BODY COMPOSITION IN A SAMPLE OF THE ADULT POPULATION FROM MOSCOW

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Abstract
Objectives. To evaluate body composition and describe the prevalence of various types of obesity in a sample of the adult population from Moscow.
Material and methods. A cross-sectional study included measurements of weight, height, waist and hip circumferences, and bioimpedance analysis for body composition assessment in the sample of 131 adults (44 males aged 21 to 73 years and 87 females aged 18 to 67 years) from Moscow. Body mass index (BMI), waist to hip ratio (WHR), waist to height ratio (WHtR) were calculated.
Results. Up to 30% of the adults were classified as overweight and obese (BMI ≥ 25 kg/m^2); among them more than half had signs of central obesity. Almost 20% of females with normal BMI had increased body fat and were classified as normal weight obese. A significant increase in body fat mass and a decrease in lean muscle mass were associated with ageing.
Conclusions. About a third of the adults from the studied sample were classified as overweight and obese. Central obesity was observed in conjunction with general obesity. The prevalence of normal weight obesity was higher in the group of females. Because the "obesogenic" environment promotes chronic positive energy balance, people with normal BMI may also have excessive body fat and the subsequent health risks similarly to people with general obesity. Further research is needed to estimate the prevalence of different types of obesity in the Moscow population.
Keywords: obesogenic environment, Moscow city, normal weight obesity, central obesity, adults.

Introduction

The prevalence of overweight and obesity in the world has almost tripled over the past 50 years and continues to grow, especially in highly urbanized areas. Simultaneously, central obesity and normal weight obesity occur more and more often. Normal weight obesity is a condition in which individuals have normal weight by body mass index (BMI) but excessive body fat. Excessive body fat mass is associated with an increased risk of communicable and non-communicable diseases (Bhaskaran, dos-Santos-Silva, Leon, Douglas, & Smeeth, 2018).

In the highly urbanized areas, dwellers are placed into the surroundings where the overall negative effects promote general obesity with normal weight and central obesity. The "obesogenic"

environment encourages unhealthy eating habits and contributes to the consumption of high-calorie foods due to its availability and low cost (Pinho et al., 2020). In conjunction with a sedentary lifestyle, people are most often placed in a positive energy balance, which over time becomes chronic and results in excessive accumulation of body fat. The results of a study conducted by Baciu in 2010 on a group of 472 subjects, aged between 11 and 14 years, were compared with those of the 1977 study conducted on a sample of 142 children, considered as a control group, showed that higher consumption of sweets, snacks, the high percentage of children who eat cooked food in the evening, sausages or cheeses, as well as those who eat in front of the TV or computer/smartphone contributed to the increase of the percentage of overweight children in the study group (8.62%) compared to the control group (7.27%), the difference being statistically significant ($p < 0.05$) in the case of boys (Baciu, 2011).

Body mass index (BMI) is one of the commonly used adiposity measures in epidemiological studies. However, BMI has some limitations. BMI leads to an error in the estimation of adiposity when evaluating normal weight obesity. The use of the additional tools and techniques such as waist to hip ratio (WHR), waist to height ratio (WHtR) and an analysis of body composition is recommended. Body composition analysis allows assessing the risk of normal weight obesity as it evaluates the ratio of fat and lean mass (Stefan, 2020). The anthropometric indices provide information about the fat topography and can be used as a tool for diagnosing of central obesity.

The purpose of the present study was to evaluate body composition, amount of body fat mass and its distribution in a sample of the adult population from Moscow.

Material and methods

The cross-sectional study was conducted by the Research Institute and Museum of Anthropology of Lomonosov Moscow State University. Unrelated individuals aged ≥ 18 years of both sexes and permanently residing in Moscow participated in the present study. The study involved 131 individuals (87 females aged 18 to 67 and 44 males aged 21 to 73). Participants provided data on demographics, lifestyle, habits, pregnancy (for female subjects) and diseases. All participants provided their informed consent. To ensure the objectivity of measurement all participants followed the provided instructions. They were asked not to consume alcohol and not to exercise 24 hours prior to the examination, not to consume liquids or food 4 hours prior. The examinations were performed preferably in the morning.

The anthropometric examination program was identical to those used in the Research Institute and Museum of Anthropology of Lomonosov Moscow State University (Negasheva, 2017) and included measurements of height, weight, waist and hip circumferences using GPM anthropological instruments (Siber-Hegner GPM, Switzerland, Zurich). The following anthropometric indices were calculated: body mass index (BMI), waist to hip ratio (WHR) and waist to height ratio (WHtR). BMI is defined as weight in kg divided by height in m squared (kg/m^2). WHR was calculated as waist circumference (cm) divided by hip circumference (cm). WHtR was calculated as waist circumference (cm) divided by height (cm). A bioelectrical impedance analyzer (Medas, Russia) was used to estimate body composition. Bioimpedance testing was performed at 50 kHz according to the standard integrated "wrist - ankle" methodology. The measurements were done on the right side of the body while the individuals were in supine position. Special skin electrodes for bioimpedance testing were applied (F3001 FIAB, Italy). The ABC02-0362 software was used to calculate the absolute and relative values of fat and lean mass, as well as the mass of water (Nikolayev, Smirnov, Bobrinskaya, & Rudnev, 2009). Ethical

approval was obtained from the Bioethics Committee of the Lomonosov Moscow State University (No. 116-d dated 09/08/2020).

The cut-off points of BMI and body fat were used to identify general and normal weight obesity. The cut-off of body fat was sex-specific, i.e. 25% of body fat in males and 30% of body fat in females (Čuta, Bařicová, Černý, & Sochor, 2019). Individuals who had BMI over 30 kg/m^2 or body fat content above the recommended thresholds were classified as obese. Individuals who had normal BMI (< 25 kg/m^2) and excessive fat content (25% in males and 30% in females) were classified as normal-weight obese.

Statistical analysis was carried out in R Statistical Software (version 4.0.3) and included exploratory data analysis according to the standard protocol (Zuur, Ieno, & Elphick, 2010), Mann–Whitney *U* test and Kruskal-Wallis test followed by the Bonferroni's *post hoc* test.

Results

Baseline phenotypic characteristics of the males and females are provided in Table 1. As expected, male subjects were on average heavier and taller compared to female subjects, while females had higher body fat mass and lower lean mass compared to males. There were significant differences in waist circumference, BMI, WHR and WHtR between groups.

Table 1

Anthropometrical characteristics of males and females

Variable	Males, n = 44	Females, n = 87
Height, cm**	176.0 (39)⸸	166.0 (40.5)
Weight, kg*	74.3 (129.3)	61.4 (94.9)
Waist circumference, cm*	80.0 (102.1)	74.0 (73.0)
Hip circumference, cm	97.0 (63.2)	95.4 (69.0)
WHR***	0.85 (0.4)	0.74 (0.46)
BMI, kg/m^2*	23.0 (40.6)	22.0 (31.0)
WHtR*	0.45 (0.57)	0.42 (0.45)
Body fat mass, kg (BIA)*	11.8 (87.5)	17.15 (66.2)
Body fat, % (BIA) **	16.1 (45.5)	28.3 (39.0)
Lean mass, kg (BIA) ***	62.2 (45.3)	44.7 (30.8)

*p-value < .05 **p-value< .01, ***p-value < 0.01, ⸸ Median (interquartile range)

As shown in Table 1, the variability of such obesity-related traits as BMI or body fat mass was high in female and male subjects. Hence, the individuals were divided into four groups in accordance to their BMI. The first group included 11 individuals (3 males and 8 females) who had BMI lower than 18.5 kg/m^2. The second group included 83 (25 males and 58 females) normal-weight individuals (BMI from 18.5 to 24.9 kg/m^2). The third and fourth groups included 19 (9 males and 10 females) overweight (BMI from 25.0 to 29.9 kg/m^2) and 18 (7 males and 11 females) obese (BMI ≥ 30 kg/m^2) individuals.

Table 2 shows differences between the individuals in accordance to their BMI. Individuals who were classified as overweight or obese by BMI had a higher amount of body fat mass, WHR and WHtR in comparison to normal-weight individuals. BMI was associated with the obesity-related traits such as body fat mass (rho=0.80 in males and rho=0.86 in females), WHtR

(rho=0.86 in males and rho=0.88 in females), and WHR (rho=0.68 in males and rho=0.55 in females).

Table 2

Anthropometrical characteristics of males and females according to the BMI categories

Variable	BMI groups			
	Underweight	Normal weight	Overweight	Obese
N	11	83	19	18
Weight, kg**	50.7 (18.3)⇣	63.9 (39.5)	80.4 (39.3)	97.6 (96.5)
Waist circumference, cm**	63.5 (19.5)	72.0 (30.7)	85.0 (23.0)	106.0 (77.0)
Hip circumference, cm**	87.5 (8.0)	95.0 (28.0)	104.0 (19.0)	116.0 (53.0)
WHR***	0.70 (0.25)	0.76 (0.27)	0.84 (0.23)	0.92 (0.36)
BMI, kg/m^2 **	17.3 (1.5)	21.9 (6.0)	26.5 (4.8)	34.0 (27.7)
WHtR**	0.37 (0.1)	0.4 (0.15)	0.5 (0.16)	0.63 (0.38)
Body fat mass, kg (BIA)**	8.7 (9.6)	13.35 (22.)	23.9 (27.2)	39.0 (65.3)
Body fat, % (BIA)***	17.3 (14.8)	22.4 (27.6)	31.1 (26.9)	39.7 (28.3)
Lean mass, kg (BIA)***	44.8 (15.5)	48.1 (37.1)	55.5 (29.9)	56.3 (45.7)

*p-value < .05 **p-value< .01, ***p-value < 0.01, ⇣ Median (interquartile range)

Based on BMI, the 20% (95%CI 18 –21%) of males were overweight (BMI ≥ 25 kg/m^2) and 16% (95% CI 14 – 17%) were obese (BMI ≥ 30kg/m^2). Whereas, in females, prevalence of overweight and obesity was lower and amounted to 11% (95%CI 10 – 12%) and 13% (95% CI 12 - 14%), respectively. Pooled overweight and obesity data revealed that 28% (36% of males and 24% of females) had BMI over 25 kg/m^2. When the sex-specific cut-offs based on body fat content were used, 31% (95% CI 28% - 33%) of males and 41% (95% CI 39 – 42%) of females were classified as obese.

To determine the normal weight obesity frequency, the sex-specific cut-offs based on body fat content and BMI were applied. Individuals with BMI less than 25 kg/m^2 and increased body fat (25% in males and 30% in females) can be classified as normal weight obese. Both criteria based on BMI and body fat content indicated that normal-weight males showed no signs of normal weight obesity. All male individuals who were classified as normal-weight had normal body fat content, whereas overweight and obese (BMI ≥ 25 kg/m^2) males had more than 25% of body fat. Thus, in the group of males, body fat increased alongside with BMI. The opposite situation prevailed in the group of females: up to 17% (95% CI 16 – 18%) of females were normal weight obese, i.e. had normal BMI and increased body fat content.

Up to 64% (95% CI 49% - 78%) of overweight and obese individuals had WHtR greater than recommended threshold (WHtR ≥ 0.5). There were no individuals with normal-weight central obesity. All individuals who had signs of central obesity were classified as overweight or obese. WHtR was correlated with body fat mass (rho=0.75 in males and rho=0.73 in females). All individuals with WHtR higher than 0.5 had excessive body fat content. Since WHtR is the anthropometric index commonly used to determine central obesity, the associations between WHtR, BMI, and body fat were used as indicators of increased prevalence of central obesity in the group of overweight and obese adults.

To analyze the age-related differences in body composition, the sample was divided into two age groups. The first group included 33 males aged 21 – 35 years and 45 females aged 18-35

years. The second age group included 11 males aged 36-73 and 42 females aged 36 – 67 years. Table 3 shows age-related differences in obesity-related traits in the two age groups. Based on BMI, 35% (95% CI 24 – 52%) and 54% (95% CI 36 – 88%) of females and males from the second age group were classified as overweight and obese. In the first age group, 13% (95% CI 7 – 24%) of females and 30% (95% CI 18 – 47%) of males had BMI higher than 25 kg/m^2. In both males and females, most obesity-related traits increased with age (Table 3).

Table 3

Anthropometrical characteristics of the two age groups

Variable	Age group					
	Males		P-value	Females		P-value
	21-35 years	36-73 years		18-35 years	36-67 years	
N	33	11		45	42	
Weight, kg	69.9 (18.7)⸸	83.8 (30.70)	0.03	61.0 (18.1)	61.9 (26.1)	0.30
Waist circumference, cm	78.1 (5.6)	96.5 (29.5)	0.01	69.1 (8.9)	75.0 (21.5)	0.005
Hip circumference, cm	94.0 (7.0)	101.2 (16.4)	0.03	95.0 (9.0)	95.8 (16.3)	0.16
WHR	0.84 (0.08)	0.93 (0.13)	0.007	0.73 (0.05)	0.77 (0.13)	0.001
BMI, kg/m^2	22.8 (3.3)	25.8 (8.7)	0.06	21.5 (3.3)	23.1 (8.7)	0.002
WHtR	0.45 (0.06)	0.54 (0.15)	0.01	0.41 (0.05)	0.45 (0.15)	0.00009
Body fat mass, kg	10.2 (10.3)	23.7 (15.9)	0.03	16.9 (8.7)	17.3 (15.0)	0.11
Body fat, %	14.5 (9.3)	24 (12.0)	0.04	26.8 (9.2)	29.6 (14.1)	0.03
Lean mass, kg	61.2 (7.2)	64.4 (16.2)	0.12	44.1 (8.5)	44.8 (8.7)	0.76

⸸ Median (interquartile range)

Discussion

On a relatively small sample of the adult population from Moscow, it was shown that 30% of adults had BMI greater than 25 kg/m^2 and were classified as overweight and obese. These findings were in accordance with Soboleva and his colleagues (2014). In the Russian Federation, the prevalence of overweight and general obesity accounted to 20% in males and 30% in females (Soboleva et al., 2014).

Up to 38% of individuals had body fat content above recommended thresholds. Pasco, Nicholson, Brennan and Kotowicz (2012) reported a linear relationship between BMI and body fat mass. In the present study, the male individuals with an excessive body fat content had increased BMI above the recommended threshold. In the group of females, 17% of subjects with normal BMI had excessive body fat content - and thus can be classified as normal weight obese. There is compelling evidence linking normal weight obesity and a higher risk of several health conditions including cardiovascular diseases and type 2 diabetes (De Lorenzo et al., 2007). Romero-Corral and his colleagues (2010), who utilized the same sex-specific cut-off points, reported that individuals with normal weight obesity had impaired insulin sensitivity as body fat increased. The prevalence of metabolic syndrome in normal weight obese individuals was four-fold higher than in individuals with low body fat content. Čuta et al. (2019) showed that

approximately 14% of the European urban adult female population of Brno had signs of normal weight obesity.

Central obesity in adults is associated with an increased risk of mortality (Zhang, Rexrode, Van Dam, Li, & Hu, 2008). Weight gain with accumulation of abdominal fat is a cardiovascular risk factor. Obese individuals with central obesity have worse prognosis of coronary heart disease than those who have high BMI value without signs of central obesity (Oliveros, Somers, Sochor, Goel, & Lopez-Jimenez, 2014). In the present study, increased BMI was associated with central obesity-related traits such as waist circumference, WHR, and WHtR. More than half of the adults who were overweight and obese by BMI had central obesity (WHtR ≥ 0.5).

Pasco and his colleagues (2012) showed that peaks of obesity occurred in males aged 60-69 years and in females aged 50-59 years. The same age-related differences in body composition and prevalence of obesity were detected. In the group of elderly females, the ratio of fat to lean masses was higher than in younger females. The changes in body composition with aging are well documented (Borkan, Hults, Gerzof, Robbins, & Silbert, 1983; Fukagawa, Bandini, & Young, 1990; Santoro et al., 2018). Visceral fat tends to increase with age as well as the prevalence of central obesity (Wong et al., 2020). However, changes in body composition are often independent of body weight and BMI (Santoro et al., 2018). Gender differences in body composition across age groups can be caused by hormonal differences (Lauretta, Sansone, Romanelli, & Appetecchia, 2017).

The study has some limitations that should be mentioned. Firstly, the sample size of the male and elderly groups was small. Secondly, the bioimpedance method instead of "gold" standard techniques was used to determine body composition.

Despite the limitations, the findings allow to conclude that, in the highly urbanized and obesogenic environments, individuals with normal BMI may also have excessive body fat and the subsequent health risks like individuals with general obesity. On the one hand, urbanization stimulates economic development and increases income per capita, and thus allows people to eat a variety of foods. On the other hand, the demand for processed and preserved food increases among residents of highly urbanized areas together with eating-out behavior (Seto & Ramankutty, 2016). Unhealthy eating practices and sedentary lifestyle can result in increased prevalence of obesity in the urban populations (Ebrahim et al., 2010, Fox, Feng, & Asal, 2019; Islam, Kathak, Sumon, & Molla, 2020). That is why campaigns for healthy eating that establish new nutrition programs in schools and pay special attention to nutrition education are necessary to ensure a proper nutrition policy that can help improve human health (Baciu, 2013). Urban communities from developing countries are most affected by the obesogenic factors (Kuddus, Tynan, & McBryde, 2020). In the developed countries, the prevalence of obesity is the same both in the urban and rural populations (Peytremann-Bridevaux, Faeh, & Santos-Eggimann, 2007). In this sense, the findings are in accordance with previous studies and thus allow to conclude that established changes in body composition of the adults living in Moscow correspond to global trends.

Conclusions

On a relatively small sample of the adult population from Moscow, it was shown that the prevalence of general obesity accounted to 16% and 13% in the male and female groups. More than half of the adults with BMI greater than 25 kg/m^2 had signs of central obesity. When the sex-specific cut-offs based on body fat content were used, 31% of males and 41% of females were

classified as obese. Up to 17% of females were classified as normal weight obese. The findings of the present study revealed that BMI alone measurement led to false-negative results. Additional anthropometric tools are recommended to apply. An evaluation of body fat and its distribution using anthropometric indices and body composition analysis seems to be more promising. Individuals with normal BMI may also have excessive body fat and subsequent health risks as people with general obesity in the "obesogenic" environment that promotes chronic positive energy balance.

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