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Association between Nutrition, Dyslipidemia and Fasting Blood Sugar among School-aged Children in Krupa na Uni, Bosnia and Herzegovina

Povezanost uhranjenosti, dislipidemije i jutarnje glikemije kod dece školskog uzrasta u Krupi na Uni, Bosna i Hercegovina

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Summary

Introduction. Obesity is a chronic multifactorial disease that has a significant impact on children's health and quality of life.
Objective. The study aimed to determine the incidence of overweight and obesity in primary school-age children in Krupa na Uni, Bosnia and Herzegovina, as well as dyslipidemia and diabetes in obese participants.
Methods. An epidemiological cross-sectional study was performed, including 40 (47.1%) girls and 45 (52.9%) boys. The subjects had a medical history, reviewed medical documentation, and performed a set of laboratory tests that included fasting blood glucose, total cholesterol, and triglycerides.
Results. Normal nutrition was found in 54 (63.5%), malnutrition in 12 (14.1%), overweight in 5 (5.9%), and obesity in 14 (16.5%) school-age children. The age (p=0.477) and gender (p=0.435) did not statistically significantly affect the weight status. A significant number of school-age children had elevated blood glucose values (prediabetes 28.2%, diabetes 2.4%). Most (96.4%) of the participants had normal blood cholesterol levels. Obesity was a significant predictor for elevated blood triglyceride (p=0.002), but not for glucose (p=0.726) and cholesterol values (p=0.749). Overweight and obesity were found in more than a fifth of school-age children. Elevated triglyceride levels were predominantly present in obese school-age children. Obesity did not significantly affect blood glucose and cholesterol values. Diabetes was established in obese children with a positive family history.
Conclusion. Obesity as a risk factor for the onset of chronic non-communicable diseases is unjustifiably neglected in school-aged children.
Keywords: child, obesity, blood glucose, diagnosis, non-communicable diseases

Sadržaj

Uvod. Gojaznost je hronična multifaktorska bolest koja ima značajan uticaj na zdravlje i kvalitet života dece.
Cilj rada. Studija je imala za cilj da utvrdi učestalost prekomerne težine i gojaznosti kod dece školskog uzrasta u Krupi na Uni, Bosna i Hercegovina, kao i prisustvo dislipidemije i dijabetesa kod gojaznih učesnika.
Metod. Urađena je epidemiološka studija preseka, uključujući 40 (47,1%) devojčica i 45 (52,9%) dečaka. Ispitanicima je uzeta anamneza, pregledana je medicinska dokumentacija i sprovedeni su laboratorijski testovi koji su uključivali glikemiju natašte, ukupan holesterol i trigliceride u krvi. **Rezultati**. Normalna uhranjenost utvrđena je kod 54 (63,5%), neuhranjenost kod 12 (14,1%), prekomerna težina kod 5 (5,9%), a gojaznost kod 14 (16,5%) dece školskog uzrasta. Starost (p=0,477) i pol (p=0,435) nisu statistički značajno uticali na telesnu masu. Značajan broj dece školskog uzrasta imao je povišene vrednosti glukoze u krvi (predijabetes 28,2%, dijabetes 2,4%). Većina (96,4%) ispitanika imala je normalan nivo holesterola u krvi. Gojaznost je bila značajan prediktor povišenih vrednosti triglicerida u krvi (p=0,002), a niie uticala na vrednosti glukoze (p=0,726) i holesterola (p=0,749). Prekomerna težina i gojaznost pronađeni su kod više od petine dece školskog uzrasta. Povišene vrednosti triglicerida bili su pretežno prisutni kod gojazne dece školskog uzrasta. Gojaznost nije značajno uticala na vrednosti glukoze i holesterola u krvi. Dijabetes je utvrđen kod gojazne dece sa pozitivnom porodičnom anamnezom.
Zaključak. Gojaznost kao faktor rizika za nastanak hroničnih nezaraznih bolesti je neopravdano zanemarena kod dece školskog uzrasta.
Ključne reči: dete, gojaznost, glukoza u krvi, dijagnoza, hronične nezarazne bolesti

Introduction

According to the International Classification of Diseases, obesity is classified as an endocrine disease, nutrition, and metabolism (ICD-XI; E66) (1). It is a chronic multifactorial disease accompanied by abnormal or excessive accumulation of adipose tissue that poses a health risk (1,2,3,4). The World Health Organization describes the epidemic of childhood obesity as one of the most serious public health challenges of the 21st century (6-11).

According to that, 41 million children under the age of 5 and 340 million children and adolescents aged 5 to 19 are overweight or obese (5). Obesity can have a significant impact on children's health, well-being (social and psychological), and self-esteem (12). It is associated with poor academic performance and a lower quality of life that a child experiences (12).

Obese children often have an abnormal lipid profile with high concentrations of total cholesterol, triglycerides, and low levels of high-density lipoprotein cholesterol (12). Low-density lipoprotein cholesterol levels are usually normal, but qualitative changes can occur (they become smaller, denser, and more atherogenic) (12). In obese children, insulin resistance is common, and in combination with relative insulin deficiency may result in the development of diabetes mellitus (13-15). An obese child requires an individually tailored multidisciplinary approach (1,3).

Diagnosis of obesity requires a thorough clinical examination that identifies the etiology of obesity, comorbidities present, eating habits, physical activity, social, family, and psychological factors that predispose to obesity, readiness, and motivation for treatment (1). The aim of obesity therapy is primarily a permanent change in eating habits and lifestyle (3).

The Aim

This study aimed to examine the frequency of overweight and obesity in children aged from six to fifteen in the observed primary school. The research aimed to examine dyslipidemia, hyperglycemia, or diabetes, and to determine the association between overweight and obesity in school-age children in the observed primary school in Krupa na Uni, Bosnia and Herzegovina.

Material and Methods

An epidemiological cross-sectional study was performed in 30 days, from 15. Jule 2021. to 15. August 2021. The study sample was school-age children of the primary school in Krupa na Uni. In the research methodology, the anamnesis of all examinees was taken, medical documentation was reviewed if they had it, and a physical examination was made for all participants who met the inclusive criteria. All participants underwent a set of laboratory tests that included fasting blood glucose, total cholesterol, and triglycerides.

Stratification of nutritional status was determined from the percentile concerning body mass index, age, and sex. The current body height was expressed in meters (m), and body mass was expressed in kilograms (kg). Children's nutrition was determined based on the Body Mass Index (BMI=kg/m^2). The status of malnutrition below the 5th percentile was marked as malnutrition, from the 5th to the 85th percentile as normal nutrition, from the 85th to the 95th percentile as overnutrition, and above the 95th percentile as obesity.

Measurements of glucose, cholesterol, and triglycerides in the blood were performed on an empty stomach (light dinner, not after 19:00 hours). Blood samples (5 mL) were collected by venipuncture in a vacuum tube with a blood clotting activator (polystyrene resin).

After sampling, centrifugation was performed for 10 minutes at a speed of 3,500 rpm (Nahita 2615 digital centrifuge, Auxilab SL, Spain). Serum analysis was performed with a Refletron Plus apparatus (Roche Diagnostics GmbHm Mannheim, Germany). Blood glucose values from 5.6 mmol/L to 6.9 mmol/L were marked as prediabetes. Blood glucose values >7.0 mmol/L in the fasting sample, in two repeated separate venous blood samples, were marked as diabetes. Cholesterol and triglyceride levels in the blood above the 95th percentile for age were marked as elevated. MS Office Excel 2021 database was used for processing and analysis of collected data.

Statistical analysis of the data was performed with the software package SPSS. The results obtained were described and presented in tables and graphs.

Results

The study included 85 primary school-age children. Among them, 40 (47.1%) were girls, and 45 (52.9%) were boys. The average age of the examined population was 11.7 years (Table 1).

Table 1. Distribution of participants by age and gender
Tabela 1. Distribucija pacijenata po uzrastu i polu

Age / Years	Gender		
	Male	Female	Total
6	1	5	6
7	5	3	8
8	6	3	9
9	10	5	15
10	3	5	8
11	4	3	7
12	3	7	10
13	3	2	5
14	8	4	12
15	2	3	5
Total	45	40	85

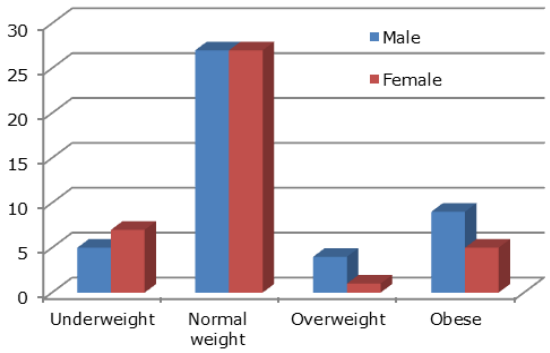
Normal nutrition was found in 54 (63.5%) participants in the study, malnutrition in 12 (14.1%), overweight in 5 (5.9%), and obesity in 14 (16.5%). The age of the school-age children did not have a statistically significant effect on the level of physical nutrition (p=0.477) (Table 2).

Table 2. Distribution of participants by age and weight status
Tabela 2. Distribucija pacijenata po uzrastu i telesnoj težini

Age/ Years	Weight status - category					Chi-Square test	Chi-Square p-value	Fisher Exact test	Fisher Exact test p-value
	<5.00 Underweight	5.00-84.99 Normal weight	85.00-94.99 Over weight	95.00+ Obese	Total				
6	1	3	0	2	6	26.136	0.511	23.356	0.477
7	2	2	2	2	8				
8	1	8	0	0	9				
9	4	7	2	2	15				
10	0	6	0	2	8				
11	1	4	0	2	7				
12	2	6	1	1	10				
13	0	4	0	1	5				
14	0	10	0	2	12				
15	1	4	0	0	5				
Total	12	54	5	14	85				

Normal nutrition was found in 27 (67.5%) girls, malnutrition in 7 (17.5%), overweight in 1 (2.5%), and obesity in 5 (12.5%). In boys, 27 (60%) were normally fed, 5 (11.2%) were malnourished, 4 (8.9%) overweighted and 9 (20.0%) were obese. The sex of the primary school-age children did not have a statistically significant effect on the level of physical nutrition (p=0.435) (Fig 1).

Figure 1. Distribution of participants by gender and weight status
Grafikon 1. Distribucija pacijenata po polu i telesnoj težini



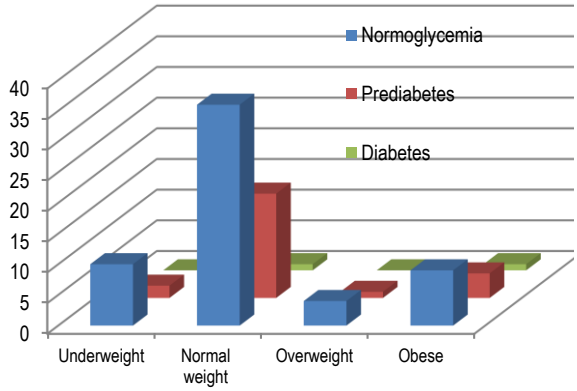
In 59 (69.4%) study participants normal blood glucose values, prediabetes in 24 (28.2%), and diabetes in 2 (2.4%) were found.

Among 24 (28.2%) participants with prediabetes, 17 (70.8%) had normal weight, 2 (8.3%) were underweight, 1 (4.2%) was overweight and 4 (16.7%) were obese.

Among two (2.4%) participants with diabetes in this study, one child was overweight (50.0%) and the other was obese (50.0%).

The level of physical nutrition of the school-age children did not have a statistically significant effect on blood glucose values (p=0.726) (Fig 2).

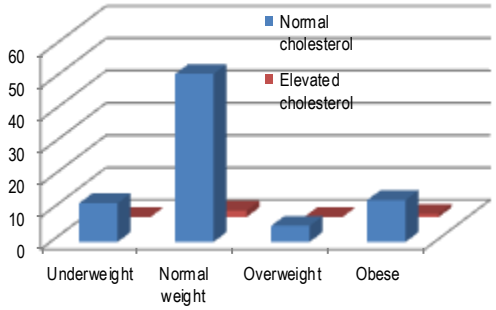
Figure 2. The relationship between the weight status and school-age children's glycemia
Grafikon 2. Povezanost između telesne težine i nivoa glikemije dece školskog uzrasta



Normal blood cholesterol values were found in 82 (96.4%) school-age children and elevated in 3 (3.6%). Among the 3 (3.6%) participants in the study with elevated blood cholesterol values, 2 (66.7%) were normal weight and 1 (33.3%) was obese.

The level of physical nutrition of the school-age children did not have a statistically significant effect on blood cholesterol values (p=0.749) (Fig 3).

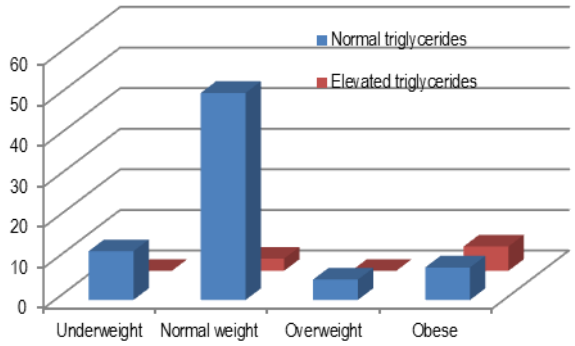
Figure 3. The relationship between the weight and school-age children's cholesterol
Grafikon 3. Poveznaost između telesne težine I nivoa holesterola dece školskog uzrasta



Normal blood triglyceride values were found in 76 (89.4%) school-age children and elevated in 9 (10.6%). Among 9 (10.6%) school-age children with elevated blood triglyceride levels, 3 (33.3%) were normal weight and 6 (66.7%) were obese. There was a statistically significant effect of the level

of physical nutrition of the subjects on the values of triglycerides in the blood (p=0.002) (Fig 4).

Figure 4. The relationship between the weight status and school-age children's triglycerides
Grafikon 4. Povezanost između telesne težine i nivoa triglicerida dece školskog uzrasta



Discussion

Childhood obesity is a global public health problem (11). Worldwide, the number of obese children is growing at an alarming rate (11). Since 1975, the prevalence of obesity has tripled (7). Global body nutrition is growing by 0.32 kg/m^2/10 years in girls, or 0.40 kg/m^2/10 years in boys (16). The children in the highest percentiles of physical nutrition recorded the fastest growth of obesity (5). Extremely high prevalence of overeating and childhood obesity was found in Mexico (64.0% girls and 54.3% boys), slightly lower in the Middle East (Bahrain, 38.5% and Kuwait, 31.8%) and the United States (13.9% children aged 2-5, 18.8% children aged 6-11 and 17, 4% adolescents aged 12-19) (7-11).

The countries of Southeast Asia and the Western Pacific, including India, Malaysia, Vietnam, China, Australia, South Korea, and Japan, have a slightly more modest prevalence (7-11). The lowest prevalence rate was found in African countries (7-11). Our study found the existence of overweight in 5.9% (n=5) of respondents, and obese in 16.5% (n=14). The lower percentage of overweight and obese children is explained by lower socioeconomic status (limited pocket money and reduced purchase of fast food and snacks) and an active lifestyle (walking to school, working on a farm).

Dyslipidemia in obese children occurs as a consequence of elevated concentrations of free fatty acids in the liver, insulin resistance, and proinflammatory condition (17,18). Increased concentration of fatty acids in the liver results in increased synthesis of triglycerides in the liver (17,18). Reduced insulin activity promotes the breakdown of triglycerides and fatty acid synthesis, inhibits the breakdown of apolipoprotein B100, and increases the concentration of low-density lipoprotein cholesterol (17,18). Excessive caloric intake (dietary lipids and carbohydrates) contributes to dyslipidemia (17,18). In obese children, there is an increased concentration of apolipoprotein C-III, increased activity of hepatic lipoprotein lipase, and decreased affinity of apolipoprotein A-I (17,18). Excessive activity of cholesterol ester transport proteins increases triglyceride content (17,18). Fat cells produce adipokines (adiponectin and resistin) and macrophages involved in lipid metabolism (17,18). An increase in triglyceride levels in obese children contributes to decreased adiponectin concentrations, increased resistin concentration, and α-tumor necrosis factor contributes to the increase in triglyceride concentration and interleukin 1 (17,18). Increased concentrations of proinflammatory cytokines reduce the reverse transport of cholesterol by reducing the production of apolipoprotein AI, the concentration of ABCA1 and ABCG1 transporters, lecithin cholesterol esters within high-density lipoproteins, impaired cholesterol transport), cholesterol ester transport protein concentrations, class B protein I protein scavenger receptor concentrations (17,18). Dyslipidemia in obese children predominantly develops around the second year of life and during puberty (19).

Hypertriglyceridemia is more common in younger children, while elevated cholesterol levels are observed in adolescents (19). Our study found a consistent significantly more frequent presence of elevated blood triglyceride levels in obese children (p=0.002).

The National Health and Nutrition Examination Survey in the United States among 9,187 children ages 12 to 19 identified dyslipidemia in 42.9% of obese children (20). A significantly lower percentage, 28.0%, was found among 16,228 children from eight European countries aged 2-9 years (21). A two-year retrospective study of 823 obese children aged 2 to 18 years in Turkey found dyslipidemia in 42.9% of respondents (22). A study among 230 overweight and obese children in Iran identified dyslipidemia in 16.9% and 69.58% of moderately and severely obese respondents (23). Bogalusa heart study in seven cross-sectional studies among 9,167 children aged 5 to 17 found that obese children are 2.4 times more likely to have elevated total cholesterol and 7.1 times more likely to have elevated triglycerides than normal-fed children (24). A study in Iran found that obese children had elevated levels of total cholesterol (14.0% of obese) and elevated triglycerides (23.9% of obese study participants) (25). A five-year study in Denmark among 2,141 children found that obese children had statistically significantly higher values of total cholesterol (except for the youngest girls) and triglycerides compared to children with normal nutrition (26). According to the same, obese children are 6.2 times more likely to develop dyslipidemia (26).

A cross-sectional study in China among 538 children aged 9 to 15 years confirmed a statistically significant effect of diet on triglyceride levels and total cholesterol (27). On the other hand, a case-control study among 282 obese children

aged 6 to 11 in Vietnam identified a statistically significant association between obesity and hypertriglyceridemia (28). Research by authors from Brazil (147 obese school-age children) and Ghana (802 children aged 9 to 15 years) yielded similar results (29, 30). In obese adolescents, endothelial dysfunction is identified with initial changes in the carotid artery and coronary blood vessels (31). Dyslipidemia in childhood (predominantly elevated total cholesterol values) results in early atherosclerosis and calcification (31).

Our study identified one-third of children with hyperglycemia but did not establish the existence of a statistically significant presence of elevated blood glucose values in obese (p=0.726). A prospective cohort study of 35,633 obese children aged 2 to 18 found elevated fasting blood glucose in 5.7% (32). There was a statistically significant association of hyperglycemia with the male gender, older age, and higher body nutrition (32). A prospective cohort study among 1,199 obese children and 86 normally fed aged 2 to 10, found elevated fasting blood glucose in 3.7% Polish and 9.1% Swedish cohort participants (33). A study in Mexico among 165 children aged 5 to 16 identified 17.0% with elevated fasting blood glucose (predominantly older girls) and 4% with elevated glycosylated hemoglobin test (Hemoglobin A1c) (34).

A study of 90 obese children aged 8 to 18 in Brazil identified elevated blood glucose values in 8.4% of moderately obese children and 10.1% of severely obese children (35). On the other hand, a cross-sectional study in Venezuela among 121 obese children (mean age 8.7+/-3.43) did not establish the presence of elevated blood glucose values (36). The United Kingdom study of 103 obese children aged 2 to 18 identified elevated fasting blood glucose in only 0.8% of respondents (37). A study in the United States among 167 obese children aged 4 to 18 years found prediabetes in 4% of respondents (38). A slightly higher prevalence, 7.9%, was identified by a cross-sectional study in Korea (39). In eight years of a prospective cohort study in Germany, Austria, and Switzerland among 109,772 obese respondents aged 2 to 20, prediabetes was present in 11.1%, and diabetes mellitus in 1.4% (40). A study on 520 children in Germany (aged 14.0+/-2.0) identified diabetes mellitus in 1.5% of respondents (41). In our study, two children with diabetes had a positive family history of diabetes (mother, grandmother, and grandfather). A study at 5 specialized centers for obesity and diabetes in Germany identified diabetes mellitus in more severely obese children with positive family history and the presence of metabolic syndrome (41).

A study of 247 obese Latin American children with an average age of 11.1±1.7 years with a positive family history of diabetes mellitus found that maternal, but not paternal, diabetes can have a significant impact on β-cell function, insulin sensitivity, and blood glucose levels, and can be considered a risk factor for the future development of type 2 diabetes in children (42).

Our research was done on a relatively small sample. The research included children from rural areas, who walk to school every day and who have different lifestyles and eating habits compared to children from urban areas. The diagnosis of obesity, which can be detected promptly, predominantly by systematic examinations of primary school students, is an unjustifiably neglected measure of prevention of serious chronic non-communicable diseases, as well as screening methods for many other health and social risks.

Timely change in eating and living habits has been proven to prevent early illness and premature mortality in risk groups. Positive outcomes require a multidisciplinary, balanced approach to the family, all levels of the education and health systems, line ministries, the wider community, the media, and the food and pharmaceutical industries. Children's health is the foundation of the health and stability of both the family and the entire community.

Conclusion

Based on the conducted research, among children of the age of primary school, in the observed primary school in Krupa na Uni, Bosnia and Hercegovina, we conclude that more than a fifth of the sample was overweight and obese. Almost a third of the observed children had hyperglycemia. Prediabetes was present in 24 children, while two children had diabetes. Hyperglycemia was not statistically significantly associated with childhood obesity. Diabetes was predominantly present in obese children with a positive family history (type 2 diabetes mellitus in the first or second generation). Normal blood cholesterol levels were found in most subjects. No statistically significant effect of body nutrition on blood cholesterol levels was observed. Elevated triglyceride values were present in two-thirds of mostly obese children. A statistically significantly more frequent existence of elevated triglyceride values was found in obese study participants.

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