried out, population, study design, criteria for diagnosis of metabolic syndrome, and the prevalence of metabolic of syndrome and its components.

Quality of studies

Study quality was assessed independently and blindly by three reviewers using the Joanna Briggs Institute tool for cross-sectional studies (JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies) (21). This tool consists of a checklist of nine items, which determine the adequacy of the inclusion criteria; sample description; were study participants recruited in an appropriate way, was the sample size adequate, were the study subjects and setting described in detail, sufficient coverage of the identified sample, standardization of diagnostic criteria, reliability and validity of the results, use of adequate statistical analysis, and response rate adequate. The answer options were yes, no, unclear and not applicable. The divergences in the analysis were resolved by consensus.

Statistical analysis

The meta-analysis was performed using R software (R Foundation for Statistical Computing, Vienna, Austria, URL http://www.R-project.org, 2020). The prevalence of MetS reported in the selected studies among healthy Brazilian adult populations was analyzed based on different diagnostic criteria used. In each study, we extracted the total number of participants and the number of individuals with the outcome. If one of these data was not provided by the article, we obtained this value through the prevalence of metabolic syndrome.

We used random effect models to calculate pooled prevalence and 95% confidence intervals. Inter-study heterogeneity was explored quantitatively using Cochran's Q and $I^2$ tests (22). In this regard, an $I^2$ of 50% and 75% indicated substantial and considerable heterogeneity, respectively. We used the fixed effect for $I^2 < 50\%$ (low heterogeneity). We explored sources of heterogeneity by comparing MetS prevalence across subgroups defined by several study-level characteristics and meta-regression analyses. We assessed the presence of publication bias graphically using the funnel plot.

Results

The flow of the literature search is shown in Figure 1. An initial search of the electronic databases identified 1598 records. Overall, 1560 records were excluded that did not meet the inclusion criteria. Therefore, 38 studies were assessed for eligibility through full-text reading. Of these, 12 studies were excluded for consisting of specific population. Finally, 26 studies were selected for systematic review and meta-analysis.

Characteristics of the included studies

The characteristics of studies published between 2011 and 2021 on the prevalence of MetS in Brazil are included in Table 1. Most of the studies were performed in urban populations (6, 7, 23–36). One study was conducted only on female participants (27). Eight studies used the NCEP-ATP III criteria for diagnosing metabolic syndrome (27, 32, 33, 37–41); three the criteria of the IDF (28, 35, 36); ten studies used International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesit (IDF/NHLBI/AHA/WHF/IAS/ IASO) (23–25, 29–31, 34, 42–44); two studies used Joint Interim Statement (JIS) criteria for diagnosing (26, 45); one study used NCEP ATP III and IDF criteria (7); one study used modified NCEP, IDF and JIS criteria for diagnosing MetS (6); one study did not make clear which criteria it used for the diagnosis of MetS (46).
| Study and Year Published | Age Range | Sample Size (male/female) | City and region | Population | Study Design | Criteria for Diagnosis of SM | Overall Prevalence of SM (%) | Prevalence of Individual Components of SM (%) |
|--------------------------|-----------|---------------------------|-----------------|------------|--------------|-----------------------------|-------------------------------|----------------------------------------|
| Gouveia et al. 2021 (23) | 59.8 ± 19.7 | 910(341/569) | Fonte Boa, Apuí, and Manaus – Amazonas state | Adults and Older Adults – Urban | cross-sectional study | IDF/NHLBI/AHA/WHF/IASO IASO | 47.5 (39.6 men, 52.2 women) | Elevated waist circumference 56.1; High blood pressure 53.8; Elevated fasting glucose: 30 Low HDL cholesterol: 39.8; High triglyceride: 37.2 |
| Oliveira et al. 2020 (24) | 45.6 | 8199 | Pesquisa Nacional de Saúde de 2013 | Urban | analytical cross-sectional study | IDF/NHLBI/AHA/WHF/IASO IASO | 38.4 (34.6 men, 41.8 women) | Elevated waist circumference 65.5; High blood pressure 32.3; Elevated fasting glucose: N/A Low HDL cholesterol: 49.4; High triglyceride: N/A |
| Santos et al. 2020 (25) | 25 - 65 years | 818 (349/469) | Florianópolis, Santa Catarina state | Urban | population-based study | IDF/NHLBI/AHA/WHF/IASO IASO | 30.9 (36.1 men, 27.2 women) | Elevated waist circumference 50.1; High blood pressure 66.5; Elevated fasting glucose: 16 Low HDL cholesterol: 37.4; High triglyceride: 20.2 |

IDF/NHLBI/AHA/WHF/IASO IASO: International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity; IDF: International Diabetes Federation; JIS: Joint Interim Statement; NCEP-ATP III: National Cholesterol Education Program Adult Treatment Panel III; N/A: information not available.
| Study and Year Published | Age Range | Sample Size (male/female) | City and region | Population | Study Design | Criteria for Diagnosis of SM | Overall Prevalence of SM (%) | Prevalence of individual component of SM (%) |
|-------------------------|-----------|---------------------------|-----------------|------------|--------------|-----------------------------|-------------------------------|-------------------------------------|
| do Vale Moreira et al. 2020 (6) | ≥20 years | 714 (242/472) | Pindoretama, Ceará state | Urban population-based study | Modified NCEP, IDF and JIS | JIS = 36.1 | N/A |
| Moreira et al. 2020 (27) | 50.1 ± 5.5 | 419 (women) | Parnamirim - Rio Grande do Norte state | middle-aged women – Urban | cross-sectional study | NCEP ATP III | 65.6 | Elevated waist circumference 73.5; High blood pressures 60.9; Elevated fasting blood glucose: 16 Low HDL cholesterol: 63.0; High triglyceride: 40.8 |
| Carvalho et al. 2019 (26) | 23.9 years | 2017(946/1071) | Ribeirão Preto, São Paulo state | Urban | cross-sectional study | JIS | 12.2 (18.9 men; 6.3 women). | N/A |
| Luisi et al. 2019 (46) | ≥18 years | 193(74/119) | Tocantins state | Quilombola communities | observational cross-sectional study | N/A | 32.12 (17.6 men; 41.2 women) | Elevated waist circumference 58.0; High blood pressures: 4 Elevated fasting blood glucose 35.2; Low HDL cholesterol: High triglyceride 15.5 |

IDF/NHLBI/AHA/WH/IA/IASO: International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity; IDF: International Diabetes Federation; JIS: Joint Interim Statement; NCEP-ATP III: National Cholesterol Education Program Adult Treatment Panel III; N/A: information not available.
| Study and Year Published | Age Range | Sample Size (male/female) | City and region | Population | Study Design | Criteria for Diagnosis of SM | Overall Prevalence of SM (%) | Prevalence of individual component of SM (%) |
|-------------------------|-----------|---------------------------|-----------------|------------|--------------|-----------------------------|-----------------------------|---------------------------------|
| Mulatinho et al. 2019 (28) | 24 - 59 years | 375(118/257) | Fernando de Noronha Archipelago, Pernambuco state | Urban | Cross-sectional study | IDF | 11.97 (3.72 men, 8.24 women) | Elevated waist circumference 70.4; High blood pressure 0; Elevated fasting glucose: 19; Low HDL cholesterol: 21.01; High triglyceride: 19.68 |
| Mussi et al. 2019 (45) | 45 years | 842(325/517) | Guanambi, Bahia state | Quilombola communities | Cross-sectional population-based study | JIS | 25.8 (20.9 men, 28.8 women) | N/A |
| Ramires et al. 2018 (29) | ≥ 18 years | 59402 (25.920/33.482) | Brazilian Adult Population: National Health Survey – 2013 | Urban | Household-based cross-sectional | IDF/NHLBI/AHA/WHF/IAS/IASO | 8.9 (7.5 men, 10.3 women) | Elevated waist circumference 65.2; High blood pressure 40.7; Elevated fasting glucose: 7.1; HDL cholesterol: N/A; High triglyceride: N/A |

IDF/NHLBI/AHA/WHF/IAS/IASO: International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. IDF: International Diabetes Federation; JIS: Joint Interim Statement; NCEP-ATP III: National Cholesterol Education Program Adult Treatment Panel III; N/A: information not available.
| Study and Year Published | Age Range | Sample Size (male/female) | City and region | Population | Study Design | Criteria for Diagnosis of SM | Overall Prevalence of SM (%) | Prevalence of individual components of SM (%) |
|--------------------------|-----------|---------------------------|-----------------|------------|-------------|-------------------------------|--------------------------------|---------------------------------|
| França et al. 2016 (30)  | 42.2 ± 16.3 | 787 (188/599)             | Marajó Archipelago, Para state | Urban      | cross-sectional population-based | IDF/NHLBI/AHA/WHF/IAS/IASO    | 34.1 (29.8 men, 35.4 women)   | Elevated waist circumference 55.3; High blood pressure 47.6; Elevated fasting blood glucose: 24 |
| Bortolotto et al. 2016 (31) | 54.5 ± 10.3 | 959 (426/533)             | Cambé, Paraná state | ≥40 years adults - Urban | cross-sectional population-based | IDF/NHLBI/AHA/WHF/IAS/IASO    | 53.7 (48.4 men, 58 women)     | N/A                              |
| Soares et al. 2015 (42)  | 42.7 ± 19.1 | 932 (457/475)             | Indian reservations, Mato Grosso state | Xavante indigenous | cross-sectional study | IDF/NHLBI/AHA/WHF/IAS/IASO    | 66.1 (55.6 men, 76.2 women)   | Elevated waist circumference 92.6; High blood pressure 41.4; Elevated fasting blood glucose: 76 Low HDL cholesterol: 86.6; High triglyceride: 71.15 |

IDF/NHLBI/AHA/WHF/IAS/IASO: International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; Ar Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesit; IDF: International Diab Federation; JIS: Joint Interim Statement; NCEP-ATP III: National Cholesterol Education Program Adult Treatment Panel III; N/A: information not available.
| Study and Year Published | Age Range | Sample Size (male/female) | City and region | Population | Study Design | Criteria for Diagnosis of SM | Overall Prevalence of SM (%) | Prevalence of individual component of SM (%) |
|-------------------------|------------|--------------------------|----------------|------------|-------------|-----------------------------|-----------------------------|-------------------------------------|
| Martini et al. 2014 (32) | ≥ 20 years | 1112(468/644) | Ourinhos, São Paulo state | Urban | observational cross-sectional study | NCEP ATP III | 24.1 (27.8 men, 20.3 women) | Elevated waist circumference | 36.7; High blood pressure | 46.2; Elevated fasting glucose: 13 |
| Moreira et al. 2014 (33) | 55.0 ± 14.7 | 1369(667/702) | Population in Brazil | Urban | cross-sectional, population-based study | NCEP ATP III | 22.7 (23.3 men, 22.7 women) | N/A |
| Pimenta et al. 2013 (37) | ≥ 18 years | 491 (246/245) | Virgem das Graças and Caju, in the rural areas of the municipalities of Ponto dos Volantes and Jequitinhonha, respectively, Minas Gerais state | Rural | cross-sectional population-based | NCEP ATP III | 14.9 (6.5 men, 23.3 women) | Elevated waist circumference | 11.6; High blood pressure | 59.7; Elevated fasting glucose: 10 |
| da Rocha et al. 2013 (38) | 55.5±13.23 | 73 (23/50) | Village Pinhalzinho located at Planalto/Nonoai City, Rio Grande do Sul state | Kaingang indigenous | cross-sectional descriptive and analytical study | NCEP ATP III | 23.3 (47.1 men, 52.9 women) | N/A |
| Dutra et al. 2012 (34) | ≥ 18 years | 2130 (586/1544) | Brasilia, Federal District | Urban | cross-sectional, population-based study | IDF/NHLBI/AHA/WHF/IAS/ IASO | 32 (30.9 men, 33 women) | N/A |

IDF/NHLBI/AHA/WHF/IAS/ IASO: International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; Ar Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesit; IDF: International Diabetes Federation; JIS: Joint Interim Statement; NCEP-ATP III: National Cholesterol Education Program Adult Treatment Panel III; N/A: information not available.
| Study and Year Published | Age Range | Sample Size (male/female) | City and region | Population | Study Design | Criteria for Diagnosis of SM | Overall Prevalence of SM (%) | Prevalence of individual component of SM (%) |
|--------------------------|-----------|---------------------------|----------------|------------|--------------|-----------------------------|-----------------------------|--------------------------------|
| Santos et al. 2012 (43) | 38±14.8   | 162 (98/64)               | Medial region of the Xingu Indigenous Park, Mato Grosso state | Khisédjê indigenous | cross-sectional study | IDF/NHLBI/AHA/WHF/IAS/IASO | 27.8 (19.4 men, 40.6 women) | Elevated waist circumference High blood press 6.8; Elevated fasting blood glucose: 12 Low HDL cholesterol: 66.2; High triglyceride: 43.5 |
| Gomes et al. 2012 (35)  | 57 ± 16   | 131 (54/77)               | Community of Mombuca/Guatapara, São Paulo state | Japanese-Brazilian - Urban | cross-sectional study | IDF | 35.8 (36.2 men, 63.8 women) | Elevated waist circumference; High blood pressure 46.6; Elevated fasting blood glucose: N/A; Low HDL cholesterol: 44.3; High triglyceride: 26.7 |
| Gronner et al. 2011 (7) | 30 – 79 years | 1116 (396/720) | São Carlos, São Paulo state | Urban | cross-sectional population-based study | NCEP-ATP III and IDF | ATP III 40.5 (36.1 men; 42.9 women) IDF 48.1 (49.2 men; 47.5 women) | Elevated waist circumference | 56.2 (NCEP and IDF criteria); High blood pressure 59.2; Elevated fasting blood glucose: 13 Low HDL cholesterol: 76.3; High triglyceride: 16.8 |

IDF/NHLBI/AHA/WHF/IAS/IASO: International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; Ar Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesit; IDF: International Diabetes Federation; JIS: Joint Interim Statement; NCEP-ATP III: National Cholesterol Education Program Adult Treatment Panel III; N/A: information not available.
| Study and Year Published | Age Range | Sample Size (male/female) | City and region | Population | Study Design | Criteria for Diagnosis of SM | Overall Prevalence of SM (%) | Prevalence of individual component of SM (%) |
|-------------------------|-----------|--------------------------|-----------------|------------|--------------|-----------------------------|-----------------------------|---------------------------------------------|
| da Rocha et al. 2011 (39) | ≥40 years | 150(67/83) | Porto Alegre e Planalto/Nonoai, Rio Grande do Sul state | Kaingang e Guarani indigenous | cross-sectional, descriptive and analytical | NCEP-ATP III | 65.3 (40.3 men / 85 women) | Elevated waist circumference 87.6; High blood pressure 82.5; Elevated fasting blood glucose: 86; Low HDL cholesterol: 72.3; High triglyceride: 85.5 |
| Oliveira et al. 2011 (44) | 36 ± 1 | 606 (268/338) | Jaguapiru village, Dourados, Mato Grosso do Sul state | Indigenous population | cross-sectional study | IDF/NHLBI/AHA/WHF/IAS/IASO | 35.7 (26.1 men / 43.4 women) | Elevated waist circumference 60.9; High blood pressure: 40.3; Elevated fasting blood glucose: 11; Low HDL cholesterol: N/A; High triglyceride: N/A |

IDF/NHLBI/AHA/WHF/IAS/IASO: International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; Ar Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesit; IDF: International Diabetes Federation; JIS: Joint Interim Statement; NCEP-ATP III: National Cholesterol Education Program Adult Treatment Panel III; N/A: information not available.
| Study and Year Published | Age Range | Sample Size (male/female) | City and region | Population | Study Design | Criteria for Diagnosis of SM | Overall Prevalence of SM (%) | Prevalence of individual components of SM (%) |
|--------------------------|-----------|---------------------------|-----------------|------------|-------------|------------------------------|------------------------------|-----------------------------------|
| Anjos et al. 2011 (40)   | 32 years  | 82(33/49)                 | Cândido de Abreu, state Paraná | Kaingang Indigenous | cross-sectional study | NCEP-ATP III | 11 (0 men, 18.4 women) | Elevated waist Circumference 37.8; High blood pressures: |
|                          |           |                           |                 |            |             |                              |                              | 26.8; Elevated fasting glucose: 9.4 |
|                          |           |                           |                 |            |             |                              |                              | Low HDL cholesterol: 13.4; High triglycerides: 11 |
| Silva et al. 2011 A (36) | 20 – 64 years | 287 (73/214)              | Metropolitan region of Sao Paulo, Sao Paulo state | Urban | descriptive and analytical study | IDF | 36.6 | N/A |
| Silva et al. 2011 B (41) | N/A       | 246 (91/155)              | Inhaumas, district of Santa Maria da Vitória, Bahia state | Rural | cross-sectional study | NCEP-ATP III | 15.4 (11.9 men, 17.5 women) | N/A |

IDF/NHLBI/AHA/WHF/IAS/IASO: International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. IDF: International Diabetes Federation; JIS: Joint Interim Statement; NCEP-ATP III: National Cholesterol Education Program Adult Treatment Panel III; N/A: Information not available.

The studies selected in this systematic review comprised 84,522 subjects, 57.5% of whom were women and 42.5% men. The prevalence of metabolic syndrome is reported by all the studies ranged from 8.9–66.1%. Most of the studies where participants were both male and female, reported prevalence data for all but also for males and females separately. Many studies presented prevalence of individual components of MetS (7, 23–25, 27–30, 32, 35, 37, 39, 40, 42–44, 46); The component with the highest prevalence was waist circumference (WC) (23, 24, 27–29, 39, 40, 42, 44, 46) followed by blood pressures (25, 32, 37).

General prevalence of MetS and analysis based on the gender of study participants

To calculate the general prevalence, a meta-analysis was performed with the 26 studies that reported the prevalence of MetS in Brazilian adults, using the random effects model. The general prevalence estimate was 33% (95% CI: 0.27; 0.39). There was a large amount of heterogeneity in the prevalence of metabolic syndrome ($I^2=99.56\%$; Cochran Q-statistic $p < 0.01$; Fig. 2). In the funnel graph, there is an asymmetry, which suggests a possible publication bias (Fig. 3).
The prevalence of MetS in female and male was respectively 38% (95% CI: 0.31; 0.46) and 26% (95% CI: 0.20; 0.32). However, there was no statistical difference between the two groups. There was significant heterogeneity ($I^2 = 99.48$%; Cochran Q-statistic $p < 0.01$; Fig. 4) in the prevalence of MetS in females and in male ($I^2 = 98.60$%; Cochran Q-statistic $p < 0.01$; Fig. 5).

Subgroup analysis

Subgroup analysis based on criteria used to define metabolic syndrome

Studies that used the NCEP-ATP III criteria to define MetS had the pooled prevalence of metabolic syndrome of 31% [95% CI: 0.18; 0.45] with high heterogeneity ($I^2 = 99.20$%; Cochran Q-statistic $p < 0.01$; Fig. 6). The pooled prevalence of metabolic syndrome of studies that used JIS criteria to diagnose metabolic syndrome was 25% [95% CI: 0.11; 0.38] with high heterogeneity ($I^2 = 98.81$%; Cochran Q-statistic $p < 0.01$). The weighted pooled prevalence of metabolic syndrome of studies that used IDF/NHLBI/AHA/WHF/IAS/IASO criteria was 37% [95% CI: 0.27; 0.47], with high heterogeneity ($I^2 = 99.71$%; Cochran Q-statistic $p < 0.01$). The prevalence of MetS in studies that used the IDF criteria was 33% [95% CI: 0.22; 0.45], with high heterogeneity ($I^2 = 97.65$%; Cochran Q-statistic $p < 0.01$) There was not statistically significant difference between studies based on diagnostic criteria ($p = 0.71$). In addition, there was high heterogeneity in prevalence estimates across studies (all heterogeneity $p < 0.01$).

Subgroup analysis based on habitat of study participants

The pooled prevalence of MetS in the population living in urban, rural, quilombola and indigenous areas were respectively (34% 95% CI: 0.27; 0.40), (15, 95% CI: 0.12; 0.18), (28%, 95% CI: 0.22; 0.34), and (37%, 95% CI: 0.19; 0.56). There was high heterogeneity in studies: in urban area ($I^2 = 99.59$%; Cochran Q-statistic $p < 0.01$; Fig. 7), in quilombola area ($I^2 = 66.37$%; Cochran Q-statistic $p < 0.01$) and in indigenous area ($I^2 = 98.62$%; Cochran Q-statistic $p < 0.01$). There was not statistically significant difference between studies based on habitat ($p = 0.36$). In addition, there was high heterogeneity in prevalence estimates across studies ($p < 0.01$).

Subgroup analysis based on Brazilian regions of study participants

The pooled prevalence of MetS in the Brazilian population in the South, Southeast, North, Northeast and Midwest regions were respectively (37%, 95% CI: 0.17; 0.56), (30%, 95% CI: 0.20; 0.30), (38%, 95% CI: 0.29; 0.48), (31%, 95% CI: 0.18; 0.44) and (39%, 95% CI: 0.22; 0.57). There was high heterogeneity in South region ($I^2 = 98.72$%; Cochran Q-statistic $p < 0.01$; Fig. 8), in Southeast region, ($I^2 = 98.86$%; Cochran Q-statistic $p < 0.01$), North region ($I^2 = 94.02$; Cochran Q-statistic $p < 0.01$); in Northeast region, ($I^2 = 99.25$%; Cochran Q-statistic $p < 0.01$) and in Midwest regions ($I^2 = 99.14$; Cochran Q-statistic $p < 0.01$). There was not statistically significant difference between studies based on regions ($p = 0.87$). In addition, there was high heterogeneity in prevalence estimates across studies ($p < 0.01$).

Subgroup analysis based on age of study participants

The pooled prevalence of MetS among studies with participants 45 years of age or older was 42% [95% CI: 0.30; 0.53] with high heterogeneity ($I^2 = 98.88$%; Cochran Q-statistic $p < 0.01$; Fig. 9). The studies that the participants had less than 45 years old, the pooled prevalence of MetS was 43% [95% CI: 0.19; 0.66], with high heterogeneity ($I^2 = 99.03$%; Cochran Q-statistic $p < 0.01$). There was not statistically significant difference between studies based on age of participants ($p = 0.92$). In addition, there was high heterogeneity in prevalence estimates across studies ($p < 0.01$).

Subgroup analysis based on year of study implementation

The pooled prevalence of MetS among the studies that was implementation in 2015-2019 was 31% [95% CI: 0.19; 0.43] with high heterogeneity ($I^2 = 99.39$%; Cochran Q-statistic $p < 0.01$; Fig. 10). The studies that were implementation in 2010-2014 presented the prevalence of metabolic syndrome in 35% [95% CI: 0.25; 0.46] with high heterogeneity ($I^2 = 99.55$%; Cochran Q-statistic $p < 0.01$). The studies that were implementation in 2005-2009, weighted pooled prevalence of metabolic syndrome was 28% [95% CI: 0.20; 0.36], with high heterogeneity ($I^2 = 98.35$%; Cochran Q-statistic $p < 0.01$). There was not statistically significant difference between studies based on year of study implementation ($p = 0.82$). In addition, there was high heterogeneity in prevalence estimates across studies ($p < 0.01$).

Meta-regression analyses

To assess the sources of heterogeneity, we performed a meta-regression. In these analyses, age and year of implementation variables were not significantly associated with heterogeneity ($p = 0.73$, $p = 0.62$, respectively).

Analysis of quality of studies

The quality of the studies was assessed according to the set of criteria based on JBI guidance and are summarized in Table 2. A set of nine criteria was used to assess the quality of the studies. The sample frame was appropriate to address a target population in almost all articles with one exception (32). Fourteen study participants were sampled appropriately (6, 7, 24, 25, 28–31, 33, 34, 36, 40, 44, 45). The sample size was adequate in 19 studies (6, 7, 23, 24, 26–29, 31–33, 37, 38, 41–46). Study subjects and setting was described in detail in all articles. The data analysis was conducted with sufficient coverage of the identified sample in 77% studies (6, 7, 23, 24, 26, 27, 29, 31–33, 35, 37, 39–46). Valid methods were used of identify of the condition in almost all articles with one exception (46). The condition was measured in a standard and reliable way for all participants and there was an appropriate statistical analysis in all the studies. The response rate was adequate and, if not, the low response rate was adequately managed in almost all articles with two exceptions (31, 44).
| Study                          | 1- Was the sample frame appropriate to address the target population? | 2- Were study participants sampled in an appropriate way? | 3- Was the sample size adequate? | 4- Were the study subjects and the setting described in detail? | 5- Was the data analysis conducted with sufficient coverage of the identified sample? | 6- Were valid methods used for the identification of the condition? | 7- Was the condition measured in a standard, reliable way for all participants? | 8- Was there appropriate statistical analysis? | 9- Was the response rate adequate, and if not, was the low response rate managed appropriately? |
|-------------------------------|---------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------|---------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------|
| Gouveia et al. 2021 (23)      | Yes                                                                 | No                                                       | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Oliveira et al. 2020 (24)     | Yes                                                                 | Yes                                                      | Yes                               | Yes                                                             | Unclear                                                                         | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Santos et al. 2020 (25)       | Yes                                                                 | Yes                                                      | No                                | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| do Vale Moreira et al. 2020 (6) | Yes                                                                 | Yes                                                      | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Moreira et al. 2020 (27)      | Yes                                                                 | No                                                       | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Carvalho et al. 2019 (26)     | Yes                                                                 | Unclear                                                 | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Luisi et al. 2019 (46)        | Yes                                                                 | No                                                       | Yes                               | Yes                                                             | Yes                                                                              | No                                                                               | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Mulatinho et al. 2019 (28)    | Yes                                                                 | Yes                                                      | Yes                               | No                                                              | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Mussi et al. 2019 (45)        | Yes                                                                 | Yes                                                      | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Ramires et al. 2018 (29)      | Yes                                                                 | Yes                                                      | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| França et al. 2016 (30)       | Yes                                                                 | Yes                                                      | No                                | Yes                                                             | No                                                                               | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Bortoletto et al. 2016 (31)   | Yes                                                                 | Yes                                                      | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | No                                                                               |
| Soares et al. 2015 (42)       | Yes                                                                 | Unclear                                                 | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Martini et al. 2014 (32)      | No                                                                  | No                                                       | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Moreira et al. 2014 (33)      | Yes                                                                 | Yes                                                      | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Pimenta et al. 2013 (37)      | Yes                                                                 | Unclear                                                 | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| da Rocha et al. 2013 (38)     | Yes                                                                 | No                                                       | Yes                               | No                                                              | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Dutra et al. 2012 (34)        | Yes                                                                 | Yes                                                      | No                                | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
| Santos et al. 2012 (43)       | Yes                                                                 | Unclear                                                 | Yes                               | Yes                                                             | Yes                                                                              | Yes                                                                              | Yes                                                                                 | Yes                                                             | Yes                                                                              |
studies demonstrate that some studies may have publication bias, which corroborates with evident asymmetry on the funnel plot. Furthermore, some studies did not present sufficient coverage of the identified sample for data analysis. These criteria for evaluating the quality of study quality assessment shows that in many studies participants were not sampled in an appropriate way and the sample size was inadequate, which is a concern. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this connection with MetS.

Discussion

We have conducted this review including studies performed in the last decade to obtain a comprehensive estimate of burden of MetS in Brazilian adult population. In total, we analysed data from 26 studies that involved 84,522 participants. We have also captured the gender distribution, habitat differences, geographical region, criteria used to define metabolic syndrome, age of study participants and year of the study implementation estimates to find any significant difference in the estimates of MetS. Our meta-analysis revealed that the pooled estimate of MetS prevalence among subjects in Brazil was 33%. This estimate was higher than the prevalence of 29.6% observed in Brazil in 2013 and approached the worldwide prevalence of 20–25% (3, 14). The prevalence was also higher than that found in Malaysia (27.5%) (47), in the Philippines (19.7%) (48), Bangladesh (30.0%) (19) and Nigeria, whose prevalence was 31.7%, 27.9% and 28.1%, according to the definitions of WHO, ATPIII and IDF, respectively (49). The prevalence was also higher than that found in Malaysia (27.5%) (47), in the Philippines (19.7%) (48), Bangladesh (30.0%) (19) and Nigeria, whose prevalence was 31.7%, 27.9% and 28.1%, according to the definitions of WHO, ATPIII and IDF, respectively (49). The prevalence was also higher than that found in Malaysia (27.5%) (47), in the Philippines (19.7%) (48), Bangladesh (30.0%) (19) and Nigeria, whose prevalence was 31.7%, 27.9% and 28.1%, according to the definitions of WHO, ATPIII and IDF, respectively (49). The prevalence was also higher than that found in Malaysia (27.5%) (47), in the Philippines (19.7%) (48), Bangladesh (30.0%) (19) and Nigeria, whose prevalence was 31.7%, 27.9% and 28.1%, according to the definitions of WHO, ATPIII and IDF, respectively (49). The prevalence was also higher than that found in Malaysia (27.5%) (47), in the Philippines (19.7%) (48), Bangladesh (30.0%) (19) and Nigeria, whose prevalence was 31.7%, 27.9% and 28.1%, according to the definitions of WHO, ATPIII and IDF, respectively (49). The prevalence was also higher than that found in Malaysia (27.5%) (47), in the Philippines (19.7%) (48), Bangladesh (30.0%) (19) and Nigeria, whose prevalence was 31.7%, 27.9% and 28.1%, according to the definitions of WHO, ATPIII and IDF, respectively (49). The prevalence was also higher than that found in Malaysia (27.5%) (47), in the Philippines (19.7%) (48), Bangladesh (30.0%) (19) and Nigeria, whose prevalence was 31.7%, 27.9% and 28.1%, according to the definitions of WHO, ATPIII and IDF, respectively (49).

This study demonstrated increased waist circumference as the most frequent individual component of metabolic syndrome, and high blood pressure was shown the second most prominent metabolic syndrome component. The increased prevalence of abdominal obesity and high blood pressure on Brazilian population can have numerous causes. A study, with data from three cohorts, revealed that WC can predict the deterioration of other MetS components, indicating that visceral obesity plays a central role in the development of the syndrome (55). In addition, the prevalence of MetS components varied greatly from one country to another. Overall, the component-weighted mean showed low HDL cholesterol as the most frequent component (62.9%), followed by hypertriacylglycerolemia (46.7%).

Environmental factors related to lifestyle, such as physical inactivity, unbalanced food and stress and are closely linked with higher prevalence of obesity and especially for the accumulation of adipose tissue in the abdominal region, tissue directly involved in the genesis of insulin resistance, which is a possible connection with MetS. The decrease in insulin action in tissues, such as adipose tissue, leads to an increase in the inflammatory process, which induces this resistance. As a consequence, the accumulation of visceral adipose tissue in the body generating a high-risk cardiometabolic condition (56). In addition, insulin promotes renal sodium reabsorption and, in hyperinsulinemic conditions, an exacerbation of this action is expected. In fact, comparing individuals with and without MetS, it was observed that patients with the syndrome had significantly greater proximal sodium reabsorption, which can cause hypertension (57).

Study quality assessment shows that in many studies participants were not sampled in an appropriate way and the sample size was inadequate, which is a concern. Furthermore, some studies did not present sufficient coverage of the identified sample for data analysis. These criteria for evaluating the quality of studies demonstrate that some studies may have publication bias, which corroborates with evident asymmetry on the funnel plot.

| Study | 1- Was the sample frame appropriate to address the target population? | 2- Were study participants sampled in an appropriate way? | 3- Was the sample size adequate? | 4- Were the study subjects and the setting described in detail? | 5- Was the data analysis conducted with sufficient coverage of the identified sample? | 6- Were valid methods used for the identification of the condition? | 7- Was the condition measured in a standard, reliable way for all participants? | 8- Was there appropriate statistical analysis? | 9- Was the response rate adequate, and if not, was the low response rate managed appropriately? |
|-------|-----------------------------------------------------------------------|------------------------------------------------------|---------------------------------|---------------------------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Gomes et al. 2012 (35) | Yes | Unclear | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Gronner et al. 2011 (7) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| da Rocha et al. 2011 (39) | Yes | Unclear | Unclear | Yes | Yes | Yes | Yes | Yes | Yes |
| Oliveira et al. 2011 (44) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No |
| Anjao et al. 2011 (40) | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Silva et al. 2011 A (36) | Yes | Yes | No | Yes | No | Yes | Yes | Yes | Yes |
| Silva et al. 2011 B (41) | Yes | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
We observed considerable heterogeneity among the included studies to estimate the prevalence of MetS in the Brazilian adult population. Prevalence of metabolic syndrome was the same in males and females, remaining with high heterogeneity. The wide variation in the prevalence of MetS among populations in Brazil can be attributed to heterogeneity among the included studies. The country, in addition to being continental in size, has great epidemiology, demographic and socio-economic variability and multicultural characteristics, which makes the population very diverse, making it difficult to generalize the findings of this study in Brazil.

The subgroup analysis based on habitat, geographical region, criteria, age and year of study implementation was conducted in order to try to overcome this limitation. However, heterogeneity remained even after these subgroup analysis. Hence, we tried to explain the between-study variabiity using meta-regression and found the potential sources of heterogeneity. However, meta-regression analyses did not indicate enough factors to explain the observed heterogeneity. We suggest that other factors such as lifestyle, alcohol and tobacco consumption, stress, diet and physical inactivity may influence MetS heterogeneity. Furthermore, the small number of studies in some regions of Brazil did not allow for a more robust analysis of the prevalence in these areas.

Other studies that assessed the prevalence of MetS in different countries also observed high heterogeneity among their data. Meta-analyses performed with data from the general population of Bangladesh (19), Iran (53), China (58), Middle East (59) and Mexico (18) showed heterogeneity greater than 90%. The study carried out in Bangladesh identified that the main source of heterogeneity was the geographical area of the population. In the study conducted in China, the age of participants was associated with lack of homogeneity. In Mexico, the diagnostic criteria used were significantly associated with the heterogeneity. However, as in our work, the studies carried out in Iran and the Middle East, after performing analyzes by subgroups such as habitat, genus and diagnostic criteria, it was not possible to identify the source of this heterogeneity.

Like other studies, this our systematic review and meta-analysis study has some limitations, like there is no uniformity of metabolic syndrome definitions, age groups, waist circumference and hyperglycemia cut-offs, and study settings in the studies included in the present review, resulting in limitations in comparability. Furthermore, we could not estimate the role of important risk factors on MetS such as physical activity and diet, since the studies included had not measured the effects of these factors. This review, we conduct some subgroup analyzes with limited data, such as MetS prevalence based on age of participants, because many included studies did not present this information.

The major strength of the study is that we have tried to provide the first review with metaanalyses on burden of MetS among adult population in Brazil. In addition, the strength is the comprehensiveness of the process, which included a search of four different databases, well-defined inclusion/exclusion criteria, and extensive use of reference lists.

**Conclusion**

This systematic review and meta-analysis evaluated the scientific literature on the prevalence of metabolic syndrome in Brazil. Our review indicates a high prevalence of MetS in the healthy Brazilian adult population, when compared to numerous countries and with a world estimate. Furthermore, the high prevalence remained when we subdivided the data according to different criteria, such as diagnostic, gender, age and geographic area of subjects studied, which suggests urgent attention from both the clinical and public health viewpoint. Information on how MetS and its components are distributed could provide a great deal of insight into MetS and assist in the planning and implementation of future prevention and control programmes.

**Abbreviations**

AHA: American Heart Association; BMI: Body mass index; DM2 type 2 diabetes mellitus; HDL: High density lipoprotein; IDF: International Diabetes Federation; MetS: Metabolic syndrome; IAS: International Atherosclerosis Society; IASO: International Association for the Study of Obesit; JBI: Joanna Briggs Institute; JIS: Joint Interim Statement; NCEP-ATP III: National Cholesterol Education Program Adult Treatment Panel III; NHLBI: National Heart, Lung, and Blood Institute; PRISMA: Preferred Reporting Items for Systematic Review and Meta-analysis; WC: Waist circumference; WHF: World Heart Federation; WHO: World Health Organization.

**Declarations**

**Ethics approval and consent to participate**

Not Applicable.

**Consent for publication**

Not Applicable.

**Availability of data and materials**

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

**Competing interests**

The authors declare that they have no competing interests
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Authors’ contributions

MS directed the present study. LTSV, LSBS, VASJ, LFB, LRM and MS contributed to the study concept and design. LTSV, LSBS, VASJ and MS helped with article searches, review and selection. LTSV, LSBS, VASJ, LFB, LRM and MS performed the analysis and interpreted the results. LFB, LRM and MS contributed drafting the manuscript. LFB, LRM and MS worked as methodological advisors. All authors revised it critically for important intellectual content, read and approved the final manuscript.

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Figures
Figure 1

Flow diagram of studies included in the systematic review
| Authors and year                | Weight(%) | Proportion [95% C]  |
|--------------------------------|------------|---------------------|
| Gouveia et al, 2021            | 3.46%      | 0.47 [0.44, 0.51]   |
| Oliveira et al, 2020           | 3.52%      | 0.38 [0.37, 0.39]   |
| Santos et al, 2020             | 3.46%      | 0.31 [0.28, 0.34]   |
| do Vale Moreira et al, 2020*   | 3.47%      | 0.36 [0.33, 0.40]   |
| do Vale Moreira et al, 2020**  | 3.46%      | 0.35 [0.32, 0.39]   |
| do Vale Moreira et al, 2020*** | 3.48%      | 0.30 [0.26, 0.33]   |
| Carvalho et al, 2019           | 3.51%      | 0.12 [0.11, 0.14]   |
| Moreira et al, 2019            | 3.45%      | 0.66 [0.61, 0.70]   |
| Luisi et al, 2019              | 3.37%      | 0.32 [0.26, 0.39]   |
| Mulatimbo et al, 2019          | 3.46%      | 0.12 [0.08, 0.15]   |
| Mussi et al, 2019              | 3.49%      | 0.26 [0.23, 0.29]   |
| Ramires et al, 2018            | 3.52%      | 0.09 [0.09, 0.09]   |
| Franca et al, 2016             | 3.48%      | 0.34 [0.31, 0.37]   |
| Bortoleto et al, 2016          | 3.48%      | 0.54 [0.51, 0.57]   |
| Soares et al, 2015             | 3.49%      | 0.66 [0.63, 0.69]   |
| Martini et al, 2014            | 3.50%      | 0.24 [0.22, 0.27]   |
| Moreira et al, 2014            | 3.50%      | 0.23 [0.20, 0.25]   |
| Pimenta et al, 2013            | 3.48%      | 0.15 [0.12, 0.18]   |
| Da Rocha et al, 2013           | 3.21%      | 0.23 [0.20, 0.25]   |
| Dutra et al, 2012              | 3.51%      | 0.32 [0.30, 0.34]   |
| Santos et al, 2012             | 3.35%      | 0.28 [0.21, 0.35]   |
| Gomes et al, 2012              | 3.29%      | 0.36 [0.28, 0.44]   |
| Gronner et al, 2011***         | 3.49%      | 0.48 [0.45, 0.51]   |
| Gronner et al, 2011****        | 3.46%      | 0.41 [0.38, 0.43]   |
| da Rocha et al, 2011           | 3.32%      | 0.65 [0.58, 0.73]   |
| de Oliveira et al, 2011        | 3.47%      | 0.31 [0.27, 0.35]   |
| Anjos et al, 2011              | 3.36%      | 0.11 [0.04, 0.18]   |
| Silva et al, 2011A             | 3.41%      | 0.37 [0.31, 0.42]   |
| Silva et al, 2011B             | 3.45%      | 0.15 [0.11, 0.20]   |

**Random effects model**

heterogeneity: $Q = 8802.90, df = 28, p < .01, I^2 = 99.50\%$

Figure 2

Forest plot of prevalence of metabolic syndrome in Brazilian population. * prevalence according to the JIS criteria, ** prevalence according to the IDF criteria, *** prevalence according to the modified NCEP-ATPIII criteria and **** prevalence according to the NCEP-ATPIII criteria.
Figure 3

Forest plot of prevalence of metabolic syndrome in adult males in Brazilian population.
Figure 4

Forest plot of prevalence of metabolic syndrome in adult females in Brazilian population.
Figure 5

Forest plot of prevalence according criteria used to define metabolic syndrome in Brazilian population. * prevalence according to the JIS criteria, ** prevalence according to the IDF criteria and **** prevalence according to the NCEP-ATPIII criteria.
Figure 6

Forest plot of prevalence of metabolic syndrome according habitat of study participants in Brazilian population. * prevalence according to the JIS criteria, ** prevalence according to the IDF criteria, *** prevalence according to the modified NCEP_ATPIII criteria and **** prevalence according to the NCEP-ATPIII criteria.
Figure 7

Forest plot of prevalence of metabolic syndrome according regions of study participants in Brazilian population. * prevalence according to the JIS criteria, ** prevalence according to the IDF criteria, *** prevalence according to the modified NCEP_ATPIII criteria and **** prevalence according to the NCEP_ATPIII criteria.
Figure 8

Forest plot of prevalence of metabolic syndrome according age of study participants in Brazilian population. * prevalence according to the JIS criteria, ** prevalence according to the IDF criteria, *** prevalence according to the modified NCEP_ATPIII criteria and **** prevalence according to the NCEP_ATPIII criteria.
Figure 9

Forest plot of prevalence of metabolic syndrome according year of study implementation in Brazilian population.

### Authors and year

**>=45 years**

| Authors         | Weight(%) | Proportion [95% CI] |
|-----------------|-----------|---------------------|
| Gomes et al. 2012 | 9.59%     | 0.36 [0.28, 0.44]   |
| Da Rocha et al. 2013 | 9.34%     | 0.23 [0.14, 0.33]   |
| Bortolotto et al. 2016 | 10.18%    | 0.54 [0.51, 0.57]   |
| Mussi et al. 2019 | 10.20%    | 0.26 [0.23, 0.29]   |
| Moreira et al. 2019 | 10.07%    | 0.66 [0.61, 0.70]   |
| Oliveira et al. 2020 | 10.28%    | 0.38 [0.37, 0.39]   |
| Gouveia et al. 2021 | 10.16%    | 0.47 [0.44, 0.51]   |

RE Model for Subgroup: $Q = 325.25, df = 6, p < 0.01, i^2 = 98.88\%$

**<45 years**

| Authors         | Weight(%) | Proportion [95% CI] |
|-----------------|-----------|---------------------|
| Santos et al. 2012 | 9.79%     | 0.28 [0.21, 0.35]   |
| Soares et al. 2015 | 10.19%    | 0.66 [0.63, 0.69]   |
| Franca et al. 2016 | 10.17%    | 0.34 [0.31, 0.37]   |

RE Model for Subgroup: $Q = 236.16, df = 2, p < 0.01, i^2 = 99.03\%$

RE Model for All Studies: $Q = 622.35, df = 9, p < 0.01, i^2 = 99.96\%$

Test for Subgroup Differences: $Q_{int} = 0.01$, df = 1, p = 0.92

![Forest plot](image-url)
Figure 10

Funnel plot of the studies that evaluated the prevalence of metabolic syndrome in Brazilian population. * prevalence according to the JIS criteria, ** prevalence according to the IDF criteria, *** prevalence according to the modified NCEP_ATPIII criteria and **** prevalence according to the NCEP_ATPIII criteria.