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Actual prevalence of obesity and its correlation with medical and social factors among the employed population in the Saratov region

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ABSTRACT

BACKGROUND: Obesity is a common, multifactorial disease that significantly contributes to other chronic noncommunicable diseases, which are the leading causes of premature mortality worldwide. The observed increase in the prevalence of obesity is attributable to a wide range of behavioral, medical, social, and biological factors.

AIM: To assess of the actual prevalence of obesity among the employed population in the Saratov region and its correlation with medical and social factors.

MATERIAL AND METHODS: A cross-sectional study was conducted to assess the prevalence of obesity among 3,721 employees, evaluating a range of medical and social factors, including sex, age, education, place of residence, physical activity, and risk factors for metabolic syndrome. The R programming language was used for statistical analysis. A probit regression model was created to determine the probability of obesity based on the presence or absence of specific factors.

RESULTS: A univariate analysis demonstrated a correlation between obesity and a number of medical and social factors, including sex, age, education, labor intensity, physical activity, and the risk factors for metabolic syndrome. A regression analysis revealed a lower prevalence of obesity among males engaged in physically demanding work and among females with a university degree. A regression analysis demonstrated a positive correlation between obesity and the markers of cardiometabolic risk, including an above-normal waist circumference, hyperglycemia, low HDL, and hypertension, in the overall study population and male participants. In the female cohort, the analysis identified an above-normal waist circumference and hypertension as correlates of obesity. The notable finding was that triglyceride levels were not associated with obesity in any of the groups. The study had several limitations, including those related to region (the Saratov region), age (working-age population), and occupational status (employed population).

CONCLUSION: A representative sample of the employed population in the Saratov region was used to establish the obesity prevalence patterns among males and females in various age groups. Additionally, the study identified the major medical and social risk factors for obesity. It is essential to consider the probability of a high body fat percentage among individuals with normal body weight and those who are overweight to prevent and mitigate cardiometabolic risks. The findings of this study are potentially beneficial for the creation of preventative strategies integrated into employee wellness initiatives focused on maintaining the wellbeing, quality of life and professional longevity of the employed population.

Keywords: obesity; employed population; cardiometabolic risk; bioelectrical impedance analysis; BMI.

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Фактическая распространённость ожирения и его связь с медико-социальными факторами среди работающего населения Саратовской области

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АННОТАЦИЯ

Обоснование. Ожирение относится к распространённой мультифакториальной патологии и вносит существенный вклад в развитие других хронических неинфекционных заболеваний, которые являются ведущими причинами преждевременной смертности во всем мире. Тенденции к росту заболеваемости ожирением обусловлены широким спектром поведенческих, медико-социальных и биологических факторов.

Цель. Оценка фактической распространённости ожирения среди работающего населения Саратовской области и его связь с медико-социальными факторами.

Материал и методы. В рамках поперечного исследования изучена распространённость ожирения среди 3721 работающего с учётом медико-социальных факторов (пол, возраст, уровень образования, место проживания, уровень физической активности, наличие факторов метаболического синдрома). Для статистического анализа применяли язык программирования R. Вероятность развития ожирения с учётом наличия или отсутствия определённых факторов выявляли с помощью построения модели пробит-регрессии.

Результаты. Данные одномерного анализа показали связь ожирения со следующими медико-социальными факторами: пол, возраст, уровень образования, тяжесть труда, уровень физической активности, а также с факторами метаболического синдрома. Результаты регрессионного анализа свидетельствуют о том, что среди мужчин, занимающихся тяжёлым трудом, и среди женщин с высшим образованием ожирение встречается статистически значимо реже. И в общей группе участников исследования, и в группе мужчин регрессионный анализ показал наличие положительной связи ожирения с показателем окружности талии, превышающим норму, гипергликемией, низким уровнем ЛПВП и артериальной гипертензией, которые являются маркерами кардиометаболического риска; в группе женщин — с показателем окружности талии, превышающим норму, и артериальной гипертензией; во всех группах наблюдения отсутствует связь ожирения с уровнем триглицеридов. Исследование имеет региональные (Саратовская область), возрастные (трудоспособное население) и профессиональные (работающее население) ограничения.

Заключение. На репрезентативной выборке работающего населения Саратовской области установлены особенности распространения ожирения среди мужчин и женщин в разных возрастных категориях, определены приоритетные медико-социальные факторы риска развития ожирения. Вероятность повышенного процентного содержания жировой массы среди лиц с оптимальной и избыточной массой тела обусловливает необходимость учитывать это с целью профилактики и минимизации кардиометаболических рисков. Полученные данные целесообразно использовать при разработке профилактических мероприятий в рамках корпоративных программ, направленных на сохранение здоровья, качества жизни и профессионального трудового долголетия работающего населения.

Ключевые слова: ожирение; работающее население; кардиометаболический риск; биоимпедансометрия; ИМТ.

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萨拉托夫州在职人口中肥胖的实际流行率及其与医疗社会因素的关联

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摘要

背景。肥胖是一种常见的多因素病理，对其他慢性非传染性疾病的发展具有重要影响，这些疾病是全球过早死亡的主要原因。肥胖发病率的增长趋势由广泛的行为、医疗社会和生物因素引起。

研究目的。评估萨拉托夫州在职人口中的实际肥胖流行率及其与医疗社会因素的关联。

材料和方法。在横断面研究中，调查了3721名在职人员的肥胖情况，并考虑了医疗社会因素（性别、年龄、教育水平、居住地、身体活动水平和代谢综合征因素）。使用R编程语言进行统计分析。通过建立概率回归模型评估在考虑某些因素存在或不存在的情况下肥胖发展的可能性。

结果。单因素分析数据显示，肥胖与以下医疗社会因素有关：性别、年龄、教育水平、工作强度、身体活动水平以及代谢综合征因素。回归分析结果表明，从事重体力劳动的男性和具有高等教育的女性肥胖发生率显著较低。在总体参与者组和男性组中，回归分析表明肥胖与腰围超标、高血糖、低高密度脂蛋白胆固醇水平和高血压呈正相关，这些都是心脏代谢风险的标志；在女性组中，肥胖与腰围超标和高血压呈正相关；在所有观察组中，肥胖与甘油三酯水平无关。本研究具有地区（萨拉托夫州）、年龄（劳动人口）和职业（在职人口）的限制。

结论。在萨拉托夫州在职人群的代表性样本中，确立了不同年龄段男性和女性的肥胖分布特征，并确定了导致肥胖发展的优先医疗社会风险因素。对于体重正常和超重人群中的高脂肪含量的可能性，需要在预防和减少心脏代谢风险时加以考虑。所得数据可用于制定旨在保护健康、提高生活质量和延长在职人口职业寿命的企业预防计划。

关键词：肥胖；在职人口；心脏代谢风险；生物电阻抗测量；BMI。

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BACKGROUND

Obesity is a common, multifactorial disease that significantly contributes to other chronic noncommunicable diseases (cardiovascular diseases, stroke, type 2 diabetes, cancer, etc.), which are the leading causes of premature mortality worldwide [1]. Higher obesity incidence rate in the employed population is an extremely relevant issue as lower productivity and the treatment cost of the effects of obesity is a serious burden on the public economy [2]. Despite the active implementation of various strategies and government programs [3] aimed at improving the state of health of various populations, obesity rates continue growing. According to forecasts, its prevalence in the Russian Federation may increase several times by 2030 [4].

Thus, obesity incidence monitoring in the working-age population in the Russian Federation and its constituent entities, analysis and determination of major modifiable factors based on regional differences are urgent tasks of preventive medicine [5, 6].

AIM: The study aimed to assess the actual prevalence of obesity in the employed population in the Saratov Region and its correlation with medical and social factors.

MATERIALS AND METHODS

A cross-sectional study was conducted at the Saratov Medical Scientific Center of Hygiene in 2021–2023. During regular medical examinations, 3,721 employees aged 22 to 75 were examined including 2,409 (64.74%) men (mean age 45.60±11.56) and 1,312 (35.26%) women (mean age 47.69±11.04). All study participants were clinically healthy.

Inclusion criteria are the employee population of the Saratov Region; men aged 22–65, and women aged 21–60. Exclusion criteria are individuals taking antihypertensive and lipid-lowering drugs and individuals who did not sign informed consent.

To assess obesity grade, we used the Quételet index (BMI=kg/m^2) based on the criteria recommended by WHO (1997) (normal body weight with a BMI of 18.5–24.9; excess body weight with a BMI of 25.0–29.9; obesity with a BMI of 30.0 and higher). The body fat proportion was determined by bioimpedance analysis (computerized cardiorespiratory system and tissue hydration monitoring complex KM-AR-01 DIAMANT) [7]. Based on the body fat percentage scale, three levels were distinguished: 7.2% and less is the low level; 7.3–14.5% is the normal level; 14.6% and higher is the high level.

Age groups were determined by the classification adopted at the 7th All-Union Conference on Age Morphology, Physiology, and Biochemistry (Moscow, 1965), i.e. Early Adulthood group (22–35 years for men, 21–35 years for women); Middle Age group (36–60 years for men, 36–55 years for women); and Late Adulthood group (61–74 years for men, 56–74 years for women).

To collect data on education (high school/university degree) and place of residence (urban/rural), we used a standard questionnaire. The high school group included participants with general high school, vocational, and intermediate vocational education; the university degree group included participants with university degrees. The urban group included participants living in cities and towns; the rural group included participants living in villages, rural areas, and urban-type settlements.

We studied the relationship between BMI, physical activity, and employment factors (work intensity and stress). To assess physical activity, we used the International Physical Activity Questionnaire (IPAQ) as it records all types of daily physical activity at home and at work in points. Hypodynamia criteria for Early Adulthood group participants are less than 21 points, less than 14 points for Middle Age group participants, and less than 7 points for the Late Adulthood group.

Metabolic syndrome was assessed by the 2005 Adult Treatment Panel III (ATP III) [8], i.e. waist circumference of 102 cm or more for men and 88 cm or more for women, indicating abdominal obesity (in case of hereditary predisposition to cardiovascular diseases or type 2 diabetes mellitus, the borderline waist circumference in men is reduced to 94 cm); fasting hyperglycemia (higher than 5.6 mmol/L); hypertriglyceridemia (higher than 1.7 mmol/L); low high density lipoprotein (HDL) (less than 1.04 mmol/L for men and 1.29 mmol/L for women); blood pressure (higher than 130/85 mmHg).

The R programming language was used for statistical processing. Pearson's chi-square test was used to compare groups. A probit regression was built using the generalized linear model (GLM) function with the parameter "family = binomial (link = "logit")."

The studied indicators are presented as binary variables. The response is also a binary value (normal body weight or obesity). The probability of obesity in relation to certain factors was determined by a probit regression model:

$$p=\Phi(\beta_0+\sum_{i=1}^{n}\beta_i x_i),$$

where p is the probability of obesity; β_0 is the intercept; x_i may take the value of 0 or 1, if the regression does not have or has the factor with i number; β_i are the coefficients corresponding to x_i factors; Φ is the Laplace transform.

The study was conducted in accordance with bioethical requirements after the participants had signed informed consent (Minutes No. 8 of the local Ethics Committee meeting dated April 29, 2024).

RESULTS

Obesity prevalence is significantly higher in women of all age groups compared to men. In men, obesity is significantly more common in age Middle Age group and the

Late Adulthood group compared to Early Adulthood group. In women, a significant difference in the prevalence of obesity is noted between all age groups; this value increases with age (see Table 1).

In the examined sample, a significant relationship was found between obesity and medical and social factors, including above-normal waist circumference, hyperglycemia, hypertriglyceridemia, low HDL, arterial hypertension, university degree, work intensity, and physical inactivity. However, there is no relationship between obesity and work stress, place of residence, smoking, and marital status (see Table 2).

In both the general group and the male group, regression analysis showed a positive relationship of obesity with above-normal waist circumference, hyperglycemia, low HDL, and arterial hypertension, i.e. indicators of cardiometabolic risk. In the female group, there was a positive relationship of obesity with above-normal waist circumference and arterial hypertension. In all observation groups, obesity was not related to triglyceride levels (see Table 3).

Regression analysis indicates that a university degree and intensive work significantly reduce the probability of obesity; whereas physical inactivity, on the contrary, contributes to its development in the general group of subjects. Sex classification of participants showed that for men intensive work reduces the probability of obesity; whereas a university degree reduces the probability of obesity in women (see Table 4).

We analyzed body fat percentage in individuals with normal body weight, overweight individuals, and individuals with obesity (see Fig. 1).

It is significant that 0.75% individuals with normal BMI have a high body fat percentage; whereas 30.34% obese individuals have a normal body fat percentage, and 10.94% obese individuals have a low body fat percentage.

DISCUSSION

In all age groups, obesity is more prevalent in women than in men. It may be caused by a few reasons, including socio-cultural and biological factors, phenotype, behavior, metabolic differences, etc. [9, 10]. In women, the prevalence of obesity increases with age, reaching the highest values in the Late Adulthood group, which is consistent with data from other studies [11, 12]. In men, the prevalence of obesity also increases with age, but there is no difference between Middle Age group and the Late Adulthood group. This is consistent with the study, which found that BMI starts to increase at 35–40 years of age in men and at 55–60 years of age in women [13].

This study showed that the prevalence of obesity is higher in individuals with low physical activity; whereas it is lower in individuals whose work is considered intense, which is probably caused by higher physical activity [14, 15]. In the contemporary job market, most professions involve using the computer for work; thus, employees are hypodynamic as they have to spend most of their working hours in a sitting position [14]. In turn, balance between energy consumption and energy requirements is a key condition for maintaining body weight.

Individuals with a university degree are less likely to develop obesity, apparently due to a commitment to a healthy lifestyle, awareness of the adverse effects of low physical activity, poor nutrition, and other factors associated with the development of obesity and other diseases [16, 17]. Some studies show that the incidence of obesity is significantly lower in women with a university degree, which is evidenced by this study; whereas in men, the level of education is often not related to this indicator [18].

The relationship between BMI and most metabolic syndrome indicators is reasonable and evidenced by a population study by Ortega et al. [19]. They found that high BMI has a closer relationship with cardiometabolic risk than other obesity indices. However, there is ingoing debate about the obesity paradox providing that the survival prognosis in cardiovascular diseases is higher in individuals with BMI-defined obesity [20]. Elagizi et al. described the relationship between favorable outcomes in individuals with

Table 1. Prevalence of obesity in the employee population by sex and age

Age groups	Male (*n*=2,409)	Female (*n*=1,313)	Pearson's chi-square test	
			Male	Female
I (early adolescence), *n* = 713	105 (19.02%)	44 (27.33%)	χ^2=39.573; p_{1-2} <0.001	χ^2=6.946; p_{1-2}=0.009
	χ^2=5.204; *p*=0.023			
II (middle age), *n* = 2,483	544 (33.15%)	322 (38.24%)	χ^2=0.393; p_{2-3}=0.531	χ^2=9.044; p_{2-3}=0.003
	χ^2=6.352; *p*=0.012			
Late adolescence, *n* = 526	67 (31.02%)	149 (48.06%)	χ^2=12.856; p_{1-3} <0.001	χ^2=18.838; p_{1-3} <0.001
	χ^2=15.284; *p* <0.001			
Total	716 (29.72%)	515 (39.22%)		
	χ^2=34.659; *p* <0.001			

Note: Note: p_{1-2} is the statistical significance of the indicators between Early Adulthood group and Middle Age group; p_{2-3} is the statistical significance of the indicators between Middle Age group and the Late Adulthood group; p_{1-3} is the statistical significance of the indicators between Early Adulthood group and the Late Adulthood group.

Table 2. Analysis of the relationship between obesity and medical and social factors

Factors	Obesity incidence, %		χ^2; *p*
	No	Yes	
Metabolic syndrome factors			
Above-normal waist circumference	0.05	0.69	786.44; <0.001
Hyperglycemia	0.29	0.49	66.68; <0.001
Hypertriglyceridemia	0.29	0.54	83.54; <0.001
Low HDL	0.28	0.49	67.96; <0.001
Arterial hypertension	0.22	0.43	101.81; <0.001
Social and behavioral factors			
University degree	0.34	0.28	10.80; 0.001
Work intensity	0.37	0.27	11.51; 0.001
Work stress	0.34	0.33	0.00; 0.97
Urban resident	0.34	0.32	1.10; 0.29
Hypodynamia	0.31	0.44	5.61; 0.02
Smoking	0.38	0.35	3.05; 0.08
Marital status	0.325	0.329	0.03; 0.8

Table 3. Analysis of the relationship between obesity and some clinical indicators in the employed population (probit regression)

Factors (ratio)	All participants (*n*=730)		Male (*n*=526)		Female (*n*=204)	
	Value	*p*	Value	*p*	Value	*p*
Intercept (β_0)	–3.64	<0.001	–3.58	<0.001	–3.84	<0.001
Above-normal waist circumference (β_1)	3.71	<0.001	3.66	<0.001	3.96	<0.001
Hyperglycemia (β_2)	0.56	0.009	0.58	0.03	0.46	0.20
Hypertriglyceridemia (β_3)	–0.27	0.27	–0.24	0.45	–0.33	0.36
Low HDL (β_4)	0.73	0.001	0.87	0.006	0.61	0.06
Arterial hypertension (β_5)	1.01	<0.001	0.98	<0.001	0.99	0.001

cardiovascular diseases, excess body weight, and Grade I obesity rather than more severe obesity [21]. Today, opinions on the obesity paradox are controversial. It is possible that this phenomenon may be caused by an obesity assessment error, incorrect study design, etc. In addition, the mechanisms of the positive effect of obesity on the cardiovascular system have not been described [22]. Thus, a high BMI in a patient is still a reason for including him/her in the cardiometabolic risk group [21].

The study shows that some individuals with a normal BMI have higher body fat percentage. It may be indicative of excess visceral fat, which can increase cardiometabolic risk as visceral adipose tissue acts as an independent endocrine organ and has a pronounced influence on carbohydrate and lipid metabolism, unlike subcutaneous adipose tissue [23]. However, in overweight and obese cases, body fat percentage can be either high or normal; therefore, in clinical practice, the possible metabolically healthy obesity should be considered [24]. In this case, the BMI of athletes can significantly exceed 25 kg/m^2 due to high muscle mass; whereas the proportion of fat tissue is low. Thus, to assess obesity, including cardiometabolic risks, it is advisable to rely on check-ups and assess risks in individuals with normal body weight as well [25].

The observed relationship between obesity and other indicators of metabolic syndrome (abdominal obesity, hyperglycemia, low HDL, arterial hypertension) is an evidence of the synergistic effect in the development of cardiometabolic disorders and obesity-associated diseases (cardiovascular diseases, type 2 diabetes mellitus, etc.) as evidenced by the studies [26–28]. Indeed, this paper does not study all the factors associated with obesity that contribute to its development (nutrition, smoking, alcohol, etc.). It should be considered that numerous factors related to the probability of

Table 4. Analysis of the relationship between obesity and some social factors in the employed population (probit regression)

Factors (ratio)	All participants (n=730)		Male (n=526)		Female (n=204)	
	Value	*p*	Value	*p*	Value	*p*
Intercept (β_0)	–0.49	<0.001	–0.35	0.001	–0.22	0.07
University degree (β_1)	–0.33	0.05	–0.10	0.40	–0.48	0.02
Work intensity (β_2)	–0.38	0.02	–0.24	0.04	–0.10	0.69
Low physical activity (β_3)	0.44	0.04	0.27	0.10	0.39	0.12

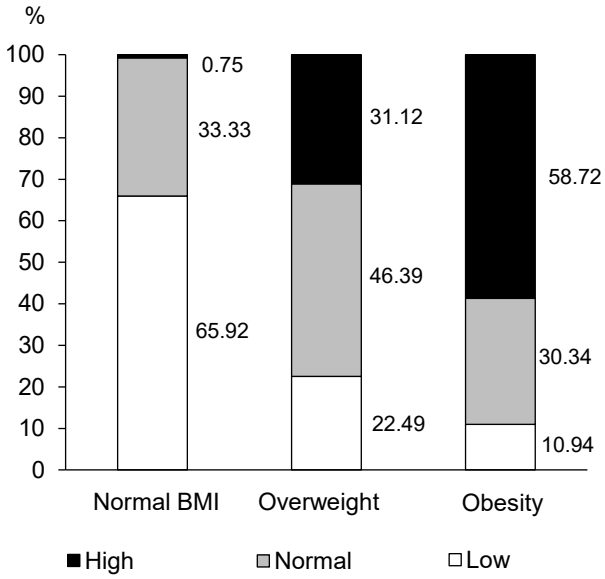

Fig. 1. Body fat in individuals with normal body weight, overweight, and obese individuals.
Note: BMI, body mass index.

obesity have complex interdependencies and a synergistic effect; thus, it is extremely difficult to assess their interaction and study the probability of obesity.

The study may be the basis for software and digital technologies, personalized sensor technologies, and digital strategies for assessing individual and group risks of obesity and associated diseases in the employed population [29, 30]. It is highly relevant for the implementation of the federal project Development of Incentive System to Encourage Healthy Lifestyle, Including Healthy Nutrition and Giving Up Bad Habits as part of the national Demography Project.

CONCLUSION

A representative sample of the employed population in the Saratov Region was used to establish the obesity prevalence patterns in males and females in various age groups. The study identified the major medical and social obesity risk factors (sex, age, education, work intensity, physical activity). It is essential to consider the probability of a high body fat percentage in individuals with normal BMI to prevent and mitigate cardiometabolic risks. The findings of this study are potentially beneficial for the creation of preventative strategies integrated into employee wellness initiatives focused on maintaining the wellbeing, quality of life, and professional longevity of the employed population.

ADDITIONAL INFO

Authors' contribution. V.N. Dolich — the concept and design of the study, writing a text; N.E. Komleva — writing a text, editing; M.V. Pozdnyakov — data collection and processing; S.I. Mazilov — statistical data processing; I.V. Zaikina — writing text; I.N. Lutcevich — writing text. All authors confirm that thei authorship meets the international ICMJE criteria (all authors have made a significant contribution to the development of the concept, research and preparation of the article, read and approved the final version before publication).

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Consent for publication. Written consent was obtained from all the study participants before the study screening in according to the study protocol approved by the local ethic committee.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. В.Н. Долич — концепция и дизайн исследования, написание текста; Н.Е. Комлева — написание текста, редактирование; М.В. Поздняков — сбор и обработка данных; С.И. Мазилов — статистическая обработка данных; И.В. Заикина — написание текста; И.Н. Луцевич — написание текста. Все авторы подтверждают соответствие своего авторства международным критериям ICMJE (все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией).

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Информированное согласие на участие в исследовании. Все участники до включения в исследование добровольно подписали форму информированного согласия, утверждённую в составе протокола исследования этическим комитетом.

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