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INFLUENCE OF OVERWEIGHT AND OBESITY ON REVERSIBILITY OF BRONCHIAL OBSTRUCTION IN CHILDREN WITH BRONCHIAL ASTHMA

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ABSTRACT. ***Introduction.*** Most modern publications report the formation of an obstructive pattern of external respiration in children with a combination of bronchial asthma (BA) and obesity, including due to the formation of dysanapsis in them. However, data on the effect of overweight and obesity on the reversibility of bronchial obstruction in patients with BA and obesity are rare and contradictory. ***The aim of the study*** was to study the effect of overweight and obesity on the reversibility of bronchial obstruction in children and adolescents with asthma. ***Materials and methods.*** A single-center observational cross-sectional pilot study was conducted. 161 patients with asthma aged from 8 to 17 years were examined. Anthropometric and spirometric parameters were measured, z body mass index (BMI), WC (waist circumference)/height, bronchodilation coefficient (BDC) were calculated. The study participants were divided into two groups: group 1 — with normal body weight (BW), group 2 — with overweight, obesity. ***Results.*** BDC was statistically significantly lower in the group with overweight, obesity, amounting to 5.57 [1.07; 9.16]% versus 10.20 [3.67; 17.94]%, p <0.001. BDC was statistically significantly lower in the group with abdominal type of obesity, amounting to 5.83 [1.07; 9.16]% versus 7.67 [3.67; 13.76]%, p=0.034. Negative correlations were found between BDC and z BMI, WC/height, R=−0.29, p=0.0002, R=−0.31, p=0.004, respectively. ***Conclusions.*** In patients with BA and overweight, obesity, the reversibility of bronchial obstruction in tests with bronchodilators is lower than in patients with normal BW. This may reflect the formation of a fixed obstruction component in overweight and obese patients.

KEYWORDS: *bronchial asthma, obesity, overweight, spirometry, children*

ВЛИЯНИЕ ИЗБЫТОЧНОЙ МАССЫ ТЕЛА И ОЖИРЕНИЯ НА ОБРАТИМОСТЬ БРОНХИАЛЬНОЙ ОБСТРУКЦИИ У ДЕТЕЙ С БРОНХИАЛЬНОЙ АСТМОЙ

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РЕЗЮМЕ. ***Введение.*** В большинстве современных публикаций сообщается о формировании обструктивного паттерна внешнего дыхания у детей с сочетанием бронхиальной астмы (БА) и ожирения, в том числе вследствие формирования у них дисанапсиса. Однако данные о влиянии избыточной массы тела, ожирения на обратимость бронхиальной обструкции у пациентов с БА и ожирением единичны и противоречивы. ***Цель исследования*** **—** изучить влияние избыточной массы тела, ожирения на обратимость бронхиальной обструкции у детей и подростков с БА. ***Материалы и методы.*** Было проведено одноцентровое наблюдательное поперечное пилотное исследование. Обследован 161 пациент с БА в возрасте от 8 до 17 лет. Проведено измерение антропометрических и спирометрических показателей, рассчитаны z индекса массы тела (ИМТ), ОЖ (окружность живота)/рост, коэффициент бронходилатации (БДК). Участники исследования разделены на две группы: 1-я группа — с нормальной массой тела (МТ), 2-я группа — с избыточной МТ и ожирением. ***Результаты.*** БДК был статистически значимо ниже в группе с избыточной МТ, ожирением, составив 5,57 [1,07; 9,16]% против 10,20 [3,67; 17,94]%, p <0,001. БДК был статистически значимо ниже в группе с абдоминальным типом ожирения, составив 5,83 [1,07; 9,16]% против 7,67 [3,67; 13,76]%, p=0,034. Выявлены отрицательные корреляционные взаимосвязи между БДК и z ИМТ, ОЖ/рост, R= −0,29, p=0,0002, R= −0,31, p=0,004, соответственно. ***Выводы.*** У пациентов с БА и избыточной МТ, ожирением обратимость бронхиальной обструкции в тестах с бронхолитиками ниже, чем у пациентов с нормальной МТ. Это может отражать формирование фиксированного компонента обструкции у пациентов с избыточной МТ и ожирением.

КЛЮЧЕВЫЕ СЛОВА: *бронхиальная астма, ожирение, избыточная масса тела, спирометрия, дети*

INTRODUCTION

Overweight and obesity contribute to negative modifications in bronchial asthma (BA) and exacerbate its course. BA phenotype in combination with obesity is complex. It is not fully understood in children and adolescents [1–3]. Most modern publications report the formation of obstructive pattern of external respiration in children and adolescents with a combination of BA and obesity, including the formation of dysanapsis [4–9].

At the same time, there are few and contradictory data on reversibility of bronchial obstruction in overweight and obese patients with BA. J.A. Castro-Rodríguez et al. demonstrated that girls who became overweight or obese between the ages of 6 and 11 years were more likely to demonstrate reversibility of bronchial obstruction than girls who were not overweight or obese [10]. At the same time, K.G. Tansitira et al. reported that sensitivity to BD decreased with increasing body mass index (BMI) in obese children [11]. A.E. Dixon et al. performed a research in adults and found no association between obesity and reversibility of airway obstruction [12].

Thus, at present, the influence of obesity on the reversibility of bronchial obstruction in children and adolescents with the phenotype 'BA and obesity' cannot be considered ascertained.

AIM

To study the effect of overweight and obesity on the reversibility of bronchial obstruction in children and adolescents with bronchial asthma.

MATERIALS AND METHODS

Design. A single-center observational cross-sectional research was conducted.

Conditions. The study was conducted in the Children's City Clinical Hospital No. 1 in Nizhny Novgorod, Russia in 2021–2024.

Participants. The study included patients with atopic BA, they were 8 to 17 years old, and received treatment. Atopy-related family history (asthma, allergic rhinitis, conjunctivitis, atopic dermatitis, urticaria) was assessed. Sensitization to major aeroallergens (house dust mite, cat, dog, pollen allergens) was tested by *in vivo* (prick tests) or *in vitro* (with determination of specific IgE) methods [13].

Inclusion criteria for the research were:

1) diagnosis of BA established according to current international consensus documents (GINA, 2016–2024) [1];
2) age of patients between 8 and 17 years.

Non-inclusion criteria were:

1) patients with a BMI greater than +2.5Z;
2) presence of acute infectious diseases and fever;
3) presence of diabetes mellitus, autoimmune disorders, primary immunodeficiencies, oncological diseases, atopic dermatitis, parasitic diseases;
4) severe course of BA [1];
5) systemic use of glucocorticoids;
6) use of non-steroidal anti-inflammatory drugs, angiotensin-converting enzyme inhibitors used for epilepsy.

Ethical review

The study was approved by the Ethical Committee of the Volga Region Research Medical University (protocol No. 8 dated 27.05.2022). All participants and all primary caregivers gave their written informed consent.

Data sources

Anthropometric indices. All patients were assessed for basic anthropometric indices. All measurements were performed without shoes, outer clothing and headwear. Anthropometric parameters (height, body weight and BMI) were estimated using the tables developed by WHO, taking into account sex and age of patients (https://www.who.int/tools/child-growth-standards).

1. BMI calculation:

$$\text{BMI} = \text{body weight (kg)} / \text{height (m)}^2.$$

According to BMI estimation, children were divided into two groups:

- Group 1 — normal body weight (BMI values from −1Z to +1Z);
- Group 2 — overweight and obese (BMI values above +1Z but not more than +2.5Z).

2. Measurement of abdominal circumference (AC) was performed. Measurements were taken at the end

of normal exhalation using a flexible tape, at equidistant circumference between the upper border of the iliac crest and the lower edge of the rib. Abdominal obesity was assumed if the AC exceeded the 90th percentile [14, 15].

3. The ratio of abdominal circumference to height was calculated using the formula:

AC / height = Abdominal circumference / Height.

Spirometry. Spirometry studies were performed with Mastercreen pneumospirometer (Jaeger, Germany). When analyzing spirometry data, the following parameters were evaluated:

- FVC (l) — forced vital capacity of the lungs, reflects the lung volume;
- FEV_1 (l/s) — forced expiratory volume in 1 second;
- FEV_1/FVC — index serving as the main parameter of spirometry for diagnostics of obstructive disorders.

Spirometry data were measured in absolute values and the ratio FEV_1/FVC was calculated.

Bronchodilation coefficient (BDC) was calculated according to the formula [16]:

$$BDC = \frac{\text{Index after bronchodilator, l} - \text{Index before bronchodilator, l}}{\text{Index before bronchodilator, l}} \cdot 100\%.$$

In addition, z FEV_1/FVC was calculated using the Global Lung Function Initiative calculator (http://gli-calculator.ersnet.org/index.html), created with the support of the European Respiratory Society (ERS, https://www.ersnet.org).

Statistical analysis. Statistical analysis was performed using Statgraphics Centurion v.16. Quantitative indicators were evaluated for conformity to normal distribution, for this purpose the Shapiro-Wilk criterion was used (when the number of subjects was less than 50) or the Kolmogorov–Smirnov criterion (when the number of subjects was more than 50), as well as the asymmetry and excess indices. Data are presented as Me [Q1; Q3], where Me — median, [Q1; Q3] — 1st and 3rd quartiles in case distribution differs from a normal distribution. The Mann-Whitney test was used to compare quantitative variables in two independent groups. Differences between two dependent groups were determined using Wilcoxon's W-criterion. Correlation analyses were performed for normally distributed variables using Pearson's correlation coefficient, and for non-normally distributed variables using Spearman's rank correlation coefficient. Categorical data were described with absolute values and percentages. Differences were assessed using Pearson's χ^2 criterion. If the number of expected observations in any of the cells of the four-field table was less than 10, Fisher's exact test was used to assess the significance level of differences. Differences were considered statistically significant at $p < 0.05$.

The study was a pilot trial, so no sample size calculation was performed. Inclusion was restricted to those patients who had no omissions in the examinations performed.

RESULTS

Patients with 'normal body weight' and 'overweight/obesity' were compared by gender and age (Table 1). The parameters z Height, z BMI were statistically significantly higher in patients who were overweight

Table 1. Clinical characteristics of patients

Таблица 1. Клиническая характеристика пациентов

Параметры / Parameters	Все пациенты / All patients (N=161)	Нормальная масса тела / Normal body weight (N=92)	Избыточная масса тела и ожирение / Overweight and obese (N=69)	Значение p / p-value
Возраст, лет / Age, years	11,0 [9,0; 14,0]	10,0 [8,0; 14,0]	12,0 [9,0; 14,0]	0,498
Мальчики, n=66 / Boys, n=66	74,5% (120/161)	77,2% (71/92)	71,0% (49/69)	0,682
z Роста / z Height	0,73 [0,06; 1,60]	0,41 [-0,10; 1,16]	1,20 [0,56; 1,81]	<0,001
z ИМТ / z BMI	0,75 [–0,07; 1,40]	0,15 [–0,39; 0,55]	1,54 [1,23; 2,10]	<0,001

Ending of the Table 1 / Окончание табл. 1

Параметры / Parameters	Все пациенты / All patients (N=161)	Нормальная масса тела / Normal body weight (N=92)	Избыточная масса тела и ожирение / Overweight and obese (N=69)	Значение p / p-value
ОЖ перц / WC perc	78,0 [70,0; 95,0]	72,0 [67,0; 78,0]	85,0 [81,0; 97,0]	<0,001
ОЖ/рост / WC/height	0,48 [0,44; 0,53]	0,44 [0,42; 0,46]	0,53 [0,48; 0,56]	<0,001
z $ОФВ_1$/ФЖЕЛ / z FEV_1/FVC	–1,46 [–2,23; –0,62]	–1,32 [–2,23; –0,43]	–1,64 [–2,19; –0,88]	0,028
БДК, % / BDC, %	7,38 [2,51; 14,40]	10,20 [3,67; 17,94]	5,57 [1,07; 9,16]	<0,001

Note: BDC — bronchodilation coefficient; BMI — body mass index; AG — abdominal circumference; FEV_1 — forced expiratory volume in 1 second; FVC — forced vital capacity.
Примечание: БДК — коэффициент бронходилатации; ИМТ — индекс массы тела; ОЖ — окружность живота; $ОФВ_1$ — объем форсированного выдоха за 1 секунду; ФЖЕЛ — форсированная жизненная емкость легких.

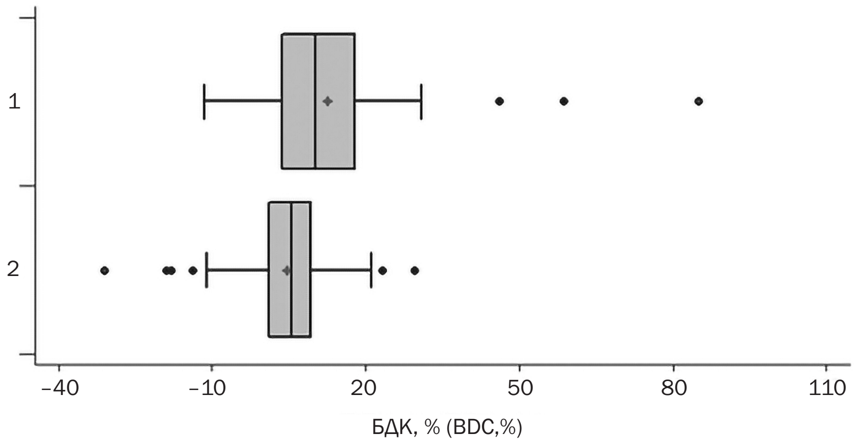


Fig. 1. Bronchodilation coefficient in children with asthma and different BMI (1 — normal body weight, 2 — overweight, obesity)

Рис. 1. Коэффициент бронходилатации у детей с бронхиальной астмой и различным ИМТ (1 — нормальная масса тела, 2 — избыточная масса тела, ожирение)

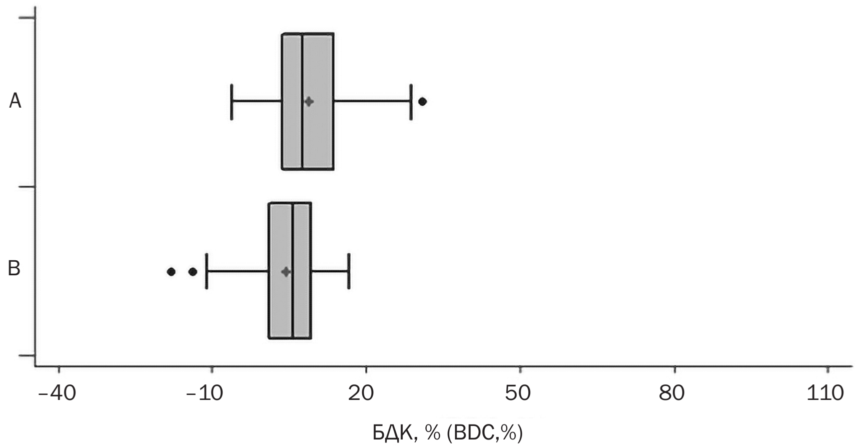
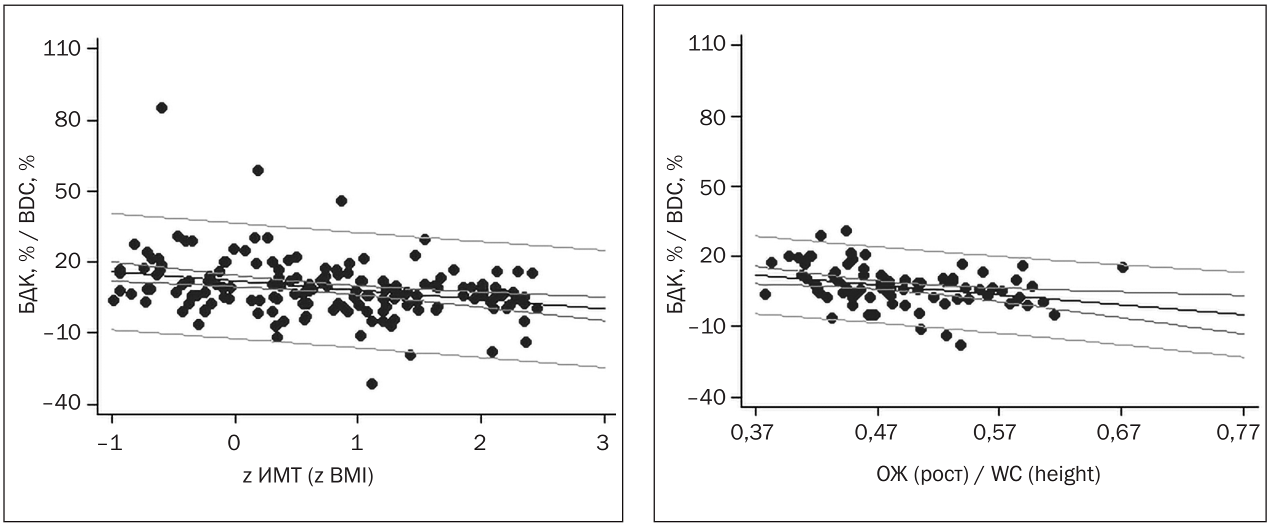


Fig. 2. The coefficient of bronchodilation in the groups: A — with the absence of abdominal type of obesity; B — with the presence of abdominal type of obesity

Рис. 2. Коэффициент бронходилатации в группах: A — с отсутствием абдоминального типа ожирения; B — с наличием абдоминального типа ожирения

z ИМТ z BMI	ОЖ/рост WC/height



−0,29; 0,0002	−0,31; 0,004

Fig. 3. Correlations between bronchodilation coefficient and z BMI, WC/height. The data is presented in the form of R, p, where R — the correlation coefficient, p — the level of statistical significance

Рис. 3. Корреляционные взаимосвязи между коэффициентом бронходилатации и z ИМТ, ОЖ/рост. Данные представлены в виде R, p, где R — коэффициент корреляции, p — уровень статистической значимости

and/or obese (p <0.05). The values of ACpertz, AC/growth were statistically significantly higher, and the parameters z FEV1/FVC were statistically significantly lower in the group of patients with overweight and obesity, all p <0.05. Bronchodilation ratio (BDR) was statistically significantly lower in the overweight and obese groups (p <0.001) (Fig. 1).

The bronchodilation ratio was statistically significantly lower in the group with abdominal type of obesity, being 5.83 [1.07; 9.16]% versus 7.67 [3.67; 13.76]%, p=0.034 (Fig. 2).

Negative correlations were found between bronchodilation ratio and z BMI, AC/height, R= −0.29, p=0.0002, R= −0.31, p=0.004, respectively (Fig. 3).

DISCUSSION

The current research focused on the effect of overweight and obesity, including abdominal obesity, on the reversibility of bronchial obstruction in spirometry tests with bronchodilators in children and adolescents with BA and overweight and obesity. Available researches devoted to abdominal type of obesity affecting the reversibility of obstruction have not been found.

The reversibility of bronchial obstruction in tests with bronchodilators in patients with the combination of BA with overweight and obesity appeared to be lower than in patients with normal body weight, being 5.57 [1.07; 9.16]% and 10.20 [3.67; 17.94]%, respectively, p <0.001. This may reflect the formation of a fixed component of obstruction in overweight and obese patients.

In addition to BMI, measurement of abdominal circumference, which is an anthropometric marker of the abdominal type of obesity, is a valuable anthropometric method for assessing obesity in children and adolescents. The bronchodilation ratio was statistically significantly lower in the group with abdominal type of obesity, being 5.83 [1.07; 9.16]% versus 7.67 [3.67; 13.76]%, p=0.034.

The results obtained correspond to the data of K.G. Tansitira et al. and Gonzalez-Uribe V. et al. [16, 17].

The mechanisms underlying the relationship between BMI and reversibility of bronchial airway obstruction in asthma continue to be investigated and possibly include a combination of factors, namely the effect of low-intensity systemic inflammation on changes in lung mechanics, airway structure, and susceptibility to BA.

The accumulation of adipose tissue in the airway walls of patients with BA and obesity is now considered an important potential mechanism for the changes in external respiration observed in obesity-related BA [18].

CONCLUSION

Therefore, patients with BA and overweight or obesity have a lower reversibility of bronchial obstruction in bronchodilator tests than patients with normal body weight. This may reflect the formation of a fixed component of obstruction in overweight and obese patients.

ADDITIONAL INFORMATION

The author' contribution to the work. Khramova R.N. — conceptualization, investigation, visualization, writing: review and editing.

Competing interests. The authors declare that they have no competing interests

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Informed consent to publication. The author received written consent from the legal representatives of the patients to publish medical data.

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Конфликт интересов. Автор заявляет об отсутствии конфликта интересов.

Источник финансирования. Автор заявляет об отсутствии внешнего финансирования при проведении исследования.

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