

Research Article

Normal-Weight Obesity and Body-Composition Profiles Among Pakistani Healthy Young Adults: A Cross-Sectional Study

Dr Maryam Iqbal¹, Prof Dr Shemaila Saleem², Dr Arooj Anthoney³

¹MBBS; MPhil Scholar, Department of Physiology, Shaheed Zulfiqar Ali Bhutto Medical University (SZABMU), Islamabad.

²MBBS, MPhil, PhD, MPH; Head of Department, Physiology, Federal Medical College, Islamabad.

³MBBS; MPhil Trainee, Department of Physiology, Shaheed Zulfiqar Ali Bhutto Medical University (SZABMU), Islamabad.

Email: ¹maryamiqofficial@gmail.com, ²drshemailasaleem@gmail.com, ³aroojpeter@gmail.com

Received: 10.06.26, Revised: 15.07.26, Accepted: 25.07.26

Abstract

Background: Body mass index (BMI) is widely used to classify weight status but does not distinguish adipose from lean tissue. Normal-weight obesity (NWO) describes individuals whose BMI lies within the conventional normal range despite elevated body fat percentage (BF%).

Objective: To estimate the prevalence of NWO among normal-BMI healthy young adults, compare prevalence by sex, and examine selected body-composition characteristics of participants with NWO versus normal-weight non-obese (NWN) participants.

Methods: This cross-sectional study included 96 healthy young adults aged 18-25 years from a public-sector medical college in Islamabad, Pakistan. Anthropometry and body composition were assessed using an eight-electrode segmental bioelectrical impedance analysis (BIA) device (Run Star FG2001). NWO was operationally defined as BMI 18.5-24.9 kg/m² together with BF% ≥25% in males or ≥32% in females. Prevalence was estimated among normal-BMI participants with Wilson 95% confidence intervals (CIs). Sex differences were assessed using Fisher's exact test and a crude prevalence ratio (PR). Primary body-composition comparisons were restricted to NWO and NWN participants; selected associations were further evaluated with parsimonious regression adjustment for sex and BMI.

Results: Of 96 participants, 66 (68.8%) had BMI 18.5-24.9 kg/m²; 20 (20.8%) were underweight and 10 (10.4%) had BMI ≥25 kg/m². Among normal-BMI participants, 23/66 met the NWO definition (34.8%; 95% CI 24.5-46.9%). NWO was present in 22/42 normal-BMI females (52.4%) and 1/24 normal-BMI males (4.2%), corresponding to a crude PR of 12.57 (95% CI 1.81-87.51; Fisher's exact $p < 0.001$). Compared with NWN participants ($n=43$), NWO participants ($n=23$) had higher BF% and BIA-derived visceral-fat grade and lower skeletal-muscle percentage and BIA-estimated basal metabolic rate (BMR) in unadjusted analyses. After adjustment for sex and BMI, skeletal-muscle percentage was not independently associated with NWO ($\beta = -1.13$ percentage points, 95% CI -3.62 to 1.36; $p = 0.375$), whereas BIA-estimated BMR remained lower ($\beta = -108.5$ kcal/day, 95% CI -157.7 to -59.4; $p < 0.001$) and visceral-fat grade remained higher ($\beta = 1.68$ units, 95% CI 0.54-2.82; $p = 0.004$).

Conclusion: NWO was identified in approximately one-third of normal-BMI participants in this single-center sample and was markedly more frequent among females. Several large unadjusted body-composition differences were substantially attenuated after accounting for sex, while differences in BIA-estimated BMR and visceral-fat grade persisted. Larger representative studies using validated reference body-composition methods and cardiometabolic biomarkers are needed.

Keywords: Normal-Weight Obesity, Body Composition, Body Mass Index, Bioelectrical Impedance Analysis, Body Fat Percentage, Medical Students, Pakistan.

INTRODUCTION

Obesity is a major contributor to global morbidity, and BMI remains the most widely used anthropometric index for classifying underweight, normal weight, overweight and obesity.¹ Its practical advantages are substantial, but BMI cannot distinguish fat mass from fat-free mass or identify the distribution of

adiposity. Consequently, some individuals classified as normal weight by BMI may nevertheless have elevated BF%. This phenotype is commonly termed normal-weight obesity (NWO).

The clinical relevance of NWO arises from evidence that normal BMI does not necessarily imply a favorable adiposity profile. Two

systematic reviews and meta-analyses published in 2022 found that adults with NWO had a higher prevalence or odds of several cardiometabolic abnormalities than normal-weight lean comparison groups.^{5,6} These findings do not establish that high BF% invariably confers cardiometabolic disease in every normal-weight individual, but they support investigation of body composition beyond BMI when the research question concerns adiposity phenotype.

Prevalence estimates vary substantially because no single universally accepted BF% threshold defines NWO and because studies use different populations and body-composition methods. Recent studies have reported NWO in adolescents, women, young adults, adults with type 2 diabetes, and general community samples using BIA, skinfold-derived estimates, ultrasound, or other approaches.⁷⁻¹² In a 2025 systematic review from Southeast Asia, pooled prevalence was high but extremely heterogeneous, underscoring the influence of population characteristics, cut-offs and measurement methods.¹²

South Asian populations are of particular interest because BMI may incompletely capture adiposity-related heterogeneity. Pakistani data are limited but not absent. Fatima et al. demonstrated discordance between BMI and BIA-derived body fat classification in a Pakistani sample,² while Arshad et al. reported NWO among young adults in Lahore using an equation-derived BF% estimate.³ Thus, the relevant evidence gap is not whether BMI-body-fat discordance exists in Pakistan, but how NWO is distributed and phenotypically characterized in specific young adult groups using body-composition assessment.

The present study therefore aimed primarily to estimate NWO frequency among normal-BMI healthy young adults using prespecified sex-specific BF% thresholds. Secondary objectives were to compare the frequency by sex and to examine selected BIA-derived body-composition characteristics between participants with NWO and normal-weight non-obese (NWN) participants, with attention to sex as a potential confounder.

METHODS

Study Design and Setting

A cross-sectional study was conducted in the Department of Physiology of a public-sector medical college in Islamabad, Pakistan, from July to September 2025.

Participants and Recruitment

Male and female volunteers aged 18-25 years were recruited using purposive convenience sampling. Exclusion criteria were pregnancy, implanted devices, acute illness or fever, edema, known endocrine disorders, use of medications considered likely to affect body water, and refusal to participate or provide consent.

Sample Size

The sample size was calculated using the WHO sample size calculator with the following parameters:

- Confidence level: 95%
- Level of significance: 5%
- Anticipated prevalence of normal-weight obesity: 28.8%, based on the study by Arshad et al. among young adults in Pakistan³
- Absolute precision (margin of error): 10%
- Design effect: 1

The minimum sample size calculated for estimation of a single population proportion was 79 participants. After accounting for an anticipated 10% non-response/incomplete-data rate, the required sample size was 88 participants. A total of 96 participants were included in the study (n=96).

Anthropometry

Data collection was performed by trained research assistants. Participants wore light clothing and removed footwear. Body weight was measured using a calibrated digital scale and height using a stadiometer. BMI was calculated as weight in kilograms divided by height in meters squared. For descriptive purposes, BMI was categorized as underweight (<18.5 kg/m²), normal weight (18.5-24.9 kg/m²), and BMI ≥25 kg/m².

Bioelectrical Impedance Assessment

Body composition was estimated using an eight-electrode segmental BIA device (Run Star FG2001) with integrated hand and foot contact electrodes. BIA measures electrical impedance and uses device-specific algorithms together with participant characteristics to estimate body-composition variables; it does not directly measure adipose tissue. The study recorded BF%, skeletal-muscle percentage, BIA-estimated BMR and a device-derived visceral-fat grade. Independent validation of this specific device model against a reference method such as dual-energy X-ray absorptiometry (DXA) in Pakistani young adults could not be established from the material

available for this manuscript and is considered a limitation.

Before measurement, participants were instructed to avoid excessive physical activity for 24 hours, refrain from eating for at least 2-3 hours, empty the bladder, remove footwear and metallic accessories, and undergo testing in light clothing. Measurements were obtained while participants stood upright on the platform and held the hand electrodes with the arms slightly abducted. Three consecutive readings were obtained with short intervals and the mean was recorded according to the study protocol.

Operational Definition of NWO

NWO was defined a priori as BMI 18.5-24.9 kg/m² together with BF% $\geq$ 25% in males or $\geq$ 32% in females.⁹ Participants with BMI 18.5-24.9 kg/m² and BF% below the corresponding sex-specific threshold were classified as NWNO. Participants with BMI outside 18.5-24.9 kg/m² were excluded from the primary NWO-versus-NWNO comparison. Because no universal BF% threshold for NWO exists, this definition should be interpreted as an operational study definition rather than a diagnostic standard.

Statistical Analysis

Analyses were performed in SPSS version 25. Continuous variables were summarized using mean $\pm$ standard deviation (SD) when approximately normally distributed; categorical variables were summarized using frequencies and percentages. The primary prevalence analysis was restricted to participants with BMI 18.5-24.9 kg/m². NWO prevalence was reported as n/N, percentage, and Wilson 95% CI. Sex differences in prevalence were evaluated with Fisher's exact test because of the small number of male NWO cases, and the crude female-to-male PR was reported with a 95% CI.

Body-composition comparisons were restricted to NWO and NWNO participants. Welch's independent-samples t-test was used for continuous outcomes where unequal variance was plausible; ordinal or clearly non-normal device-derived variables were additionally considered with rank-based testing. Because elevated BF% is part of the NWO definition, the BF% group difference was treated as descriptive rather than as an independent inferential finding.

Parsimonious multivariable linear models were used for selected body-composition outcomes to evaluate whether group differences persisted

after adjustment for sex and BMI. Because only one normal-BMI male met the NWO definition, a female-only analysis was used as a sensitivity analysis. Two-sided $p < 0.05$ was considered statistically significant, with secondary analyses interpreted as exploratory and emphasis placed on effect estimates and 95% CIs.

Ethical Considerations

Ethical approval was obtained from the Ethical Review Board of Shaheed Zulfiqar Ali Bhutto Medical University, Islamabad, Pakistan (No. F.1-1/2015/ERB/SZABMU/1440). Written informed consent was obtained from all participants before participation, and confidentiality was maintained.

RESULTS

Participant Characteristics and BMI Distribution

Ninety-six participants were included. Thirty-five (36.5%) were male and 61 (63.5%) were female. Mean height was 165.5 $\pm$ 9.7 cm and mean body weight was 57.5 $\pm$ 10.5 kg. Mean BMI was 20.99 $\pm$ 3.15 kg/m². Of the 96 participants, 20 (20.8%) were underweight, 66 (68.8%) had normal BMI, and 10 (10.4%) had BMI $\geq$ 25 kg/m². Descriptive body-composition characteristics of the total sample are shown in Table 1.

Prevalence of Normal-Weight Obesity

Among the 66 participants with BMI 18.5-24.9 kg/m², 23 met the prespecified NWO definition, yielding a prevalence of 34.8% (95% CI 24.5-46.9%). Expressed relative to the complete recruited sample, 23/96 participants (24.0%; 95% CI 16.5-33.4%) had NWO; however, the normal-BMI denominator is the primary estimand for the present analysis.

Sex-Specific Prevalence

Among normal-BMI participants, 22/42 females (52.4%; 95% CI 37.7-66.6%) and 1/24 males (4.2%; 95% CI 0.7-20.2%) met the NWO definition. The crude female-to-male PR was 12.57 (95% CI 1.81-87.51; Fisher's exact $p < 0.001$). The wide CI reflects the presence of only one male NWO case and indicates substantial imprecision in the sex-specific effect estimate.

NWO Versus NWNO Body-Composition Characteristics

The primary normal-BMI comparison included 23 participants with NWO and 43 with NWNO. NWO participants had a slightly higher mean BMI than NWNO participants (21.99 $\pm$ 1.63 vs 20.99 $\pm$ 1.65 kg/m²; mean difference 1.00

kg/m², 95% CI 0.15-1.85; $p=0.022$). As expected from the operational definition, BF% was substantially higher in NWO than NWNO participants ($36.28 \pm 3.93\%$ vs $20.58 \pm 6.63\%$; mean difference 15.70 percentage points, 95% CI 13.10-18.30; $p<0.001$); this comparison is descriptive because BF% defines group membership.

In unadjusted analyses, NWO participants had lower skeletal-muscle percentage ($19.88 \pm 4.51\%$ vs $29.03 \pm 10.48\%$; mean difference -9.15 percentage points, 95% CI -12.86 to -5.44; $p<0.001$), lower BIA-estimated BMR (1138 ± 120 vs 1378 ± 201 kcal/day; mean difference -240 kcal/day, 95% CI -319 to -161; $p<0.001$), and higher visceral-fat grade (7.65 ± 1.53 vs 4.28 ± 2.19 ; mean difference 3.37 units, 95% CI 2.45-4.29; $p<0.001$) (Table 3).

Adjusted Analyses

After adjustment for sex and BMI, the skeletal-muscle difference was markedly attenuated and no longer statistically significant ($\beta=-1.13$ percentage points, 95% CI -3.62 to 1.36; $p=0.375$). In contrast, BIA-estimated BMR remained lower in the NWO group (adjusted $\beta=-108.5$ kcal/day, 95% CI -157.7 to -59.4; $p<0.001$), while visceral-fat grade remained higher (adjusted $\beta=1.68$ units, 95% CI 0.54-2.82; $p=0.004$) (Table 4). These adjusted results suggest that the large unadjusted skeletal-muscle difference was largely attributable to differences in sex composition between groups.

Female-Only Sensitivity Analysis

Because only one male participant with normal BMI met the NWO definition, a female-only sensitivity analysis compared 22 female NWO participants with 20 female NWNO participants. Skeletal-muscle percentage did not differ materially ($19.36 \pm 3.84\%$ vs $20.32 \pm 2.61\%$; $p=0.345$), whereas BIA-estimated BMR remained lower (1118.5 ± 76.5 vs 1197.8 ± 104.2 kcal/day; $p=0.009$) and visceral-fat grade remained higher (7.64 ± 1.56 vs 5.70 ± 1.89 ; $p=0.001$) in women with NWO (Supplementary Table S1). These subgroup findings are exploratory and should be interpreted cautiously because of the modest sample size.

DISCUSSION

In this single-center sample of Pakistani healthy young adults, approximately one-third of participants with a normal BMI met the prespecified sex-specific BF% definition of

NWO. The phenotype was strongly concentrated among women, although the sex-specific PR was imprecise because only one normal-BMI male met the NWO criterion. A second important observation was methodological: several large unadjusted body-composition differences, particularly skeletal-muscle percentage, were substantially attenuated after accounting for sex, whereas differences in BIA-estimated BMR and visceral-fat grade persisted in adjusted and female-only sensitivity analyses.

The prevalence estimate should be interpreted in relation to both the denominator and the operational definition. NWO is conceptually restricted to people whose BMI lies within a defined normal range; therefore, the primary prevalence estimate in this study is 23 of 66 normal-BMI participants (34.8%), rather than 23 of all 96 recruited participants. This distinction also improves comparability with studies that explicitly use a normal-BMI denominator.

Prevalence estimates remain highly sensitive to the selected BF% cut-offs, age distribution, sex composition, ethnicity and method used to estimate body fat. Recent studies illustrate this variability: Kaczmarek reported 16.5% NWO among Polish adolescents using age- and sex-specific percentile criteria,¹⁰ Falbova et al. reported sex-specific NWO estimates in Slovak young adults using lower BF% thresholds than the present study,¹¹ and a Southeast Asian meta-analysis reported substantial between-study heterogeneity.¹²

Pakistani evidence provides important context. Arshad et al. reported NWO among young adults in Lahore using BF% estimated from the Deurenberg equation,³ while an earlier Pakistani study demonstrated substantial discordance between BMI and BIA-derived body-fat classification across a broader age range.² The present study therefore does not establish the existence of BMI-body-fat discordance in Pakistan for the first time. Its novelty includes that it characterizes NWO in a young healthy adult sample using segmental BIA, a prespecified sex-specific definition, an explicit normal-BMI denominator, and analyses that examine sex confounding.

The marked female predominance requires cautious interpretation. NWO definitions commonly use sex-specific BF% thresholds because body-fat distribution and lean mass differ by sex. In the present data, 22 of 23 NWO cases were female. This imbalance can create large apparent differences in variables such as

skeletal-muscle percentage and BMR even in the absence of an independent NWO effect. The disappearance of the skeletal-muscle association after adjustment for sex and BMI, together with the non-significant female-only difference, demonstrates why unadjusted comparisons can be misleading. Similar caution is appropriate when comparing studies whose sex distributions and NWO thresholds differ substantially.^{8,10,11}

The persistence of higher visceral-fat grade in adjusted and female-only analyses is potentially informative, but the finding should not be equated with direct measurement of visceral adipose tissue. The FG2001 output is a device-derived index generated from electrical impedance and proprietary algorithms. Studies using other body-composition methods have nevertheless reported that NWO can coexist with greater central or visceral adiposity, including recent young-adult and adult cohorts.^{7,11,13} Thus, the present finding is physiologically plausible but requires confirmation using a validated reference approach.

BIA-estimated BMR also remained lower among NWO participants after adjustment and within the female-only sensitivity analysis. Because BMR was estimated by the device rather than measured by indirect calorimetry, the result should be interpreted as an algorithm-derived body-composition characteristic rather than evidence of a directly measured metabolic-rate abnormality. The association may reflect differences in body size and composition embedded in the device algorithm. Future studies could pair body-composition assessment with measured resting energy expenditure to determine whether this pattern persists independently of prediction equations. The present study did not measure fasting glucose, insulin, HbA1c, lipid profile, blood pressure outcomes or prospective cardiovascular events. It therefore cannot establish that participants with NWO had cardiometabolic dysfunction or increased future disease risk. That question is supported by external literature rather than by the current dataset. Meta-analyses have associated NWO with metabolic syndrome, hypertension, diabetes and dyslipidemia compared with normal-weight lean groups, and individual studies have observed adverse cardiometabolic profiles in Ethiopia and India.⁷ However, those findings should not be extrapolated directly to this sample without corresponding biomarkers.

From a screening perspective, the findings demonstrate discordance between conventional BMI classification and BF%-based adiposity classification in a subset of normal-BMI participants. This supports the principle that BMI and body composition answer different questions.

Strengths and Limitations

Strengths include use of a prespecified sex-specific NWO definition, explicit separation of NWO from NWN participants within the normal-BMI range, standardized pre-BIA instructions, reporting of prevalence precision, and analysis of sex as an important confounder rather than relying exclusively on unadjusted group comparisons. The study also contributes body-composition data from a young Pakistani population that remains underrepresented in the international NWO literature.

Several limitations are important. The cross-sectional design precludes causal inference. Participants came from a single medical college and were recruited using non-probability sampling, limiting generalizability beyond this specific student population. The sample was modest, and only one normal-BMI male met the operational NWO definition, producing a very wide CI for the sex-specific PR. Body composition was estimated by BIA rather than a reference technique such as DXA, and independent validation of the specific FG2001 model in Pakistani young adults could not be verified. BIA estimates are influenced by device algorithms and measurement conditions. NWO prevalence also depends on the selected BF% thresholds, for which no universally accepted international standard exists. Cardiometabolic biomarkers were not measured.

CONCLUSION

Normal-weight obesity was identified in approximately one-third of normal-BMI participants in this single-center sample of Pakistani healthy young adults and was markedly more frequent among females. BMI and BF%-based classification were therefore discordant in a subset of apparently normal-weight participants. Large unadjusted differences in skeletal-muscle percentage were substantially attenuated after accounting for sex and BMI, emphasizing the importance of confounder control when characterizing NWO. Higher BIA-derived visceral-fat grade and lower BIA-estimated BMR persisted in adjusted analyses, but these device-derived findings require confirmation with validated reference

methods. Larger representative studies incorporating cardiometabolic biomarkers are needed before population-level or clinical screening recommendations can be made.

DECLARATIONS

Ethics Approval and Consent to Participate

Ethical approval was obtained from the Ethical Review Board of Shaheed Zulfiqar Ali Bhutto Medical University, Islamabad, Pakistan (No. F.1-1/2015/ERB/SZABMU/1440). Written informed consent was obtained from all participants.

Consent for Publication

Not applicable.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Competing Interests

The authors declare no competing interests.

Data Availability

The dataset analyzed during the current study is available from the corresponding author on reasonable request, subject to applicable ethical and institutional requirements.

Authors' Contributions

Dr Maryam Iqbal contributed to study conception, methodology, investigation, data collection, analysis, and drafting and revision of the manuscript. Dr Arooj Anthoney contributed to methodology, investigation, data collection, analysis and drafting of the manuscript. Prof Dr Shemaila Saleem supervised the study and contributed to methodology, analysis, interpretation and critical revision. All authors read and approved the final manuscript.

Acknowledgments

The authors thank the Department of Physiology for institutional support, Mr Imdad Ali for help with data collection, and the students who volunteered to participate in the study.

REFERENCES

1. Christensen DL, Bygbjerg IC. Assessing worldwide trends of underweight and obesity. *Lancet*. 2024;404(10463):1642. doi:10.1016/S0140-6736(24)00576-X.
2. Fatima SS, Rehman R, Chaudhry B. Body mass index or body fat! Which is a better obesity scale for Pakistani population? *J Pak Med Assoc*. 2014;64(11):1225-1228. PMID:25831635.
3. Arshad D, Sohail Z, Khan N. Association of normal weight obesity with dietary habits among young adults in Pakistan. *Pak J Public Health*. 2022;12(3):137-142. doi:10.32413/pjph.v12i3.1064.
4. Manapurath RM, Hadaye R, Gadapani B. Normal weight obesity: role of apoB and insulin sensitivity in predicting future cardiovascular risk. *Int J Prev Med*. 2022;13:31. doi:10.4103/ijpvm.IJPVM_139_20. PMID:35392312.
5. Mohammadian Khonsari N, Khashayar P, Shahrestanaki E, et al. Normal weight obesity and cardiometabolic risk factors: a systematic review and meta-analysis. *Front Endocrinol (Lausanne)*. 2022;13:857930. doi:10.3389/fendo.2022.857930. PMID:35399938.
6. Rakhmat II, Putra ICS, Wibowo A, et al. Cardiometabolic risk factors in adults with normal weight obesity: a systematic review and meta-analysis. *Clin Obes*. 2022;12(4):e12523. doi:10.1111/cob.12523. PMID:35412026.
7. Gebremedhin S, Mekonene M, Hagos S, et al. Association between normal-weight obesity and cardiometabolic risk factors among adults in Addis Ababa, Ethiopia. *Sci Rep*. 2023;13(1):22772. doi:10.1038/s41598-023-49039-8. PMID:38123576.
8. Parfenteva OI, Kulemin NA, Bondareva EA, Ahmetov II. Prevalence and predictors of normal-weight obesity among women. *Nutrients*. 2024;16(16):2579. doi:10.3390/nu16162579. PMID:39203715.
9. Yogesh M, Mody M, Makwana N, Patel J. Exploring the silent epidemic: investigating the hidden burden of normal weight obesity in type 2 diabetes mellitus in India - a cross-sectional study. *Clin Diabetes Endocrinol*. 2024;10(1):47. doi:10.1186/s40842-024-00199-0. PMID:39676161.
10. Kaczmarek M. Normal weight obesity in adolescents: patterns and associated factors. *Front Nutr*. 2025;12:1637885. doi:10.3389/fnut.2025.1637885. PMID:40761357.
11. Falbova D, Sulis S, Oravska P, et al. The prevalence of normal weight obesity in Slovak young adults and its relationship

- with body composition and lifestyle habits. *Bratisl Med J.* 2025;126:2698-2707. doi:10.1007/s44411-025-00273-8.
12. Sruthi KG, Aditya C, Panda P, Mohanty JR, Behera MR. Prevalence of normal weight obesity among adults in Southeast Asia: insights from a systematic review and meta-analysis. *Metab Open.* 2025;28:100416. doi:10.1016/j.metop.2025.100416. PMID:41321405.
 13. Kapoor N, Lotfaliany M, Sathish T, et al. Prevalence of normal weight obesity and its associated cardio-metabolic risk factors - results from the baseline data of the Kerala Diabetes Prevention Program (KDPP). *PLoS One.* 2020;15(8):e0237974. doi:10.1371/journal.pone.0237974. PMID:32841271.
 14. Singhal N, Mathur P, Pathak R. Validity of simple, novel measures of generalized and central obesity among young Asian Indian women. *Indian J Med Sci.* 2011;65(12):518-527. PMID:23548252.
 15. Singh RB, Niaz MA, Beegom R, et al. Body fat percent by bioelectrical impedance analysis and risk of coronary artery disease among urban men with low rates of obesity: the Indian paradox. *J Am Coll Nutr.* 1999;18(3):268-273. doi:10.1080/07315724.1999.10718862. PMID:10376784.

Tables

Table 1. Characteristics of the Study Sample (N=96)

Characteristic	Value
Age, years	18-25 (eligibility range)
Male sex, n (%)	35 (36.5)
Female sex, n (%)	61 (63.5)
Height, cm	165.5 ± 9.7
Weight, kg	57.5 ± 10.5
BMI, kg/m ²	20.99 ± 3.15
Underweight BMI (<18.5), n (%)	20 (20.8)
Normal BMI (18.5-24.9), n (%)	66 (68.8)
BMI ≥25, n (%)	10 (10.4)
Body fat, %	25.66 ± 10.18
Skeletal muscle, %	25.58 ± 9.91
BIA-estimated BMR, kcal/day	1287 ± 218
Visceral-fat grade	5.3 ± 2.99

Data are mean ± SD unless otherwise indicated. BMI, body mass index; BIA, bioelectrical impedance analysis; BMR, basal metabolic rate.

Table 2. Normal-Weight Obesity Prevalence Among Participants with Normal BMI

Group	NWO, n/N	Prevalence, %	95% CI	Female:male PR (95% CI)	Fisher p
All normal-BMI participants	23/66	34.8	24.5-46.9	—	—
Females	22/42	52.4	37.7-66.6	12.57 (1.81-87.51)	<0.001
Males	1/24	4.2	0.7-20.2	1.00 (reference)	—

NWO, normal-weight obesity; CI, confidence interval (Wilson); PR, prevalence ratio.

Table 3. Unadjusted Body-Composition Comparison: NWO Versus NWN

Variable	NWO (n=23)	NWN (n=43)	Mean difference	95% CI	p
BMI, kg/m ²	21.99 ± 1.63	20.99 ± 1.65	1.00	0.15 to 1.85	0.022
Body fat, %	36.28 ± 3.93	20.58 ± 6.63	15.70	13.10 to 18.30	<0.001*
Skeletal muscle, %	19.88 ± 4.51	29.03 ± 10.48	-9.15	-12.86 to -5.44	<0.001
BIA-estimated BMR, kcal/day	1138 ± 120	1378 ± 201	-240	-319 to -161	<0.001

Visceral-fat grade	7.65 ± 1.53	4.28 ± 2.19	3.37	2.45 to 4.29	<0.001
--------------------	-------------	-------------	------	--------------	--------

Data are mean ± SD. NWNNO, normal-weight non-obese. *Descriptive only, because BF% defines NWO group membership.

Table 4. Adjusted Association of NWO Status with Selected Body-Composition Outcomes

Outcome	Adjusted β for NWO	95% CI	p	Covariates
Skeletal muscle, %	-1.13	-3.62 to 1.36	0.375	Sex, BMI
BIA-estimated BMR, kcal/day	-108.5	-157.7 to -59.4	<0.001	Sex, BMI
Visceral-fat grade	1.68	0.54 to 2.82	0.004	Sex, BMI

Supplementary Table S1. Female-Only Sensitivity Analysis

Outcome	Female NWO (n=22)	Female NWNNO (n=20)	p
Skeletal muscle, %	19.36 ± 3.84	20.32 ± 2.61	0.345
BIA-estimated BMR, kcal/day	1118.5 ± 76.5	1197.8 ± 104.2	0.009
Visceral-fat grade	7.64 ± 1.56	5.70 ± 1.89	0.001

Data are mean ± SD.