Article

Normal Weight Obesity and Grip Strength: A Cross-Sectional Study

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Abstract

Obesity is a global health concern affecting all income levels, with body mass index (BMI) traditionally used for diagnosis. However, BMI does not accurately reflect body composition. Normal weight obesity (NWO) describes individuals with a normal BMI but elevated body fat percentage and has been associated with metabolic abnormalities and reduced physical fitness. This cross-sectional study included 384 adults aged 18–40 years with a BMI between 18.5 and 24.9 kg/m^2. Anthropometric measurements and body composition were assessed using an InBody H20 bioelectrical impedance device, and handgrip strength was measured with a Camry electronic dynamometer. NWO was defined as body fat percentage $\geq$20% in men and $\geq$30% in women. The overall prevalence of NWO was 77.3%. Although prevalence appeared higher in men than in women, this difference was not statistically significant after adjustment for multiple comparisons. Participants with NWO showed significantly higher body fat percentage, visceral fat index, hip circumference, and blood pressure compared with normal weight non-obese individuals after Holm–Bonferroni correction. Skeletal muscle mass was lower in the NWO group, although this difference did not remain statistically significant after adjustment. Multivariate logistic regression identified right-hand grip strength as an independent protective factor against NWO.

Keywords: normal weight obesity; hand strength; metabolic syndrome; adiposity

1. Introduction

Obesity is recognized as a growing healthcare community problem with a huge impact on morbidity, mortality, and the economy of developed and developing countries [1,2]. Currently, approximately a third of the global population is classified as overweight or obese [3,4]. Overweight and obesity represent the fifth leading cause of death around the world, regardless of country and income level [5].

Traditionally, obesity has been diagnosed as a high value in the body mass index (BMI) determined by the Quetelet formula [4,6]. This index began to be used in 1842 when Quetelet, a Belgian mathematician, noticed that in people he considered having a "normal body composition", weight was proportional to height squared [5].

Over the past four decades, BMI has been widely used to classify populations as normal weight, overweight, or obese; however, important limitations in its use have been recognized. BMI does not discriminate between mesomorphic and endomorphic body types and therefore cannot determine whether an elevated BMI reflects increased lean mass or excess fat mass. Moreover, it does not account for body fat distribution or for metabolic abnormalities that may be present in individuals who do not meet the BMI criteria for overweight or obesity. Clinical manifestations such as acanthosis nigricans, identifiable on physical examination, provide relevant information regarding insulin resistance that is not captured by BMI alone [6–9].

In 2006, De Lorenzo et al. described the association of normal weight and high-fat content with metabolic abnormalities [10]. This finding was called normal weight obesity (NWO), which identifies individuals with a normal BMI (18.5–24.9 kg/m^2) and an increase in the percentage of body fat according to their age group.

To date, there is no specific consensus on the cutoff point for normal body fat percentage; therefore, several classifications are used to identify it. These range between <19–25% for men and <30–35% for women and are further subdivided according to age. In individuals aged 20–39 years, a body fat percentage of <19% in men and <32% in women is considered normal; between 40 and 59 years, <21% and <33%; and between 60 and 79 years, <24% and <35% for men and women, respectively [11].

Normal weight obesity is associated with hypercholesterolemia and low muscle mass in specific groups, such as people living with HIV [12]. Furthermore, a poorer physical condition has been observed in individuals with normal weight obesity compared to those with normal weight non-obese (NWNO) [13].

Handgrip strength, measured through dynamometry, is an objective indicator of functional capacity and muscular strength of the hand and forearm. It quantifies, in kilograms, the maximum force exerted during a voluntary contraction. In addition to reflecting the strength of the hand flexor muscles, it has also been proposed as a global marker of muscle strength and overall health status, showing correlations with lean mass, functional capacity, mobility, and risk of disability. Handgrip strength has been independently associated with sarcopenia, frailty, cardiovascular risk, and all-cause mortality [14].

This prospective, cross-sectional, observational study was designed to determine, as a primary endpoint, the prevalence of NWO in a Latin American youth population. Secondary endpoints were to determine its association to grip strength.

2. Materials and Methods

2.1. Participants

Adults were recruited from a primary health care unit of the national social security system in Mexico. Eligible participants were men and women aged 18 to 40 years with a normal BMI (18.5–24.9 kg/m^2). Exclusion criteria included patients with a diagnosis of malignant neoplastic diseases, whether under treatment or not, women with a current pregnancy or who had been pregnant within the past year, individuals with unintentional weight loss greater than 10% in the previous twelve months, patients who had undergone cosmetic procedures such as liposuction or lipectomy within the past two years, patients with ascites or fluid retention secondary to liver disease or symptomatic congestive heart failure, along with those with mental illnesses under pharmacological treatment that could significantly affect body weight, and individuals with endocrine disorders such as hypothyroidism or hyperthyroidism.

2.2. Settings

This study was conducted at a primary care unit in Mexico between September 2024 and June 2025. Participants were invited to take part during routine family medicine ap-

pointments. A non-probabilistic consecutive sampling strategy was employed, whereby all patients meeting the inclusion criteria were invited to participate. In total, 459 individuals were invited; of these, 58 did not complete the evaluation due to early departure from the clinic or refusal to undergo bioelectrical impedance analysis and were therefore excluded. An additional 17 participants were excluded for not meeting the BMI eligibility criteria, as they presented values ≥ 25 kg/m^2 at the time of assessment. Anthropometric and body composition measurements were performed under non-fasting conditions.

2.3. Measurements

All participants underwent a standardized evaluation of anthropometry, blood pressure, body composition and handgrip strength. Body frame size was calculated using the height-to-wrist circumference ratio, according to the classification proposed by Nowak and Schulz (1987): in men, >10.4 small, 9.6–10.4 medium, and <9.6 large; in women, >11 small, 10.1–11 medium, and <10.1 large [15]. Handgrip strength was measured using a Camry electronic hand dynamometer (CAMRY Mod: EH101) with a maximum capacity of 90 kg after a demonstration and practice session guided by the inspector; participants stood upright with their elbow bent at 90°, without bending or extending the torso and performed the grip strength test by squeezing the dynamometer with maximum effort. Each hand was tested twice in an alternating sequence, with a minimum rest period of 60 s between trials. The highest value recorded was used for analysis. The dynamometer was used exclusively for research purposes and received no additional calibration. Body composition was assessed using the InBody H20 bioelectrical impedance scale (InBody Co., Ltd., Seoul, Republic of Korea) with the patients standing barefoot and following manufacturer's instructions.

Measurements included body weight, body fat percentage, skeletal muscle mass, and body mass index following the manufacturer's standardized protocol. Body fat percentage thresholds were defined as $\geq 20\%$ for men and $\geq 30\%$ for women, based on established clinical criteria and intending to reduce the impact of a systematic underestimation of BFP conducted by the BIA device [16,17].

2.4. Data Analysis

A descriptive statistical analysis was conducted for quantitative variables, including measures of central tendency and dispersion. For qualitative variables, frequencies and percentages were calculated. The proportions of sex and body frame between NWO and NWNO participants were compared using Pearson's χ^2 test or Fisher's exact test, as appropriate. For quantitative comparative variables, the Kolmogorov–Smirnov test was used to assess data distribution. Depending on normality, either independent-samples Student's *t*-tests or Mann–Whitney U tests were applied. To control for Type I error due to multiple comparisons, the Holm–Bonferroni correction was applied within predefined families of comparisons. Adjusted *p* values (*p*Holm) were calculated, and statistical significance was determined based on corrected values. A binary logistic regression analysis was performed to assess the independent association of anthropometric and dynamometric variables with normal weight obesity. Multicollinearity among independent variables was evaluated using variance inflation factors (VIF), with values > 5 considered indicative of significant collinearity. A two-tailed *p* value < 0.05 was considered statistically significant. All analyses were performed using SPSS version 22.0 (SPSS Inc., Armonk, NY, USA).

2.5. Ethical Considerations

Approval was obtained from the Institutional Review Board (R20241904056) as well as written informed consent from all the participants. All procedures and privacy measures concerning human beings were carried out in accordance with the Declaration of Helsinki.

3. Results

3.1. Sample Characteristics

A total of 384 subjects aged 18 to 40 years with a BMI between 18.5 and 24.9 were included in the study. For the primary analysis, NWO was defined using a BFP cut-off of $\geq$20% in men and $\geq$30% in women, identifying 297 (77.3%) individuals as NWO. Given the lack of a universally standardized BFP threshold for NWO, a sensitivity analysis was additionally performed using more conservative cut-off points ($\geq$25% for men and $\geq$35% for women), resulting in an estimated prevalence of 87 (22.7%) NWO patients and 297 (77.3%) NWNO patients. All subsequent analyses were conducted using the primary NWO definition ($\geq$20%/$\geq$30%), unless otherwise specified.

After adjusting for multiple comparisons using the Holm–Bonferroni correction, the group comparison reads as follows: although the prevalence of NWO was higher in men than in women (80.2% vs. 70.2%), this difference was not statistically significant (pHolm = 0.16). The NWO group exhibited significantly higher values for weight, BMI, body fat percentage, visceral fat index, and both systolic and diastolic blood pressure compared with the NWNO group (all pHolm < 0.05). Table 1 presents the sociodemographic, anthropometric, and clinical characteristics of the participants.

Table 1. Participant characteristics.

		Group				
		NWNO	**NWO**	**Total**	p	p **(Holm-Adjusted)**
		n = 87 (22.7)	**n = 297 (77.3)**	**N = 384**		
Sex	Woman	39 (44.8)	92 (31)	131 (34.1)	0.02	0.16
	Men	48 (55.2)	205 (69)	253 (65.9)		
Body Frame/Build	Small	50 (57.5)	198 (66.7)	248 (64.6)	0.28	0.99
	Medium	17 (19.5)	47 (15.8)	64 (16.7)		
	Large	20 (23)	52 (17.5)	72 (18.8)		
Age		26.8 ± 6.8	29.3 ± 6.2	28.7 ± 6.4	0.001	0.017
Height (cm)		1.6 ± 0.07	1.6 ± 0.06	1.6 ± 0.06	0.07	0.42
Weight (kg)		62.7 ± 7.5	66.1 ± 6.6	65.3 ± 7	<0.001	0.017 *
Body Mass Index (BMI) (kg/m^2)		22.5 ± 1.4	23.3 ± 1.2	23.1 ± 1.3	<0.001	0.017 *
Body Fat Percentage (%)		20.4 ± 4	27.0 ± 5.2	25.5 ± 4	<0.001	0.017 *
Skeletal Muscle Mass (kg)		30.7 ± 4.9	29.5 ± 3.6	29.8 ± 4	0.03	0.21
Visceral Fat Index (Inbody score)		5.8 ± 1.6	8.4 ± 1.7	7.8 ± 1.9	<0.001	0.017 *
Waist Circumference (cm)		84.0 ± 6.1	85.8 ± 5.9	85.4 ± 6	0.01	0.09
Hip Circumference (cm)		88.8 ± 5.1	90.5 ± 5.1	90.1 ± 5.1	0.008	0.08
Waist-to-Hip Ratio (WHR)		0.9 ± 0.03	0.9 ± 0.04	0.9 ± 0.04	0.66	0.99
Wrist Circumference (cm)		15.3 ± 1.7	15.4 ± 1.4	15.4 ± 1.4	0.73	0.99
Systolic Pressure (mmHg)		111.4 ± 12.9	116.2 ± 12.4	115.1 ± 12.6	0.002	0.02
Diastolic Pressure (mmHg)		69.2 ± 10.4	73.6 ± 10.2	72.6 ± 10.3	0.001	0.017 *
Handgrip Strength—Left Hand (kg)		32.2 ± 9.6	34 ± 7.4	33.6 ± 8	0.12	0.6
Handgrip Strength—Right Hand (kg)		30.4 ± 9.1	31.2 ± 7.4	31 ± 7.8	0.46	0.99

p values were obtained using chi-square tests for categorical variables and independent-samples t-tests for continuous variables. Holm–Bonferroni correction was applied across 17 pairwise comparisons to control the family-wise error rate. * For results reported as p < 0.001, Holm-adjusted p values were calculated conservatively using p = 0.001.

3.2. Sample Characteristics According to Sex

In Table 2, body frame distribution differed significantly between sexes after adjustment (pHolm = 0.016), with small body frame predominating among women (86.3%), whereas medium and large frames were more frequent in men. After Holm correction, men showed significantly greater height, weight, BMI, skeletal muscle mass, wrist circumference, systolic and diastolic blood pressure, and handgrip strength in both hands compared with women (all pHolm < 0.05).

Table 2. Participation characteristics according to sex and metabolic status.

		Group									p^{c}
		Total n = 384	Women				Men				
			NWO n = 92	NWNO n = 39	p^{a}	Total n = 131	NWO n = 205	NWNO n = 48	p^{b}	Total n = 253	
Body Frame/Build	Small	255 (66.4)	72 (78.3)	34 (87.2)	0.016	113 (86.3)	126 (61.5)	16 (33.3)	0.016	142 (56.1)	0.016
	Medium	100 (26.0)	19 (20.7)	4 (10.3)		17 (13.0)	28 (13.7)	13 (27.1)		83 (32.8)	
	Large	29 (7.6)	1 (1.1)	1 (2.6)		1 (0.8)	51 (24.9)	19 (39.6)		28 (11.1)	
Age, years		28.7 ± 6.4	29.16 ± 6.20	24.41 ± 6.09	0.016	27.75 ± 6.5	29.45 ± 6.26	28.75 ± 6.85	0.99	29.3 ± 6.3	0.168
Height (cm)		1.60 ± 0.06	1.621 ± 0.049	1.614 ± 0.052	0.99	1.60 ± 0.04	1.708 ± 0.051	1.709 ± 0.056	0.99	1.70 ± 0.05	0.016
Weight (kg)		65.3 ± 7.0	60.59 ± 5.60	57.51 ± 5.77	0.05	59.6 ± 5.8	68.61 ± 5.53	67.07 ± 5.93	0.616	68.3 ± 5.6	0.016
Body Mass Index (BMI) (kg/m^2)		23.1 ± 1.3	23.03 ± 1.56	22.05 ± 1.57	0.016	22.6 ± 1.5	23.49 ± 1.07	22.93 ± 1.23	0.03	23.3 ± 1.1	0.016
Body Fat Percentage (%)		25.5 ± 4.0	33.89 ± 1.77	23.95 ± 2.63	0.016	30.9 ± 5.0	24.00 ± 2.74	17.56 ± 2.24	0.016	22.7 ± 3.6	0.016
Skeletal Muscle Mass (kg)		29.8 ± 4.0	25.86 ± 2.78	26.08 ± 2.67	0.99	25.9 ± 2.7	31.20 ± 2.68	34.54 ± 2.52	0.016	31.8 ± 2.9	0.016
Visceral Fat Index (Inbody score)		7.8 ± 1.9	8.72 ± 1.61	5.85 ± 1.57	0.016	7.8 ± 2.0	8.28 ± 1.74	5.94 ± 1.73	0.016	7.8 ± 1.9	0.99
Waist Circumference (cm)		85.4 ± 6.0	86.00 ± 6.90	85.13 ± 7.09	0.99	85.7 ± 6.9	85.76 ± 5.52	83.22 ± 5.08	0.048	85.2 ± 5.5	0.99
Hip Circumference (cm)		90.1 ± 5.1	92.75 ± 4.95	91.33 ± 4.98	0.822	92.3 ± 4.9	89.52 ± 4.90	86.85 ± 4.49	0.016	89.0 ± 4.9	0.016
Waist-to-Hip Ratio (WHR)		0.9 ± 0.04	0.92 ± 0.05	0.93 ± 0.04	0.99	0.9 ± 0.05	0.95 ± 0.02	0.95 ± 0.02	0.99	0.9 ± 0.02	0.016
Wrist Circumference (cm)		15.4 ± 1.4	14.04 ± 0.71	13.81 ± 0.88	0.72	13.9 ± 0.7	16.06 ± 1.17	16.63 ± 1.15	0.042	16.1 ± 1.8	0.016
Systolic Blood Pressure (mmHg)		115.1 ± 12.6	113.48 ± 12.66	105.51 ± 10.31	0.016	111.1 ± 12.5	117.44 ± 12.14	116.35 ± 12.91	0.99	117.2 ± 12.2	0.016
Diastolic Blood Pressure (mmHg)		72.6 ± 10.3	70.98 ± 10.38	65.13 ± 8.92	0.036	69.2 ± 10.2	74.78 ± 9.92	72.60 ± 10.42	0.99	74.3 ± 10.0	0.016
Handgrip Strength—Left Hand (kg)		33.6 ± 8.0	24.71 ± 4.55	23.12 ± 5.09	0.56	24.2 ± 4.7	38.18 ± 3.92	39.74 ± 4.62	0.187	38.4 ± 4.0	0.016
Handgrip Strength—Right Hand (kg)		31.0 ± 7.8	21.94 ± 4.17	21.89 ± 4.30	0.99	21.9 ± 4.1	35.45 ± 4.07	37.47 ± 5.22	0.048	35.8 ± 4.3	0.016

Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. p^{a}: comparison between NWO and NWNO within women. p^{b}: comparison between NWO and NWNO within men. p^{c}: comparison between women and men (total groups). Comparisons were performed using Pearson's χ^2 test or Fisher's exact test for categorical variables and Student's t-test for independent samples for continuous variables. Holm–Bonferroni correction was applied separately within each family of comparisons (women, men, and total sex comparisons), with 16 pairwise tests per family, to control the family-wise error rate.

Conversely, women exhibited significantly higher body fat percentage and hip circumference than men (pHolm = 0.016 for both). No statistically significant differences were observed between sexes in age (pHolm = 0.168), visceral fat index (pHolm = 0.99), or waist circumference (pHolm = 0.99) after correction.

Stratified analyses within each sex comparing NWO and NWNO groups are also presented, revealing significant differences primarily in adiposity-related and body composition variables after Holm adjustment.

3.3. Multivariate Analysis

In multivariate logistic regression analysis, age (OR = 1.049; 95% CI: 1.005–1.095; p = 0.029), male sex (OR = 6.062; 95% CI: 1.875–19.601; p = 0.003), higher BMI (OR = 1.45; 95% CI: 1.189–1.768; p < 0.001), and greater hip circumference (OR = 1.107; 95% CI: 1.014–1.207; p = 0.022) were independently associated with increased odds of NWO. Conversely, higher right-hand grip strength was associated with lower odds of NWO (OR = 0.917; 95% CI: 0.857–0.981; p = 0.012). The remaining variables were not independently associated with NWO. Multicollinearity diagnostics indicated no significant collinearity among predictors (all variance inflation factors < 5). Table 3 displays the complete analysis.

Table 3. Multivariate analysis for anthropometry association with NWO.

	B	Sig.	Exp(B)	95% C.I. for EXP(B)	
				Lower Limit	Upper Limit
Age	0.048	0.029	1.049	1.005	1.095
Sex	1.80	0.003	6.062	1.875	19.601
Body Mass Index	0.372	<0.001	1.45	1.189	1.768
Waist Circumference (cm)	−0.026	0.47	0.974	0.906	1.047
Hip Circumference (cm)	0.101	0.02	1.107	1.014	1.207
Systolic Blood Pressure (mmHg)	0.002	0.74	1.002	0.990	1.015
Diastolic Blood Pressure (mmHg)	0.027	0.07	1.027	0.997	1.057
Handgrip Strength—Left Hand (kg)	−0.007	0.83	0.993	0.930	1.060
Handgrip Strength—Right Hand (kg)	−0.087	0.01	0.917	0.857	0.981
Constant	−17.646	<0.001	0.000		

Odds ratios (OR) and 95% confidence intervals (CI) were estimated using binary logistic regression analysis with NWO as the dependent variable. B represents the regression coefficient, Exp(B) the odds ratio, and Sig. the corresponding p value. All variables shown were entered simultaneously into the model. Statistical significance was defined as p < 0.05.

4. Discussion

In the present study, conducted in young adults with normal weight according to BMI, we found a high estimated prevalence of NWO, characterized by excess adiposity with a trend toward lower muscle mass. This finding is consistent with previous reports suggesting that this phenotype is an underestimated cardiometabolic risk factor [6].

Participants with NWO were older and had higher weight, BMI, body fat percentage, visceral fat index, and hip circumference, as well as higher blood pressure levels compared to subjects with NWNO. These findings align with studies that describe NWO as an intermediate risk state between overt obesity and healthy normal weight. A systematic review conducted in 2022 reported that these patients have higher risks of developing metabolic diseases such as type 2 diabetes mellitus, dyslipidemia, and hypertension [18].

Although skeletal muscle mass was lower in the NWO group, this difference did not remain statistically significant after adjustment for multiple comparisons. Nevertheless, reduced muscle mass remains clinically relevant, as relative sarcopenia has been associated with insulin resistance and an increased risk of metabolic syndrome. In addition, the accumulation of intramyocellular adipose tissue promotes the release of

pro-inflammatory cytokines, which may impair anabolic pathways and contribute to insulin resistance [19]. Supporting this concept, a study conducted in young Japanese women reported that approximately 60% of individuals with NWO exhibited characteristics overlapping with sarcopenia [20].

The absence of significant differences in handgrip strength, despite lower muscle mass, could be explained by the youth of the sample and the predominance of men, who generally have higher levels of absolute strength. Longitudinal studies are needed to evaluate whether strength loss becomes evident at later stages, as differences in physical fitness have been described in the literature [21–23].

The estimated prevalence of NWO was higher in men than in women, which is interesting given that higher relative adiposity is generally associated with females. However, in our population, men showed higher BMI and muscle mass, which may favor the diagnosis of NWO based on fat percentage and distribution criteria. Literature describes that men with excess visceral fat, even with a normal BMI, present a higher risk of hypertension and metabolic disturbances than women. This estimated prevalence also contrasts with that reported in a study of 14–19-year-olds, which found a prevalence of 1.8% in males and 22.2% in females. The difference in total percentages and between sexes may be explained by the body fat thresholds used to determine normal weight obesity. In that study, cut-off points were ≥25% for males and ≥28% for females, allowing more body fat for men and less for women compared to our study, which used cut-off points of 20% and 30%, respectively [24].

These findings highlight the lack of standardized body fat reference values adjusted for BMI ranges. With the inclusion of a sensitivity analysis using more conservative cut-off points, the estimated prevalence decreased to 22.7%, which is closer to, yet still higher than, that reported in the international literature.

The marked reduction in prevalence from 77.3% to 22.7% after applying a more conservative body fat percentage threshold underscores the substantial impact that diagnostic cut-off selection has on the classification of normal weight obesity. This variability reflects the absence of universally accepted adiposity criteria and demonstrates how relatively small modifications in BFP thresholds can lead to considerable differences in epidemiological estimates.

The primary cut-offs (≥20% for men and ≥30% for women) were selected to account for the known systematic underestimation of body fat percentage by bioelectrical impedance analysis devices, thereby prioritizing sensitivity [16,17]. In contrast, the more conservative thresholds increased specificity but substantially reduced the number of individuals classified as NWO. Given that our region has one of the highest prevalences of adult obesity in Mexico, a higher proportion of individuals with excess adiposity despite normal BMI may be expected [25].

In the absence of a consensus on adiposity thresholds and their association with morbidity and mortality, the use of empirical values and percentiles continues, despite their limited precision. A study conducted in 2000 assessed the possibility of standardizing adipose tissue ranges considering BMI and ethnicity, but concluded that prospective studies are needed to evaluate morbidity and mortality in different populations [11].

Moreover, the predominance of a small body frame in women is consistent with the lower height and muscle mass observed, which results in a higher relative fat proportion. These findings support the idea that diagnosing NWO should always consider body composition parameters and population differences beyond BMI alone [16,26].

The regression model indicated that age, male sex, BMI, and hip circumference were independently associated with a higher likelihood of NWO, while greater right-hand grip strength was associated with lower odds of this condition. These findings suggest that incorporating muscle strength and body composition indicators may be useful in cardiometabolic risk assessment [27]. Although right-hand grip strength did not show significant differences in univariate analyses, its association emerged in the multivariate model after adjustment for age, sex and anthropometric variables, indicating a potential independent effect that becomes evident only when relevant confounders are considered.

The finding that hip circumference, rather than waist circumference, was associated with NWO contrasts with evidence linking central adiposity to higher metabolic risk. This result could be explained by population differences or by the effect of body proportionality in young male adults, warranting further investigation [28].

Clinical Implications and Limitations

Our findings underscore the need to identify individuals with NWO in clinical practice, as a normal BMI does not guarantee the absence of metabolic risk or that a patient is metabolically healthy. Measuring body composition and muscle strength should be considered part of preventive screening, particularly in young adults. Since one of the main goals of primary care is early prevention and intervention, finding low muscle mass or elevated body fat percentage would indicate the need for targeted interventions.

Study limitations include its cross-sectional design, which prevents establishing causality, the use of a commercial bioimpedance scale and the absence of a BFP standardized threshold.

According to the literature, BIA devices tend to systematically underestimate BFP when compared with dual-energy X-ray absorptiometry (DXA), which is considered the reference standard for body composition assessment [17,29,30]. Such underestimation may introduce measurement bias and lead to misclassification, particularly in prevalence estimates. Furthermore, the BIA device used in this study is not formally validated for research purposes and should not be regarded as a substitute for DXA when the latter is available. Therefore, the use of BIA represents a methodological limitation of this study. Any potential applicability in routine clinical practice should be interpreted with caution and limited to settings in which DXA is not available.

Because the estimated prevalence of NWO is highly dependent on the cut-off points applied, the use of lower thresholds can substantially increase prevalence estimates. As noted by De Lorenzo et al., there is no consensus regarding the optimal BFP values to define obesity, and given that fat mass distribution varies across populations, the application of a single universal cut-off remains challenging [16]. Taken together, these methodological limitations contribute to the wide range of NWO prevalence reported in the literature and underscore the need for caution when interpreting and comparing studies addressing NWO [16].

Despite these limitations, our findings are consistent with previous reports and provide clinically relevant insights for daily practice.

5. Conclusions

Normal weight obesity represents an emerging and potentially underrecognized condition in primary care, largely due to the absence of standardized diagnostic criteria and the limitations of commonly used body composition assessment methods. In this northern Mexican population, where obesity is a major public health concern, the estimated prevalence of NWO was substantial under both permissive and restrictive body fat cut-off scenarios.

Age, male sex, higher BMI within the normal range, and greater hip circumference were independently associated with increased odds of NWO, whereas higher muscle strength appeared to exert a protective effect. These findings reinforce the importance of incorporating body composition parameters and functional assessments into routine clinical evaluation, as BMI alone may fail to identify individuals at increased cardiometabolic risk.

Although the use of bioelectrical impedance analysis constitutes a methodological limitation for research purposes, it reflects a pragmatic tool frequently employed in real-world clinical practice. Future prospective studies across diverse populations are warranted to refine diagnostic thresholds and clarify the long-term cardiometabolic implications of normal weight obesity.

Author Contributions: N.A.-V. and G.E.-O. designed the study. All authors did statistical analyses. All authors contributed to writing the report. All authors provided critical conceptual input, analyzed and interpreted the data, and critically revised the report. N.A.-V. is the designated guarantor. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Instituto Mexicano del Seguro Social UMF07 (R20241904056).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Research data used in the analysis will be available upon request, through the corresponding author.

Conflicts of Interest: All authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

NWO	Normal weight obesity
NWNO	Normal weight non-obesity
BMI	Body mass index
BIA	Bioimpedance analysis
DXA	DXA Dual-Energy X-ray Absorptiometry

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