

The dynamics of nutritional status indicators in elementary school children

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Poor nutritional status is a major problem currently faced by children, so the aim of this research was to determine the dynamics of nutritional status indicators in one generation of elementary school children. The study was conducted on a sample of 107 school children observed for four years. Body height, body mass, back skinfold, forearm skinfold and arm circumference were measured. Body mass index and body fat percentage were also measured and the children's nutritional status was determined. Trend analysis of nutritional status indicators was performed by polynomial regression analysis. Study results showed that the participants' nutritional status estimated by body mass index and body fat percentage differed and that there was a significant influence of time on the indicators of nutritional status in both genders. Poor nutritional status was more frequently recorded in boys than in girls, unlike several years ago when girls had poorer nutritional status than boys.

Keywords: morphological characteristics, longitudinal study, elementary school children, trend analysis

INTRODUCTION

Nutritional status of children is one of the indicators of development and future potential of a community (1). Monitoring the nutritional status of children offers a number of benefits, points to consistency of the growth process and development, helps in understanding the current state and in predicting the state of health in adulthood (2). This is why it is important to continuously monitor the nutritional status of children from early age. Anthropometric measurements are particularly important in assessing the nutritional status of children (3) and the most common measurements are body height, body mass, skinfolds and girths (4).

While underdeveloped and developing countries are struggling with malnutrition (5), developed countries are faced with the problem of overweight and obesity. Obesity is one of the most important public health problems faced by children in developed countries (6-8). Because of that, today's children are increasingly suffering from diseases characteristics of adulthood such as type 2 diabetes (9), high cholesterol and high blood pressure (10), problems with bones and joints, apnea and low self-esteem (11).

During the last few decades, the number of obese children has increased (12-14), having imposed an increased need for monitoring body fat during childhood and adolescence

(15). The period of elementary education is critical for the development of overweight and obesity (16). Thus, the aim of this study was to determine the dynamics of nutritional status indicators in one generation of elementary school children.

SUBJECTS AND METHODS

Sample of participants

A convenience sample of one generation of elementary school children was selected. The participants were children attending two elementary schools in the City of Zagreb, who were monitored from the first to fourth grade. Due to dispersal of participants, of the total number of 120 children, complete data on four-year measurements included 107 children of both genders (59 girls and 48 boys).

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Sample of variables

Anthropometric variables used to calculate indicators of nutritional status included body height, body mass, back skinfold and forearm skinfold, and upper arm circumference. Body mass index (BMI) (body mass/body height² (kg/m²) was calculated as the ratio of body mass and square of height (17). With the help of percentile curves, the level of the children's nutritional status was determined (18). Based on skinfold values, the proportion of body fat to total body mass of the children was calculated according to Slaughter *et al.* equation (19). Nutritional status of the participants was determined according to percentile values of the body fat percentage (20).

Measurement protocol

Measurement of specified variables was conducted longitudinally over four years. One generation of school children were followed from first to fourth grade. Morphological characteristics were measured once a year, in February in the morning. The first measurement was conducted in 2012 and the last one in 2015.

During each measurement, body height, body mass and arm circumference were measured once, while the back and arm skinfolds were measured three times and the mean values were calculated. All variables were measured by the same anthropometric instruments in school gyms of the two schools, and the participants were barefoot and lightly dressed.

The measurements were carried out by trained assistants. All anthropometric measurements were performed according to the instructions of the International Biological Program (21). Before starting the research, parents were informed about the research and approval signature of at least one parent was requested for the participation of their child in this study. Survey was carried out in accordance with the Ethics Code for research with children (22). At any time, children could have withdrawn from the research if they wanted to.

Statistical data processing

The Statistica for Windows version 12 software was used on the collected data analysis. Descriptive parameters were calculated for all variables. Trend analysis of the nutritional status indicators was performed by polynomial regression analysis.

RESULTS

The mean values of BMI according to gender and age followed normal nutritional status curve throughout the years

TABLE 1. Descriptive indicators of morphological characteristics of study children from 1st to 4th grade

1 st grade					
	Gender	Mean	Min	Max	SD
Body height	M	128.76	116.00	141.30	5.67
	F	126.67	110.90	137.60	5.41
Body weight	M	27.56	22.10	34.30	3.37
	F	26.66	17.50	36.80	4.08
Body mass index	M	16.59	13.95	20.96	1.47
	F	16.55	13.37	21.71	1.84
Upper arm girth	M	18.99	16.50	23.30	1.52
	F	19.01	15.00	23.00	1.80
Back skinfold	M	5.95	4.00	10.00	1.66
	F	6.67	4.00	12.00	2.18
Forearm skinfold	M	10.00	6.00	16.00	2.68
	F	11.94	6.00	20.00	3.56
Body fat percentage	M	15.44	9.60	24.35	3.69
	F	17.39	9.50	25.13	4.40
2 nd grade					
	Gender	Mean	Min	Max	SD
Body height	M	135.67	123.00	148.30	5.68
	F	133.79	115.50	146.00	5.71
Body weight	M	31.02	17.10	41.20	4.37
	F	30.74	20.90	43.10	5.21
Body mass index	M	16.84	8.33	20.60	1.89
	F	17.10	13.20	22.97	2.20
Upper arm girth	M	20.27	17.10	24.50	1.74
	F	20.32	15.00	24.70	2.04
Back skinfold	M	7.33	4.00	20.00	3.63
	F	8.67	4.00	25.00	4.26
Forearm skinfold	M	11.91	6.00	23.00	4.22
	F	14.01	6.00	23.00	4.50
Body fat percentage	M	18.19	9.60	36.83	6.17
	F	20.26	9.50	34.27	5.99
3 rd grade					
	Gender	Mean	Min	Max	SD
Body height	M	140.51	128.40	154.10	5.70
	F	138.89	120.50	152.50	6.11
Body weight	M	34.97	26.10	48.60	4.73
	F	34.50	23.10	49.40	6.20
Body mass index	M	17.61	15.16	21.37	1.61
	F	17.81	12.92	24.52	2.52
Upper arm girth	M	21.04	17.30	25.60	2.05
	F	21.19	16.30	26.90	2.63
Back skinfold	M	8.85	4.00	25.00	4.87
	F	11.35	4.00	33.00	7.08
Forearm skinfold	M	14.14	5.00	25.00	5.41
	F	17.96	6.00	38.00	7.18
Body fat percentage	M	21.09	8.54	40.75	7.65
	F	24.45	9.50	48.46	8.53
4 th grade					
	Gender	Mean	Min	Max	SD
Body height	M	145.33	130.30	159.00	6.31
	F	144.65	124.70	159.40	6.88
Body weight	M	38.92	27.50	56.20	5.92
	F	38.18	24.50	53.20	7.43
Body mass index	M	18.35	15.09	22.72	1.99
	F	18.17	13.14	27.27	2.80
Upper arm girth	M	22.82	18.00	28.50	2.51
	F	23.01	17.20	28.50	2.73
Back skinfold	M	10.89	4.00	31.00	5.76
	F	12.86	4.00	33.00	7.68
Forearm skinfold	M	18.12	6.00	39.00	7.15
	F	19.40	7.00	33.00	6.74
Body fat percentage	M	25.74	10.64	50.92	9.09
	F	26.49	10.55	45.73	8.66

M = male; F = female; Mean = arithmetic mean; Min = minimum; Max = maximum; SD = standard deviation

TABLE 2. Nutritional status of boys and girls from 1st to 4th grade

Grade			Percentage of underweight	Percentage of normal weight	Percentage of overweight	Percentage of obese
1 st	CDC	M	0%	73%	15%	13%
		F	2%	69%	24%	5%
		M & F	1%	71%	20%	8%
	McCarthy <i>et al.</i>	M	14.58%	72.92%	8.33%	4.17%
		F	35.59%	61.02%	3.39%	0.00%
		M & F	26.17%	66.35%	5.61%	1.87%
2 nd	CDC	M	0%	71%	21%	8%
		F	5%	68%	22%	5%
		M & F	3%	69%	21%	7%
	McCarthy <i>et al.</i>	M	18.75%	58.33%	10.42%	10.42%
		F	23.73%	59.32%	10.17%	6.78%
		M & F	21.49%	58.88%	10.28%	9.35%
3 rd	CDC	M	0%	71%	19%	10%
		F	5%	68%	24%	3%
		M & F	3%	69%	21%	7%
	McCarthy <i>et al.</i>	M	16.67%	41.67%	16.67%	25.00%
		F	16.95%	45.76%	20.34%	16.95%
		M & F	16.82%	43.93%	18.69%	20.56%
4 th	CDC	M	0%	71%	19%	10%
		F	5%	75%	17%	3%
		M & F	3%	73%	18%	7%
	McCarthy <i>et al.</i>	M	8.33%	31.25%	25.00%	35.42%
		F	15.25%	50.85%	13.56%	20.34%
		M & F	12.15%	42.06%	18.69%	27.10%

M = male; F = female, M & F = both genders together; CDC = nutritional status based on BMI; McCarthy *et al.* = nutritional status based on % body fat

of measurements. However, the mean percentage of body fat in boys grew significantly in third and especially fourth grade.

Table 2 shows nutritional status of study participants estimated by BMI (18) and body fat percentage (20). Participants were divided into four groups: underweight, normal weight, overweight and obese. The participants differed according to these two classifications. Throughout the years of measurement, the distribution of nutritional status based on BMI did not change, i.e. there was an equal percentage of underweight, overweight and obese throughout the four grades. However, the distribution of participants according to body fat percentage was quite different. Over years, the high percentage of underweight children decreased, while the percentage of overweight and obese children increased significantly, especially in third and fourth grades.

Results of polynomial regression analysis according to gender are shown in Tables 3-5. The results showed a significant

influence of time on the nutritional status indicators in both genders.

Results showed a significant positive correlation between BMI and time in both genders, however, the correlation was higher in boys ($r=0.37$; $p=0.00$) than in girls ($r=0.24$; $p=0.00$). High positive correlations were observed in the body fat percentage variable in both boys and girls, although with a slightly higher correlation in boys ($r=0.50$; $p=0.00$) than in

TABLE 3. Polynomial regression analysis of body mass index in boys and girls

Regression model significance	M	F-value (1.189) = 30.83782				
	F	F-value (1.233) = 14.50044				
Variables	Standardized beta regression coefficient		t-value		p-level of significance	
	M	F	M	F	M	F
Grade	0.37	0.24	54.96	43.971	0.00*	0.00*

M = male; F = female; *p-values statistically significant at $p \leq 0.05$

TABLE 4. Polynomial regression analysis of body fat percentage in boys and girls

Regression model significance	M		F-value (1.190) = 63.48050			
	F		F-value (1.234) = 63.23265			
Variables	Standardized beta regression coefficient		t-value		p-level of significance	
	M	F	M	F	M	F
Grade	0.50	0.46	4.0434	4.9835	0.00*	0.00*

M = male; F = female; *p-values statistically significant at $p \leq 0.05$

TABLE 5. Polynomial regression analysis of upper arm girth in boys and girls

Regression model significance	M		F-value (1.190) = 90.81777			
	F		F-value (1.234) = 96.13017			
Variables	Standardized Beta regression coefficient		t-value		p-level of significance	
	M	F	M	F	M	F
Grade	0.56	0.53	50.256	3.9520	0.00*	0.00*

M = male; F = female; *p-values statistically significant at $p \leq 0.05$

girls ($r=0.46$; $p=0.00$). Significant equal correlations were recorded for forearm girth in boys ($r=0.56$; $p=0.00$) and girls ($r=0.53$; $p=0.00$). Similar significant correlations were observed for forearm girth in boys ($r=0.56$; $p=0.00$) and girls ($r=0.53$; $p=0.00$).

DISCUSSION

The epidemic of overweight and obesity affects ever more children, not just adults. This is why the aim of this study was to determine the dynamics of nutritional status indicators in one generation of elementary school children. Distribution of participants according to BMI and body fat percentage was very different (Table 2). BMI gives a rough estimate of the nutritional status that is accepted everywhere, while its disadvantages are ignored and it can be said that in the absence of better methods, the benefits of BMI outweigh its drawbacks (23). Assessment of the frequency of certain nutritional status in the surveyed sample of children over four years did not reveal changes. Only the classification of nutritional status according to the percentage of body fat reveals a greater incidence of overweight and obesity in boys as they get older as determined in other studies (24-26).

The results of polynomial regression analysis showed significant growth of the nutritional status indicators (BMI, body fat percentage, upper arm circumference) over four years. Significant positive correlations were observed in all variables in both genders, especially in the variables of body

fat percentage and upper arm circumference, the values of which increased more than expected in both boys and girls during their primary education. Similar results of BMI linear growth as in this study have been reported *Freedman et al.* (27) on a sample of 11,478 children and adolescents (5-17 years). A similar pattern of increasing BMI in children from two to 10 years according to gender has been shown in the research by the Lifestyles Statistical Team from 2014 (28). *Prineas et al.* (29) also found a significant increase of arm circumference in both genders, especially in puberty, while the arm circumference of Indian girls was significantly smaller throughout primary education (14.78-16.95 cm) (30) as compared with girls in this study (19.01-23.01 cm).

The mean BMI values in this study followed the curve of normal growth and development and it is concluded that the majority of boys and girls had a slight BMI over four years. However, more positive correlations in both genders for the body fat percentage variable suggest that this variable is a better indicator of body composition than BMI. *Sardinha et al.* (31) have stated that skinfolds are better nutritional status indicators and that BMI and circumference are the only reasonable alternative. Figures 3 and 4 show a significant linear increase in the mean values of body fat percentage over four years (by more than 25% in fourth grade) in both genders, particularly in boys. According to the classification by *Williams et al.* (32), boys with over 25% of body fat and girls with over 30% of body fat are classified as fat; therefore, it is concluded that the boys in this study belonged to the group of children with excessive body fat percentage. A similar linear increase of body fat percentage over years was found in the study by *Schwandt et al.* (33). On a sample of over 20,000 German children and adolescents aged 3-18 years, their study showed the percentage of body fat in girls to have increased continuously from 3 to 18 years, whereas in boys it grew steeply from 5 to 11 years, followed by slow decline.

Studies have shown that people who were obese in childhood would most likely be obese in adulthood (34-36), thus entailing additional problems and cost to the society. *Valeiro et al.* (37) showed that overweight or obese children aged seven years were prone to maintaining this state until their puberty. On the basis of their study results, *Herman et al.* (38) conclude that the chances of a person to become obese in adulthood are 6.2 times higher in obese children than in those with normal weight.

CONCLUSION

Based on our study results, it is concluded that in both genders there was a significant effect of time on the nutritional status indicators (BMI, body fat percentage and circumfer-

ence). Although it was expected that body fat percentage would significantly grow over time in girls, it appeared that body fat percentage in fourth-grade boys increased significantly as compared to previous years. Concerning body fat percentage, girls on average belonged to the group of normally nourished children, whereas boys on average belonged to the group of overweight children and were at risk of becoming overweight or obese adults. To stop the current trend of nutritional status in the measured sample, preventive measures should be applied as soon as possible.

Early prevention of obesity is a long and arduous but extremely important process, not only for health and social problems such children are exposed to, but also as an effort to reduce the proportion of obese adult population.

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SUKOB INTERESA/CONFLICT OF INTEREST

Autori su popunili the *Unified Competing Interest form* na www.icmje.org/coi_disclosure.pdf (dostupno na zahtjev) obrazac i izjavljuju: nemaju potporu niti jedne organizacije za objavljeni rad; nemaju financijsku potporu niti jedne organizacije koja bi mogla imati interes za objavu ovog rada u posljednje 3 godine; nemaju drugih veza ili aktivnosti koje bi mogle utjecati na objavljeni rad./All authors have completed the *Unified Competing Interest form* at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.

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SAŽETAK

Dinamika pokazatelja stanja uhranjenosti u osnovnoškolaca

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Loše stanje uhranjenosti danas je glavni problem u djece pa je cilj ovog istraživanja bio utvrditi dinamiku pokazatelja stanja uhranjenosti u jednom naraštaju osnovnoškolske djece. Istraživanje je provedeno na uzorku od 107 školske djece promatrane kroz četiri godine. Mjerenja su obuhvatila tjelesnu visinu, tjelesnu masu, kožni nabor leđa, kožni nabor nadlaktice i opseg nadlaktice. Također su mjereni indeks tjelesne mase i postotak tjelesne masti te je određeno stanje uhranjenosti djece. Analiza trenda pokazatelja stanja uhranjenosti provedena je polinomijalnom regresijskom analizom. Rezultati su pokazali razlike u stanju uhranjenosti ispitanika procijenjenom prema indeksu tjelesne mase i postotku tjelesne masti te značajan utjecaj vremena na pokazatelje stanja uhranjenosti u oba spola. Loše stanje uhranjenosti češće je zabilježeno u dječaka nego u djevojčica, za razliku od istraživanja provedenog prije nekoliko godina kad su djevojčice imale lošije stanje uhranjenosti od dječaka.

Ključne riječi: morfološke značajke, longitudinalno istraživanje, osnovnoškolska djeca, analiza trenda