NORMAL-WEIGHT OBESITY FREQUENCY IN THE CENTRAL EUROPEAN URBAN ADULT FEMALE POPULATION OF BRNO, CZECH REPUBLIC

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SUMMARY

Objectives: The universally recognized indicator of nutritional status, BMI, has some shortcomings, especially in detecting overweight and obesity. A relatively recently introduced normal weight obesity (NWO) describes a phenomenon when individuals are found to have normal weight as indicated by BMI but have an elevated percentage of body fat. Normal weight obese individuals face a higher risk of developing metabolic syndrome, cardiometabolic dysfunction and have higher mortality. No studies have been previously performed which would map NWO in Brno, Czech Republic.

Methods: In a sample of 100 women from Brno, we assessed the percentage of normal weight obese individuals using bioelectric impedance analysis (BIA) – three different analyzers were utilized: Tanita BC-545 personal digital scale, InBody 230 and BodyStat 1500MDD. Also, a caliperation method was used to estimate body fat percentage. Various body fat percentage cut-off points were used according to different authors.

Results: When the 30% body fat (BF) cut-off was used, up to 14% of the women in our sample were found to be normal weight obese. When the sum of skinfolds or the 35% BF cut-off point are selected as a criterion for identifying normal weight obesity (NOW), only 1 of 100 examined women was identified as normal weight obese; at the 35% BF cut-off, BodyStat analyzer categorized no women as normal weight obese. Also, when the 30% BF or 66th percentile BF cut-off points were utilized, BodyStat identified pronouncedly fewer women from our sample to be normal-weight obese than the two other analyzers.

Conclusions: On a pilot sample of Czech women, we demonstrated that depending on the selected cut-off (there is no clear agreement on cut-off points in literature), up to 14% of the examined women were found to be normal weight obese.

Key words: normal weight obesity, body fat, bioimpedance, skinfolds, risk factor of cardiovascular disease

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INTRODUCTION

Overweight and obesity are considered a global problem affecting all strata of the human population (1, 2), which has led to the notion "epidemic of obesity" or, especially for children and adolescents, "pandemic of obesity" (3). The prevalence of overweight individuals in absolute numbers is staggering, as are the subsequent health risks with respective individual and population/healthcare/social costs. The percentage projections are even more disturbing: according to estimates based on 2005 population data, up to 57.8% of the population could be either overweight or obese by 2030 (4). However, the majority of these estimates were created using BMI data. With the assistance of experts who participated in the International Obesity Task Force in 1997, the World Health Organization (WHO) stated that an adult person is considered obese when BMI $\geq$30 kg/m^2 (5). However, obesity is defined (also by the WHO) as "abnormal or excessive fat accumulation that may impair health" (6). Therefore, BMI cannot be an objective indicator of obesity as it does not provide an assessment of how individual body composition components affect overall body weight. Therefore, apart from misdiagnosing muscular athletes as obese although their elevated BMI is caused by enhanced skeletal muscle mass, individuals with low fat free mass and a high content of body fat can be found to have normal body mass index (7). BMI also cannot differentiate between central and peripheral fat (8). Central (or abdominal) obesity is strongly associated with a risk of future cardiovascular disease (9).

In addition to BMI, there are several other methods that can be used to estimate adiposity. There has been great progress made in the field of biophysical advanced methods to study body composition, yet among anthropologists, there remains a strong tendency not to abandon traditional caliperation methods (based on skinfold thicknesses measured at different numbers of standard locations and using different equations to estimate total subcutaneous fat depending on the author). There is even a wider variety of biophysical or clinical advanced methods used to estimate body fat content in humans (10). Of these methods, the method of bioelectric impedance analysis (BIA) is the most ubiquitous thanks to its relatively low-cost and easy-to-use operation. Although its reliability when compared to a reference method (DEXA) is disputed, several authors have found the method to be satisfactorily reliable (11–14).

As mentioned above, BMI as an indicator of obesity can lead to both false-positive and false-negative results. Especially troubling is the latter case – a person whose BMI indicates normal values of weight, but is not aware that he/she has an elevated percentage of body fat (or does not realize its seriousness) might feel at ease, yet faces a higher risk of developing metabolic syndrome or cardiometabolic dysfunction and might face higher mortality (7). De Lorenzo et al. (15) first described the association between normal values of BMI, increased body fat (BF) percentage and metabolic abnormalities and defined a new term/risk factor: normal weight obesity (NWO).

However, just as there is no clear understanding among authors as to the "cut-off" values of body fat that indicate obesity, the same is true of normal weight obesity cut-offs (7). There are various definitions of normal weight obesity – the majority of all authors agree that NWO is defined by normal value of body weight and BMI (<25 kg/m^2) and some indicator of nutritional imbalance. Some define it as an increased percentage of body fat – the authors of the original study (15) use a fixed cut-off point (>30%). Other investigators have proposed sex- and gender-specific BF cut-offs, for women varying between 30 and 37%; some authors propose different BF percentiles – 66th (16) up to the 95th percentile (17). Madeira et al. (18) used an anthropometric indicator to evaluate adiposity in NWO identification – as a cut-off value, they used the 90th percentile for the sum of triceps and subscapular skinfolds. We have adopted several of the proposed NWO definitions/cut-offs to identify such women in a Czech sample.

This study aims to assess the percentage of NWO individuals in a sample of Brno women using various methods and cut-off points.

MATERIALS AND METHODS

One hundred young women aged between 20–30 years participated in this study. The study participants were recruited among Gynfit, Ltd. gynaecological centre patients using a consecutive sampling technique. Participation was voluntary and anonymity was granted as each participant was assigned a unique code. Pregnant women were excluded from the study. In our consecutive sample, we reached a 71% response rate (140 women were addressed, 100 participated, average age 24.7 ± 3.05 SD). None of the women who agreed to the examination later withdrew from the study. A signed informed consent was necessary for inclusion in the study. The informed consent form also included a leaflet containing instructions that needed to be followed to ensure the condition of measurement objectivity – no alcohol consumption 24 hours prior to examination, no strenuous physical exercise 12 hours prior, no ingestion of food or liquids 4 hours prior; it was also necessary to undergo the examination with an empty urinary bladder. In addition, the participants declared in the informed consent that they had no diagnosed heart defect or disease and that they were not in early stages of pregnancy (as bioimpedance examination can present a certain health risk in these cases).

All participants were examined by one female researcher in a closed examination room in their underwear at standard room temperature, during the centre opening hours. Because the participants came to the centre for their scheduled appointments with the physician, it was not possible to perform all examinations during the same (preferably morning) hours.

The participants' body height and weight were measured and recorded, and BMI was calculated based on measured values. Body height was measured in the standard anatomical position using a GPM anthropometer (DKSH, Switzerland), body weight was recorded using a Tanita BC-545 (Tanita Co., Japan) digital personal scale/BIA analyzer. Subscapular and triceps skinfold thicknesses were measured on the right side using a Best type caliper (model BEST II K-501, Trystom Czech Republic); the subscapular skinfold is located under the lower angle of the scapula, running obliquely (parallel to the medial scapular edge), the triceps skinfold is located on the dorsal surface of the upper arm on the triceps muscle, in the middle of the distance from the acromion scapulae to the olecranon ulnae. This skinfold is oriented vertically. A simple sum of these skinfolds was computed and the 90th percentile of the sum was used as the cut-off (18).

The participants' body fat percentage was then assessed using a bioimpedance analysis method (in compliance with all standard and manufacturer specified examination conditions). Three different bioimpedance analyzers were used: Tanita BC-545 personal digital scale, InBody 230 (InBody Co., Ltd., Korea) and BodyStat 1500MDD (Bodystat Limited, UK). All the analyzers were tetrapolar, dual-frequency and all used multiple electrodes (Tanita and InBody 8 electrodes, BodyStat 4 electrodes). However, each machine design required specific measurement protocols. Examinations performed using Tanita BC-545 and BodyStat 230 analyzers were performed standing on the machine's platform, holding either retractable handles (Tanita) or folding handles connected to a vertical control and display panel (InBody). Examinations using the BodyStat 1500MDD were performed in the supine position with the upper limbs not touching the trunk and the lower limbs not touching each other. Disposable adhesive electrodes were connected to the analyzer body via guide cables. The electrodes were placed on the dorsum of the right hand slightly proximally from the metacarpal heads and on the distal part of the right forearm where it meets the wrist. One of the remaining two electrodes was placed on the dorsum of the foot slightly proximally from the metatarsal heads and the last one was placed on the line connecting the inner and outer side of the ankle.

The following different cut-off points for body fat content percentage to identify NWO were utilized – 30% (gender and age independent) (19), or fixed sex-specific for women (18), 35% (fixed-sex specific for women) (20). We also used a gender specific cut-off defined by the 66th percentile of body fat percentage (16).

RESULTS

To identify normal weight obese individuals, we used two fixed different cut-offs (19, 20) and a cut-off based on the 66th percentile of body fat (16). The sum of triceps and subscapular skinfolds (90th percentile) was also used.

As seen in Table 1, when the sum of skinfolds or the 35% BF cut-off point is selected as a criterion for identifying NWO, only 1 of the 100 examined women was identified as normal weight obese; at the 35% BF cut-off, the BodyStat analyzer categorized no women as normal weight obese. Also, when the 30% BF or 66th percentile BF cut-off points were utilized, BodyStat identified pronouncedly fewer women from our sample to be normal weight obese than the two other analyzers. Using the sex-specific

66th percentile of body fat in our sample, the results were similar for all three analyzers. Tanita BC-545 (the 66th BF percentile for this device was 29.4% BF) identified 13% of women as normal weight obese, InBody 230 (the 66th BF percentile for this device was 27.6% BF) identified 14% of women as normal weight obese and BodyStat 1500MDD (the 66th BF percentile for this device was 26.5% BF) identified 12% of women as normal weight obese. When sum of skinfolds (90th percentile) was used to identify normal weight obese individuals in our sample, only one of the women was found to be NWO (Table 2).

DISCUSSION

Our findings are in accordance with Marques-Vidal et al. (21), who utilized a 30% BF cut-off point (fixed sex-specific for women) on a sample of the Portuguese population. They reported a 10% prevalence of normal weight obese women. However, in our study, we used three analyzers and although generally agreeing with the above stated conclusion, individual findings were significantly different. These findings are discussed in a previous paper (10). When using a fixed sex-specific cut-off point which identifies NWO on a higher (35%) level of BF in our sample, only one woman was found to be normal weight obese (and one of the analyzers, the BodyStat, did not identify any woman to be normal weight obese). Other authors recommend using age and sex-specific cut-off points. Kyle et al. (17) recommend as cut-off an age and sex-specific value – the 95th percentile of the corresponding population. Using this cut-off, no women in our sample were found to be normal weight obese. Marques-Vidal et al. (16) proposed a different sex-specific cut-off point for women based on the 66th percentile of body fat. Using this parameter, 12% to 14% of women from our sample (depending on the BIA device used) were classified as NWO. These values are substantially higher than what Marques-Vidal et al. (16) found – 5.4% of women with NWO in their sample.

In this paper, on a small sample of young women, we aimed to ascertain whether in Czech women the normal weight obese proportion follows the prevalence found in other European countries. We believe it is important that anthropologists and health professionals understand the concept of normal weight obesity. Our results show that based on the selected method/parameters/device and cut-off points, the frequency of NWO varies significantly, but up to 14% of women can be misidentified as metabolically healthy with a low cardiovascular risk. This false-negative identification bears a high risk – several authors found an association of NWO with metabolic dysregulation, inflammation and metabolic syndrome – all risk factors of coronary heart disease and cardiovascular disease (8, 15, 18, 19). In addition, Romero-Corral et al. (8) demonstrated that NWO is associated with cardiovascular disease and all-cause mortality. Even more, it was shown that normal weight central obesity defined by the waist-hip ratio is associated with higher mortality than BMI-defined obesity (22). In a subsample of women included in NHANES study, women with normal weight central obesity also had a higher mortality risk than those with a similar BMI, but no central obesity, as well as those who were obese according to BMI only (22). However, as mentioned above, there is no clear understanding on defining normal weight obesity (and obesity in general) by body fat content. Body fat distribution is also an important cardiovascular disease risk factor (23). For these reasons, the information about determining NWO in the general population is limited and further studies are needed to shed light on the relation between body fat content (and finding optimal cut-offs) and its distribution and metabolism, cardiovascular disease and mortality.

***Table 1.** Percentage of women with normal weight obesity – bioimpedance analysis (N = 100)*

NWO as defined by	Tanita BC-545	InBody 230	BodyStat 1500MDD
≥ 35% BF	1 (1%)	1 (1%)	0
≥ 30% BF	13 (13%)	12 (12%)	5 (5%)
66th percentile BF	13 (13%)	14 (14%)	12 (12%)

BF – body fat; NWO – normal weight obesity

***Table 2.** Percentage of women with normal weight obesity – caliperation method (N = 100)*

Normal weight obesity as defined by	Sum of triceps and subscapular skinfolds
90th percentile sum of skinfolds	1 (1%)

Limitations of the Study

The study was conceived as an introductory survey of NWO occurrence in the city of Brno. When evaluating obesity, indicators of thyroid function, fasting glycaemia, information on the use of contraceptives form a valuable background. The pilot nature of the study and its extent did not allow for collection of this data and fasting glycaemia, thyroid function indicators, contraceptive use etc. are not available. The fact that our sample only includes young women can be considered a limiting factor as only one sex is monitored.

CONCLUSION

BMI has been widely disputed as an indicator of obesity. Various substituting methods have been proposed, and quite recently, the concept of normal weight obesity was introduced by De Lorenzo et al. (15). On a relatively small sample of Czech women, we demonstrated that depending on the selected cut-off, up to 14% of the women were found to be normal weight obese. NWO is strongly associated with cardiovascular disease. This high-risk group needs to be recognized in clinical practice as well as in research for better adiposity-based risk stratification and prevention/treatment planning.

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