

Trend of Growth and Level of Nutrition in Children from 7 to 14 Years

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ABSTRACT

The research was conducted with the aim of determining the trend of development of morphological characteristics in female and male students aged seven (7) to fourteen (14) years. The sample of examinees was drawn from the population of female and male students from first (1) to eighth (8) grade of elementary schools in Split. In total, 771 female students and 840 male students were measured. Height, weight and upper arm and dorsal skin folds were measured, and used in calculation of fat tissue percentage. The results indicate the increase of body height and mass, what is in concordance with the secular trend. The increased percentage of fat tissue, especially in first four grades of elementary school, is a characteristic of this population, especially boys. The characteristic of this population is obesity, caused by the inadequate nutrition and lack of kinesiological activity. In later age, the trend of height growth and gaining weight continues, but the weight increase occurs due to fat tissue increase, not increase of muscle tissue.

Key words: growth, secular trend, development, fat tissue

Introduction

Anthropometric characteristics describe the body build. Part of anthropological features are defined as characteristics responsible for growth and development dynamics, as well as characteristics of morphological features build, such as the growth of bone length and width, muscle mass and subcutaneous fat tissue. The basic parameters of bodily development are body height and weight, and their structural components: muscle mass and fat tissue. Analysis of these components shows the rate of body stature development. The acquisition of objective knowledge regarding the examinee's state of bodily development, especially contributed by the mutual comparison of certain measured anthropological measures, observation of progress, stagnation, or deterioration of certain anthropological measures (comparison of data of repeated measuring conducted in defined time intervals), offers a possibility of observing the physical development of a child or an adolescent, influence of certain types of bodily exercise on morphological characteristics of individual, or observance of morphological changes that occur by gaining or treating injuries, damages or illnesses of certain body parts.

The index method is often used in reviewing the measured dimensions, body height and mass. This method shows the relations between two anthropometric mea-

asures. The body mass index can be used for the purposes of average population and sedentary individuals (often burdened with excessive body mass) exercise and inclusion into a program of bodily exercise.

Today, the anthropometric measures are used in determining body composition and constitution – somatotype, within the diagnostic procedure.

Through the definition of body composition the ratio of fat and non-fat component in total body mass can be calculated. There are different procedures that use anthropological measures in determining body composition. Today, the Jackson and Pollock method (1985)¹ is most often recommended in diagnostic work, in which measures of three skin folds are used to determine the percentage of body fat.

The morphological habitus is most often determined in the area of sports medicine and kinesiology. The constitution is influenced by endogenous and exogenous factors. Regarding the fact that most school children today spend very little time performing bodily activities, and more and more time in playing computer games, watching the television, eating snacks and fast food, they become more and more obese.

The significant relation between obesity and hours spent in watching television was determined on the sample of American children².

The differences of somatotype regarding the gender are noticed from the earliest age, although they become less visible when children reach school age, but more and more visible during maturation period. The population of women shows greater development of endomorphy and lesser development of mesomorphy, in comparison to men. In the area of ectomorphy the differences are not expressed. The longitudinal studies indicated the variability of somatotype with age, during the period of growth and development. Significant differences during growth are noticed in children's somatotype, especially in larger time intervals (yearly changes in the somatotype components were mostly low due to the «roughness» of measuring scales in the Heath and Carter method)³. From the end of young child age to the end of pre-school age, boys change their somatotype from endomesomorphy to balanced mesomorphy. The maturation brings a more pronounced mesomorph component in boys, resulting in ectomesomorphy, balanced ectomorphy – mesomorphy. Girls of pre-school age show shift from endomesomorphy to central somatypes. Many authors described the relation between constitutional type and time of maturation setting. They noticed that boys of mesomorph and endomesomorph constitution often mature sooner, while boys of ectomorph and mesoectomorph build more often belong to the group of late maturation. Since the girls mature sooner, they show a more expressed endomorph component, what is in concordance with the cognition on the alterations of body constitution in relation to maturation.

Growth, maturation and development are immensely important areas of biological anthropology studies, since the organism of child or adolescent is in the very intensive period of turbulent and important physiological changes in which the body copes with the physical strain different than later in the adult age. Knowledge of the laws of growth and development, as well as the morphological and functional-physiological changes that occur in that life period, is essential for anyone directing a child or an adolescent towards a bodily activity. The growth phenomenon, which strictly speaking means the quantitative changes, is the augmentation of body, conditioned by the augmentation of mass and size, resulting from the augmentation and multiplication of cells and intercellular matter.

Although the genetic factors of growth influence the speed of maturation and the reached level of growth and development, the surrounding conditions are extremely significant, what is confirmed by the fact that the growth of body height and weight in children and adults increases from century to century. Such increase is a consequence of better quality nutrition, better life conditions and successful fighting of many diseases (secular trend). The physical growth of children is measured in a very simple mode, by measuring body height and weight.

In a research conducted in 2012⁴, where growth pace, degree of nutritional status, as well as possible differences of children coming from different demographic areas

(2009)⁵. In Slavonia were researched, the sample of examinees consisted of 801 students (407 male and 394 female students) of 1st to 4th grade of elementary schools in Slavonia. The sample of variables consisted of anthropometric measures of body mass and height, and the body mass index (BMI) was calculated. The lack of significant difference in the observed anthropometric characteristics between the children of urban and rural areas was noticed. The steady body height and mass growth trend was noted in both genders. The BMI values showed a negative trend of growth in both genders, as well as an increase of number of children in the zone of obesity risk, during the first fourth grades. The significant differences were observed only between genders in first and second grades, where the boys were more dominant in body height and mass. The systematic observation of anthropological characteristics should be obligatory during the period of children's growth and development so as to be able to use timely and adequate approach and prevent negative consequences for the health.

Prskalo et al.⁶, using the sample of 199 students (93 male and 106 female students), aged 7 to 9 years, measured 7 morphological variables (body height, body mass, fist, upper arm, abdominal, dorsal and lower leg skin folds) based on which they calculated body mass index and the percentage of subcutaneous fat tissue. Significant differences of the measured morphological characteristics regarding the gender were measured. The significant changes of morphological characteristics regarding the age were determined in girls aged 7 to 9 years. The differences in subcutaneous fat tissue were most strongly expressed in girls aged 9 years.

Pejčić⁷ also conducted a research on the female students of younger school age, from grade 1 to grade 4. The sample of examinees consisted of 655 students (348 boys and 307 girls), while 4 morphological and 6 motor variables were examined (hand tapping, standing long jump, sprint 20 m, pull up endurance, trunk lift and obstacle test backwards). The aim of this research was not only to determine the differences between boys and girls, but also the quality and quantity of the differences, with the aim of applying the results in the process of optimum planning, programming and operationalization of physical education classes. The conclusion of the research was that there were certain differences in the morphological variables: boys had higher body mass and forearm circumference while body height and subcutaneous fat tissue were approximately the same in both genders.

In their longitudinal studies Malina and Bouchard⁸ proved that the differences between boys and girls in most of the measured anthropometric characteristics (body height, body mass, leg length, hips width, shoulders width etc.) were almost insignificant until the age of thirteen and fourteen, when the arrival of puberty causes significant changes.

The research conducted by Schaefer et al.⁹ determined the increased body weight and obesity among healthy children in Germany. The research included 2554 children of both genders, aged 6 to 19. The obesity indicators were the

body mass index and subcutaneous fat tissue measures. The researchers also tried to determine the possible body weight increase during growing up.

The comparison of body mass index results of measured children with the results in other countries showed that German children had worse results than French children and were equal with the children of Sweden and Great Britain, and better than their peers in North America and Italy.

They also concluded that the body mass index, as well as subcutaneous fat tissue, continually grew during growing up period and were higher as the measured children were older.

Freedman et al. (2004)¹⁰ researched the relation between BMI and subcutaneous fat tissue and body height among 1196 children and adolescents, comparing the fat mass index (FMI) and fat-free mass index (FFMI) with body mass index (BMI). The results showed that BMI was a good indicator of subcutaneous fat tissue amount in children and adolescents, so the results of BMI that were higher than 85 percentiles were highly correlated with the FMI results. Unlike these results, the children whose BMI results were higher than 50 percentiles had higher correlation with the FFMI results. The authors concluded that high BMI results indicated the significant presence of subcutaneous fat tissue in children. They also consider that the BMI results enabled a satisfactorily differentiation among children with the decreased amount of subcutaneous fat tissue and lower BMI values.

In the transition countries, the obesity growth trend was also present, and the obesity was present in 60% female and 50% male population. In children, the obesity grew by 50% in the last two decades of the twentieth century. The research showed that the bodily activity decreased by 50% in the adolescent period, and that the girls became significantly more inactive than the boys¹¹.

The negative influence of obesity for the health, that is, the possibility of developing different diseases in the obese individuals was confirmed by numerous scientists^{12–17} dealing precisely with this problem, and it would be unanimously agreed that involvement in any bodily activity was one of possible solution to the obesity problem.

This research was conducted with the aim of determining the trend of morphological development changes in female and male students of elementary schools in Split.

Sample and Methods

Sample of examinees

The sample of examinees was represented by elementary school boys and girls, aged 7 to 14. The measuring was conducted in elementary schools in Split. The total number of 771 female students and 850 male students was measured.

The measuring was conducted in February 2014, according to International Biological Program (IBP). Professors and students of Faculty of Kinesiology in Split par-

ticipated in the measuring procedure. Both school shifts were subjected to measuring, and the measuring procedure lasted for one month.

Sample of variables

Body height

The anthropometer was used in this measuring. The examinee had to stand on a flat surface, with the weight equally divided on both feet. The shoulders were relaxed, and the head set in the Frankfurt horizontal position, meaning that the imagined line connected the lower edge of left orbit and left ear tragus helix in a horizontal position. The anthropometer was set vertically against the examinee's back, touching it at sacrum and interscapular area. The horizontal leg of the anthropometer was lowered to the vertex point, adhering without pressure.

Body mass

Body mass was measured by a decimal scale with a movable weight or a digital scale. Before the beginning of measuring, the scale was set into zero position. The examinee was standing on the scale wearing underwear.

BMI

Body fat percentage. The formula for calculating the percentage of fat tissue: equation of Slauter et al., 1998¹⁸.

Data processing methods

The obtained results were processed using the descriptive statistics, and following characteristics were calculated: arithmetic mean, minimum and maximum result. All the variables had normal distribution. The Statistica 11 software was used in data processing.

Results and Discussion

The results of this research were compared with the results of research conducted by Prebeg et al.¹⁹ on the population of female students. The female students (Table 1) aged up to ten years in this research were shorter than the same population measured in 1997, and the difference was the greatest in seven year old students (6 cm) (Figure 1).

In later years, this difference in body height decreased until years ten (10) and eleven (11), and at the age of twelve (12), girls from this research were two centimeters taller, and this difference persisted until age fourteen (14), when it reached 3 cm (Table 2, Figure 2).

The greatest growth in body height until year fourteen (14) was achieved in the tenth (10) year, and it reached approximately 10 cm. After that, there was a mild decrease at the age of eleven (11) and twelve (12), when the body height growth was 8 or 7 cm per year. Also, the

TABLE 1
HEIGHT (CM) OF FEMALE STUDENTS ACCORDING TO AGE

Girls – height				
Age	N	\bar{X}	Minimum	Maximum
7	43	122.23	110.00	141.00
8	61	130.87	112.00	150.00
9	49	135.96	121.00	152.00
10	52	145.54	125.00	163.00
11	167	153.60	136.50	170.00
12	129	160.32	143.50	178.00
13	117	164.77	145.50	180.50
14	153	168.05	151.00	181.00

N (number of examinees), \bar{X} (arithmetic mean), Minimum (lowest result), Maximum (highest result)

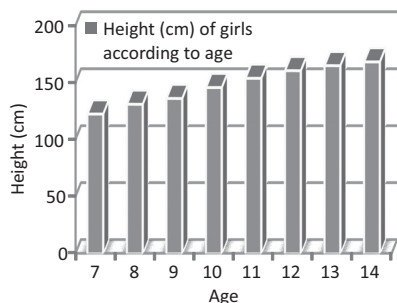


Fig. 1. Graphical display of female students' height according to age.

TABLE 2
YEARLY HEIGHT INCREASE (cm)

Age	Height increase according to age
7–8	8.64
8–9	5.09
9–10	9.58
10–11	8.06
11–12	6.72
12–13	4.45
13–14	3.28

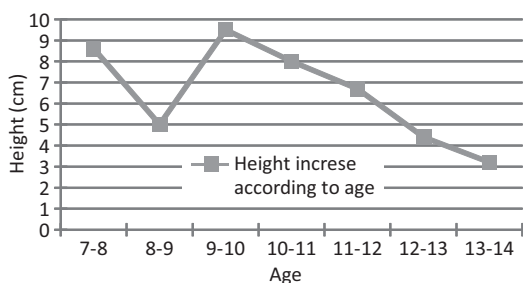


Fig. 2. Graphical display of height increase according to age.

growth was significant between years seven (7) and eight (8), when it reached 8 cm (Table 3, Figure 3).

TABLE 3
WEIGHT OF FEMALE STUDENTS (KG) ACCORDING TO AGE

Girls – weight				
Age	N	\bar{X}	Minimum	Maximum
7	43	27.99	20.80	39.50
8	61	31.62	21.40	47.90
9	49	34.54	24.00	56.70
10	52	39.79	28.00	68.40
11	167	44.66	29.00	69.00
12	129	49.47	35.00	68.00
13	117	55.59	33.00	85.00
14	153	57.91	37.00	87.00

N (number of examinees), \bar{X} (arithmetic mean), Minimum (lowest result), Maximum (highest result)

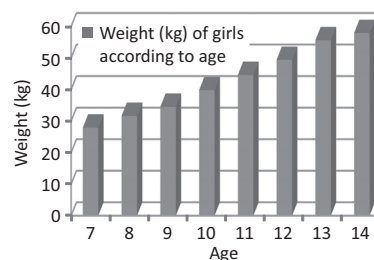


Fig. 3. Graphical display of weight of girls according to age.

By comparing the body weight of our examinees with the results of research by Prebeg²⁰, it is obvious that they significantly differed in every age group. Only in the nine-year-old (9) age group, the girls from this research had lower body weight than those measured in 1997, while in all other age groups the body mass of our examinees was in average 3–4 kilograms higher.

The greatest growth of body weight occurred between age twelve (12) and thirteen (13) (6.12 kg), in parallel with the lowest growth of body height (Table 4). Also, a signifi-

TABLE 4
WEIGHT INCREASE (kg) ACCORDING TO AGE

Age	Weight increase according to age
7–8	3.63
8–9	2.92
9–10	5.25
10–11	4.87
11–12	4.81
12–13	6.12
13–14	2.32

cant growth occurred between age nine (9) and ten (10) (5.25 kg), when the greatest body height growth occurred (9.5 cm). Among the population of girls from the research of Prebeg (2002), the highest growth of body mass occurred in the period from age of ten (10) to eleven (11), but the growth was lower (5 kg) (Figure 4).

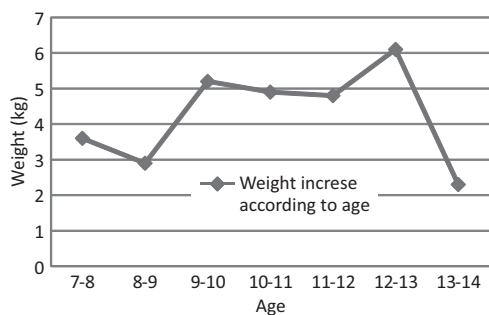


Fig. 4. Graphical display of weight growth according to age.

The accumulation of fat tissue at the abdominal and dorsal area was significant in all age groups. By comparing these results with the ones obtained in 1997 a great difference can be noticed, especially in the abdominal skin fold measure, where the obtained results were twice as high as in our research.

The comparison of previous research conducted during the last decade in the republic of Croatia^{20,21}, indicate that the examinees in this research significantly differed in the body weight measure (Table 5, Figure 5). Starting

TABLE 5
WEIGHT OF MALE STUDENTS (KG) ACCORDING TO AGE

Boys – weight				
Age	N	\bar{X}	Minimum	Maximum
7	36	28.81	19.80	54.90
8	62	33.98	23.20	62.80
9	59	36.83	25.80	57.60
10	44	41.99	28.70	62.00
11	122	44.43	29.00	78.00
12	119	49.10	31.00	78.00
13	112	56.95	38.00	95.00
14	100	64.57	39.50	94.00

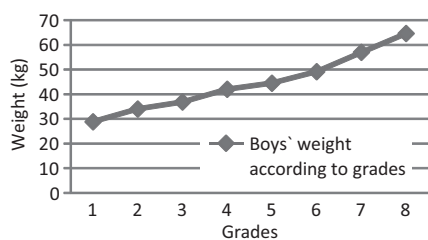


Fig. 5. Graphical display of weight of boys according to grades.

from the age seven (7), the boys in this research were in average 2 kg heavier (seven (7) years), 4 kg (eight (8), nine (9) and twelve (12) years), 6 kg at the age of ten (10), and 7 kg at the age of thirteen (13) and fourteen (14), than the population of boys measured in 1997. Regarding the body height it is interesting to mention that the examinees measured in 1997 were considerably taller than our examinees at the seventh (7) year, while the examinees from this research were taller at the age of twelve (12) and thirteen (13) (Table 6, Figure 6). In the later years there were no greater differences in the body height measures between

TABLE 6
HEIGHT (CM) OF MALE STUDENTS ACCORDING TO AGE

Boys – height				
Age	N	\bar{X}	Minimum	Maximum
7	36	122.00	111.00	140.00
8	62	134.76	120.00	152.00
9	59	136.42	119.00	155.00
10	44	145.11	128.00	161.00
11	122	153.77	135.00	173.00
12	119	158.62	142.00	177.00
13	112	169.00	142.50	195.00
14	100	173.27	151.50	194.00

N (number of examinees), \bar{X} (arithmetic mean), Minimum (lowest result), Maximum (highest result)

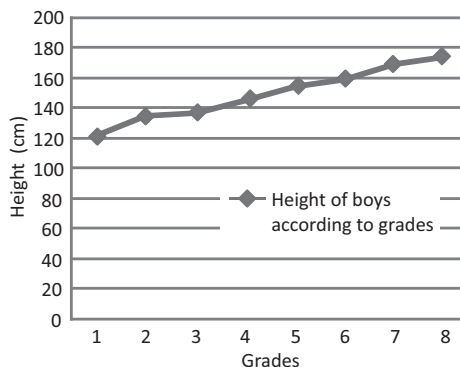


Fig. 6. Graphical display of height growth according to age.

the two populations of students. The lowest growth of body mass occurred between the age of ten (10) and eleven (11), then eight (8) and nine (9), while the highest growth occurred between the age of twelve (12) and thirteen (13), and between age thirteen (13) and fourteen (14) – (7.8 kg) (Table 7, Figure 7).

The maximum growth of mass was late in comparison to maximum body height growth. The year of the highest height growth was between age twelve (12) and thirteen (13), amounting to 10.4 cm (Table 8, Figure 8).

Also, the height growth between the age seven (7) and eight (8) is noticeable (12 cm), as well as between age nine

TABLE 7
WEIGHT INCREASE (KG) ACCORDING TO AGE

Age	Weight increase according to age
7–8	5.17 kg
8–9	2.85 kg
9–10	5.16 kg
10–11	2.44 kg
11–12	4.67 kg
12–13	7.85 kg
13–14	7.62 kg

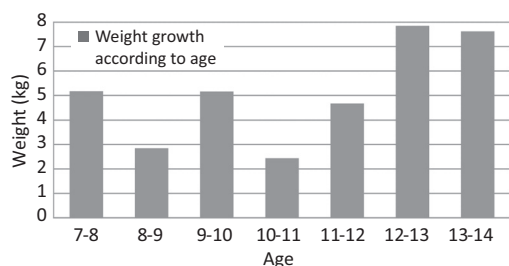


Fig. 7. Graphical display of weight growth according to age.

TABLE 8
YEARLY INCREASE OF HEIGHT (cm)

Years	Height increase according to age
7–8	12.76 cm
8–9	1.66 cm
9–10	8.69 cm
10–11	8.66 cm
11–12	4.85 cm
12–13	10.38 cm
13–14	4.27 cm

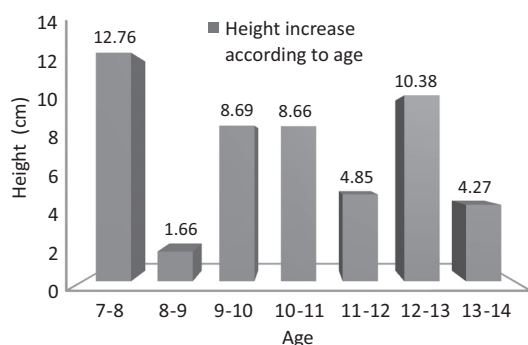


Fig. 8. Graphical display of yearly height increase (cm).

(9) and ten (10) (8.5 cm), when the lowest growth of body weight was noted (2.5 kg). It is interesting to mention, that in the population of boys measured in 1997, the highest growth of body height was noted between age thirteen (13)

and fourteen (14) (8 cm), therefore, one year later than in the population included in this research.

Simultaneously with the increased speed of skeleton growth, the augmentation of muscle mass occurred, with the peak of muscle mass increase coinciding with the peak of growth speed. This phenomenon was not followed by the loss of body fat, since the accumulation of subcutaneous fat tissue was highest in this period [age twelve (12) to thirteen (13)] (Table 9). The examinees measured in 1997 had significantly lower values of subcutaneous fat tissue on the abdominal and dorsal area than the examinees in this research (up to 100% lower at the abdominal region). The order of skeleton growth was regular, and began by leg growth. The highest growth was in the period from age twelve (12) to fourteen (14). The development of skeleton width and depth was mostly expressed in the period from age thirteen (13) to fourteen (14). The shoulder width was the last to indicate the growth acceleration.

TABLE 9
FEMALE STUDENTS GRADES 1–8

Grade	BMI	Percentiles	Fat tissue %	Evaluation regarding BMI
1	18.8	91	21.80	Excessive nutritional status
2	18.4	85	22.50	Excessive nutritional status
3	18.7	80	22.40	Normal nutritive status
4	18.8	75	22.20	Normal
5	18.9	67	21.60	Normal
6	19.3	65	21.70	Normal
7	20.5	65	22.40	Normal
8	19.7	53	22.30	Normal

From the comparison of female and male students' body composition it is obvious that male students had higher amount of fat tissue in the period from first (1) to fourth (4) grade, while female students had higher amount of fat tissue only in first (1) and second (2) grade of elementary school (Table 10)

The trend of obesity increase, not only in adult but in children's age, is worrying. The results of a research conducted at 10 locations in Croatia showed that 10% of children was obese already in pre-school age, and 21% was risking the obesity development. The problem is that obesity is usually not recognized as an illness that causes direct and indirect changes in structure and function of almost all organ systems, but is primarily perceived as an aesthetic flaw. Further on, the possibilities of curing obesity in children's age are very limited. It is important to emphasize that children should not be put »on diets«.

Children should acquire basic healthy nutritive and life habits to grow up with. Seemingly simple procedures such as regular and diverse meals, using the fresh and good

TABLE 10
MALE STUDENTS GRADES 1–8

Grade	BMI	Percentiles	Fat tissue %	Evaluation regarding BMI
1	19.3	94	16.50	Excessive nutritional status
2	18.9	89	18.50	Excessive nutritional status
3	19.8	90	19.27	Excessive nutritional status
4	20.0	87	21.10	Excessive nutritional status
5	18.8	71	18.15	Normal
6	19.5	70	19.17	Normal
7	20.0	67	16.98	Normal
8	21.6	76	17.60	Normal

quality food, healthy cooking, enough water to drink, less than 2 hours of sitting in front of the computer and one hour of physical activity a day, in a long term can prevent obesity and a number of other health problems.

Hypokinesia and unhealthy life habits are relatively easy to prevent, especially in young age. Children should be directed towards involvement in some kinesiological activity and decrease the amount of time spent in front of the computer.

The consequence of hypokinesia is obesity as the next one in the line of disorders that are caused by the insufficient amount of bodily activity. As a consequence of insufficient amount of movement and lack of powerful musculature, greater height and body mass directly influence

bones and joints, what is statistically confirmed by the results of physical examinations in elementary schools, as well as the problems of bad posture and spinal and feet deformities.

The only regular obligatory mode of exercise for school children are physical education classes two or three hours a week (duration 45 min each), what is, according to results of many researches²², not enough for optimum individual development of functional and motor abilities of students. Also, we often find researches that emphasize the problem of decrease in certain abilities.

Conclusions

The research was conducted with the aim of determining the trend of development of morphological characteristics in female and male students aged seven (7) to fourteen (14) years. The sample of examinees was drawn from the population of female and male students from first (1) to eighth (8) grade of elementary schools in Split. In total, 771 female students and 840 male students were measured. Height, weight and upper arm and dorsal skin folds were measured, and used in calculation of fat tissue percentage. The results indicate the increase of body height and mass, what is in concordance with the secular trend. The increased percentage of fat tissue, especially in first four grades of elementary school, is a characteristic of this population, especially boys.

The characteristic of this population is obesity, caused by the inadequate nutrition and lack of kinesiological activity. In later age, the trend of height growth and gaining weight continues, but the weight increase occurs due to fat tissue increase, not increase of muscle tissue.

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TREND RASTA I STUPANJ UHRANJENOSTI KOD DJECE OD 7 DO 14 GODINA

SAŽETAK

Cilj ovog istraživanja bio je utvrditi trend rasta i stupanj uhranjenosti učenika i učenica od 1. do 8. razreda splitskih osnovnih škola. U tu svrhu na uzorku od 771 učenice i 654 učenika izmjerena je visina tijela i masa tijela te se iz mjera kožnih nabora nadlaktice i leđa izračunao postotak masti. Izračunom prirasta tjelesne težine i rasta može se primjetiti da učenici splitskih osnovnih škola prate sekularan trend. Postotak masti ukazuje da sve više djece u nižim razredima ima veću količinu masnog tkiva, dok se u višim razredima taj postotak normalizira. Problem pretilosti i hipokinezije prisutan je i na ovom uzorku ispitanika. Možemo zaključiti da naši ispitanici ne odstupaju od rezultata nekih drugih istraživanja te da je neophodno ukazati na trend povećanja količine masnog tkiva na uštrb mišićne mase, te na sve veću hipokineziju djece u Splitskim osnovnim školama.