

Beyond BMI: Applying the New Obesity Diagnostic Criteria in adolescents from Generation XXI Cohort

Para além do IMC: Aplicação dos Novos Critérios de Diagnóstico para a Obesidade em Adolescentes da Coorte Geração XXI

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Abstract

Background: Childhood obesity is a growing global public health concern. Recently, the *Lancet Diabetes & Endocrinology* Commission and the Portuguese Directorate-General of Health (DGS) proposed new diagnostic frameworks that extend beyond body mass index (BMI) by incorporating central adiposity measures and clinical manifestations to better identify obesity-related health risks. This study evaluated the application of these criteria in Portuguese adolescents.

Methodology: This cross-sectional observational study used data from the Generation XXI cohort, specifically the assessment conducted at age 13. Obesity was initially classified according to the World Health Organization (WHO) criteria, using objectively measured data, as well as according to the criteria of the DGS's Integrated Care Pathway for People with Obesity and the new Lancet model, which defines preclinical and clinical obesity. Clinical manifestations were assessed using questionnaires, clinical examinations, and blood and urine tests.

Results: According to the WHO criteria, 23.7% of participants had pre-obesity and 9.6% had obesity. Using the new frameworks, the prevalence of pre-obesity was 20.9%, while 9.3% met the criteria for clinical obesity. Overall, 46.1% of adolescents presented at least one clinical manifestation potentially related to obesity, with the central nervous system (25.3%) and the metabolic system (17.7%) being the most frequently affected. Compared to BMI alone, the new criteria reclassified 373 adolescents. Of these, 125 who were initially classified as having pre-obesity were reclassified as normal weight, and 220 were reclassified as having obesity.

Conclusions: The criteria established by the DGS and The Lancet classify a greater number of adolescents as obese by combining BMI with measures of central

adiposity and clinical manifestations. Further studies are needed to standardize the assessment of obesity-related clinical manifestations.

Keywords

Obesity, Adolescent, Clinical Obesity, Preclinical Obesity, Diagnose

Resumo

Introdução: A obesidade infantil constitui um problema crescente de saúde pública a nível mundial. Recentemente, a Comissão da *Lancet Diabetes & Endocrinology* e a Direção-Geral da Saúde (DGS) propuseram novos modelos de diagnóstico que vão além do índice de massa corporal (IMC), incorporando medidas de adiposidade central e manifestações clínicas. Este estudo avaliou a aplicação destes critérios em adolescentes portugueses.

Metodologia: Este estudo observacional transversal utilizou dados da coorte Geração XXI, nomeadamente a avaliação aos 13 anos. A obesidade foi inicialmente classificada de acordo com os critérios da Organização Mundial da Saúde (OMS), com dados objetivamente medidos, bem como pelos critérios do Percurso de Cuidados Integrados para a Pessoa com Obesidade da DGS e pelo novo modelo da *Lancet* que define obesidade pré-clínica e clínica. As manifestações clínicas foram avaliadas através de questionários, exames clínicos e análises ao sangue e à urina.

Resultados: De acordo com os critérios da OMS, 23,7% dos participantes apresentavam pré-obesidade e 9,6% obesidade. Utilizando os novos modelos, a prevalência de pré-obesidade foi 20,9%, enquanto 9,3% preencheram os critérios para obesidade clínica. No total, 46,1% dos adolescentes apresentaram pelo menos uma manifestação clínica potencialmente relacionada com a obesidade, sendo o sistema nervoso central (25,3%) e o metabólico (17,7%) os mais frequentemente afetados. Comparativamente ao IMC isolado, os novos critérios reclassificaram 373 adolescentes. Dos quais 125 inicialmente classificados com pré-obesidade passaram para peso normoponderal e 220 para obesidade.

Conclusão: Os critérios da DGS e da *Lancet* classificam um maior número de adolescentes com obesidade ao combinarem o IMC com medidas de adiposidade

central e manifestações clínicas. São necessários mais estudos para uniformizar a avaliação das manifestações clínicas relacionadas com a obesidade.

Palavras-Chave

Obesidade, Adolescentes, Obesidade clínica, Obesidade pré-clínica, Diagnóstico

List of Abbreviations and Acronyms

BMI - Body Mass Index

DGS - Direção Geral da Saúde (Directorate-General of Health)

G21- Generation XXI

NAFLD - Non-Alcoholic Fatty Liver Disease

PCIPO - Percurso de Cuidados Integrados para a Pessoa com Obesidade
(Integrated Care Pathway for People with Obesity)

WC - Waist Circumference

WtHR - Waist to Height Ratio

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Introduction

Obesity is described by excess of body fat causing damage to the health of the individual ⁽¹⁾ that may impact the human body and it can be responsible for the development of innumerable diseases and disorders ⁽²⁾, such as type II diabetes, metabolic syndrome or cardiovascular problems, resulting in an increase of disability-adjusted life-years and a reduction in both population life expectancy and healthy life expectancy ⁽³⁾.

The expected growth of pre-obesity and obesity among the population can be linked to the rapidly increase of childhood and adolescent obesity. It is estimated that, in the last 30 years, the global childhood obesity marked up 244% and it is expected to be enlarged more 121% in the next 30 more years ⁽³⁾. Therefore, the global rise of obesity, on an epidemic level ^(3, 4), remains an important topic for public health ⁽⁵⁾.

No ultimo ian-af a prevalencia de adolescents between 10 to 17 years with pre-obesity and obesity was 32.3% ⁽⁶⁾.

More specifically in Porto, there were a rise of pre-obesity prevalence from age 7 to 10 (22,1% and 26,1%, respectively) and a slight increase of the obesity prevalence at the same ages (15,5% and 16,8%, respectively) ⁽⁷⁾.

Traditionally, in clinical practice, the most common criterion to diagnose obesity is a Body Mass Index (BMI), which is expressed as the ratio of body weight in kilograms divided by height in square meter (kg/m^2), greater than or equal to 30 (for adults) ⁽¹⁾ or a BMI-for-age greater than 2 standard deviations above the WHO Growth Reference median (for children aged 5 to 19 years) ^(8, 9).

However, this criterion has been criticized for multiple reasons - it can not measure the fat distribution along the body, does not differentiate between fat or lean mass, lacks information relative to the health status of the individual ⁽¹⁰⁾ and it does not provide any insights into the heterogeneity of obesity or its genetic, metabolic, physiological or psychological origins ^(5, 11).

In 2024, the Lancet Diabetes & Endocrinology Commission proposed a reframing definition that moves beyond a BMI-centric model toward a framework of "Clinical Obesity"⁽¹⁰⁾. This new criterion defines obesity as a chronic, systemic disease characterized by excess adiposity that could result in organ or tissue dysfunction ⁽¹⁰⁾. In addition to the anthropometric measures, it also considers clinical complications from the disease to diagnose preclinical and clinical obesity. Besides BMI measurements, it takes into account other anthropometric indicators of central adiposity, such as waist circumference (WC) and waist to height ratio (WtHR). Clinical and preclinical diagnosis are differentiated by the presence of symptomology related to obesity.

To the best of our knowledge the first study on the topic, a large-scale longitudinal study, suggests that this new definition not only increases the identified prevalence of obesity but also superiorly identifies individuals at higher risk for cardiovascular and metabolic mortality ⁽⁸⁾.

Simultaneously, in Portugal, the Directorate-General of Health (DGS) developed a manual called "Percurso de Cuidados Integrados para a Pessoa com Obesidade" (PCIPO) for a complete and multidisciplinary approach regarding obesity. The same document establishes a national norm for a differential diagnosis and treatment for obesity analogue to the new criteria published by the Lancet Diabetes & Endocrinology Commission. According to the PCIPO, beyond clinical

and preclinical obesity, the pre-obesity with increased cardiometabolic risk is also defined. It takes into account anthropometric measurements accordingly to what is conventionally considered pre-obesity, anthropometric indicators of central adiposity and the possible presence of symptomology related to excess adiposity. With no evidence for clinical obesity in childhood and adolescence and with the possible indication of differences in prevalences when using the new criterion, this study may be important to give an insight for future strategies and interventions regarding the new approach.

Aim

The main objective of this paper is to evaluate the prevalence of clinical criteria for obesity in adolescents from the Generation XXI cohort by applying the 2024 Lancet Commission diagnostic framework.

We also aim to evaluate the prevalence of pre-obesity with increased cardiometabolic risk, preclinical and clinical obesity according to the PCIPO criterion. We intend to compare the conventional diagnostic with the new framework developed.

Methodology

Study design

This is a cross-sectional descriptive observational study using data from the Generation XXI (G21) cohort, a large birth population-based cohort established in metropolitan area of Porto, Portugal (2005-2006).

Participants

G21 comprises 8495 mothers and 8647 newborns recruited between April 2005 and August 2006 in all five existing public maternity units. During the hospital stay, mothers who delivered live births with at least 24 gestational weeks were invited to participate in the study, of whom 92 % agreed ^(12, 13). The participants were invited to go through re-evaluations and follow-ups along the years including the one that was performed at 13 years (participation of 54 % since follow-up was interrupted in March 2020 due to issues related to the COVID-19 pandemic).

This study used data from the 13-year-old evaluation. All the evaluations complied with the Ethical Principles for Medical Research Involving Human Subjects expressed in the Declaration of Helsinki, and the 13-year follow-up evaluation was approved by the ISPUP Ethics Committee. All procedures were explained to participants, and informed consent was signed by one of the parents or legal guardians and by the participants.

The eligible population for the present study consists of adolescents from G21 followed at age 13 with a complete anthropometric data (weight, height, waist circumference and hip circumference) evaluated at the same age (n=4623). Participants evaluated under non-ideal conditions were excluded from the study, remaining 4565 eligible adolescents, to anthropometric based analysis (Appendix 1, Fig. 1).

The information about symptomatology and limitations related to excess adiposity was not available for all the 4565 participants. Of the 8 criteria considered, only 1 participant had no available information for any of the criterion. A total of 4510 participants (98.8%) had data available for at least four of the eight criteria. These were considered when evaluating clinical symptomatology.

Anthropometric data

Trained examiners performed anthropometric measurements according to standard procedures. Weight was measured with light clothes and no shoes to the nearest 0.1 kg with a scale (Type UM-018 Body Fat & Water Monitor, Tanita Corporation, Tokyo, Japan) and body height was measured standing upright to the nearest 0.1 cm using a portable stadiometer (Seca 218, Seca Corporation, Hamburg, Germany). Based on these measurements, BMI was calculated and classified according to age- and sex-specific z-scores from the WHO growth reference ⁽⁹⁾ into: Underweight, < -2 SD; Normal weight, $-2 \leq \text{SD} \leq 1$; Pre-obesity, $1 < \text{SD} \leq 2$ and obesity was defined as $> +2$ SD. WC was taken to the nearest 0.1 cm and measured at the midpoint between the lower limit of the rib cage and the iliac crest ⁽¹⁴⁾, with the adolescent in a standing position, with the abdomen relaxed, arms at the sides, and feet positioned together. A WC between the 75th and 90th percentiles for age and sex (P75-P90) was considered indicative of pre-obesity, whereas a WC above the 90th percentile for age and sex (P90) was considered indicative of obesity, according to cut-offs for the European-American population ^(15, 16). WtHR was calculated as the quotient between WC and height, and 0.5 was the cutoff point for central adiposity in children ^(17, 18).

Differential diagnosis of obesity

Pre-obesity with increased cardiometabolic risk was defined according to the PCIPO by DGS ⁽¹⁹⁾, as one of 2 scenarios for a child between 5 to 18 years old: BMI Z-score classified as pre-obesity and WtHR > 0.5 or WC between 75 to 90 percentiles; or BMI Z-score classified as pre-obesity and any clinical manifestations related to excess adiposity.

Preclinical and clinical obesity were classified according to 2024 Lancet Commission diagnostic framework ⁽¹⁰⁾. Preclinical obesity is characterized by BMI Z-score for obesity and, WtHR > 0.5 or WC percentile > P90 for age and sex without any symptom of organ dysfunction nor limitations of age-adjusted daily activities.

As for the clinical obesity the criterion consists of BMI Z-score for obesity; and WtHR > 0.5 or WC percentile > P90 for age and sex; and signs and symptoms of dysfunction of one or more organs or systems associated with adiposity or limitations of age-adjusted activities of daily living evaluated by the reasons for missing physical activity during school, as a proxy.

Adolescents with both anthropometric indicators of central obesity (WC and WtHR) above the established cut-off values were also classified as having obesity⁽⁸⁾.

To evaluate clinical manifestations of organ dysfunction and limitations of age-adjusted daily activities, information from two different questionnaires, one made for the caregivers and the other to the adolescents themselves, was considered. In addition, blood pressure was measured, and blood and urine samples were collected for clinical laboratory analyses.

From the 13 organ and system dysfunctions suggested by Lancet and DGS (Appendix 2, Table 1), the collected data allowed the assessment of 7: central nervous system, respiratory system, metabolic system, liver, cardiovascular system, renal system and musculoskeletal system. Central nervous system criterion was met when the adolescent self-reported feeling pain, more specifically headache in the last 3 months. Respiratory questions applied only to adolescents with a parent-reported asthma diagnosis; adolescents without this diagnosis were assumed to be asymptomatic; among those with asthma, we assessed whether caregivers reported, in the past month, sleep-disrupting

symptoms (shortness of breath, wheezing, coughing, chest tightness or pain), and, in the past year, a healthcare visit due to wheezing or asthma. For the metabolic system, the criterion was considered present when there was hyperglycaemia (glucose > 250 mg/dL) or glucose intolerance (glycated haemoglobin > 5.7%), and one of the three criteria of dyslipidaemia, defined by elevated triglyceride levels (≥ 130 mg/dL), reduced HDL cholesterol levels (<40 mg/dL), or elevated total cholesterol levels (>200 mg/dL) ⁽²⁰⁾. Regarding liver, the age- and sex-specific cutoffs for Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) from the study Li, X. and colleagues ⁽²¹⁾ were applied. The renal criterion was considered present when adolescents presented microalbuminuria, determined by an albumin-to-creatinine ration between 30 and 300 mg/g ⁽²²⁾. Regarding cardiovascular system, we considered the previous diagnosis of hypertension reported by parents or Z-score values of systolic or diastolic pressures between +2 to +2.5 ^(23, 24). For musculoskeletal system, self-reported pain, from recurrent tripping or falling in the last 3 months, was considered. Although we had no information about the cause of the fall, we considered the fall as a potential indicator of any motor abnormality or leg malalignment. If the adolescent reported no pain, there was no pain from recurrent tripping nor falling. Finally, as an indicator of the limitations of daily activities, we used the information referring to practice of physical education in school and any kind of sport outside of school. Adolescents were considered to have a limitation of daily activity when they did not attend physical education classes at school (not considering cases with reasonable motives like articulated school with dance classes, construction

work in the gym or health problems not related to obesity) or did not practice sports.

Statistical analysis

Statistical analyses were conducted using the IBM SPSS Statistics version 30.0. Data were presented using descriptive statistics, reporting absolute frequencies (n) and percentages (%) for categorical variables, and mean and standard deviation (sd) for continuous variables.

Cross-tabulations were used to describe and compare the prevalence of pre-obesity and obesity categories across different classification criteria, with presenting the distribution of participants according to the WHO definition and the new definitions proposed by *The Lancet* and the PICPO from DGS.

Results

The total sample of 4565 adolescents presented an average age of 160 (SD 3.25) months and 48.4% (n= 2209) were female.

Table 1. Characterization of the sample.

Variables	Total, n=4565 Mean (SD)	Boys, n=2356 (51.6%) Mean (SD)	Girls, n=2209 (48.4%) Mean (SD)
Age, months	160.04 (3.25)	159.99 (3.24)	160.09 (3.27)
Weight, kg	53.17 (11.59)	53.01 (12.08)	53.34 (11.05)
Height, cm	159.85 (7.61)	161.20 (8.55)	158.42 (6.14)
Waist circumference, cm	74.21 (10.20)	74.47 (10.47)	73.93 (9.90)
WC P75-P90	961 (21.1%)	443 (19.0%)	510 (23.0%)
WC > P90	623 (13.6%)	283 (12.2%)	327 (15.0%)
Hip circumference, cm	87.57 (9.38)	85.27 (9.05)	90.04 (9.10)
WtHR	0.46 (0.06)	0.46 (0.06)	0.47 (0.06)
WtHR>0.5	1019 (22.3%)	514 (22.1%)	484 (22.2%)
BMI, kg/m ²	20.70 (3.74)	20.25 (3.61)	21.18 (3.81)
BMI Z-score categories			
Underweight (< -2SD)	104 (2.3%)	68 (2.9%)	36 (1.6%)
Normal (-2 ≤ SD ≤ 1)	2939 (64.4%)	1504 (63.8%)	1435 (65.0%)
Pre-obesity (1 < SD ≤ 2)	1082 (23.7%)	542 (23.0%)	540 (24.4%)
Obesity (> 2SD)	440 (9.6%)	242 (10.3%)	198 (9.0%)

Note: Data are presented as absolute frequencies (n) and percentages (%) for categorical variables, and mean and standard deviation (sd) for continuous variables

The mean weight was 53.17 kg and the mean height was 159.85 cm, corresponding to a mean BMI of 20.70 (SD 3.74) kg/m². The mean waist and hip circumferences were 74.21 and 87.57 cm respectively, while the mean WtHR was 0.46. Regarding the central adiposity indicators, 21.1% of adolescents had WC values between the 75th and 90th percentiles, 13.6% were above the 90th percentile, and 22.3% presented a WtHR above 0.5. According to the BMI z-score from the WHO growth reference, 64.4% adolescents had normal weight, 23.7% were considered as having pre-obesity and 9.6% had obesity (table 1).

Table 2. Household Characterization.

Variables	General n=4565	Boys n=2356 (51.6%)	Girls n=2209 (48.4%)
Mother age at birth (years)	30.03 (5.06)	29.91 (5.01)	30.16 (5.12)
Maternal education			
Number completed school years	11.32 (4.31)	11.35 (4.24)	11.28 (4.38)
< 9 years	1834 (40.2%)	920 (39.0%)	914 (41.4%)
9 to 12 years	317 (6.9%)	160 (6.8%)	157 (7.1%)
> 12 years	2392 (52.4%)	1260 (53.5%)	1132 (51.2%)
Missing	22 (0.5%)	16 (0.7%)	6 (0.3%)
Paternal Education			
Number completed school years	10.67 (4.20)	10.68 (4.29)	10.66 (4.09)
< 9 years	1205 (26.4%)	638 (27.5)	567 (25.7%)
9 to 12 years	223 (4.9%)	120 (5.1%)	103 (4.7%)
> 12 years	1236 (27.1%)	642 (27.2%)	594 (26.9%)
Missing	1901 (41.6%)	956 (40.6%)	945 (42.8%)
Household monthly income of caregiver			
<1000€	757 (16.6%)	373 (15.8%)	384 (17.4%)
1000-2000€	2142 (46.9%)	1130 (48.0)	1012 (45.8%)
>2000€	1473 (32.3%)	751 (31.9%)	722 (32.7%)
Not part of the household/prefer not to say/does not know	164 (3.6%)	87 (3.7%)	77 (3.4%)
Missing	29 (0.6%)	15 (0.6%)	14 (0.6%)
Perception and classification of household income			
Insufficient	220 (4.8%)	121 (5.1%)	99 (4.5%)
Need to be careful with expenses	1733 (38.0%)	912 (38.7%)	821 (37.2%)
Enough for the needs	1525 (33.4%)	761 (32.3%)	764 (34.6%)
Comfortable	964 (21.1%)	496 (21.1%)	468 (21.2%)
Missing	123 (2.6%)	66 (2.8%)	57 (2.6%)

Note: Data are presented as absolute frequencies (n) and percentages (%) for categorical variables, and mean and standard deviation (sd) for continuous variables

Referring to the parents, on average, maternal age was 30 years old and 52,4% had higher education, compared to the 27.1% regarding the paternal education. Almost half the caregivers (46.9%) reported between 1000 to 2000€ household

income, 38.0% of caregivers perceived their income as “need to be careful with expenses” and 33.4% as “enough for the needs” (table 2).

Table 3. Prevalence of organ or tissue dysfunction.

		Available Information for criteria	Adolescents that meet the criteria
Organ or tissue dysfunction			
Central Nervous System	Recurrent headaches in the last 3 months	4504 (98.7%)	1141 (25.3%)
Respiratory System	Shortness of breath in the last month	4509 (98.7%)	147 (3.3%)
	Trip to health care facilities due to asthma or wheezing in the last 12 months		
	Asma symptoms that disturbed sleep		
Metabolic System	Cluster of hyperglycaemia or glucose intolerance with high triglyceride levels, high cholesterol or low HDL cholesterol	3735 (88.1%)	661 (17.7%)
Liver	Elevated AST and ALT testes	3729 (81.7%)	77 (2.1%)
Renal System	Microalbuminuria	323 (7.1%)	17 (5.3%)
Cardiovascular System	Raised arterial blood pressure	4497 (98.5%)	403 (8.8%)
Musculoskeletal System	Pain caused by falling	4506 (97.8%)	126 (2.8%)
Limitations of daily activities	Failure to attend school physical education and lack of sport practice outside of school	4505 (98.7%)	13 (0.3%)
Number of available clinical criteria			
0 available criteria			1 (0.0%)
1 available criterion			19 (0.4%)
2 available criteria			3 (0.1%)
3 available criteria			32 (0.7%)
4 available criteria			22 (0.5%)
5 available criteria			779 (17.1%)
6 available criteria			74 (1.6%)
7 available criteria			3325 (72.8%)
8 available criteria			310 (6.8%)
At least one positive organ or tissue dysfunction indicator			2103 (46.1%)

As presented in table 3, 46.1% (n=2103) of adolescents had experienced at least one symptom of organ or tissue dysfunction, compatible with excess fat. The most affected tissues or organs were the central nervous system (25.3%) and the metabolic system with 17.7% (n=661). On the contrary, only 13 (0.3%) adolescents had any limitation of age-adjusted daily activities.

Table 4. Prevalence of pre-obesity and clinical obesity.

		Available Information for criteria	Adolescents that meet the criteria
Pre-obesity with increased cardiometabolic risk			
Prevalence of pre-obesity without clinical symptomatology		4565 (100%)	827 (18.1%)
Prevalence of pre-obesity with clinical symptomatology		4510 (98.8%)	937 (20.8%)
Obesity			
BMI + 1 Anthropometric Indicator of Central adiposity		4565 (100%)	420 (9.2%)
2 Anthropometric Indicators of Central adiposity		4565 (100%)	612 (13.4%)
Anthropometric obesity		4565 (100%)	656 (14.4%)
Preclinical obesity		4510 (98.8%)	225 (5.0%)
Clinical Obesity		4510 (98.8%)	424 (9.3%)

The prevalence estimates of pre-obesity, preclinical and clinical obesity are presented in table 4. The prevalence of pre-obesity without considering clinical symptomatology was about 18.1% and with symptomatology rises up to 20.8%. Among adolescents classified as having obesity based on anthropometric measures alone, 14,4% (n=656), approximately two-thirds, 9.3% (n=424) also met the criterion for clinical obesity.

Table 5. BMI WHO classification compared to new anthropometric-based classification.

New definition \ WHO	Underweight	Normal weight	Pre-obesity	Clinical and preclinical obesity	Total
Underweight	104 (100.0%)	0	0	0	104 (100.0%)
Normal weight	0	2931 (99.7%)	0	8 (0.3%)	2939 (100.0%)
Pre-obesity	0	255 (23.6%)	599 (55.4%)	228 (21.1%)	1082 (100.0%)
Obesity	0	20 (4.5%)	0	420 (95.5%)	440 (100.0%)
Total	104 (2.3%)	3206 (70.2%)	599 (13.1%)	656 (14.4%)	4565 (100.0%)

Comparing the traditional WHO classification of obesity with the new definition, 8 adolescents classified as having normal weight with WHO definition, were considered as having obesity according to the new definition. In 253 cases (23.8%) of adolescents considered pre-obesity were then classified as normal weight. Lastly, 20 adolescents who were classified in the obesity category, had normal weight according to the new definition (table 5).

Table 6. BMI WHO classification compared to new classification.

New definition \ WHO	Underweight	Normal weight	Pre-obesity	Preclinical obesity	Clinical obesity	Total
Underweight	101 (100.0%)	0	0	0	0	101 (100.0%)
Normal weight	0	2904 (99.7%)	0	3 (0.1%)	5 (0.2%)	2912 (100.0%)
Pre-obesity	0	125 (11.8%)	717 (67.5%)	94 (8.9%)	126 (11.9%)	1062 (100.0%)
Obesity	0	20 (4.6%)	0	128 (29.4%)	290 (66.0%)	435 (100.0%)
Total	101 (2.2%)	3049 (67.6%)	717 (15.9%)	225 (5.0%)	418 (9.3%)	4510 (100.0%)

Note: Analysis performed for adolescents with valid information for at least 4 clinical criteria

Among adolescents with available information for at least four clinical criteria (table 6), five participants previously classified as having normal weight were reclassified as having clinical obesity, whereas 127 adolescents currently classified as having normal weight had previously been classified as having pre-obesity.

Discussion

The application of the new definition of obesity, which requires the presence of at least one indicator of central adiposity in addition to BMI, resulted in only a slight decrease in obesity prevalence compared with the traditional BMI-based definition, from 9.6% to 9.2%. Alternatively, the new definition also considers people with both anthropometric indicators of central adiposity as having obesity, regardless of BMI classification, resulting in a prevalence of 13.4%. This indicates that an additional 3.8% of adolescents in our sample had altered anthropometric indicators beyond BMI alone, suggesting the presence of increased adiposity that would not have been identified using BMI-based classification only. These findings reinforce the importance of incorporating measures of central adiposity, which have been associated with increased fat mass and cardiovascular risk factors associated with obesity, into the assessment of obesity in adolescents ⁽²⁵⁾.

These results may suggest that, for adolescents, using BMI solely for diagnosing obesity may not be enough, as previously suggested in other studies in adults ^(26, 27).

In our sample 22.3% of adolescents had a WtHR above 0.5, which was substantially higher than the 12.7% reported in an Italian sample. However, the prevalence of pre-obesity/obesity in that study was also considerably lower (23.3%) than that observed in our sample (33.3%) ⁽²⁸⁾.

BMI does not give information about fat distribution, when evaluating other anthropometric indicators of central adiposity and clinical symptomatology, adolescents who previously had obesity are now considered normal weight and vice-versa ⁽²⁹⁾. This result may occur due to unique body composition of each adolescent ⁽³⁰⁾. Since they are still in developing stages and at different rates, some can already have more muscle mass or more bone density, for example. That may contribute for an elevated BMI but, when analyzing central adiposity and clinical symptomatology there is no other indicator for obesity. On the other hand, an adolescent with lower BMI but higher adiposity indicator and/or clinical symptomatology may indicate an early disruption and early signs of obesity. In order to correctly test these hypotheses, a DEXA evaluation could be needed for future investigations.

The assessment of obesity-related clinical manifestations presents additional challenges, especially when relying on previously collected data not specifically designed to evaluate these criteria. However, this assessment is essential, as it allows the identification of individuals with clinical consequences of obesity, complementing the information provided by anthropometric measures and contributing to a more comprehensive characterization of the disease.

Intracranial hypertension is frequently associated with obesity, with its clinical manifestations including headaches and vision loss ^(31, 32). However, as the information considered in our analysis was limited to the presence of headaches in the previous three months, it was not possible to study the underlying cause. Therefore, the prevalence of children with this affected system may be overestimated.

Regarding the respiratory system, obesity has been associated with respiratory impairments, including asthma ⁽²⁷⁾. However, the lack of information for the entire population may have resulted in an underestimation of these manifestations.

Although microalbuminuria can express the health of renal function, it is still controversial whether it is the best option to correctly access it on children with obesity. As it can be higher in taller children with lower weight and consequently lower BMI ⁽³³⁾. This could give a more comprehensive perspective as into why the prevalence of microalbuminuria is so low in our results.

The main limitation of this study was the inability to establish a causal relationship between the identified clinical manifestations and obesity. Although these criteria should reflect obesity-related consequences, the previously collected data did not allow confirmation of their underlying cause. Also, we had no information available about the reproductive system, apnoea or hypopnoea during sleep affecting the upper airways and recurrent or chronic urinary incontinence to evaluate the well function of renal system. Lastly, for the limitations of age-adjusted activities, we only took into account the expected practice of physical activity of children.

Despite the limitations mentioned above, this study has several important strengths. To the best of our knowledge, this is one of the first studies to apply the 2024 Lancet Commission diagnostic criteria for obesity in adolescents, and the first to evaluate their applicability in Portuguese population. Furthermore, the integration of these criteria with the PCI framework provides a more comprehensive perspective on obesity diagnosis, allowing the characterization of both anthropometric changes and obesity-related clinical manifestations.

Finally, with the diagnosis of obesity as preclinical or clinical enables healthcare professionals to select the most appropriate treatment and implement health interventions tailored to the needs of each population.

Conclusion

To summarize, the prevalence of obesity increases when implementing the new criteria. The inclusion of additional anthropometric indicators, such as waist circumference and waist-to-height ratio, provides a more comprehensive characterization of adiposity beyond BMI, while the assessment of clinical manifestations contributes to identifying the health impact of obesity.

These findings highlight the importance of moving towards a more comprehensive approach to obesity diagnosis in adolescents. However, further research is needed to establish standardized and systematic criteria for the assessment of clinical obesity and its associated manifestations.

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Appendix 1

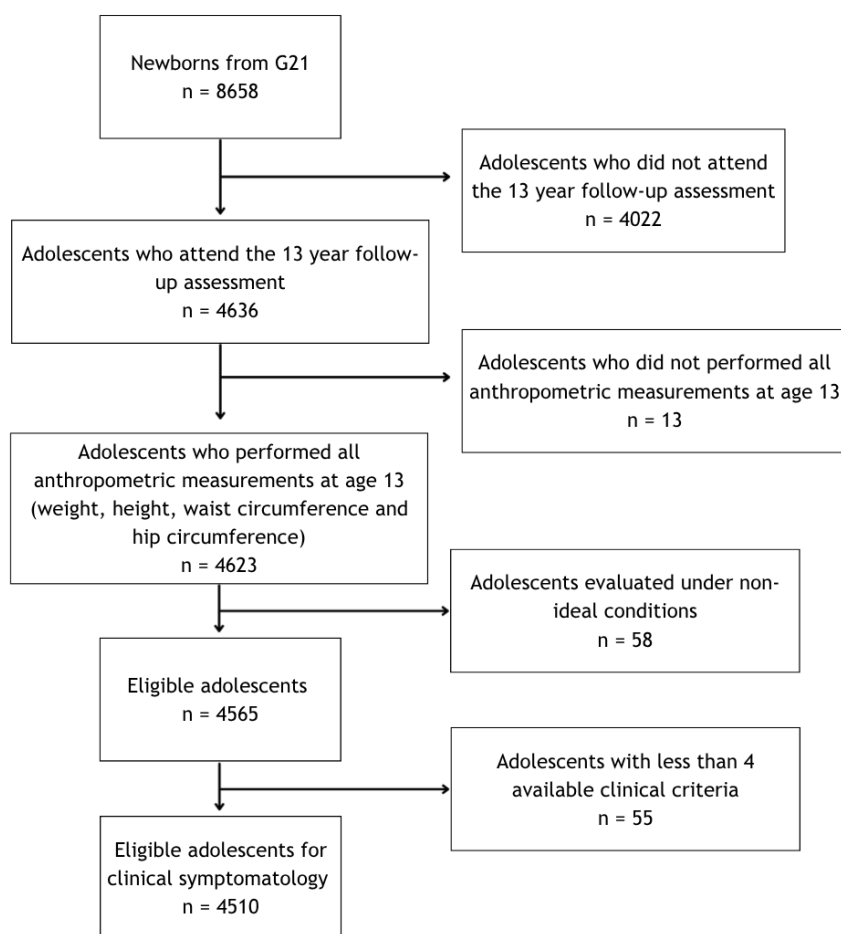


Fig 1. Participant inclusion and exclusion flowchart

Appendix 2

Table 1. Clinical symptomatology in *Lancet Diabetes & Endocrinology* Commission, PCI and Beyond BMI

	<i>Lancet Diabetes & Endocrinology</i> Commission	PCIPO from DGS	Generation XXI
Central Nervous System	Vision loss, recurrent headaches, or both (due to raised intracranial pressure)	Symptoms of intracranial hypertension, such as vision loss and/or recurrent headaches	Headache in the last 3 months
Respiratory System	Hypoventilation, breathlessness, wheezing, or any combination of these (due to reduced lung compliance, diaphragmatic compliance, or both)	Hypoventilation and/or dyspnea and/or wheezing due to decreased pulmonary and/or diaphragmatic compliance	Shortness of breath in the last month Trip to health care facilities due to asthma or wheezing in the last 12 months Asma symptoms that disturbed sleep
Metabolism	The cluster of hyperglycemia or glucose intolerance, with high triglyceride levels, high LDL cholesterol or low HDL cholesterol	Cluster: hyperglycemia, hypertriglyceridemia, and low HDL cholesterol	Custer of hyperglycaemia or glucose intolerance with high triglyceride levels, high cholesterol or low HDL cholesterol
Liver	Elevated liver function tests due to metabolic dysfunction-associated steatotic liver disease (Elevated liver markers)	Hepatic steatosis associated with metabolic dysfunction, with fibrosis	Elevated AST and ALT testes
Renal	Microalbuminuria	Microalbuminuria with a decreased estimated glomerular filtration rate (eGFR)	Microalbuminuria
Reproductive	Polycystic ovary syndrome	Anovulation, oligomenorrhea, and polycystic ovary syndrome (PCOS) Male Hypogonadism	No available information
Upper airways	Apnoea or hypopnoea during sleep (due to increased upper airways resistance)	Sleep apnea/hypopnea caused by excessive relaxation of the upper airway muscles, resulting in total or partial airway obstruction	No available information
Cardiovascular System	Raised arterial blood pressure	Reduced left ventricular systolic function - hear failure with preserved ejection fraction Reduced left ventricular systolic function - heart failure with preserved ejection fraction Pulmonary hypertension Chronic fatigue and lower extremity edema due to diastolic dysfunction - Heart failure with preserved ejection fraction Recurrent deep vein thrombosis and/or pulmonary thromboembolism Hypertension	Raised arterial blood pressure Ever diagnosis of hypertension
Urinary System	Recurrent or chronic urinary incontinence	Recurrent/Chronic Urinary Incontinence	No available information
Musculoskeletal system	Recurrent or chronic, severe knee pain, or tripping or falling (due to pes planus or leg malalignment) Acute pain, recurrent or chronic pain, limitations of mobility, tripping or falling, or any combination of these (due to slip epiphysis)	Chronic, severe pain in the knee or hip, accompanied by joint stiffness and reduced range of motion	Pain caused by falling
Lymphatic		Lymphedema of the lower extremities associated with chronic pain and/or limited joint mobility	No available information

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Parecer do orientador do Trabalho Complementar



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PARECER DO ORIENTADOR DO TRABALHO COMPLEMENTAR

Na qualidade de orientadora do trabalho complementar de estágio da estudante Marta Sousa Peixoto do 4.º ano da licenciatura de Ciências da Nutrição, da Faculdade de Ciências da Nutrição e Alimentação da Universidade do Porto, venho por este meio emitir o meu parecer.

Nos últimos meses a Marta desenvolveu o trabalho de investigação: “Beyond BMI: Applying the New Obesity Diagnostic Criteria in adolescents from Generation XXI Cohort”. Trata-se de um tema pertinente e atual, sobre o qual a evidência científica disponível ainda é limitada, o que tornou o processo de revisão da literatura e de tomada de decisão mais desafiante.

Considero que este foi um período importante para a estudante, que lhe permitiu adquirir competências de análise de dados quantitativos com recurso ao software SPSS e escrita científica em língua inglesa.

Ao longo do desenvolvimento do trabalho, procurou dar resposta aos desafios encontrados e reconheço o esforço na concretização deste estudo.

Resta-me desejar-lhe felicidades para o seu futuro pessoal e profissional.

Porto, 31 de julho de 2026,

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