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Reproductive health of adolescent girls with overweight and obesity living in a large industrial region

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ABSTRACT

AIM: This study aimed to assess the reproductive health of adolescent girls with obesity living in a large industrial territory.

MATERIALS AND METHODS: A one-time study was conducted on 105 teenage girls aged 15–17 years. The main group consisted of 70 girls with overweight and obesity, who were divided into a group with menstrual irregularities (N1=42) and without disorders (N2=28). The control group included 35 girls with normal body weight and no menstrual irregularities. Morbidity was studied. Body mass index (BMI), pituitary (thyroid-stimulating hormone [TSH], follicle-stimulating hormone, and luteinizing hormone) and sex hormones (estradiol, DHEA-SO4, AMH, and testosterone), alanine aminotransferase, aspartate aminotransferase, total cholesterol, and ultrasound data of the thyroid gland and abdominal organs were determined. A quantitative assessment of treatment adherence and lifestyle modification was performed.

RESULTS: The average BMI values in the main and control groups were 31.1 (4.9) and 20.0 (1.9) kg/m^2, respectively (p <0.001). A statistically significant predominance of the incidence of cardiovascular pathologies was found in the main group (χ^2=2.58, p=0.014; OR=5.7; 95% CI, 1.2–26.2), as well as a more frequent occurrence of urinary tract, nervous system, and endocrine diseases. In the main group, echographic signs of liver and pancreatic pathologies were detected in 22 (31.4%) girls and diffuse changes in the thyroid gland in combination with cystic formations or hypoplasia in 31 (44.0%). The number of antral follicles was normal in all patients. A statistically significant difference in TSH (p <0.001), LH (p=0.015), and DHEA-SO4 (p=0.002) was obtained between the main and control groups. Adolescents aged 15 years were more adherent to treatment (χ^2=13.28; p=0.003).

CONCLUSION: Statistically significant differences in clinical and laboratory data and treatment adherence were found in adolescent girls with overweight and obesity living in a large industrial region when compared with healthy girls, which dictates the need to improve and implement personalized medical and psychological programs.

Keywords: obesity; adolescence comorbidity; reproductive health; treatment adherence.

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Оценка репродуктивного здоровья девочек-подростков с избыточной массой тела и ожирением, проживающих в крупном индустриальном регионе

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АННОТАЦИЯ

Цель. Оценить особенности репродуктивного здоровья девочек-подростков с избыточной массой тела и ожирением, проживающих в условиях высокой техногенной нагрузки.

Материалы и методы. Проведено одномоментное исследование 105 девочек-подростков 15–17 лет. Основная группа состояла из 70 девочек с избыточной массой тела и ожирением и была подразделена на 2 подгруппы: с нарушением менструального цикла (N1=42) и без нарушений (N2=28). Контрольная группа включала 35 девочек с нормальной массой тела без нарушений менструального цикла. Изучали заболеваемость, определяли индекс массы тела (ИМТ), уровень гипофизарных (ТТГ, ФСГ, ЛГ) и половых (эстрадиол, ДЭА-SO4, АМГ, тестостерон) гормонов, АЛТ, АСТ, общего холестерина, проводили УЗИ щитовидной железы и органов брюшной полости. Проанализировали количественную оценку приверженности лечению и модификации образа жизни.

Результаты. Средний ИМТ в основной группе составил 31,1 (4,9) кг/м^2, в группе контроля — 20,0 (1,9) кг/м^2 (p <0,001). Обнаружено статистически значимое преобладание частоты сердечно-сосудистой патологии у девочек основной группы (χ^2=2,58, p=0,014; ОШ=5,7; 95% ДИ: 1,2; 26,2), более частая встречаемость заболеваний мочевыводящих путей, нервной системы и эндокринной патологии. Выявлены эхографические признаки патологии печени, поджелудочной железы у 22 (31,4%) девочек основной группы, диффузные изменения щитовидной железы в сочетании с кистозными образованиями или гипоплазией — у 31 (44,0%). Количество антральных фолликулов у всех было нормальным. Получено статистически значимое различие между подростками основной и контрольной групп по ТТГ (p <0,001), ЛГ (p=0,015) и ДЭА-SO4 (p=0,002). Более заметную приверженность лечению проявляли подростки 15 лет (χ^2=13,28; p=0,003).

Заключение. Выявленные отличия клинических, лабораторных данных и приверженности лечению у девочек-подростков с избыточной массой тела и ожирением, проживающих в условиях высокой техногенной нагрузки, диктует необходимость более углубленного изучения вероятных причин заболеваемости, а также усовершенствования оздоровительных программ.

Ключевые слова: ожирение; подростки; коморбидность; репродуктивное здоровье; приверженность лечению.

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评估生活在大型工业化地区的超重和肥胖少女的生殖健康状况

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摘要

目标。评估生活在高技术负荷条件下的超重和肥胖少女生殖健康的特点。

材料与方法。对105名15-17岁的少女进行了一次性调查。主要组由70名超重和肥胖的女孩组成，分为两个亚组：有月经不调（N1=42）和无月经不调（N2=28）。对照组包括35名体重正常且无月经失调的女孩。我们研究了发病率，测定了体重指数（BMI）、垂体激素（TTH、FSH、LH）和性激素（雌二醇、DEA-SO4、AMH、睾酮）水平。此外，还测定了谷丙转氨酶、谷草转氨酶、总胆固醇、甲状腺和腹部超声波。对坚持治疗和改变生活方式的情况进行了定量评估分析。

结果。主要组的平均体重指数为31.1(4.9)千克/平方米，对照组为20.0(1.9)千克/平方米（p<0.001）。据统计，主要组的女孩心血管疾病发病率较高（x^2=2.58，P=0.014；OR=5.7；95% CI：1.2；26.2），泌尿系统疾病、神经系统和内分泌疾病的发病率也较高。主要组中有22名（31.4%）女孩出现了肝脏和胰腺病变的超声征象，31名（44.0%）女孩出现了甲状腺弥漫性变化，并伴有囊肿形成或发育不良。所有青少年的前卵泡数量均正常。主要组和对照组的青少年在促甲状腺激素（p<0.001）、促黄体激素（p=0.015）和硫酸去氢表雄酮（p=0.002）方面的差异具有统计学意义。15岁青少年对治疗的依从性更明显（x^2=13.28；p=0.003）。

结论。生活在高人为负荷下的超重和肥胖少女，在临床、实验室数据和坚持治疗方面存在差异，因此有必要对可能的发病原因进行更深入的研究，并改进健康改善计划。

关键词： 肥胖；青少年；合并症；生殖健康；坚持治疗。

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INTRODUCTION

The primary task of ensuring Russia's national security is to solve the demographic problem. One of the reasons for the current population decline is the unsatisfactory state of women's reproductive health due to deviations in reproductive behavior and somatic health problems [1, 2]. Late (delayed) motherhood, which limits a family's ability to have many children as the most effective factor in population growth, is associated with high gynecological morbidity and comorbidity, predominantly obesity and diabetes mellitus [3, 4].

In the 21st century, obesity has become a global problem, especially in developed countries. According to the World Health Organization, there are now more overweight and obese people than normal weight and underweight people combined [5]. The dietary factor is considered to be the main cause of obesity [6, 7], but emotional eating also plays an important role [8]. At the same time, there is discussion about the early manifestations of metabolic disorders in adolescence, which aggravate during puberty [9, 10]. In addition, the lifestyle of adolescents, which is characterized by high anthropogenic pollution, significantly influence the course of the diseases and the effectiveness of treatment.

Metabolic syndrome, including obesity, is generally considered difficult to treat. Psychological characteristics of the behavior of overweight patients are one of the complicating factors [11–13]. If patients are reluctant and sometimes openly resistant to treatment, why should we fight against obesity? For gynecologists, the answer is obvious because fat metabolism involves female sex hormones, including estrogen, and directly affects reproductive health.

The **study aim** was to evaluate reproductive health characteristics of overweight and obese teenage girls living in a large industrial region.

MATERIALS AND METHODS

In 2022–2023, a cross-sectional study was conducted at the state healthcare institution of the Moscow region "Balashikha Regional Hospital."

Balashikha is part of a large industrial agglomeration with a population of over 600,000 people and a developed industrial infrastructure.

The study included 105 teenage girls aged 15–17 years who were divided into two groups. The main group included 70 overweight and obese girls (ICD-10 code E66: Obesity due to excess calories).

Only subjects who voluntarily signed a consent to participate in the study were included.

Depending on the status of menstrual function, the main group was divided into two subgroups: subgroup 1 for subjects with menstrual disorders (N1=42), subgroup 2 for subjects without menstrual disorders (N2=28). The control group included 35 girls of the same age with normal body weight and no menstrual disorders.

The study protocol was approved by the local ethics committee of the M.F. Vladimirsky Moscow Regional Research and Clinical Institute (Summary of the Minutes of the Meeting No. 12 held on 31 August 2023).

The examination was performed as part of an annual medical examination in a children's clinic in accordance with the standards and rules for pediatric medical examinations [14]. The incidence of the disease in preschool and school-age children was evaluated, and the age of menarche and menstrual characteristics were determined. Grades of obesity were determined by body mass index (BMI) in kg/m^2 with calculation of standard deviations (BMI SDs) [15].

Laboratory tests were limited to those included in the routine examination. Tests included blood chemistry (alanine aminotransferase [ALT], aspartate aminotransferase [AST], total cholesterol), blood concentrations of pituitary hormones (thyroid stimulating hormone [TSH], follicle stimulating hormone [FSH], luteinizing hormone [LH]), and sex hormones (estrogen, progestin, testosterone), luteinizing hormone [LH]) and sex hormones (estradiol, progesterone, dehydroepiandrosterone sulfate [DHEAS], testosterone) by enzyme-linked immunosorbent assay (ELISA). Thyroid and abdominal ultrasound with visualization of internal genitalia were also performed. Ovarian reserve was assessed based on the number of antral follicles in both ovaries and the serum anti-Müllerian hormone (AMH) concentration.

To assess psychological attitudes toward the disease and the potential for therapeutic and health-promoting measures, adherence to treatment and lifestyle modification was quantified using a KOP-25B1 adolescent questionnaire. In the control group, potential adherence to treatment was assessed using a KOP-25B2 questionnaire [16]. Depending on obtained results, high (>75%), moderate (50–75%) and low (<50%) adherence was determined [17]. The survey was conducted after obtaining informed consent from the parents of the girls.

Statistical processing of the material used a Jupyter Notebook environment using the Python programming language, and SciPy, NumPy, Pandas, Penguin libraries were used for statistical analysis and data processing [18]. For quantitative data, a test was performed to determine the normality of the data distribution (using the Kolmogorov–Smirnov test). If the data were normally distributed, the mean (M) and standard deviation (SD) were calculated and the data were expressed as M (SD). If the data were not normally distributed, the median (Me) and the upper and lower quartiles (Q1, Q3) were calculated and the data were expressed as Me [Q1; Q3]. When comparing the parameters for three groups with a normal distribution, an analysis of variance was performed (Welch's ANOVA, the absence of equality of variances was confirmed by the Levene's test), and the Tukey's range test was used for a post hoc analysis. The Student's parametric t-test was used to compare two groups. The Kruskal–Wallis test was used to compare three groups when the data distribution was not normal, and the Dunn post hoc test was used to detect

statistically significant differences. The Pearson correlation coefficient was calculated to assess the relationship between variables. For categorical data analysis, the Pearson's χ^2 test was used to assess differences, and the effect size was estimated using the odds ratio and corresponding 95% confidence interval. Differences were considered statistically significant at a level of p <0.05.

RESULTS

The mean age of subjects was 15.9 (0.84) years in the main group and 15.5 (0.70) years in the control group (p=0.74). The mean BMI was 31.1 (4.9) kg/m^2 in subgroup 1 of the main group, 30.8 (4.5) kg/m^2 in subgroup 2 (p=0.49), and 20.0 (1.9) kg/m^2 in the control group (p <0.001 for comparison of subgroups 1 and 2).

Table 1 presents the distribution of subjects in the main group by BMI and the presence of menstrual cycle disorders.

The distribution by BMI showed a predominance of subjects with grade I obesity in both subgroups.

Obesity as a disease can contribute to comorbidities. This is particularly important for the reproductive potential of future parents. Therefore, addressing this issue is an important part of managing overweight and obese patients. Table 2 presents data on comorbidities in subjects.

Table 2 shows the prevalence of general medical conditions in subjects in the main group, and every fourth girl examined demonstrated a statistically significant difference in cardiovascular disorders, especially congenital ones (ventricular septal defect, ectopia of the chords of the left ventricle, patent foramen ovale, aortic valve disease, mitral valve prolapse). In addition, teenage girls in the main group have a significantly higher incidence of urinary tract diseases (chronic pyelonephritis, chronic cystitis), endocrine disorders (hypothyroidism, autoimmune thyroiditis, hyperprolactinemia), and autonomic nervous system disorders.

Menarche was found to occur at normal age in all subjects. In the control group, the subjects reported no menstrual disorders; the cycle was established immediately and was regular. In subgroup 1, menstrual disorders included oligomenorrhea in 22 of 42 subjects, dysmenorrhea in 17, and abnormal uterine bleeding in 3. It should be noted that most of these subjects noticed the current disorders from menarche.

Abdominal ultrasound in subgroup 1 showed echographic signs of liver disorders, pancreatic disorders, or their combination in 15 (36%) of 42 subjects, with lesions typical of fatty liver disease in 4 subjects. No abnormalities

Table 1. Distribution of girls in the main group depending on body mass index and the presence of NMC

Body mass index		Main group (N = 70)		
		No. of subjects	Subgroup 1 (N = 42)	Subgroup 2 (N = 28)
+1.0 to +2.0 (overweight)		9	4	5
Obesity	+2 to +3 (grade I)	45	28	17
	+3 to +4 (grade II)	14	8	6
	More than +4 (grade III)	2	2	—

Table 2. Nature of comorbidity in adolescent girls

Comorbidity	Main group (N = 70)		Control group (N = 35)	*p*
	Subgroup 1 (N1 = 42)	Subgroup 1 (N1 = 42)		
Cardiovascular disorders	11 (26%)	7 (25,0%)	2 (5,7%)	χ^2=2.58 p=0.014; OR=5.7; 95% CI: 1.2, 26.2
Chronic urinary tract disorders	8 (19,0%)	3 (10,7%)	1 (3,0%)	χ^2=2.64; p=0.10
Autonomic nervous system disorders	9 (21,4%)	6 (21,0%)	3 (8,6%)	χ^2=2.72; p=0.10
Digestive system disorders	6 (14,3%)	6 (21,0%)	2 (5,7%)	χ^2=1.74; p=0.19
Endocrine disorders	3 (7,1%)	2 (7,1%)	1 (4,5%)	χ^2=0.39; p=0.54
Anemia	5 (11,9%)	2 (7,1%)	1 (3,0%)	χ^2=1.22; p=0.27
ENT disorders	3 (7,1%)	1 (3,5%)	—	χ^2=1.1; p=0.30
No disorders detected	18 (42,9%)	10 (35,7%)	24 (68,6%)	χ^2=7.6; p=0.006; OR=3.3; 95% CI: 1.4, 7.7

Significance of differences between the main and control groups.

Table 3. Results of the hormonal studies in the compared groups

Hormonal tests	Main group (N = 70)		Control group (N = 35)	*p*
	Subgroup 1 (N1 = 42)	Subgroup 2 (N2 = 28)		
Thyroid stimulating hormone	2.2 [1.7; 3.2]	2.1 [1.2; 3.1]	1.2 [1.0; 1.5]	< 0.001 (0.01*; < 0.001**)
Follicle-stimulating hormone	4.6 [3.1; 5.5]	4.2 [3.1; 6.01]	5.1 [3.1; 7.5]	0.39
Luteinizing hormone	4.6 [3.3; 6.7]	5.1 [3.3; 6.9]	2.93 [1.9; 3.8]	0.015 (0.02; 0.04)
Estradiol	156.5 [102.5; 436.5]	156.5 [117.0; 481.0]	258.0 [117.5; 387.5]	0.43
DHEAS	6.2 [3.9; 7.6]	6.35 [4.2; 7.5]	4.0 [2.9; 5.7]	0.002 (0.004; 0.01)
Anti-Mullerian hormone	4.2 [3.1; 6.2]	4.8 [3.3; 6.9]	3.8 [3.0; 4.9]	0.18
Free testosterone	0.8 [0.5; 1.1]	1.0 [0.5; 1.2]	0.7 [0.5; 95.0]	0.11

* Differences between subgroup 1 and control group;
** Differences between subgroup 2 and the control group (based on a posteriori tests).
No statistically significant differences were found between subgroups 1 and 2.

were found in 27 (64%) subjects. In subgroup 2, 7 (25%) of 28 subjects also had diffuse lesions in the liver or pancreas, and one girl had gallstone disease; 21 (75%) subjects had no abnormalities.

Thyroid ultrasound showed more frequent and significant findings; 31 (44%) of 70 subjects in the main group were found to have abnormalities. In subgroup 1, 18 (43%) of 42 subjects showed ultrasound evidence of thyroid morphologic changes, including 14 with diffuse lesions (5 cases of significant lesions, 5 cases of combination of multiple and single cystic lesions, 1 case of combination with hypoplasia, 2 cases of cysts up to 5 mm in diameter). In subgroup 2, 13 (46%) of 28 subjects had diffuse thyroid lesions, and only one case was combined with a 3 mm cystic lesion. In the control group, diffuse thyroid lesions were found in 8 (23%) of 35 subjects. The differences were statistically significant (χ^2=4.6; *p*=0.033; odds ratio (OR)=2.7; 95% confidence interval (CI) 1.1, 6.7).

Pelvic ultrasound was performed to assess the ovarian reserve. No subjects were identified with a decreased number of antral follicles. In subgroup 1, however, morphologic changes in gonads were found in 9 (21%) of 42 subjects. These included 2 cases of multifollicular ovaries and 7 cases of cystic lesions not exceeding 45 mm in diameter (functional cysts). In subgroup 2, similar results were obtained; ovarian cysts up to 42 mm in diameter were found in 6 (21.4%) of 28 subjects. In the control group, functional ovarian cysts up to 40 mm in diameter were detected in 2 (5.7%) of 35 subjects. In one case, a bicornuate uterus was suspected. No statistically significant differences were found between the groups for these characteristics (χ^2=3.15; *p*=0.076).

The hormonal profile is one of the most important parameters of adolescent reproductive health (Table 3).

Although all pituitary tropic hormones are within the normal range, their statistically significant difference between obese and healthy adolescents may indicate stressful functioning of the hormonal system.

Adherence to treatment and lifestyle modification were assessed in order to develop personalized treatment plans and health-promoting activities for subjects in the main group. An attempt to compare adherence to treatment and lifestyle modification using BMI did not show any association. However, ranking by age revealed some patterns. The comparison showed a greater predisposition to treatment and lifestyle modification at the age of 15 years than one year older (χ^2=13.28; *p*=0.003).

The comparison of adherence in the main group and potential adherence in the control group suggests that healthy girls are more likely to seek treatment in the case of illness than those who already have symptoms of metabolic disorders. Two components of adherence were assessed in the main group where subjects were scheduled to receive a therapeutic and health promotion intervention. These were adherence to drug therapy and adherence to lifestyle modification (Figure 1).

The density of the distribution of points in the figure shows the correlation between these two components: those who are more committed to drug therapy are also willing to

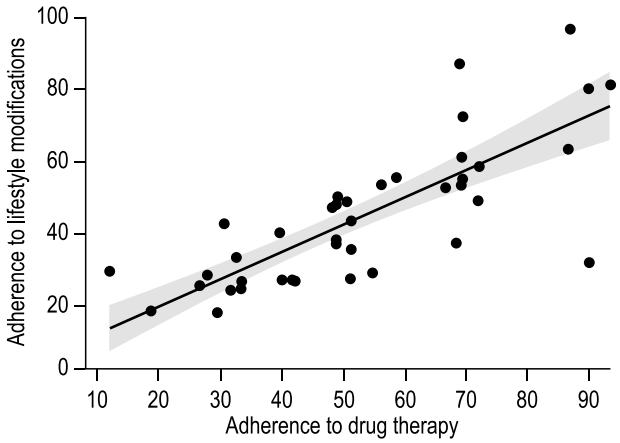

Fig. 1. Correlation between adherence to drug therapy and adherence to lifestyle modifications in the study group.

change their lifestyle (r=0.77; p <0.001). A similar pattern was found for adherence to medical support, indicating willingness to undergo medical and diagnostic procedures (r=0.68; p <0.001).

DISCUSSION

This study of potential to evaluate reproductive health of adolescent girls with obesity, showed an important role in achieving the set goal of both medical history and clinical laboratory data, psychological testing which helps to assess the chances of the effectiveness of planned treatment and preventive measures.

The negative impact of excess body weight on comorbidity is well known [19]. The study found a statistically significant prevalence of some disorders that affect both general health and reproductive health. This was mainly related to heart disease (OR=5.7; 95% CI 1.2, 26.2) and to a lesser extent to the urinary and nervous system disorders (p=0.1). A similar conclusion was reached by Greek colleagues who found atherosclerotic damage to the heart vessels in adolescent girls with polycystic ovary syndrome of different BMI [20].

A study of the hormonal profile of adolescent girls with obesity showed the significant importance of impaired production of tropic hormones, especially TSH. Metwalley et al. [21] found a direct correlation between the decreased ovarian reserve and thyroid dysfunction in adolescents. Ultrasound confirmed the presence of reproductive health risks due to morphological changes in the thyroid gland in almost half (44%) of girls with obesity (OR=2.7; 95% CI 1.1, 6.7). The absence of both ultrasound and AMH-related symptoms of decreased ovarian reserve in all subjects in the main group suggests a later onset of this complication.

Rychkova et al. [9] showed negative behavioral characteristics of overweight adolescents, including aggressive manifestations. In fact, adolescence is characterized by neuropsychiatric deviations that limit the potential for long-term treatment and rehabilitation courses that determine the outcome of the disease and its impact on reproductive health. Therefore, the study used a modern Russian technology for quantitative assessment of adherence to treatment and lifestyle modification adapted to adolescents [16]. Girls with obesity are more likely to have moderate and low adherence to treatment, so we need to consider this aspect and provide additional psychological support, possibly involving not only parents but also clinical psychologists.

Clinical and laboratory tests and adherence data were used to assess the reproductive health characteristics of overweight and obese adolescent girls in order to take timely preventive measures. The most significant predictors that are thought to have a negative impact on future fertility include thyroid dysfunction due to hypothalamic-pituitary disorders, high BMI, and poor adherence to treatment. It should be noted that the later treatment of identified disorders is initiated, the less likely it is to prevent reproductive problems.

CONCLUSION

Statistically significant differences in medical history, clinical and laboratory tests and adherence to treatment were found in a group of overweight and obese adolescent girls living in a large industrial region with high anthropogenic pollution. These findings help identify reproductive health risks and the need to improve and implement personalized medical and psychological programs to prevent these risks.

ADDITIONAL INFO

Authors' contribution. All authors confirm that their authorship meets the international ICMJE criteria (all authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work).

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Consent for publication. The patients signed an informed consent to participate in the study and publish medical data.

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