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Comparison of Body Composition Parameters Using Bioelectric Impedance Analyser and Anthropometric Parameters Between Normal Weight Obesity Indian Men and Women

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ABSTRACT

Introduction: Normal weight obesity is a known phenotype seen in South Asian population. It is defined as individuals with normal body mass index with significantly higher fat percentage. Bioelectrical impedance analysis (BIA) represents a relatively low-cost and simple method to obtain estimates of body fat and identify those at increased health risk. The primary objective was to estimate and compare the body composition parameters and anthropometric data between NWO male and female young adults.

Methods: This descriptive cross-sectional study was conducted between November 2020 to August 2021. Based on inclusion & exclusion criteria, 42 NWO participants (32 men and 10 women) were included. Bioelectrical Impedance Analyzer 2000 Quad scan was used to study BF%, and other parameters. The comparison between the genders was done using independent t- test and Mann-Whitney U test based on normality test. P-value < 0.05 was considered significant.

Results: The mean body fat mass index of women was higher as compared to men which was very significant (p=0.005). The mean body fat percentage of women was higher as compared to men which was very highly significant (p=0.000). Total body water was higher in men as comparison to female which was very highly significant (p=0.04). In addition, phase angle was also higher in men in comparison to women which was significant (p=0.04).

Conclusions: There were significant differences in body composition parameters between normal weight obese (NWO) men and women, with women showing higher body fat mass, while men exhibited higher total body water and phase angle. These findings underscore the need for gender-specific assessments of body composition and health status.

Keywords: Adiposity; Body Composition; Body Mass Index; Cross-Sectional Studies; Obesity

INTRODUCTION

Normal weight obesity (NWO) is an under-recognized health condition that is especially prevalent in South Asian populations and defined as excessive body fat despite having normal body mass index (BMI).[1] It has been called by different names, such as metabolic obesity, skinny fat and thin-fat phenotype.[2] It is a new type of obesity first described by Ruderman et al in 1981 as metabolically obese normal weight and later termed as NWO by De Lorenzo et al in 2006.[3] NWO were found to have a higher metabolic risk of impaired glucose tolerance, oxidative stress, hypertension and dyslipidemia. It is at par with those with an overt phenotype of obesity.[4]

In India, studies on the prevalence of NWO varies between 14% to 31%.[5] BMI is a widely accepted measurement to identify overweight or obesity which considers height and weight only. However, BMI alone may not be adequate to distinguish between increased mass in the form of fat, lean tissue, or bone.[6] It is ideal to measure adiposity and bioelectrical impedance analysis (BIA) is a method to determine the adiposity of the body.[7] It is a relatively simple, reliable, quick and non-invasive method. It measures the conductance of a small alternating current through the body. It passes through the muscle easier than fat due to increased water content of muscle. Thus, allows for the estimation of body fat and lean body mass.[8]

Literature search reveals different body fat cut offs percentage used for NWO and there was no consensus on diagnostic criteria of NOW.[9] We could not find studies which compares the body composition between NWO Indian men and women adult population. Therefore, we aimed to assess the body composition in NWO Indian adult population. In this study, we hypothesised there would be gender differences in body composition using BIA with women having more body fat mass. The primary objective was to compare the body composition parameters between healthy NWO men and women.

Materials & methods

Study design, setting and duration of study

This descriptive cross-sectional study was conducted in a medical college in western Uttar Pradesh from November 2020-August 2021. This was a secondary analysis of quantitative data collected as a part of thesis project. Study participants were residents, students, and employees of medical college. The Institutional Ethical Clearance was taken from IEC vide letter number SMC/UECM/2020/99/89, dated 28/7/2020. Participation was voluntary and informed consent was taken from the participant.

Inclusion criteria

(1) Age between 18-30 years
(2) Normal Body Mass Index
(3) Normal weight obesity (BMI-18.5-24.9 kg/m^2) with high body fat percentage ($\geq$20.6% in men and $\geq$33.4% in women).[10]

Exclusion criteria

(1) History of acute illness
(2) History of any chronic disease like cardiovascular disease, renal disease or endocrine disease.
(3) Pregnant females
(4) Any psychiatric illness
(5) Females on oral contraceptive pills

Data Collection Tool

Detailed history, general and systemic examination was carried out. The body composition and anthropometric measurements were measured.

Anthropometric measurements

The height was measured on a parallel plane STADIOMETER barefooted with a correction of 0.5 cm. Weight was taken barefooted with minimal clothing on, with a correction of 0.1 kg. A calibrated electronic weighing machine of EAGLE was used for the same. Waist circumference (WC) and hip circumference (HC) were both measured to the nearest 0.1 cm using a measuring tape. For WC, measurements were taken at the level of the umbilicus with arms folded across the chest. For HC, measurements were taken at the point yielding the maximum circumference over the buttocks.

Body composition measurements

The subjects were asked to fast for 4h before measurements. They were also instructed not to take coffee or exercise 24h before the test. Bioelectrical Impedance Analyzer 2000 Quad scan was used to study the BMI, BF%, and other parameters.

Parameters were recorded in a supine position on a wooden couch with arms 30 apart from the trunk and ankles around 20 cm away. The participants were not allowed to wear any ornaments made up of metal or carry a phone with them. Place where electrodes were to be placed cleaned with alcohol.

BIA was done at 50, 100 & 200 KH2. The red electrode was placed on knuckles and black on the wrist next to the ulnar head in the right upper limb. Red lead was placed behind the toes in the right lower limb, and black was between the medial and lateral malleoli. The left side was not chosen because of the heart on the left side. All readings were taken within 5 min of lying down. Body composition of females was done in the follicular phase.[11]

Sample size and sampling technique

Initially data was collected on 324 participants. It was calculated based on the prevalence of 28.1%.[12] The minimum sample size was estimated assuming the level of significance of 5%, absolute precision of 5%, and the two-tail alternative hypothesis, which came out to be 323.26 (324 participants). A list of students and employees was prepared. We randomly selected the participants through lottery system. Figure 1 shows selection of participants according to the NWO concept, 42 participants from sample size of 324 meets the criteria i.e. individuals with normal BMI with increased BF % in men ($\geq$20.6%) and in women ($\geq$33.4%). We further analysed the data based on our main objective.

Data Analysis

These data analyses were an extension of the main analyses. The normality of the continuous data was assessed through the Shapiro-Wilks test. Based on the normal distribution and homogeneity of variance test, comparison between the genders was done using Independent t- test and Mann-Whitney U test. A p-value of < 0.05 was considered significant. The data were analyzed using International Business Machines (IBM) Statistical Package for the Social Sciences (SPSS) version 26.0.

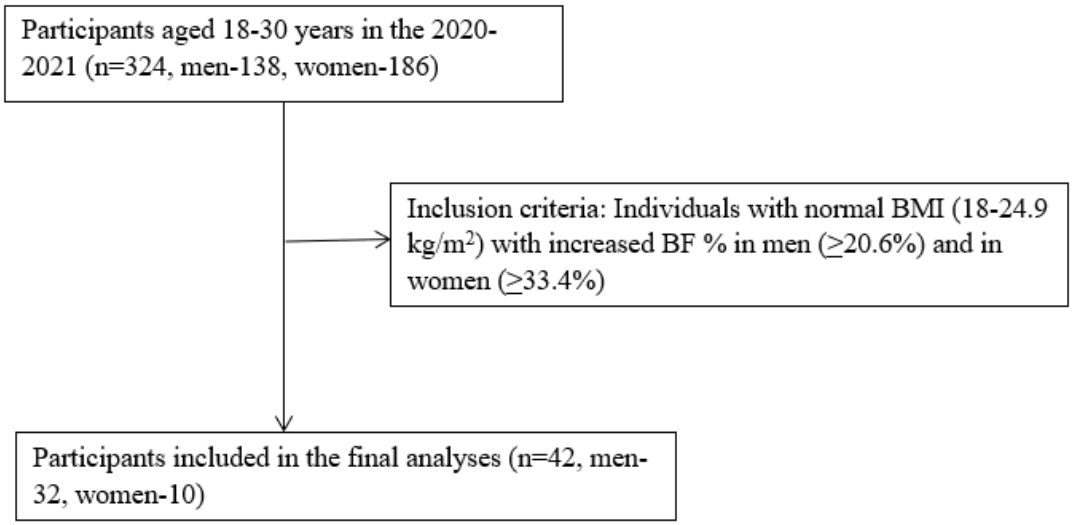

Figure 1: Selection of study participants

Results

There were a total 42 participants; proportion of men and women was 32 (76.19%) and 10 (23.81%) respectively. The average age of participants was 21.31 ± 2.52 [mean ± standard deviation (SD)] years, with an average BMI of 22.19 ± 2.52 kg/m². Table 1 shows the body composition and anthropometric parameters between the NWO men and women using Independent T test. The mean body fat mass index (BFMI) of women (7.32 ± 3.27) was higher as compared to men (5.18 ± 1.35) which was highly significant (p=0.005).

Table 1: Comparison of body composition and anthropometric parameters between normal weight obese men and women

Variables	Male (n=32) Mean ± SD	Female (n=10) Mean ± SD	t-statistics	P- value
Waist-hip ratio (WHR)	0.90 ± 0.06	0.85 ± 0.06	1.997	0.05
Lean body mass (LBM) (kg)	43.39 ± 11.60	41.5 ± 9.38	0.468	0.64
Basal metabolic rate (BMR) (kcal)	1678.41 ± 341.82	1610.9 ± 169.46	0.598	0.55
Body fat mass index (BFMI)	5.18 ± 1.35	7.32 ± 3.27	-3.004	0.005**
Free fat mass index (FFMI)	16.28 ± 3.43	16.88 ± 4.01	-0.458	0.65
Systolic Blood Pressure (SBP) (mmHg)	118.63 ± 4.41	119.4 ± 4.11	-0.492	0.62
Diastolic Blood Pressure (DBP) (mmHg)	78.5 ± 3.25	77 ± 2.35	1.347	0.18

n – Number, SD – Standard deviation, ** p <0.01, Independent t test

Table 2 shows comparison of anthropometric and body composition parameters between normal weight obese men and women using Mann-Whitney U test. The mean body fat percentage (BF %) of women (37.28 ± 3.34) was higher as compared to men (26.06 ± 5.93) which was very highly significant (p=0.000). Total body water (TBW) was higher in men (51.69 ± 7.03) as comparison to women (41.8 ± 4.86) which was very highly significant (p=0.04). In addition, phase angle was also higher in men (5.36 ± 0.73) in comparison to women (4.84 ± 0.49) which was significant (p=0.04).

Table 2: Comparison of anthropometric and body composition parameters between normal weight obese men and women

Variables	Male (n=32) Median (IQR)	Female (n=10) Median (IQR)	Z	P- value
Height (cms)	168.50 ± 11	168.00 ± 6	-0.208	0.83
Weight (kg)	67.00 ± 17	53.00 ± 20	-0.356	0.72
BMI (kg/m²)	23.10 ± 3.2	20.25 ± 5.9	-1.049	0.29
Body fat (%)	23.05 ± 8.4	36.30 ± 5.0	-3.946	0.000***
Total body water (%)	51.85 ± 5.5	43.55 ± 4.5	-3.812	0.000***
Phase angle (PhA) (50 k)	5.10 ± 0.8	5.0 ± 0.7	-2.021	0.04*

n – Number, IQR – Interquartile range, * p <0.05, *** p <0.001, Mann-Whitney U test

Discussion

The study was to compare the body composition parameters between NWO men and women. This was the secondary analysis of data collected to estimate the prevalence of NWO in Western Uttar Pradesh. Our results indicate that mean body fat mass index and body fat percentage of women was significantly higher as compared to men. Total body water and phase angle was significantly higher in men as compared to women.

Our findings on mean body fat percentage was similar to Indian study on Health of Adults (ISHA) by Taing KY et al., where mean fat percentage (whole body) were lower for men than women.[13] Rai R et al., reported strong correlation between BMI and BF% in middle-age adults and gender had greater effect on this relationship.[6] Study done in other population groups also revealed similar results. For instance, study done in pre-frail older adults revealed a significantly higher mean body fat mass (%) in women (31 $\pm$ 4.6) as compared to men (22.5 $\pm$ 4.9).[14] Study by Isabel A et al., reported significantly higher body fat mass (%) in boys as compared to girls.[15] Another study conducted among the adolescents of Assam indicate the significant difference (<0.0001) in mean body fat percentage between boys and girls (23.6 $\pm$ 6.24) with girls showing more mean body fat % as compared to boys (19.6 $\pm$ 6.23).[7]

Fat mass index (FMI) is calculated by dividing body fat mass by height squared. Study by Peltz G et al., on Mexican Americans showed significantly higher FMI in women as compared to men, similar to our findings.[16] Merchant RA et al., found significantly higher fat mass index in pre-frail older women as compared to men.[14] The differences in body fat mass between men and women can be primarily attributed to hormonal influences, particularly the roles of estrogens and androgens. Estrogens, which are more prevalent in women, promote fat storage in specific areas such as the hips and thighs, contributing to a higher overall body fat percentage and which is necessary for reproductive functions. [9,10,17]

Our result is in consistent with other studies which reported higher whole body phase angle (50 KHz) in men as compared to women.[18,19] It may be because men tend to be taller and heavier than women, have greater BMI, and higher water content than women. PhA is being considered as an indicator of nutritional status, muscle size, muscle function, and cellular integrity. Higher PhA being correlated with better nutritional status and muscle quality. In addition, it was also shown to be negatively correlated with body fat mass.[14,19] According to Dittmar et al., individuals who are obese have greater fluids in the extracellular compartments (ECF). Thus, ratio between ECF and intracellular fluid (ICF) is larger and could be the reason for the lower PhA in women. [20]

We had found significantly higher TBW in men as compared to women. Similar result was obtained by Jaremkow et al., and Gonzalez et. al., where TBW was significantly higher in men as compared to women. This could be due to greater muscle mass in men which are composed of 75% of water.[18,19] Another study in healthy adolescents from Spain found TBW (%) was significantly higher in boys as compared to girls.[15]

In our results, we could not found differences in anthropometric parameters. Evidence from other studies has shown that individuals with NWO may or may not present with changes in anthropometric parameters, such as waist circumference, waist-to-hip ratio, and waist-to-height ratio. Therefore, these parameters may not be suitable for diagnosing NWO and can provide only complementary information.[10,21]

Limitation

The limitation of this study was small and unequal sample size for comparison between genders which cannot be extrapolated to the Indian population. As this was cross-sectional and not a longitudinal study, we could not interpret on causal relationship. The lack of standardized BF% cut-offs for NWO, makes comparison between studies difficult, as modifying these cut-offs would likely change the results. The different proposed cut-off points of BF vary between 20 and 25% for men and 30 and 37% for women.[22] Future research in a larger sample size, impact of intervention and influence of gender in longitudinal studies on its prevalence and health implications would provide valuable information.

Conclusion

It is well known that there exist sex differences in body composition parameters. In this study, we found that body fat mass was higher among women than men. Phase angle which is an important indicator of better nutritional status and muscle quality was higher in men. Differences between NWO men and women reiterate the importance of sex specific evaluation of health. Having a normal BMI may mask unhealthy body fat accumulations. Early detection and prevention of normal weight obesity among young adults is critical.

Conflict of Interest: All authors declare none

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