UDC 616-056.5
DOI: 10.21668/health.risk/2023.4.07.eng

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Research article

BODY MASS INDEX OF SCHOOLCHILDREN UNDER EXPOSURE TO ENDOGENOUS AND EXOGENOUS RISK FACTORS (ON THE EXAMPLE OF THE REPUBLIC OF BASHKORTOSTAN)

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High prevalence of obesity and overweight among population poses a serious threat for public health.

A survey was accomplished in 13 schools in Bashkortostan to estimate the nutritional status as per body mass index (BMI) of schoolchildren and their parents. Next, we analyzed relationships between participants' nutritional statuses as per BMI and their age, sex, place of residence (urban / rural) and parental nutritional status as per BMI for children.

Among children, 50.0 % had normal body weight, 18.4 % had overweight, 16.9 % had underweight, 8.8 % were emaciated, and 5.9 % were obese. Among parents, these shares equaled 46.4, 33.1, 2.5, 1.3, and 16.7 % respectively. The profound analysis established that boys (as compared with girls) were overweighed and had BMI higher than its healthy range in general (overweight + obesity) statistically significantly more frequently; prevalence of obesity and also BMI higher than its healthy range in general was identified statistically significantly higher among fathers as opposed to mothers. In addition, it turned out that if parents either had BMI higher than its healthy range or were emaciated, their children had similar disorders statistically significantly more frequently. At the same time, if parents had normal body weight, their children were overweighed statistically significantly less frequently. The age of 15–17 years turned out to be associated with declining prevalence of obesity in boys (young males) and declining prevalence of elevated BMI in general in girls (young females). At the same time, a share of people with overweight and elevated BMI in general was statistically significantly higher among mothers older than 37 years. When considering places of residence, we established that both girls and mothers who lived in rural areas had BMI higher than its healthy range statistically significantly more frequently than their urban counterparts.

Keywords: *body mass index, obesity, overweight, schoolchildren, parents, urban areas, rural areas, Bashkortostan.*

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Obesity is among the most serious challenges for global healthcare in the 21st century [1–3]. According to the WHO, in 2016, 39 % of the global adult population had overweight (39 % of males and 40 % of females) and approximately 13 % were obese (11 % of males and 15 % of females) [4]. According to the Federal State Statistic Service of Russia, in 2018, prevalence of obesity in general reached 17.8 % among adult males older than 19 years and 24.5 % among adult females of the same age; prevalence of overweight was 46.9 and 34.7 % respectively[1]. In 2016, global prevalence of overweight was 19 and 18 % respectively among boys and girls aged between 5 and 19 years; obesity, 8 and 6 % [4]. In the Russian Federation in 2018, prevalence of overweight and obesity reached 21.7 and 11.5 % respectively in children aged 7–11 years; 17.4 and 4.3 %, in children aged 12–13 years; 13.0 and 2.6 %, in children aged 14–17 years[1].

Obesity has extremely deleterious effects on adults' and children's health. In particular, it is a definite risk factor able to cause diseases of the cardiovascular, respiratory, musculoskeletal, endocrine, and digestive systems as well as oncological diseases [1, 4, 5]. Child obesity can cause some additional problems including negative psychological and social outcomes [2, 4, 5].

Given all the aforementioned, it seems extremely relevant to perform regular monitoring of obesity and overweight prevalence in the country population, especially children [4, 6]. Body Mass Index (BMI) is one of the most common indicators employed to estimate children's and adults' nutritional status. Body Mass Index (BMI) is a person's weight in kilograms divided by the square of height in meters[2] [4]. The method is easily available and simple and this makes it possible to use it in screening investigations that provide valuable data on basic changes in the structure and prevalence of problems associated with malnutrition in various section of the population[2] [4, 5]. It is necessary to detect basic epidemiological regularities in analyzed deviations for further analysis of what was a likely cause for their occurrence as well as for developing and implementing effective medical and preventive activities [2, 7, 8].

Age, sex and place of residence (urban / rural) seem to be eligible parameters for estimating relationships with nutritional status of schoolchildren and their parents; for children, their parents' nutritional status should be added as well [5, 9–12]. Analyzing BMI across different sex, age, and socioeconomic groups allows tracing the overall dynamics of changes in nutritional status over time as well as estimating influence exerted on the indicator by different factors, both endogenous (physiological ones) and exogenous (environmental ones including those specific for certain stages in the society development) [12–14].

According to D. Bann et al. (2017), prevalence of elevated BMI in young people has been growing on the global scale. This creates elevated risks of adverse health outcomes due to longer time a person lives as overweighed or obese [14]. Research literature contains rather controversial data on differences in frequency of inadequate nutritional status depending on sex or place of residence [10–12, 15–20]. According to averaged data collected in early 2000es (V.A. Peterkova, O.V. Remizov, 2004) the share of obese children equaled 8.5 % among urban residents and 5.5 % among rural ones [18]. T.A. Yuditskaya (2014) reported in her work that prevalence of obesity or overweight equaled 16.2 % among urban preschoolers in the Omsk oblast and 13.0 % among their rural counterparts; the ratio was the opposite among their parents though (39.9 % and 43.1 % accordingly) [19]. At the same time in Udmurtia (M.A. Larionova, T.V. Kovalenko, 2019), obesity was statistically significantly more frequent in chil-

[1] Vyborochnoe nablyudenie ratsiona pitaniya naseleniya 2018. Itogi nablyudeniya [Sampling observation of population diets in 2018. The results]. *The Federal State Statistic Service*. Available at: https://gks.ru/free_doc/new_site/food18/index.html (January 11, 2021) (in Russian).

[2] Body mass index – BMI. *WHO, Regional Office for Europe*. Available at: https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi (January 11, 2021).

dren living in rural areas [12]. The global analysis also indicates that a considerable growth in average BMI value among adults that was observed between 1985 and 2017 is more than 55 % due to a growth in this indicator in rural areas (against the global increase in the share of urban population) [20].

In this study, our aim was to analyze the nutritional status of schoolchildren and their parents in Bashkortostan as per body mass index (BMI) and factors potentially associated with it.

Materials and methods. We accomplished an observational, multi-centered, cross-sectional, sampling, and uncontrolled study. The study protocol was approved at the meeting of the bioethics commission of the Ufa Research Institute of Occupational Health and Human Ecology held on May 07, 2019 (the meeting report No. 2-05).

The inclusion criteria: schoolchildren aged between 7 and 17 years were included; a parent of each child was included as well.

The non-inclusion criteria: a child or a parent refusing from taking part in the study; failure to provide necessary anthropometric data on a participant.

The study was accomplished in thirteen municipal budgetary secondary schools in Bashkortostan (seven were located in the city of Ufa and one in each was located in Zubovo village (Ufimskii district), Baigil'dino village, Krasnaya Gorka village (Nurimanovskii district); Blagoveshchensk town, Bedeeva Polyana village (Blagoveshchenskii district); Kudeevskii village (Iglinskii district). A period during which participants were included into the study was 2 weeks (September 2019).

Parents of participating children were offered to fill in a questionnaire with questions about sex, age, and anthropometric data of parents and their children (only one parent, a father or a mother, participated in the study at his or her own request). The questionnaire was developed for this study by the authors and included questions about a parent's and a child's sex, age, height, and weight. The given answers were then filled in an electronic table and irrelevant or incorrect data were rejected. At the next stage, BMI was calculated and participants were distributed into several groups as per their nutritional status: emaciation, underweight, normal weight (or optimal weight for children), overweight, and obesity. Children were distributed into these groups using BMI centile scales: below -2; between -2 and -1; between -1 and +1; between +1 and +2; above +2 respectively[3]. Parents were distributed into the aforementioned groups according to the following BMI ranges: below 17 kg/m^2; between 17 and 18.5 kg/m^2; between 18.5 and 25 kg/m^2; between 25 and 30 kg/m^2; equal to or above 30 kg/m^2 [21]. Next, the data were statistically analyzed. Several parameters were considered when investigating factors potentially associated with the nutritional status as per BMI including participants' age, sex, place of residence (urban/rural); additionally, parental nutritional status as per BMI was considered for children.

The performed statistical analysis involved the following: 1) correlation analysis (Kendall τ-b test); 2) contingency tables analysis (Fisher's exact two-sided test, odds ratio (*OR*), 95 % confidence interval (95 % *CI*)); 3) CHAID-analysis (decision tree analysis). It was performed in Microsoft Excel 2010 and IBM SPSS Statistics 23. Differences were considered statistically significant in all cases at a $p < 0.05$.

Results and discussion. ***Study objects (participants).*** Initially, we included 337 schoolchildren and 337 parents into the study. After the data were filled in the table and incorrect or irrelevant data were rejected, further analysis was performed using data on 272 children and 317 parents. Sex ratio (male / female) was 53.1 % (N = 144) / 46.9 % (N = 127) among children; 7.8 % (N = 24) / 92.2 % (N = 283) among parents.

Basic study results. At the first stage, correlation analysis was employed to investigate factors potentially associated with the nutri-

[3] BMI-for-age (5–19 years). *WHO*. Available at: https://www.who.int/growthref/who2007_bmi_for_age/en/ (January 11, 2021).

tional status as per BMI of schoolchildren and their parents. A statistically significant weak direct relationship was identified between a child's nutritional status as per BMI and the following parameters:

- male sex (τ-b = 0.160, p = 0.004);
- parental nutritional status as per BMI (τ-b = 0.150, p = 0.005);
- living in a rural area (τ-b = 0.133, p = 0.018).

A statistically significant weak direct relationship was identified between a parent's nutritional status as per BMI and the following parameters:

- age (τ-b = 0.229, p < 0.0001);
- male sex (τ-b = 0.188, p = 0.00047);
- living in a rural area (τ-b = 0.141, p = 0.008).

A detailed analysis of the obtained data established that 50.0 % of children had normal weight, 18.4 % had overweight, 16.9 % had underweight, 8.8 % were emaciated, and 5.9 % were obese (Figure 1). Normal body weight prevailed among parents as well (46.4 %); however, overweight and obesity were statistically significantly more frequent among them than among children (33.1 against 18.4 %, p = 0.000052, and 16.7 against 5.9 %, p = 0.000034, respectively); underweight and emaciation were statistically significantly less frequent (2.5 against 16.9 %, p < 0.00001, and 1.3 against 8.8 %, p = 0.000017, respectively).

Next, a similar analysis was performed considering the respondents' sex. All the aforementioned differences turned out to be statistically significant between both female groups (girls / mothers) (p < 0.001 in all cases); but differences between both male groups were statistically significant only for obesity prevalence (p = 0.00054), while for overweight and underweight only trends similar to previously detected regularities were found (p = 0.079 and p = 0.081) (Figure 2). Nevertheless, after we combined groups with extreme characteristics, we established that deviations associated with BMI higher than its healthy range in general (overweight + obesity) were statistically significantly more frequent among fathers than among boys (79.2 against 31.9 %, p = 0.000019), and deviations associated with BMI lower than its healthy range (underweight or emaciation) were not established at all (0.0 against 21.5 %, p = 0.0085). Normal body weight was statistically significantly less frequent among fathers than among boys (20.8 against 46.5 %, p = 0.025).

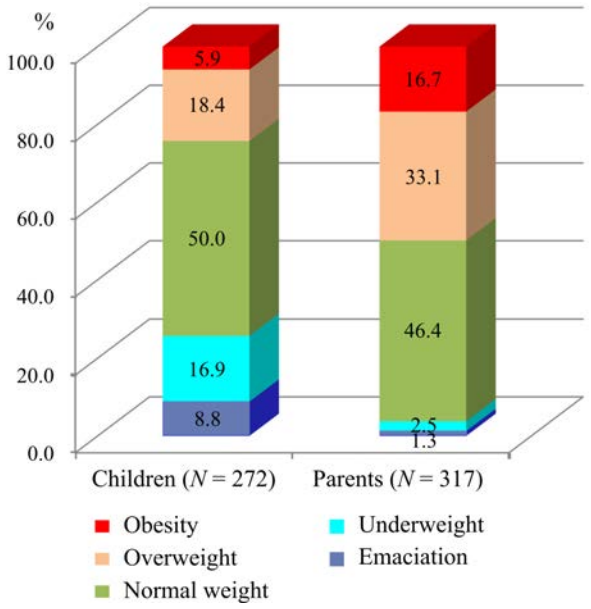

Figure 1. The nutritional status as per BMI of schoolchildren and their parents in Bashkortostan

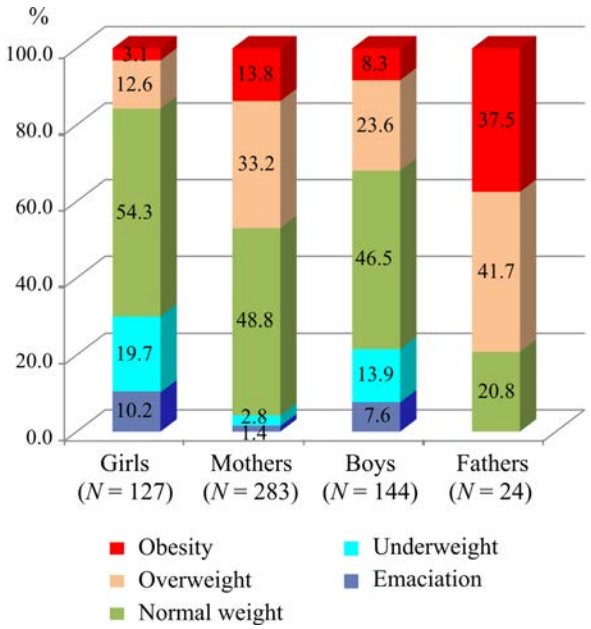

Figure 2. Sex-adjusted nutritional status as per BMI of schoolchildren and their parents in Bashkortostan

Intra-group comparison between the different sexes established that overweight and BMI higher than its healthy range in general

(overweight + obesity) were approximately two times more frequent among boys than among girls (overweight: 23.6 against 12.6 %, $p = 0.027$, $OR = 2.144$, 95 % CI: 1.119–4.108; overweight + obesity: 31.9 against 15.7 %, $p = 0.0027$, $OR = 2.511$, 95 % CI: 1.389–4.540). Moreover, obesity and BMI higher than its healthy range in general turned out to be statistically significantly more frequent among fathers than among mothers while normal body weight was statistically significantly less frequent among them (obesity: 37.5 against 13.8 %, $p = 0.0055$, $OR = 3.754$, 95 % CI: 1.537–9.167; overweight + obesity: 79.2 against 47.0 %, $p = 0.0026$, $OR = 4.286$, 95 % CI: 1.557–11.795; normal body weight: 20.8 against 48.8 %, $p = 0.0098$, $OR = 0.277$, 95 % CI: 0.100–0.761, respectively).

Next, we performed a detailed analysis of a relationship between the nutritional status as per BMI of schoolchildren and their parents. It was established that if parents either had BMI higher than its healthy range or were emaciated, their children had similar disorders statistically significantly more frequently (overweight + obesity: 31.5 against 17.4 %, $p = 0.0095$, $OR = 2.183$, 95 % CI: 1.219–3.908; emaciation: 66.7 against 8.5 %, $p = 0.023$, $OR = 21.545$, 95 % CI: 1.878–247.173). At the same time, if parents had normal body weight, their children had overweight statistically significantly less frequently (12.3 against 23.6 %, $p = 0.024$, $OR = 0.455$, 95 % CI: 0.233–0.885) (Figure 3).

Although the correlation analysis did not find any statistically significant relationship between children's BMI and age, it was established by the contingency tables analysis with identifying the following groups: 7–8 years, 9–11 years, 12–14 years, and 15–17 years. In particular, obesity was not detected in the age group of 15–17 years whereas its frequency reached 8.1 % in the remaining sample ($p = 0.0077$, $OR = 0.00$, 95 % CI not identified). In a sex-adjusted analysis, similar differences were statistically significant only in boys (0.0 against 11.0 %, $p = 0.039$, $OR = 0.00$, 95 % CI not identified). Nevertheless, in girls of this age prevalence of BMI higher than its healthy range in general (overweight + obesity) was also statistically significantly reduced (5.1 against 20.5 %, $p = 0.034$, $OR = 0.210$, 95 % CI: 0.046–0.956).

Parents were distributed as per their age using the CHAID method. As a result, the age of 37 years turned out to be the most eligible for identifying sub-groups with the greatest inter-group differences as per the BMI structure, in particular, as per prevalence of normal body weight or overweight ($p = 0.003$, $\chi^2 = 9.031$, degrees of freedom = 1). After the participating parents were stratified as per sex, this age was identified as an optimal classifier of prevailing normal body weight in mothers ($p = 0.013$, $\chi^2 = 6.116$, degrees of freedom = 1) whereas no similar regularities were found for fathers. The detailed analysis established that normal body weight was statistically significantly less frequent in parents older than

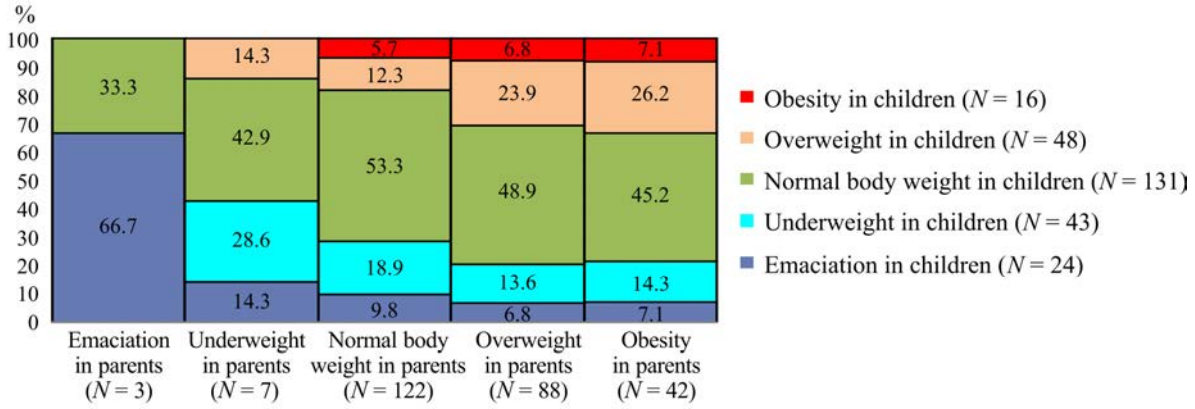

Figure 3. Relationship between the nutritional status as per BMI of schoolchildren and their parents in Bashkortostan

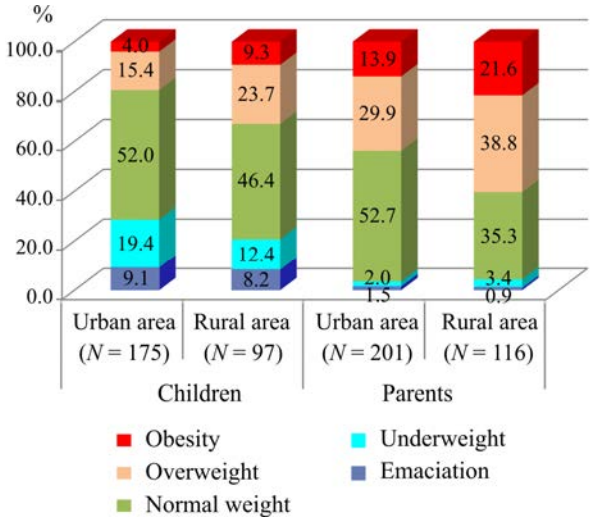

Figure 4. Nutritional status as per BMI of schoolchildren and their parents in Bashkortostan considering their place of residence

37 years than in their younger counterparts (37.7 against 56.6 % respectively, p = 0.0014, *OR* = 0.463, 95 % *CI*: 0.289–0.741), and overweight and BMI higher than its healthy range in general were statistically significantly more frequent (39.6 against 26.5 % respectively, p = 0.025, *OR* = 1.822, 95 % *CI*: 1.106–3.002, and 59.1 against 38.2 % respectively, p = 0.00043, *OR* = 2.333, 95 % *CI*: 1.455–3.741, respectively). Adjusted for sex, these differences were statistically significant only among mothers (normal body weight: p = 0.0066, *OR* = 0.495, 95 % *CI*: 0.303–0.809; overweight: p = 0.019, *OR* = 1.863, 95 % *CI*: 1.106–3.138; BMI higher than its healthy range in general: p = 0.0021, *OR* = 2.174, 95 % *CI*: 1.328–3.559, respectively).

Next, we considered any possible associations between participants' nutritional status as per BMI and their place of residence. As a result, it was shown that BMI higher than its healthy range in general (overweight + obesity) was statistically significantly more frequent in both children and parents from rural areas against urban citizens (children: 33.0 against 19.4 %, p = 0.018, *OR* = 2.042, 95 % *CI*: 1.160–3.593; parents: 60.3 against 43.8 %, p = 0.0052, *OR* = 1.954, 95 % *CI*: 1.228–3.110) (Figure 4). At the same time, only 35.3 % of parents who lived in rural areas had normal body weight whereas this indicator reached 52.7 % in urban areas (p = 0.0034, *OR* = 0.490, 95 % *CI*: 0.306–0.784). Male-female ratio did not differ substantially between urban and rural citizens (among children and parents both) (p > 0.05); nevertheless, a similar sex-adjusted analysis established that the previously detected associations remained only for girls and women (mothers) from rural areas (overweight + obesity: 1) girls: 27.1 against 8.9 %, p = 0.011, *OR* = 3.820, 95 % *CI*: 1.400–10.423, 2) women (mothers): 58.0 against 41.0 %, p = 0.0087, *OR* = 1.989, 95 % *CI*: 1.213–3.260; normal body weight: women (mothers): 37.0 against 55.2 %, p = 0.0042, *OR* = 0.477, 95 % *CI*: 0.289–0.786) (Figure 5). At the same time, when overweight and obesity prevalence were compared separately between rural and urban residents, statistically significant differences were detected only for overweight in girls (22.9 against 6.3 %, p = 0.011, *OR* = 4.400, 95 % *CI*: 1.424–13.599). It is noteworthy that obesity prevalence was even a bit lower among fathers who lived in rural areas than among their urban counterparts (30.0 against 42.9 %, p = 0.679), although the picture was quite the opposite for overweight (50.0 against 35.7 %, p = 0.679).

Discussion. This study established a significant relationship between the nutritional status as per BMI of children and the same indicator of their parents. It was shown that if parents had BMI higher than its healthy range or were emaciated, the risk of similar disorders in their children was increased. At the same time, if parents had normal body weight, their children turned out to have a considerably lower risk of overweight. Male sex was established to be a risk factor for having BMI higher than its healthy range both in children and their parents. The age of 15–17 years was shown to mark declining obesity prevalence in boys (young males) and prevalence of BMI higher than its healthy range in general in girls (young females). At the same time, we detected a statistically significant increase in the number of people with overweight and BMI higher than its healthy range in general among mothers older than 37 years. In addition to that, we established that BMI higher than its healthy range in girls and mothers was associated with living in rural areas.

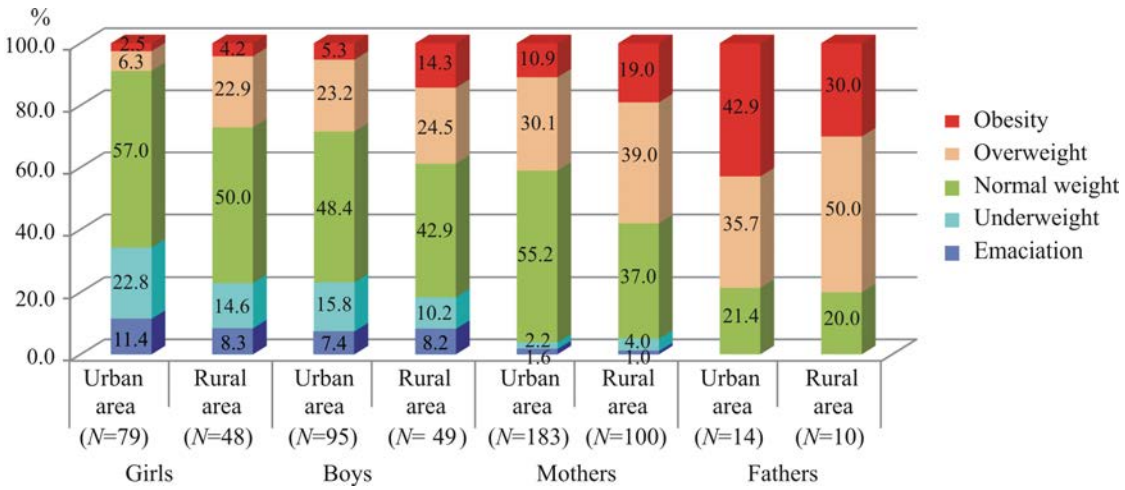

Figure 5. Nutritional status as per BMI of schoolchildren and their parents in Bashkortostan considering their place of residence and sex

On the whole, our study results are consistent with some data previously reported by foreign authors in studies where a direct relationship was identified between overweight or obesity in parents and a risk of overweight or obesity in children [5, 9]. In addition, it was established that men in developed countries had overweight more frequently than women [15–17]. Several studies that were previously performed in some regions in Russia also reported that obesity and overweight prevalence was higher among boys than among girls [10, 11].

Data on lower prevalence of obesity (in boys) and of BMI higher than its healthy range in general (in girls) among adolescents aged 15–17 years are also in line with results reported in previous studies; they indicate that frequency of overweight and obesity is minimal in this age group [10, 12, 22]. According to the WHO data collected over 2002–2014, older adolescents had overweight or obesity less frequently than younger adolescents in most European countries and regions; still, in 2014 some factors related to unhealthy lifestyles (low consumption of vegetables and fruit, high consumption of sugary drinks, and hypodynamia) were much frequently typical for the former age group [23]. This peculiarity is likely associated with constantly growing energy and nutrient expenditure during puberty and this is the most apparent in boys aged 15–18 years [24].

As a whole, regularities established in this study when analyzing place of residence are consistent with known global and regional trends. Thus, according to global data on the adult population, there was a considerable growth in mean BMI in men and women between 1985 and 2017 and BMI in rural population was shown to be growing either just as fast or even faster than BMI in urban population practically in all regions with low and middle incomes; it was persistently higher in rural areas than in urban ones in high-income and industrially developed countries, especially among women [20]. This fact is thought to be associated with so called ‘urbanization of rural life’: manual labor replaced with mechanical one, decreasing volumes of household chores, as well as higher consumption of processed carbohydrates that became more affordable [20, 25–28]. At the regional level, in Udmurtia specifically, obesity prevalence in 2015-2016 was also higher in rural children against their urban counterparts [12]. It is noteworthy that the association between BMI higher than its healthy range and living in a rural area established for females can be also caused by their lower socioeconomic welfare.

Thus, according to a sampling survey that focused on household budgets in the Russian Federation, in 2017 poverty rates in rural areas were 17.5 % higher than in cities and this gap

grew by 8.0 % against 2003[4]. Some foreign studies also reported an inverse relationship between BMI in adults and their socioeconomic status, including that in their childhood; the association was the most apparent for women [13, 14]. Moreover, an inverse relationship was also reported between a risk of overweight and / or obesity in children and their socioeconomic status [23, 29].

Thus, in this study, we analyzed BMI considering sex, age, and place of residence. The results indicate that more effective management of health risks associated with overweight and obesity requires correction of nutritional disorders not only in children but their parents as well, primarily, in males and in mothers older than 37 years. In addition to that, bearing in mind that females living in rural areas turned out to be at risk group, special attention should be paid to increasing nutrition literacy and socioeconomic welfare of this population group.

At the same time, this study did not directly consider influence exerted on BMI by various lifestyle and environmental factors such as physical activity, eating habits, education, socioeconomic status and the like. The issue requires separate profound exploration. Relevant studies are being accomplished at the moment within the Demography National Project[5].

It is also worth noting that BMI as an indicator, despite its simplicity and eligibility for monitoring studies, has some serious drawbacks that are primarily associated with impossibility to directly assess body fat by using it[6] [2]. It is extremely important to consider all risk factors associated with development of serious metabolic and hemodynamic impairments in the body [30, 31]. Special attention should also be paid to assessment of insulin resistance and at present several indexes are being suggested to achieve it: laboratory (they consider levels of insulin, glucose, and lipids, for example, HOMA-IR, TyG, TG/HDL-C and others) and complex ones (they consider lipid profile indicators and anthropometric data, for example, LAP, VAI and others). Laboratory indexes TyG и TG/HDL-C seem the most promising ones for making predictive estimations of cardiometabolic risks. This highlights the importance of including biochemical tests into monitoring programs if we want to achieve more effective management of public health risks [30, 31].

Conclusion. The present study established that the nutritional status as per BMI of schoolchildren and their parents in Bashkortostan had a direct correlation with and also depended on sex, age, and place of residence (urban / rural). The study results indicate it is necessary to provide comprehensive sanitary education for parents with fathers' mandatory participation in it. Special attention should be paid to raising nutritional literacy and socioeconomic wellbeing of rural population.

Funding. The research was not granted any sponsor support.

Competing interests. The authors declare no competing interests.

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Received: 29.08.2023
Approved: 19.10.2023
Accepted for publication: 20.12.2023