PREVENTIVE MEDICINE

SEX AND AGE SPECIFICITIES OF THE DYNAMICS OF ANTHROPOMETRIC INDICATORS CHARACTERIZING OBESITY (ACCORDING TO A PROSPECTIVE EPIDEMIOLOGICAL RESEARCH)

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ABSTRACT

Background. *Overweight and obesity significantly increase the risk of premature death and the development of chronic diseases. Many anthropometric indices have been developed to verify obesity, although the best among them remains undetermined.*

The aim of the study. *To determine the sex and age specificities of the dynamics of anthropometric indicators characterizing obesity.*

Materials and methods. *The program was implemented in the period from 2015 to 2020. It provided for the implementation of sample research. The baseline research included 1,124 women and 476 men. The average age was 54.9 ± 9.75 years and 52.6 ± 10.0 years, respectively. To identify gender specificities, all participants were divided into three age groups: 35–49 years old, 50–59 years old, and 60–70 years old. The observation period was 3 years.*

To determine the level of visceral fat, the VS-532 fat mass analyzer (Tanita Health Equipment HK Ltd., Hong Kong) was used. Body mass index (BMI), waist-to-hip ratio (WHR), visceral obesity index (VOI) were also calculated. Statistical processing of the results was carried out using the program Statistica 6.0 (StatSoft Inc., USA).

Results. *New cases of obesity developed in 30.6 % of the surveyed. There was an increase in the prevalence of obesity according to the criteria of waist circumference (by 8.9 %) and visceral fat level (by 5.4 %) and a decrease in the number of people who are obese according to WHR – by 4.2 %. Of all the indicators, only VOI showed a statistically significant decrease in the mean values over the observed period, while BMI, waist circumference and visceral fat level showed an increase.*

Conclusion. *It is necessary to apply various criteria for the diagnosis of obesity, since individual indices are not able to fully reflect the gender and age specificities of the distribution of fat in the body.*

Key words: *obesity, anthropometry, epidemiology, diagnostics*

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ПОЛОВОЗРАСТНЫЕ ОСОБЕННОСТИ ДИНАМИКИ АНТРОПОМЕТРИЧЕСКИХ ПОКАЗАТЕЛЕЙ, ХАРАКТЕРИЗУЮЩИХ ОЖИРЕНИЕ (ПО ДАННЫМ ПРОСПЕКТИВНОГО ЭПИДЕМИОЛОГИЧЕСКОГО ИССЛЕДОВАНИЯ)

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РЕЗЮМЕ

Обоснование. *Избыточный вес и ожирение существенно увеличивают риск преждевременной смерти и развития хронических заболеваний. Разработано множество антропометрических индексов, позволяющих верифицировать ожирение, хотя лучший среди них до сих пор остаётся не определённым.*
Цель исследования. *Определить половозрастные особенности динамики антропометрических показателей, характеризующих ожирение.*
Методы. *Программа реализовывалась в период с 2015 по 2020 г. и предусматривала выполнение выборочного исследования. В базовое исследование было включено 1124 женщины и 476 мужчин. Средний возраст составлял 54,9 ± 9,75 и 52,6 ± 10,0 года соответственно (p < 0,001). Для выявления особенностей, связанных с полом, все участники были разделены на три возрастные группы: 35–49 лет, 50–59 лет и 60–70 лет. Период наблюдения составлял 3 года.*
Для определения уровня висцерального жира использовался анализатор жировой массы BC-532 (Tanita Health Equipment HK Ltd., Гонконг). Также рассчитывались индекс массы тела (ИМТ), индекс «талия – бёдра» (ОТ/ОБ, окружность талии/окружность бёдер), индекс висцерального ожирения (ИВО). Статистическая обработка результатов проводилась при помощи программы Statistica 6.0 (StatSoft Inc., США).
Результаты. *Новые случаи ожирения развились у 30,6 % обследованных. Наблюдалось увеличение распространённости ожирения по критериям ОТ (на 8,9 %) и уровень висцерального жира (УВЖ; на 5,4 %) и снижение числа лиц, имеющих ожирение по ОТ/ОБ, на 4,2 %. Из всех показателей только ИВО продемонстрировал статистически значимое снижение средних значений за наблюдаемый период, в то время как ИМТ, ОТ и УВЖ – увеличение.*
Заключение. *Необходимо применение различных критериев для диагностики ожирения, так как отдельные индексы не способны в полной мере отразить половозрастные особенности распределения жира в организме.*

Ключевые слова: *ожирение, антропометрия, эпидемиология, диагностика*

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INTRODUCTION

Worldwide, the prevalence of overweight and obesity is high and continues to rise steadily. While approximately 13.0 % (650 million) of adults worldwide were obese in 2016 [1, 2], by 2030, experts estimate that this figure will be as high as 20.0 % [3]. This condition is known to significantly increase the risk of developing a large number of chronic diseases, including metabolic, cardiovascular, musculoskeletal, neurodegenerative and psychiatric diseases, as well as several forms of cancer [4]. Abdominal obesity is an independent risk factor for metabolic and cardiovascular disease and mortality [5]. Obesity-related noncommunicable diseases account for more than 5 million deaths worldwide each year, with more than half occurring in people under the age of 70 years [6]. Additionally, obesity is a major cause of reduced quality of life, disability and social disadvantage, and it is closely associated with various social factors [3, 7].

Currently, body mass index (BMI) and waist circumference (WC) are still considered the main epidemiological indicators of general and abdominal obesity [8]. However, their usefulness is diminished by the inability to account for body fat distribution [9]. Differences in adipose tissue distribution may contribute to heterogeneity in the clinical and biological manifestations of obesity. Several anthropometric indices have been developed specifically to describe fat distribution, including waist-to-height ratio, BMI, visceral adiposopathy index (VAI), and visceral fat level (VFL). Some studies were reported that waist-to-height ratio was a better predictor of arterial hypertension, diabetes mellitus and hyperlipidaemia than BMI and WC. Body shape index was a significant risk factor for premature mortality in the general population. Some studies have demonstrated that VAI is superior to BMI and WC in predicting arterial hypertension [10]. However, the best obesity verification index that predicted or was closely related to metabolic factors is still controversial and inconclusive [8, 11].

THE AIM

To determine sex and age peculiarities of the anthropometric indicators dynamics which characterise obesity.

MATERIAL AND METHODS

The research program has been organised and implemented between 2015 and 2020. It involved performing a sample survey, for which groups of respondents aged 35–70 were formed. All surveys were conducted in compliance with the "Ethical Principles for Medical Research Involving Human Subjects" in accordance with the "Rules of Clinical Practice in the Russian Federation". The study record was approved by the local ethical committee of Research Institute for Complex Issues of Cardiovascular Diseases (Minutes No. 7 as of 2015). Patients signed informed consent in the prescribed form prior to inclusion in the study. The representativeness of the sample was ensured by random selection in three consecutive stages using the Kish method. Inclusion criteria: age between 35 and 70 years inclusive; stable residence in the selected area for the next 4 years. Individuals under 35 and over 71 years of age, as well as respondents planning to move from their chosen residence in the next 4 years who declined to participate, were not included in the study.

A total of 1124 women and 476 men were included in the pivotal study. The median age for 444 males was 53.5 (44–61) years and for females 57.0 (47–63) years ($p < 0.001$); therefore, all respondents were divided into three age groups to identify sex-age differences: 35–49 years, 50–59 years, 60–70 years. Follow-up lasted 3 years from the first visit. However, during COVID-19 pandemics, it was not possible to adhere to the surveillance time frame due to restrictions on medical preventive examinations. Finally, the prospective phase ended with 60.0 % of participants from each age group at baseline who had a follow-up period of 3 years or less visiting the research centre. As the project progressed, it was found that 807 individuals had follow-up dates that met the above inclusion criteria (84.1 % response rate). Meanwhile, 44 individuals died, 32 moved to another location, and 157 individuals refused further participation in the study; 731 individuals completed the entire list of surveys.

Visceral fat levels were determined with a BC-532 fat mass analyzer (Tanita Corporation, Japan). A level of 1 to 12 conventional units was defined as a healthy level of visceral fat; 13 to 59 conventional units was defined as an elevated level. BMI, waist-to-hip ratio (WC/HC (hip circumference)) were determined using traditional formulas. Visceral adiposopathy index (VAI) was calculated using the formulas:

$$\text{in men: } VAI = WC / (39.68 + (1.88 \times BMI)) \times (TG / 1.03) \times (1.31 / HDL)$$

$$\text{in women: } VAI = WC / (36.58 + (1.89 \times BMI)) \times (TG / 0.81) \times (1.52 / HDL),$$

where: TG – triglycerides; HDL – high-density lipoproteins.

Statistical processing of the obtained data was performed using Statistica 6.0 software (StatSoft Inc., USA) (License No. AXXR003E608729FAN10 dated March 31, 2010). Quantitative variables are presented as median (*Me*) and percentiles (25 %–75 %), while qualitative attributes are presented as frequencies (percentages). The Wilcoxon test was used to compare quantitative variables (baseline and prospective measures); Pearson's Chi-square test was used to compare qualitative variables. The critical level of significance was ≤ 0.05.

RESULTS

The incidence of obesity among women at pivotal study varied from 20.9 % by VFL to 76.5 % by WC, among men from 33.4 % (VAI) to 73.9 % (WC/HC). The prevalence

of obesity by the selected criteria has been summarised in more detail by the authors previously [12]. One should be mentioned that in a comparative analysis, among all the analysed parameters characterising the presence of obesity, only VAI showed a statistically significant decrease in mean values over the observed period, while BMI, WC/HC, WC and VFL increased (Table 1).

In the prospective stage of the study, 247 new cases of obesity were diagnosed (30.6 % of the surveyed population). Sex differences were determined using WC/HC and VFL criteria. Specifically, men were more likely than women to be diagnosed with an increase in this condition by WC/HC (64.9 % vs. 35.1 %, respectively; $p < 0.001$). Meanwhile, an increase in the proportion of VFL obese individuals was recorded more in women than in men (53.7 % and 46.3 %, respectively; $p = 0.003$). The differences did not reach statistical significance for the other parameters studied: for BMI, new cases of obesity were diagnosed in 26.8 % of men and 73.2 % of women ($p = 0.617$); for WC, obesity was almost twice as common in women as in men (65.4 % vs. 34.6 %, respectively; $p = 0.382$); new cases of obesity according to VAI were recorded in 26.6 % of males and 73.4 % of females ($p = 0.494$). Statistically significant age differences were revealed only in the case of WC criterion: the maximum increase of this indicator was observed in the group of 50–59 years – 47.4 %, in the younger age group it was 35.9 % and the minimum increase was observed in the group of 60–70 years (16.7 %) ($p = 0.001$). It was also observed that the maximum prevalence of obesity according to BMI, VFL and VAI criteria was in the age group of 60–70 years (36.6 %, 44.8 % and 40.6 % respectively) and according to WC/HC criteria in the age group of 35–49 years (40.3 %).

Between 2015 and 2019, there was a decrease in the prevalence of obesity assessed by WC/HC from 74.6 % to 70.4 % ($p = 0.034$) (Fig. 1). An increase of 8.9 % ($p < 0.001$) and 5.4 % ($p = 0.010$) in the detection rate of this pathology was observed as per WC and VFL criteria, respectively.

When analysing the sex- and age-specific dynamics of obesity assessed by various criteria, statistically significant differences were revealed when studying WC and WC/HC parameters (Table 2). Specifically, the prevalence of abdominal obesity in young women increased by 11.8 %. Furthermore, both sexes aged 50–59 years also showed an increase in the incidence of obesity detection by this criterion (by 13.9 % and 12.3 %, respectively). An interesting pattern was observed when examining

TABLE 1

DYNAMICS OF OBESITY RATES DURING THE STUDY PERIOD, Me (25 %–75 %)

Indicators	Basic stage	Prospective stage	*p* value
Body mass index	29.0 (25.2–33.1)	29.3 (25.8–33.2)	< 0.001
Waist-to-hip ratio	0.88 (0.8–0.9)	0.92 (0.8–1.0)	< 0.001
Waist circumference	93.0 (83.0–103.0)	98.0 (88.0–108.0)	< 0.001
Visceral fat level	10.0 (7.0–13.0)	11.0 (8.0–14.0)	< 0.001
Visceral adiposopathy index	1.58 (0.9–2.6)	1.47 (0.9–2.4)	0.001

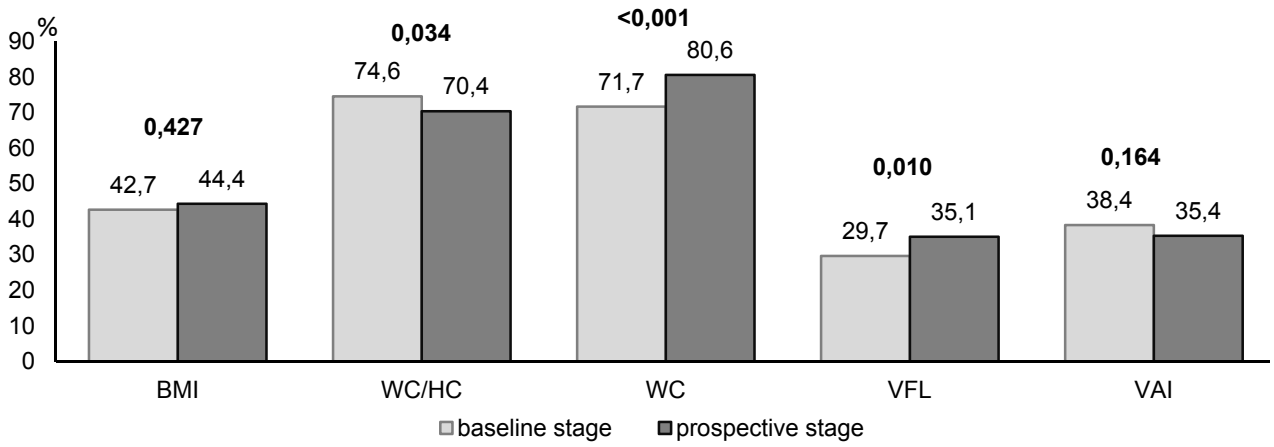

FIG. 1.

Change in the obesity prevalence diagnosed by different criteria (2015–2019)

TABLE 2

GENDER AND AGE-SPECIFIC DYNAMICS OF OBESITY ASSESSED BY DIFFERENT ANTHROPOMETRIC INDICATORS (%)

Age, years	Sex	BMI		*p* value	WC		*p* value	WC/HC		*p* value	VFL		*p* value	VAI		*p* value
		B	P		B	P		B	P		B	P		B	P	
35–49	Male	33.7	45.1	0.093	53.9	62.0	0.248	64.0	77.5	0.041	28.6	39.4	0.099	33.1	40.8	0.251
	Female	27.5	29.9	0.605	55.9	67.7	0.021	53.5	39.4	0.007	3.0	3.1	0.943	27.8	22.8	0.281
50–59	Male	37.3	31.3	0.353	60.8	74.7	0.030	76.6	89.2	0.018	51.9	62.6	0.110	39.9	33.7	0.350
	Female	47.9	49.2	0.775	76.6	88.9	0.001	75.5	63.0	0.002	21.4	23.8	0.530	43.7	42.0	0.704
60–70	Male	37.1	38.8	0.817	67.9	70.1	0.740	83.6	91.0	0.056	77.1	80.6	0.573	26.4	14.9	0.065
	Female	57.2	56.5	0.861	91.9	94.0	0.339	90.3	79.5	0.0002	33.9	37.5	0.381	47.5	43.0	0.288

Note. B – baseline stage; P – prospective stage.

trends in the prevalence of obesity by WC/HC criterion: in females, there was a decrease regardless of age group (by 14.1 %, 12.2 % and 10.8 %, respectively). Meanwhile, in men, an increase in the prevalence of obesity was revealed at the ages of 35–49 and 50–59 years (by 13.5 % and 12.6 %, respectively).

DISCUSSION

The results of a single-centre, three-year study revealed an increase in the prevalence of obesity by WC and VFL criteria and a decrease by WC/HC criteria. The sex- and age-specific dynamics of obesity according to the studied criteria consisted in an increase in the prevalence of abdominal obesity in women of 35–59 years old, but a decrease in the frequency of detection in all age groups according to the WC/HC criterion. In males, there was an increase in the detection of obesity by WC at age 50–59 years and by WC/HC at age 35–59 years. The median values of all studied indicators (except VAI), however, statistically significantly increased. This fact evidences the need to apply different criteria for the diagnosis of obesity, as BMI is probably not able to fully reflect the sex- and age-specific distribution of body fat [13].

The increasing prevalence of obesity has been observed in most countries of the world during the last decades. For instance, in a study of the Korean National Health Insurance Service's national health check-up database, the prevalence of obesity increased steadily over a 10-year period from 2009 (29.7 %) to 2018 (35.7 %) among the entire population and in all age groups. The prevalence of abdominal obesity has also increased, from 19.0 % in 2009 to 23.8 % in 2018. The increase in the prevalence of abdominal obesity was most evident in men (from 20.7 % to 28.1 %, respectively). In women, the prevalence of abdominal obesity increased from 16.2 % to 18.2 % overall, but decreased between the ages of 50–60 years [14].

Among 20 populous countries, Egypt had the highest adult obesity rate in 2015 with a rate of 34.9 %, while Vietnam had the lowest with a rate of 1.6 %. The prevalence of obesity more than doubled in 13 of these 20 countries between 1980 and 2015, and only the Democratic Republic of Congo did not show an increase in this pathology [15]. In Africa, between 1980 and 2014, the age-standardized mean BMI increased from 21.0 kg/m^2 (95 % confidence interval (95 % CI): 20.3–21.7) to 23.0 kg/m^2 (95 % CI: 22.7–23.3) in men and from 21.9 to 24.9 kg/m^2 in women [16]. There are few large epidemiologic studies in the Russian Federation. The study of obesity in the regions of the country is mostly one-sided and ignores the full range of factors affecting the incidence of these pathologies. There is currently a low efficiency in the diagnosis and treatment of obesity [17]. According to the study "Epidemiology of cardiovascular diseases and their risk factors in the Russian Federation" (ESSE-RF), the prevalence of obesity reached 29.7 % [18]. Meanwhile, in different regions of the Russian Federation, this indicator varies from 22.5 % to 44.5 % for BMI and from 43.0 % to 67.0 % for WC. Abdominal obesity was more closely associated with high risks of cardiovascular disease (CVD) and diabetes mellitus and had a significantly higher prevalence of 55.0 % vs. 33.4 % for BMI [19].

If the above trends in the prevalence of obesity persist, the chances of stabilising body weight in the general population are nil [20]. Scientists estimate that in the next five years, the global prevalence of obesity will reach 18 % and 21 % in men and women, respectively [20].

Overall, the prevalence of obesity and overweight in Middle Eastern countries remained stable from 2000 to 2020 with an average prevalence of 23 %. The prevalence of overweight, however, decreased from 34.8 % (95 % CI: 32.4–37.4) to 32.8 % (95 % CI: 31.4–34.4) over these time intervals. Meanwhile, in women, the prevalence of obesity and overweight decreased from 26.6 % (95 % CI: 22.9–30.9) and 32.3 % (95 % CI: 29.8–35.0) between

2000 and 2006 to 23.1 % (95 % CI: 20.8–25.7) and 32.8 % (95 % CI: 31.39–34.38) between 2014 and 2020, respectively. In contrast, the prevalence of obesity in men increased from 20.1 % (95 % CI: 16.24–24.82) from 2000 to 2006 to 23.5 % (95 % CI: 20.3–27.2) from 2014 to 2020. Although, the prevalence of overweight in males remained stable (39.0 %) during these periods [21].

The rate of obesity increase in Europe is higher in men than in women (3.1 % vs. 1.9 % per year). If the increase rate remains at the estimated level in 2030, Poland is likely to have more obese men (38.1 %) than women (32.7 %) and Europe will have 36.6 % and 32.0 %, respectively [22].

According to these trends, the main driving force behind the obesity epidemic, according to the authors, is the westernisation of lifestyles in countries [23, 24]. Policies implemented in society should promote behavioural change at the personal level with a focus on increasing consumption of healthy diet and physical activity [15]. However, the heterogeneity in obesity rates between countries may mean that social and other factors and their differences are associated with obesity status. Increases in obesity have more often been accompanied by improvements in the economy, especially in a number of developing countries [15].

The foregoing data suggest that there are inconsistencies in the assessment of current anthropometric indexes, and they cannot provide a comprehensive prediction of metabolic risk factors. Consequently, further studies should be conducted to elucidate the association of anthropometric parameters with cardiovascular risk factors [25, 26].

CONCLUSIONS

New cases of obesity were identified in 30.6 % of respondents during the period analysed: an increase in prevalence was observed using WC and VFL criteria (by 8.9 % and 5.4 %, respectively). While at the same time, the WC/HC criterion showed a 4.2 % decrease in the number of persons with this pathology. The median of all studied indicators (except VAI) increased statistically significantly over the three years of follow-up. Men were more likely than women to be diagnosed with an increase in this condition by WC/HC (64.9 % vs. 35.1 %, respectively; $p < 0.001$). Meanwhile, an increase in the proportion of VFL obese individuals was recorded more in women than in men (53.7 % and 46.3 %, respectively; $p = 0.003$). Age differences were only observed when the WC criterion was applied: the maximum increase was observed at 50–59 years (47.4 %) and at 35–49 years (35.9 %), while the minimum increase was observed at 60–70 years (16.7 %; $p = 0.001$). The maximum prevalence of obesity according to BMI, VFL and VAI criteria was in the age group of 60–70 years (36.6 %, 44.8 % and 40.6 %, respectively) and according to WC/HC criteria in 35–49 years (40.3 %). The choice of the best method to measure obesity for predicting CVD risk factors remains controversial. Further studies are required in populations for which the various anthropometric measures have not been thoroughly analysed and compared. A comprehensive approach to diagnosis is required, considering traditional, socio-economic and behavioural factors specific to a particular region. Targeting obesity risk reduction will help reduce the burden of circulatory disease in the adult population.

Conflict of interest

The authors of this article declare no conflicts of interest.

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