

ASSOCIATION OF SOCIAL FACTORS WITH WEIGHT STATUS ASSESSED BY WHO, IOTF, AND CDC CRITERIA AMONG MOROCCAN SCHOOL-AGED ADOLESCENTS

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Abstract

Introduction. The assessment of weight status in adolescents can vary depending on the anthropometric reference used classification. Comparing different classification systems within the same sample allows for a better understanding of how methodological choices can influence the estimation and interpretation of weight status.

Objective. This study aims to compare the weight status classification of Moroccan adolescents according to three international anthropometric references: the World Health Organization (WHO), the International Obesity Task Force (IOTF), and the Centers for Disease Control and Prevention (CDC). It also aims, on an exploratory basis, to analyze the associations between the weight status categories obtained according to these references and certain sociodemographic and socioeconomic characteristics.

Materials and Methods. A cross-sectional study was conducted with 156 Moroccan adolescents aged 16 to 18 years. Anthropometric measurements included weight, height, body mass index (BMI), waist circumference, and waist-to-height ratio (WHtR). Sociodemographic and socioeconomic data, including sex, age, parental education level, parental socioeconomic status, place of residence, household income, and housing status, were collected using a structured questionnaire. Weight status was classified according to WHO, IOTF, and CDC criteria. Statistical analyses were performed using SPSS version 26.

Results. Mean BMI did not differ significantly between girls and boys, while waist circumference and WHtR were significantly higher in girls, suggesting greater central adiposity despite comparable overall body size. Weight status classification varied depending on the reference used. According to WHO criteria, 87.1% of adolescents were classified as having a normal weight, 7.1% as overweight, and 5.8% as obese. According to IOTF criteria, 52.6% were classified as normal weight, 29.5% as overweight, and 17.9% as obese. According to CDC criteria, 7.1% were classified as underweight, 60.3% as normal weight, 17.3% as overweight, and 15.3% as obese.

Exploratory regression analyses showed that certain sociodemographic and socioeconomic characteristics were associated with weight status categories, but these associations varied depending on the classification reference used. Several odds ratios showed very high or very low values, suggesting possible instability of the estimates due to small sample sizes in some categories.

Conclusion. The results show that the choice of anthropometric reference can significantly influence the classification of adolescents' weight status and the interpretation of associated sociodemographic factors. This study does not allow for a definitive recommendation of one reference system over another, but it highlights the importance of clearly specifying the classification system used. Further studies, conducted on larger and more diverse samples, incorporating dietary, behavioral, biological and pubertal data, are needed to better assess the relevance of these references in Moroccan adolescents.

Keywords: Anthropometric measurements, WHO, IOTF, CDC, adolescents, El Jadida-Morocco

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Introduction

Adolescence is a critical period of human development, marked by major physical, hormonal and psychological transformations, and also represents a period of vulnerability to nutritional imbalances. Indeed, the WHO estimated that more than 390 million children and adolescents aged 5 to 19 years were overweight in 2022, of which 160 million suffered from obesity worldwide (WHO, 2022). The World Health Assembly report (2024) showed that the prevalence of obesity among adults in the Arab States increased from 19.6% in 2000 to 32.1% in 2022, illustrating the continued progression in these countries (FAO, IFAD, UNICEF, WFP, WHO, 2024). In the MENA (Middle East and North Africa) region, obesity rates have also grown rapidly in recent decades, strongly linked to the westernization of eating habits and a marked nutritional transition (Aboul-Enein et al., 2016). A more recent systematic review indicates that among children and adolescents in the MENA region, combined rates of overweight and obesity can reach 49%, confirming the magnitude of the phenomenon among younger people (Alruwaili et al., 2024). The alarming increase in the prevalence of overweight and obesity among adolescents in low- and middle-income countries, represents also a major concern for the scientific community and public health stakeholders (Zhang et al., 2024; WHO, 2025). Indeed, the WHO estimated that more than 390 million children and adolescents aged 5 to 19 years were overweight in 2022, including 160 million living with obesity worldwide (WHO, 2025). Indeed, the association of different forms of obesity with several comorbidity risks currently reported in adults predicts the onset of these risks at an early age in future adults. Indeed, the onset of obesity at a younger age, particularly among children and adolescents (Dunford et al., 2012; Malhotra et al., 2021; Sharma et al., 2019) and its progression would make the health situation even more alarming in the future, while worsening the impact on the health system (Swinburn et al., 2019). Furthermore, several studies have established a link between the different forms of obesity and the sociodemographic and socio-economic characteristics of adolescents and the socio-professional status of their parents (Morgen et al., 2010).

Indeed, international literature has repeatedly highlighted the impact of social determinants, including income level, parents' professional status, education level, and residential environment, on the nutritional status of adolescents (Facina et al., 2023). In Arab countries, these data are limited, fragmented, and rarely comparable due to the diversity of classification tools used (Musaiger, 2011; Alruwaili et al. 2024)). Among the factors of this disparity, the measurement of adiposity, the assessment of which uses BMI, which is an index considered a practical measure but which does not sufficiently take into account variations in body structure between ethnic groups. In addition, the universal threshold used to categorize weight status varies between organizations and may underestimate the prevalence of overweight and obesity in certain populations (Deurenberg-Yap et al., 2002; Bauer et al. 2015). Among the most widely used reference systems for assessing weight status in young people, there are, firstly, the World Health Organization (WHO) curves based on BMI Z-scores and which rely on a correspondence with adult thresholds projected at the age of 18 years, secondly, the International Obesity Task Force (IOTF) thresholds and finally, the evaluation criteria based on percentiles according to the American Center for Disease Control and Prevention. Several studies have also shown that these methods can lead to divergent estimates, making it difficult to compare the results obtained in different epidemiological studies (Al-Hazzaa et al., 2022). This observation imposes the usefulness of using more than one criterion for classifying weight status for a valid estimation and analysis of the determinants of corpulence in a population.

It is in this perspective that this work is carried out to compare the estimates of the prevalence of overweight and obesity obtained according to the IOTF, WHO and CDC criteria, in order to assess the gaps and understand the implications of socioeconomic and sociodemographic status. This approach is all the more relevant in Morocco where the context is marked by strong social disparities and where socioeconomic and sociodemographic differences can constitute influencing factors on weight status (El Kabbaoui et al., 2018; Nouayti et al., 2020).

To examine how the choice of an international anthropometric reference standard can influence the estimation of underweight, overweight, and obesity, this study aimed to compare the weight status of a sample of school-aged adolescents from the province of El Jadida, assessed according to three reference standards (WHO, IOTF, CDC). It also aimed to analyze the associations between weight status categories and certain sociodemographic and socioeconomic characteristics.

Material and methods

Study Type and Population

This is a cross-sectional study conducted among 156 adolescents, aged 16 to 18, attending school in the urban area of El Jadida province (Casablanca-Settat region, Morocco). The survey is conducted from February to June during the 2024-2025 school year. Adolescents with physical disabilities, those with chronic illnesses, or those who were absent during data collection were excluded from the survey. Participation in the study is voluntary.

Socioeconomic and Sociodemographic Characteristics

The sociodemographic data collected from the study participants included gender, age, parental education (illiterate, primary, secondary, and/or university), place of residence (urban or rural), household size, family structure (nuclear or blended), and parental marital status (married, divorced, deceased father or mother). Information on socioeconomic characteristics included parents' socio-professional categories (SPC), classified into four categories according to the classification of Orban-Segebarth et al. (1982), and adopted in recent studies in Morocco (Ouzennou et al. 2019).

The first category (SPC1) corresponds to large traders and liberal professions; SPC2 to civil servants and managers; SPC3 to artisans, employees, workers, farmers, drivers, and salespeople; and finally, SPC4 corresponds to individuals without paid employment. Other information collected concerned household income, classified into three categories: 1 – low (<3000 MAD), 2 – medium (≥ 3000 and <5000 MAD), and 3 – high (≥ 5000 MAD). Parental education was presented in terms of years of schooling : low (<7 years of schooling), medium (7 to <14 years), and high (>14 years). Finally, the type of housing was classified according to whether it was owned or rented.

Anthropometric measurements

Anthropometric parameters were also measured in the adolescents surveyed, they included weight, height, waist circumference, and hip circumference. These measurements were carried out using approved equipment according to standard protocols defined by the World Health Organization (WHO, 1995).

Participants' body weight was measured, with an accuracy of 0.1 kg, using a standard mechanical scale (Scale 500, Morocco) for adolescents wearing light clothing and without shoes. Height was measured using a tape measure with the student standing against a wall, heels together, legs straight, shoulders relaxed, arms at their sides, and head resting against the wall.

Waist circumference (WC) was recorded in a standing position with feet 25 cm apart using a non-stretchable tape, positioned without compression midway between the iliac crest and the lower edge of the last rib. Two measurements were taken, and the average of the two was used for analysis. Hip circumference (HC) was measured in a standing position with feet together, placing the tape at the pubic symphysis, around the most prominent part of the buttocks.

Waist-to-height ratio (WHtR) was also calculated to assess abdominal adiposity. A WHtR ≥ 0.5 was used to indicate excessive abdominal fat accumulation, while a WHtR < 0.5 was considered to reflect the absence of central obesity. This indicator has been reported as a useful anthropometric measure for identifying central adiposity and shows good agreement with fat mass assessment in children and adolescents (Eslami et al., 2023; Agbaje, 2024).

Body mass index (BMI) was calculated by dividing weight (in kilograms) by the square of height (in meters), or $BMI = \text{weight} / \text{height}^2$ (kg/m²). To assess adolescents' weight status, BMI values were transformed into age- and sex-specific Z scores using AnthroPlus software (version 1.0.4, 2010), according to the reference standards established by the World Health Organization (WHO) in 2007 (WHO, 2007).

Based on age-specific BMI Z scores, adolescent weight status was classified as follows: underweight (Z score ≤ -2 SD), normal weight (Z score > -2 SD and $< +1$ SD), overweight (Z score $\geq +1$ SD and $< +2$ SD) and obesity (Z score $\geq +2$ SD). Children's body size classification was also performed according to the International Obesity Task Force (IOTF) criteria, which define specific age- and sex-adjusted BMI thresholds for thinness, overweight and obesity (Cole et al., 2000).

Adolescent age was expressed in months and used to estimate the BMI percentile according to the Centers for Disease Control and Prevention (CDC) growth charts, using the LMS method, which is based on three age- and sex-adjusted parameters : L (skewness coefficient), M (median), and S (adjusted standard deviation). These parameters allow for the calculation of a standardized z-score and the corresponding percentile for each individual BMI. Weight classification was then assigned according to CDC thresholds : underweight if BMI < 5th percentile, normal weight if BMI between 5th and <85th percentile, overweight if BMI between 85th and <95th percentile and obesity if BMI ≥ 95 th percentile (Kuczmarski, 2000).

Table 1 summarizes the main classification criteria from the various WHO, IOTF, and CDC guidelines used to classify adolescent weight status to facilitate comparisons.

Table 1*Weight status classification criteria according to WHO, IOTF, and CDC guidelines*

Classification criteria	OMS 2007	IOTF	CDC 2000
Indicator used	BMI Z-score for age and sex.	Age- and sex-specific BMI thresholds, linked to adult BMI	BMI percentiles for age and sex
Underweight	Equivalent to an adult BMI < 18.5	Equivalent to an adult BMI < 18.5 kg/m ²	< 5th percentile
Normal weight	> -2 SD and < +1 SD	Between the thresholds for underweight and overweight	≥ 5th and < 85th percentile
Overweight	≥ +1 SD and < +2 SD	Équivalent à un IMC adulte ≥ 25 et < 30 kg/m ²	≥ 85th and < 95th percentile
Obesity	≥ +2 SD	Equivalent to an adult BMI ≥ 30 kg/m ²	≥ 95th percentile

Note. BMI = body mass index; SD = standard deviation; WHO = World Health Organization; IOTF = International Obesity Task Force; CDC = Centers for Disease Control and Prevention.

Data analysis

Statistical analyses were performed using SPSS software, version 26 (IBM Corp., Armonk, NY, USA). Qualitative variables were expressed as counts and percentages, while quantitative variables were presented as means ± standard deviation. Associations between categorical variables were assessed using the chi-square test.

In order to identify the factors associated with the different weight categories, a multinomial logistic regression analysis was performed, using normal weight as the reference category. Odds ratios (ORs), along with their 95% confidence intervals (95% CIs) and p values, were reported. The significance threshold was set at $p < 0.05$.

Results

Table 2 presents the distribution of socioeconomic and sociodemographic characteristics of the study sample, by sex (girls and boys), as well as the statistical significance of the differences observed between these groups. Regarding monthly income, the majority of participants (82.5%) belonged to the category of households with an income below \$300, with a similar distribution between girls (35.7%) and boys (46.8%). The difference in income distribution between girls and boys is not significant ($p = 0.06$), suggesting relative homogeneity of income within the two subgroups. Regarding the area of residence, the vast majority of the adolescents live in rural areas (82.1%), with no significant difference between sexes ($p = 0.22$). Residents of periurban and urban areas are in the minority at 14.7% and 3.2% respectively. The parents marital status was predominantly that of married couples (68%), with no significant difference between girls and boys ($p = 0.532$). Similarly, the family type is predominantly nuclear (85.3%) in both groups ($p = 0.954$). Housing status is predominantly rental (96.1%) with no significant variation by gender ($p = 0.794$). Regarding the level of education of parents, more than half of fathers (55.1%) and mothers (55.1%) have less than 7 years of schooling. The differences between girls and boys were

not statistically significant for the father ($p = 0.119$) and mother ($p = 0.371$) educational levels. Finally, the parents' professions, classified according to the SPC nomenclature (socio-professional categories), do not differ significantly between sexes. Fathers are mainly in SPC3 (69.2%), while mothers are mainly distributed between SPC3 (44.2%) and SPC4 (52.6%), with respective p -values of 0.227 and 0.606.

Table 2

The socioeconomic and sociodemographic characteristics of the sample according to sex

		Total n (%)	Girls n (%)	Boys n (%)	P-value
Monthly income	<300\$	129 (82.5)	56 (35.7)	73 (46.8)	0.06
	300-500\$	20 (13.0)	7 (4.5)	13 (8.4)	
	>500\$	7 (4.5)	6 (3.9)	1 (0.6)	
Area of residence	Rural	128 (82.1)	53 (34.0)	75 (48.1)	0.22
	Periurban	23 (14.7)	14 (9.0)	9 (5.8)	
	Urban	5 (3.2)	2 (1.3)	3 (1.9)	
Parents' Marital Status	Married	106 (68.0)	41 (26.3)	65 (41.7)	0.532
	Divorced/Widowed	50 (32.0)	28 (17.9)	22 (14.1)	
Family Type	Nuclear	133 (85.3)	55 (35.3)	78 (50.0)	0.954
	Composite	23 (14.7)	9 (5.9)	14 (8.8)	
Housing Status	Renters	150 (96.1)	67 (42.9)	83 (53.2)	0.794
	Owners	6 (3.9)	3 (1.9)	3 (1.9)	
Father's Education Level	<7	86 (55.1)	35 (22.4)	51 (32.7)	0.119
	[7-14[52 (33.3)	27 (17.3)	25 (16.0)	
	≥ 14	18 (11.5)	4 (2.6)	11 (7.1)	
Mother's Education Level	<7	86 (55.1)	38 (24.4)	48 (30.8)	0.371
	[7-14[57 (36.5)	23 (14.7)	34 (21.8)	
	≥ 14	13 (8.3)	5 (3.2)	5 (3.2)	
Father's Occupation	SPC2	24 (15.4)	10 (6.4)	14 (9.0)	0.227
	SPC3	108 (69.2)	44 (28.2)	64 (41.0)	
	SPC4	24 (15.4)	15 (9.6)	9 (5.8)	
Mother's Occupation	SPC2	5 (3.2)	4 (2.6)	1 (0.6)	0.606
	SPC3	69 (44.2)	26 (16.7)	43 (27.6)	
	SPC4	82 (52.6)	39 (25.0)	43 (27.6)	

Note. N (%) = Number (Percentage); SPC = Socio-Professional Class

Table 3 presents detailed anthropometric data by sex. It shows that the mean age of the adolescent sample was 17 ± 1 year. A comparative analysis by sex revealed no significant differences in age, weight, height, or body mass index (BMI). However, two key anthropometric parameters showed statistically significant differences between both sexes: waist circumference ($p = 0.015$) and waist-to-height ratio (WHtR) ($p = 0.004$). Indeed, the mean waist circumference of girls was higher (87 ± 17 cm) than that of boys (80 ± 15 cm), which was also reflected in a WHtR ratio above the threshold of 0.5 0.50 ± 0.09 in girls versus 0.46 ± 0.09 in boys.

Table 3*Anthropometric characteristics of adolescents by sex*

	Total	Girls	Boys	P-value
	M ±SD or n(%)	M ±SD or n(%)	M ±SD or n(%)	
Age (yrs)	17 ± 1	17 ± 1	17 ± 1	0.12
Weight (Kg)	76.86 ± 16.21	78.12 ± 16.84	75.85 ± 15.71	0.38
Height (m)	1.75 ± 0.09	1.74 ± 0.09	1.76 ± 0.09	0.09
Height (cm)	175 ± 9	174 ± 9	176 ± 9	0.09
BMI	25.09 ± 5.21	25.82 ± 5.01	24.51 ± 5.32	0.11
WC	83 ± 17	87 ± 17	80 ± 15	0.01
BMI Z-score	-10 ⁻⁷ ± 1	-0.14 ± 0.9	-0.11 ± 1.02	0,11
WHtR	0.47±0.09	0.5±0.09	0.46±0.09	0.004

Note. N (%) = number (percentage); M ± SD = mean ± standard deviation; kg = kilogram; m = meter; cm = centimeter; BMI = body mass index; WC = waist circumference; WHtR = waist-to-height ratio; WHO = World Health Organization; IOTF = International Obesity Task Force; CDC = Centers for Disease Control and Prevention.

The comparison between the three classification references is illustrated in Table 4, showing the distribution of adolescents according to the weight status categories (rows) and the WHO, IOTF, and CDC criteria (columns). According to the 2007 WHO criteria, the majority of adolescents were classified as having a normal weight, with 136 adolescents (87.1%), while overweight and obesity affected 11 adolescents (7.1%) and 9 adolescents (5.8%), respectively. In contrast, the IOTF criteria classified a higher proportion of adolescents as overweight, with 46 adolescents (29.5%), and as obese, with 28 adolescents (18%). The 2000 CDC criteria yielded intermediate proportions, with 27 adolescents (17.3%) overweight and 24 adolescents (15.3%) obese. Underweight was only observed with the CDC 2000 criteria, concerning 11 adolescents (7.1%).

Table 4*Distribution of adolescent weight status according to WHO, IOTF, and CDC references*

Weight status	OMS 2007 n(%)	IOTF n(%)	CDC 2000 n(%)
Underweight	0 (0.0)	0 (0.0)	11 (7.1)
Normal weight	136 (87.1)	82 (52.6)	94 (60.3)
Overweight	11 (7.1)	46 (29.5)	27 (17.3)
Obesity	9 (5.8)	28 (17.9)	24 (15.3)

Note. Values are expressed as numbers (n) and percentages (%). WHO = World Health Organization; IOTF = International Obesity Task Force; CDC = Centers for Disease Control and Prevention.

Table 5 presents the results of the multinomial logistic regression, using normal weight status as the reference category. No statistically significant associations were observed between sex, middle household income, area of residence, father's socioeconomic status, or the risk of overweight/obesity ($p > 0.05$). Some variables, including high monthly income, mother's education level, mother's socioeconomic status, and housing status, showed statistically significant associations; however, the extremely high or extremely low odds ratios observed suggest possible instability in the estimates, likely related to the limited sample size and small sample sizes in some categories. Therefore, these results should be interpreted with caution and considered exploratory, without allowing for conclusions about robust associations or a direct structural effect of socioeconomic or housing conditions on the nutritional status of adolescents.

Table 5

Multinomial Logistic Regression Analysis of Overweight and Obesity Using the WHO Classification According to Adolescents' Social Characteristics (Reference Category = Normal Weight)

Sociodemographic and socio-economic characteristics	BMI class according to the WHO Z-Score					
	Overweight			Obesity		
	P-Value	OR	IC 95% (min-max)	P-Value	OR	IC 95% (min-max)
Sex	0.44	0.53	0.11-2.69	0.70	0.73	0.15 – 3.54
Monthly income	0.90	0.87	0.09 – 8.17	0.75	1.47	0.14 – 15.62
Area of residence	0.07	13.13	0.81 – 211.81	<0.001	7 *10 ⁻¹⁰	7*10 ⁻¹⁰ - 7 *10 ⁻¹⁰
	0.23	2.87	0.51 – 16.15	0.63	0.56	0.05 – 6.42
Fathers' SPC	0.84	1.55	0.02 – 116.20	0.37	4.00	0.18 – 87.09
	0.46	0.49	0.07 – 3.32	0.54	2.05	0.20 – 21.11
Mothers' SPC	0.49		0.25 – 17.46	0.16	5.96	0.50 – 71.67
	0.70	0.76	0.18 – 3.15	0.05	7.18	0.93 – 55.47
Housing Status	<0.001	2,52*10 ⁻¹³	2,52*10 ⁻¹³ -2,52*10 ⁻¹³	<0.001	4.44*10 ⁻⁶	4.44*10 ⁻⁶ - 4.44*10 ⁻⁶
Father's Education Level	0.23	0.20	0.01 – 2.83	<0.001	1.09*10 ¹⁵	2.32*10 ¹⁴ – 5.1*10 ¹⁵
Mother's Education Level	0.47	0.47	0.06 – 3.68	0.17	3.16	0.60 – 16.58
Education Level	0.25	3.93	0.38 – 40.55	<0.001	2,18*10 ⁻¹¹	2,18*10 ⁻¹¹ - 2,18 *10 ⁻¹¹
	0.26	0.30	0.04 – 2.50	0.66	0.67	0.11 – 4.01
Mother's Education Level	<0.001	2,18*10 ⁻¹²	2,18*10 ⁻¹² -2,18*10 ⁻¹²	0.17	7.36	0.40 – 134.04

Note. OR = odds ratio; CI = confidence interval; SPC = socio-professional class. Very high or very low odds ratios should be interpreted with caution, as they may reflect instability in estimates due to small sample sizes in certain categories.

Table 6

Multinomial Logistic Regression Analysis of Overweight and Obesity Using the IOTF Classification According to Adolescents' Social Characteristics (Reference Category: Normal Weight)

Sociodemographic and socio-economic characteristics	BMI class according to IOTF					
	Obesity			Overweight		
	P-Value	OR	IC 95% (min-max)	P-Value	OR	IC 95% (min-max)
Sex	0.06	0.435	0.183 - 1.034	0.22	0.523	0.183 - 1.489
Monthly income	0.88	0.917	0.285 -2.944	0.36	0.458	0.085 - 2.445
	0.14	5.316	0.578 - 48.858	0.39	2.789	0.258 - 30.045
Area of residence	0.72	1.235	0.377 - 4.042	0.32	1.982	0.503 - 7.797
	0.42	0.329	0.021 - 5.090	0.91	0.879	0.078 - 9.826
Fathers' SPC	0.33	0.562	0.176 - 1.794	0.01	0.227	0.065 - 0.782
	0.46	1.732	0.394 - 7.598	0.43	1.828	0.405 - 8.237
Mothers' SPC	0.37	0.692	0.304 - 1.573	0.89	1.070	0.392 - 2.915
	<0.001	4.48*10 ⁻³⁷	4.48*10 ⁻³⁷ -4.48*10 ⁻³⁷	0.99	0.999	0.066 - 14.955
Housing Status	0.49	2.213	0.222 - 21.958	0.95	1.072	0.097 - 11.825
Father's Education Level	0.58	0.777	0.311 - 1.938	0.80	1.152	0.379 - 3.490
	0.24	0.305	0.040 - 2.291	0.71	1.445	0.200 - 10.418
Mother's Education Level	0.07	2.339	0.932 - 5.868	0.87	0.911	0.280 - 2.963
	0.81	1.249	0.199 - 7.822	0.32	0.274	0.021 - 3.556

Note. OR = odds ratio; CI = confidence interval. Very high or very low odds ratios should be interpreted with caution, as they may reflect instability in estimates due to small sample sizes in certain categories.

Table 6 presents the results of the multinomial logistic regression analysis using the IOTF classification, with normal weight serving as the reference category. Overall, the majority of sociodemographic and socioeconomic variables were not significantly associated with overweight or obesity according to this classification.

Some categories of parental variables showed statistically significant results; however, the presence of very low odds ratios, particularly for some estimates related to maternal characteristics, suggests possible instability in the model, likely due to the small sample size in some categories. Therefore, these results should be interpreted with caution and considered exploratory rather than robust associations.

Sex, monthly income, area of residence, type of housing, and parental education level were not significantly associated with overweight or obesity in the majority of categories.

Overall, the IOTF classification generated fewer statistically significant estimates than the WHO classification.

However, the presence of extreme odds ratios again necessitates a cautious interpretation of these results, which should be considered exploratory rather than robust associations.

Table 7

Multinomial Logistic Regression Analysis of Adolescent Weight Status Categories According to CDC Classification and Socioeconomic Characteristics

Sociodemographic and socioeconomic characteristics	BMI class according to CDC									
	P-Value	OR	IC 95% (min-max)	P-Value	OR	IC 95% (min-max)	P-Value	OR	IC 95% (min-max)	
Sex	<0.001	8.60*10 ¹⁴	4.76*10 ¹⁴ - 1.56*10 ¹⁵	0.245	5.63*10 ⁻¹	0.213-1.48*10 ⁶	<0.001	3.66*10 ¹⁷	3.66e ⁻¹⁷	3.66*10 ⁻¹⁷
Are of residence	0.656	1.75*10 ²	0.148 - 2.06*10 ⁶	0.113	2.63*10 ⁻¹	0.050-1.36*10 ⁶	<0.001	2.92*10 ⁻⁴	2.92*10 ⁻⁴	2.92*10 ⁻⁴
	0.384	3.93*10 ²	0.179 - 8.61*10 ⁶	0.519	2.46*10 ²	0.158- 3.83*10 ⁶	<0.001	1.14*10 ⁻⁵	1.14*10 ⁻⁵	1.14*10 ⁻⁵
Fathers' SPC	0.865	8.42*10 ⁻¹	0.116 - 6.09*10 ²	0.650	1.35*10 ²	0.366-4.99*10 ⁶	<0.001	3.64*10 ⁷	3.64*10 ⁷	3.64*10 ⁷
	0.426	2.78*10 ²	0.222 - 3.49*10 ⁶	0.958	9.52*10 ⁻¹	0.154-5.86*10 ⁶	<0.001	2.31*10 ⁻⁶	2.31*10 ⁻⁶	2.31*10 ⁻⁶
Mothers' SPC	<0.001	4.64 10 ¹⁰	2 *10 ¹⁰ - 10.73*10 ¹⁰	0.212	2.36*10 ⁻¹	0.024-2.27*10 ⁶	<0.001	1.35*10 ⁵	1.35*10 ⁵	1.35*10 ⁵
	<0.001	12.43*10 ¹⁰	5.72*10 ¹⁰ - 26.99*10 ¹⁰	0.329	3.35*10 ⁻¹	0.037-3*10 ⁶	<0.001	3.63*10 ⁻⁶	3.63*10 ⁻⁶	3.63*10 ⁻⁶
Housing Status	<.001	2.55*10 ¹⁴	1.41*10 ¹⁴ - 4.61*10 ¹⁴	0.790	1.36*10 ²	0.136-1.36*10 ⁶	<0.001	2.19*10 ⁻³	2.18*10 ⁻³	2.19*10 ⁻³
Father's Education Level	0.622	0.652	0.119 - 3.56	0.275	5.38*10 ⁻¹	0.177-1.63*10 ⁵	<0.001	4.10*10 ⁶	4.10*10 ⁶	4.11*10 ⁶
	0.180	4.98*10 ²	0.476 - 5.21 *10 ⁶	0.980	9.74*10 ⁻¹	0.135-7.02*10 ⁵	<0.001	1.67*10 ¹⁸	1.67*10 ¹⁸	1.67*10 ¹⁸
Mother's Education Level	0.265	6.99*10 ²	0.229 - 2.13 *10 ⁷	0.377	2.49*10 ²	0.327 - 1.90*10 ⁶	<0.001	2.79*10 ⁻⁹	2.79*10 ⁻⁹	2.79*10 ⁻⁹
	0.149	3.42*10 ²	0.643 - 1.8* 10 ⁶	0.872	9.16*10 ⁻¹	0.319 -2.62*10 ⁵	<0.001	3.66*10 ⁷	3.66*10 ⁷	3.67*10 ⁷

Note. OR = odds ratio; CI = confidence interval; SPC = socio-professional class. Normal weight was used as the reference category. Very high or very low odds ratios should be interpreted with caution, as they may reflect instability in estimates due to small sample sizes in certain categories.

In Table 7, the results of the multinomial logistic regression analysis show that some estimates reached statistical significance, although several extreme odds ratios suggest possible

instability in the model. Specifically, significance was reached for the estimates of thinness, based on sex, housing type, and certain categories of maternal occupation, with very high odds ratios.

The same observation can be made for overweight, where statistical significance was also reached for some outcomes, notably for sex, place of residence, parental education level, and certain parental socioeconomic categories.

However, due to the presence of extremely high or very low odds ratios, these results should be interpreted with caution and considered exploratory.

Conversely, no variable was significantly associated with obesity in this model. Overall, the results obtained with the CDC classification suggest possible statistical relationships between certain social characteristics and weight status, but confirmation is needed on larger and better balanced samples, given the apparent instability of some estimates.

Discussion

The main objective of this study was to compare the weight status classification of Moroccan school-aged adolescents according to three widely used international anthropometric standards (WHO, IOTF, and CDC), which raises questions about the interpretation of the differences observed in the published results. More specifically, the aim was to examine the extent to which the choice of reference standard could modify the estimation of underweight, overweight, or obesity within the same sample. Furthermore, this study also aimed to exploratorily analyze the possible associations between the weight status categories assessed by these different standards and certain sociodemographic and socioeconomic characteristics.

Sociodemographic and socioeconomic characteristics

Based on the results concerning these latter characteristics, the profile of the study participants reflects a generally disadvantaged socioeconomic context, a factor to consider when interpreting the results. Indeed, the sample is predominantly from rural areas, low-income households, with a relatively low level of parental education, and most of them live in rented accommodation. Adolescent weight status can be associated with low family income, particularly with regard to access to food, diet quality, and living conditions. The relationship between socioeconomic status and adiposity has already been demonstrated in children and adolescents in Europe and China (Sares-Jäske et al., 2022; Ke et al., 2023). However, it can vary depending on the context of the nutritional transition, particularly in low- and middle-income countries (Popkin et al., 2012).

The predominantly rural setting of this sample is an important contextual element. Indeed, several social and environmental factors have been associated with overweight, obesity, and overall nutritional status among adolescents in Morocco (El Kabbaoui et al., 2018) and in other countries in the region (Aounallah-Skhiri et al., 2008).

Another factor to consider is the relatively low level of parental education observed in this study. Links have indeed been established between the development of overweight in adolescence and the parents' socioeconomic status (Morgen et al., 2010), as well as between parental education level and the risk of overweight and obesity in children and adolescents (Ke et al., 2023). Similar links between these sociodemographic factors and abdominal obesity have also been reported among Moroccan schoolchildren (Lahyani et al., 2025).

The high proportion of rental housing, often linked to migration from rural to urban areas, reflects unfavorable living conditions, as was demonstrated by a previous study conducted in the same province of El Jadida, which highlighted an association between weight and certain social and behavioral factors among adolescents (Sahel et al., 2022). Another study of sub-Saharan migrants also living in this province demonstrated links between nutritional status, weight, and socioeconomic conditions (Daif et al., 2021). Although no statistically significant differences were observed between the sexes regarding the main sociodemographic characteristics in the present

study, these data underscore the importance of considering social and material conditions when interpreting weight. These variables should therefore be considered as contextual elements that allow for a better interpretation of significant estimates, without necessarily concluding that there are established social determinants of weight.

Anthropometric characteristics

The results show that the mean BMI did not differ significantly between girls and boys, suggesting comparable overall body size between the two sexes in this sample. However, girls had significantly higher values for waist circumference and waist-to-height ratio (WHtR), indicating more pronounced central adiposity in females, despite a comparable BMI. This observation raises the question of which anthropometric indicator is most appropriate for assessing the weight status of adolescents. Indeed, BMI, although widely used due to its simplicity, does not allow for the differentiation of fat mass from lean mass, nor does it allow for the assessment of the abdominal distribution of adiposity, while the location of fat mass, particularly abdominal fat, plays an important role in the development of early metabolic complications (Bauer et al., 2015).

In this study, the higher WHtR values in girls, close to the threshold of 0.5, suggest that central adiposity may not be adequately detected by BMI alone. Several studies have reported that WHtR is a simple and relevant indicator for identifying central adiposity in young people, including those with a normal BMI (Garnett et al., 2008). Similarly, the 0.5 WHtR threshold has been proposed as a useful marker for screening cardiometabolic risk, in addition to BMI and waist circumference (Ashwell et al., 2012).

These results therefore support the value of an anthropometric approach combining BMI, waist circumference, and WHtR for a more comprehensive assessment of weight status and abdominal adiposity in adolescents. The value of the WHtR in assessing central adiposity in children and adolescents has also been confirmed by recent studies in accordance with fat mass measured by DEXA or a greater ability to identify abdominal obesity compared to BMI alone (Eslami et al., 2023; Agbaje, 2024). However, as a direct body composition measurement is missing, this interpretation should remain cautious.

The results of this study show that the classification of adolescents' weight status varies considerably depending on the anthropometric reference used. This variability is particularly evident in the present study as the WHO reference classifying the majority of adolescents as normal weight, while the IOTF and CDC references identify higher proportions of overweight and obesity (Table 4). In addition, the CDC criteria stand out by identifying a proportion of underweight adolescents that does not appear with the WHO and IOTF references.

These discrepancies indicate that the choice of anthropometric reference framework is not neutral in estimating adolescents' weight status. In fact, the nature of the thresholds used by each reference framework underlies the explanation for these differences. Indeed, the WHO criteria are based on BMI Z-scores for age and sex, the IOTF criteria use age- and sex-specific BMI thresholds linked to adult values, while the CDC criteria are based on BMI percentiles for age and sex, thus meaning that the same adolescent can be classified differently depending on the system used. The variability in estimates of overweight and obesity in children according to the classification standards used has also been 1

Conclusion

The data from this study show that weight status classification varies depending on the anthropometric reference system used, with notable differences in the proportions of adolescents classified as normal weight, overweight, obese, or underweight.

These results highlight that the choice of anthropometric reference system is not neutral and can alter the interpretation of adolescents' weight status. They therefore suggest that, to

facilitate comparison between studies and avoid overinterpretation of observed proportions, the use of criteria from these reference systems (WHO, IOTF, or CDC) should be clearly specified in studies on overweight and obesity in young people.

The results also confirm the value of a more comprehensive anthropometric approach in the absence of direct body composition measurements, while acknowledging the need for cautious interpretation. They also emphasize that, to better assess abdominal adiposity and the anthropometric profile of adolescents, it is beneficial to use anthropometric indicators complementary to BMI, such as waist circumference and height-to-waist ratio.

Furthermore, some associations were observed between sociodemographic and socioeconomic characteristics and weight status categories according to the different references used. However, these associations should be interpreted with caution, given the aforementioned limitations, which preclude establishing a cause-and-effect relationship.

In conclusion, this study should be considered a comparative and exploratory analysis, providing useful methodological elements for the selection and interpretation of anthropometric references in Moroccan adolescents. The reported data also do not allow for a definitive recommendation of the use of one reference rather than another in this population and highlight the need to conduct further studies on larger and more diverse samples, integrating dietary, behavioral, biological and pubertal data, in order to better assess the relevance of these references in the Moroccan context and to guide appropriate prevention strategies.

Limitations of the Study

This study has the advantage of reporting interesting results concerning discrepancies in the estimation of adolescents' weight status depending on the anthropometric reference used, a topic still debated in the literature. This finding gives this research methodological value, as it demonstrates that the use of anthropometric reference—whether WHO, IOTF, or CDC—can influence the classification of weight status and the interpretation of estimates reaching the significance threshold. These results also underscore the importance of a clear and harmonized methodological choice in future studies conducted with Moroccan adolescents.

However, it should be emphasized that the study also has certain methodological and statistical limitations that must be considered when interpreting the results. Among these limitations, the relatively small sample size of adolescents participating in the study may reduce the statistical power of the analyses, thus limiting the generalizability of the results to all Moroccan school-aged adolescents. Furthermore, the small sample sizes in certain weight status categories or in certain sociodemographic categories may have contributed to the instability of some estimates. The same is true statistically, where several odds ratios observed in the multinomial logistic regression models are very high or very low, suggesting possible instability in the estimates. These extreme values may reflect an uneven distribution of sample sizes between categories rather than robust associations. Therefore, estimates of associations between social characteristics and weight status that reached the significance threshold should be interpreted with caution and considered exploratory rather than confirmatory.

Furthermore, certain potentially confounding variables that could influence adolescents' weight status and interact with sociodemographic and socioeconomic characteristics were not included in the analyses. This could constitute residual bias and limit the interpretation of the observed associations. These variables include dietary habits, detailed dietary intake, dietary diversity, level of physical activity, biochemical parameters, and pubertal stage.

Finally, the cross-sectional nature of the study does not allow for establishing a causal relationship between the studied social characteristics and weight status. Moreover, this study compares the application of several anthropometric references within the same sample but does

not constitute a validation study that definitively identifies the most appropriate reference for the Moroccan adolescent population.

Competing interests

The authors declare no competing interests.

Ethics Committee Approval

The study was conducted in accordance with ethical standards. Permission was obtained from local academic authorities.

Consent to participate

Oral informed consent from adolescents and written informed consent from parents was required prior to inclusion in the survey.

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