

LONGITUDINAL CHANGES OF SELECTED ANTHROPOMETRIC CHARACTERISTICS, MOTOR AND FUNCTIONAL ABILITIES IN DIFFERENT POPULATIONS OF BOYS FROM 11 TO 13 YEARS OF AGE UNDER THE INFLUENCE OF PHYSICAL EXERCISE

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Abstract

The aim of this research was conducted with the aim to examine the influence of body mass on seven measured variables that evaluate the anthropometric characteristics, the motor and functional abilities of boys from 11 to 13 years of age, to determine whether this effect differs in boys who are engaged in team sports played with a ball, martial arts or boys that are not engaged in any sport, and examine the impact of doing sport on the body mass index. The research was conducted on a sample of 147 boys and with a sample of measuring instruments consisted of 10 valid and reliable tests used in elementary and high schools in Croatia. Research used one-sided ANOVA and pairwise t-tests with Bonferroni correction. With Pearson's correlation the correlation of the body mass index with the results of functional abilities was established and the Kolmogorov-Smirnov test determined the normality of samples for residual of dependent parameters, and the Three Way Mixed ANOVA was used. The connection of body weight with six measured variables that define the physical condition of boys is great and extremely negative. A moderate degree of correlation was established (-0.45) between the body mass index (ITM) and the results of functional abilities evaluated by the six-minute run test (F6'), pull up endurance (-0.48), trunk lifts (-0.33) and standing long jump (-0.345). It was found that there is a significant difference in the ITM of non-athletes and boys who were engaged in sports ($p < 0.000000001$), but no significant difference was found between boys engaged in martial arts and boys engaged in team sports played with a ball. The highest values in variables of standing long jump were observed in boys who were engaged in some martial arts, and the lowest values in boys non-athletes ($AS = 164.47$; $SD = 26.38$; $F = 0.871$). Equally, the highest value in the variable pull up endurance had boys engaged in any kind of sport, but the influence of body weight was least evident in boys engaged in martial arts. With non-athletes the influence of body weight is significantly more negative than in boys who were engaged in sport ($AS = 29.84$; $SD = 23.92$; $F = 1.350$). A statistically significant difference in changes in anthropometric characteristics, motor and functional abilities between sports groups has not been established and it can be concluded that doing sport of any kind not only has a positive effect on motor and functional abilities but also mitigates the negative impact of body weight. The obtained results show that the Physical Education classes in elementary school alone cannot guarantee a long-term positive effect on the health and anthropological characteristics of boys.

Key words: boys, non-athletes, martial arts athletes, team's sports athletes, Body Mass Index.

Introduction

According to the World Health Organization (2016): "Physical activity has a positive effect on reducing the risk of developing heart disease, obesity, diabetes, osteoporosis, respiratory disease, etc." One of the problems occurring in physical activity research is the lack of uniform, standardized, accurate and reliable test procedures for measuring physical activity and children's physical condition. Evaluation of physical condition preparation is also hampered by the lack of benchmarks that would be the basis for the analysis of the results obtained, which is an important segment in linking the general health with physical activity, but also in obtaining guidelines for the evaluation and selection of activities that would have the greatest effect on overall health in children and adults. Children with normal body weight have better motor performance than overweight and obese children, and usually schoolboys achieve better results than schoolgirls in coordination, speed of simple movements, explosive and repetitive power,

while schoolgirls are better in flexibility (Prskalo et al., 2015). Within the "Active Brains" project of the University of Granada in Spain in 2017, it was concluded that muscle strength is directly related to the level of stress. Specifically, children with a higher level of strength show a lower level of stress, a higher level of optimism and self-confidence, and a higher general level of mental health (M. Rodrigues - Aylon et al., 2017). "Doing team sports played with a ball in age 11 to 13 positively affects the analysed variables of anthropological status than within non-athletes peers, but not in relation to martial arts athletes" over a two-year period of organized physical activity engagement. Pupils who are non-athletes have the highest values of nutrition status, but lower body mass index values provide better results in functional abilities. The research results show the superiority of subjects who are athletes compared to subjects who are not athletes and are physically active only in the Physical Education

classes in the elementary school. (Benassi et al., 2018). The results of the research of direct and indirect correlation between physical condition, obesity and length of learning with achievement in school children in Japan at the age of 12 to 13 (Ishihara et al., 2018) undoubtedly confirm that the absence of obesity, physical condition and lesser learning time, are winning combination for higher school achievement. Healthy weight status and exercise habits have indirect positive affect at the effectiveness in school.

Methods

A sample of the examinees consisted of 147 boys from Elementary school Poreč in Poreč and Elementary school Joakim Rakovac from St. Lovreč Pazentic. Of the total number of examinees, 60 examinees were trained in team sports played with a ball (football - N=21, handball - N=17, basketball - N=22), 30 participants were engaged in martial arts (karate - N=15, wrestling - N=8, kick-boxing - N=4 and taekwondo - N=3) and 57 subjects were non-athletes, i.e. subjects who did not have additional sport's activity except physical education classes 2 times a week for 45 minutes. Boys' athletes did their extracurricular activities in organized trainings three times a week for at least 60 minutes.

The main goal was to examine the relationship between the body mass and the seven measured variables that evaluate the anthropometric characteristics, the motor and functional abilities of boys aged 11 to 13 years. An additional aim was to determine whether this relationship differs in boys who are engaged in team sports played with ball, martial arts or boys who are not at all involved in sports, and establish a correlation between doing sport and body mass index.

In accordance with the goals, the following hypotheses are set: H1: body mass significantly influences the anthropometric characteristics of the motor and the functional abilities in different populations of boys, H2: influence of body mass on results in variables differs in the population of boys who are engaged in team sports played with a ball, martial arts or are not involved at all sport, H3: doing sport significantly affects the body mass index.

Examinees were measured at 11 years of age in initial measuring and at 13 years of age in final measuring (age \pm 6 months at each measurement) - at the beginning of the fifth and seventh grade of elementary school, in 2013 and in 2015. A battery of 10 valid and reliable tests, that are used in elementary and high schools (Findak, V. et al., 1996), were used and also the ITM centile variable (CDC BMI).

Motor abilities (strength, speed, coordination and flexibility) were measured by reverse training ground (MPN), standing long jump (MSD), pull up

endurance (MIV), trunk lifts (MPT), touch-toe with legs astride (MPR), hand tapping (MTR), 6 minutes run (F6'), and anthropometric characteristics height (ATV), body mass (ATT) and forearm girth (AOP).

From the results of height and body mass, the Quetlet index or body mass index (ITM) was established and used as an indicator of the degree of nutrition, and was calculated like this: body weight (kg) / body height² (m²). The calculated value for each examinee was adjusted in centile (Cole et al., 2000) according to child sex and chronological age, criteria: <5 centile = malnutrition, 5-85 cents = normal body mass, 85-95 cents = overweight, \geq 95 cents = overnourishment (obesity). All the variables are described by basic statistical parameters and test for distribution normality was performed.

To determine the dependence of the body mass index on the sports group of examinees, one-sided ANOVA was performed, followed by a pairwise t-test with Bonferroni correction for multiple testing. Pearson's correlation established the degree of correlation of the body mass index with the results of functional abilities and the Kolmogorov-Smirnov test determined the normality of samples for residual of dependent parameters, after which each was subjected to the Three Way Mixed ANOVA test. All analyses were made in software package R version 3.4.4.

Results and discussion

Table 1 shows basic descriptive parameters of all examinees on initial and final testing. The Kolmogorov-Smirnov test showed distribution normality, which shows that distribution of results does not deviate significantly from normal. From initial to final testing, all examinees achieved higher values in all variables, which was also expected due to their biological age and the stage of physical development and maturing.

Sertić et al. (2010) come to the conclusion that judo in boys aged 10 to 12 causes greater change in anthropological status than engaging in team sports. They undertook research into changes in anthropological status by employing three different kinesiology operators to verify that judo is the sport that causes larger changes in status than doing team sports played with a ball. Similarly like in this research, the examinees were divided into three groups, team sports, judo athletes and non-athletes who did not have any additional sports activity outside of physical education classes.

Similar results as in this research were obtained, giving that the boys who were engaged in judo in relation to the group of team sports played with a ball and the non-athletes during the two-year training had statistically significantly higher results and that difference increased in their favour and dropped between athletes in team sports and non-athletes.

Table 1. Basic descriptive parameters of the whole sample at the initial and final testing.

Var./ Physical Education classer.	N	Mean	Std. Dev.	Min.	Max.	Skew.	Kurt.	K-S p
ATV/i	147	149,82	7,86	130,80	167,00	,16	-,42	,094
ATT/i	147	44,97	13,70	26,00	95,00	1,60	2,85	,000
AOP/i	147	22,07	2,50	17,50	30,20	,79	,59	,046
ITM/i	147	61,01	31,49	5,00	95,00	-,45	-1,24	,000
MTR/i	147	23,83	3,95	16,00	36,00	,42	,32	,005
MSD/i	147	148,53	22,22	71,00	190,00	-,54	,50	,164
MPN/i	147	18,09	5,29	10,38	37,80	1,13	1,33	,001
MPT/i	147	31,50	7,30	6,00	57,00	-,14	1,68	,190
MPR/i	147	39,61	10,47	6,00	63,00	-,34	,41	,098
MIV/i	147	21,36	19,78	,00	85,00	1,03	,61	,000
F6'/i	147	1065,61	204,28	611,00	1472,00	,05	-,71	,166
ATV/f	147	163,76	9,46	140,00	185,70	-,07	-,34	,180
ATT/f	147	56,90	16,25	31,00	120,00	1,40	2,84	,000
AOP/f	147	23,97	2,67	18,80	34,00	,75	1,19	,189
ITM/f	147	60,39	29,90	5,00	95,00	-,39	-1,20	,000
MTR/f	147	28,59	4,02	17,00	39,00	-,05	,25	,005
MSD/f	147	164,47	26,38	91,00	211,00	-,25	-,61	,192
MPN/f	147	14,53	4,01	8,66	26,63	1,06	,68	,000
MPT/f	147	38,40	7,64	12,00	67,00	-,45	2,63	,000
MPR/f	147	44,64	12,88	4,00	75,00	-,48	,13	,003
MIV/f	147	29,84	23,92	,00	102,00	,63	-,29	,003
F6'/f	147	1176,61	228,63	626,00	1690,00	,05	-,59	,191

Note: Var. - variable / Per. -testing period (i - initial, f - final); N - the number of entities in the sample; Mean - arithmetic mean; Std. Dev. - standard deviation; Min. - minimal result; Max. - maximal result; Skew. - Distribution curve; Kurt. -flattening of the distribution

In order to test the dependence of the body mass index on the sports group of examinees, a single ANOVA was performed, which showed significant differences. It was found that there was a statistically significant difference between the body mass index of non-athletes and boys who did sports ($p < 0.0000000001$), but no significant difference was found between boys who are engaged in martial arts and boys engaged in team sports played with a ball. A moderate degree of correlation (-0.44) of the body mass index (ITM) with the results of functional abilities evaluated by the six-minute run test (F6'), and similar result was obtained by Petrić (2009), with the sample of 317 fifth grade elementary school pupils, divided by the environment in which they reside in the two groups, where it was found that the decline in body mass index (ITM) causes an increase in F6' test results, or that there is a correlation between body mass index and functional abilities.

Similar findings and conclusions were obtained from Faletar and Bonacin (2007) with 154 boys in the 7th and 8th grades of elementary school. For the first group of examinees, physical education classes in school was the only systematic exercise

model, and the examinees of the second group were included in addition to the school physical education classes, in systematic training in sports clubs (basketball, football). Differences between the two groups were significant only in body mass and hand tapping. The athletes and the non-athletes were particularly distinguished in 20 meter run, the "lying-sitting" test, triceps skin folds, pull up endurance, graspin sitting position, and long jump from a stand. The "athlete" group had considerably smaller ballast mass.

Schwarzfischer et al. (2018) investigated the effect of physical activity (PA) and sitting behavioural modal (SB), that is, total absence of physical activity, body mass index (BMI), and fat mass index (FMI) in children over five years period. The research included a sample of 600 children. Higher levels of total body activity (PA) and moderate to strong PA (MVPA) are associated with lower BMIs and FMIs, while higher levels of SB are directly linked to higher BMI and FMI over a five years period. It was concluded that a higher degree of physical activity is directly associated with lower BMI and FMI, while lower and moderate levels of physical activity have had a lower impact on BMI

and FMI. On the other hand, the middle and high degree of SB had a greater negative impact on anthropometric characteristics than the high and moderate degree of physical activity had a positive influence. In short, children who spent more time in the SB had higher BMI, even when they were taking part in MVPA activities. This observation supports inactivity as an independent risk factor for childhood obesity. In future interventions in prevention of obesity, the focus should not be solely on increasing high intensity PA, but should also emphasize the reduction in time spent in module SB. Although LPA did not show any connection with BMI, promoting LPA to reduce SB could be a more realistic goal of promoting MVPA.

The results of this research have confirmed the first hypothesis, that is, that the body mass is significantly related negatively, to the motor and functional abilities of the different population of boys. The sports group correlates most with the highest number of measured parameters, with the members of the group of non-athletes having the worst results. The highest values of the F6' test had boys who were engaged in team sports played with a ball. In the MDS variation (AS = 164.47; SD = 26.38), there was a significant difference between non-athletes children and children engaged in martial arts ($p < 0.0001$) as well as between non-athletes and children from a group engaged in team sports played with a ball ($p < 0.0001$), while there were no significant differences between the two sports groups. The values of the MDS variables were considerably lower for the non-athletes as well as for those engaged in martial arts.

The second hypothesis is confirmed, that is, that the body mass is significantly related to the results in the variables in the population of boys engaged in team sports with ball, martial arts and non-athletes. Such conclusions are also made by Badrić (2010), who on a sample of pupils' aged 11 to 12 determined quantitative changes in motor skills after the experimental ten-week programmed work with examinees enrolled in the football team within the School Sports Association. Experimental group in addition with regular Physical Education classes in school had 20 trainings and 4 control matches. The program has made significant progress in all motor skills within the experimental group. Jovanović et al. (2011) and Benassi (2013) found that the experimental group that with regular Physical education classes had attended an additional recreational program - football in the football club, achieved significantly better results in all motor tests and the most significant difference was in the variable "standing long jump" from the group that attended only regular Physical education classes. Similar research of Wu et al. (2012) establishes a three-year trend in body mass index (ITM) development and physical preparation in 16,945 subjects, aged between 12 and 16, with extreme body weight values. The subjects were divided into three groups: „overweight“, "underweight" and "normal" and were measured by the Taiwanese group of tests of physical condition.

The "overweight" group had the worst results in all variables compared to the "normal" group. In this research also, all three groups achieved better results in all variables during three years of measurement. ITM in the "underweight" group increased at a faster rate than the other two groups and this group had the best results in the aerobic endurance test, and in the tests of muscular endurance and flexibility this group achieved lower results than the "normal" group. In Wu et al. (2012) research no statistically significant difference was found in the results of standing long jump between groups of "underweight" and "normal" subjects.

Furthermore, Muratović et al. (2015) determined the differences in the motor and specific-motor skills with 250 boys in final grades of 9-year elementary school, non-athletes and handball players age 14 and 15 year. Experimental groups that, in addition to regular Physical education classes, had organized handball training in clubs, showed better motor and specific motor skills than those who were not actively involved in any form of physical activity other than regular Physical education classes. Some of the similar studies also produce similar results, such as Krstulović et al. (2010), that over 202 students of the first grades of elementary school analysed and compared the impact of the nine-month training program of judo, football and athletics on coordination, agility, flexibility, muscular endurance, cardiovascular endurance and body structure (subcutaneous fat).

Experimental group beside regular Physical education classes attended an additional program in judo, athletics and football. The authors conclude that all groups except the control group have progressed. Athletes in athletics and soccer players have made greater progress than athletes doing judo in aerobic endurance, velocity and explosive strength variables, while athletes doing judo compared to athletes in athletics and soccer players have achieved better results in the variables for assessing flexibility and muscular endurance, while the control group significantly increased values of body fat.

Szmodis et al. (2018) researched the anthropometric and physical condition of boys of the same age with a different percentage of body fat, on a significant sample of less than seven thousand boys. Examinees were boys in Hungary aged 9 to 13 (N = 6919). Except for the three low-body fat groups, values of body weight, height, body mass index and plastics and metric index were significantly higher. The results of 30 meter run, 1200 meter run, and the long jump, were worse in all groups with a higher percentage of body fat. An interesting finding of the research is that the percentage of body fat also influenced the physical condition of children who do not have excessive body weight when only a 4% range of body fat was used. The lower degree of body fat (fat mass index) result with better physical condition in the age pattern.

Furthermore, we can conclude that the highest values in the MIV variables had boys who were engaged in any type of sport, but the weight impact was least evident in boys who were engaged in martial arts. The body mass index is negatively correlated with the results of functional abilities (variable F6'). Such results were obtained by Biletić et al. in their research (2012, 2015) on 147 wrestling boys aged 11 and 12 and they also concluded wrestling boys from "light" weight group are superior, or they achieve better results in most motor and functional variables than "heavy" wrestling boys. Equally, Badrić et al. (2015) confirm that there is a significant difference in motor abilities between physically active and physically inactive pupils. They identified differences in motor skills between four sub-samples defined by the level of physical activity in free time on 434 elementary school pupils. Physically active have had nominally better results in all motor skills tests than physically inactive, which had significantly higher ITM values than those physically active.

Further analysis of the results shows that athletes, more from the group of martial arts than team sports played with a ball, are in a far better position than non-athletes and similar results have been obtained by a whole series of authors (Muratović et al., 2015, Jovanović et al., Badrić, 2010). It is well known that excess body weight is a serious obstacle to achieving a good health condition and good physical condition even in boys who are doing sports (Biletić et al., 2012). The highest values in pull up endurance test (MIV) had boys who were engaged in any type of sport, but the effect of weight was at least evident in boys who were engaged in martial arts. From all of the above, it can be realized that the influence of body weight on six measured variables which define the physical condition of the boys is great and extremely negative (Petrić 2009, Wu et al., 2012, Biletić et al., 2012), as athletes and non-athletes, with a higher body weight or equal body weight, showed 5 to 50% worse results than boys who are the same weight and are engaged in some sport.

Table 2. Results of mid values of all variables of all sports groups and all weight groups on initial and final testing.

Var./Per.	Non-athletes		Team sports played with ball		Martial arts	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
ATV/i	161.4867	5.988425	168.0067	8.51446	165.4933	5.628733
ATT/i	59.30333	17.44592	59.93	16.69884	66.32333	30.34357
AOP/i	24.32	2.733185	24.59	2.836071	25.17333	4.375778
ITM/i	70.01	25.83577	63.92667	31.83859	62.05333	30.94564
MTR/i	27.23333	1.159023	29.46333	0.954795	28.36333	1.822096
MDS/i	151.9733	17.08664	176.8533	4.970526	160.9667	28.55527
MPN/i	16.97	2.620897	13.34667	0.870881	12.47	0.936162
MPT/i	35.44	3.919541	39.87667	2.41467	39.37333	2.954341
MPR/i	43.53333	1.20093	46.27	1.837716	47.40667	4.948144
MIV/i	17.68	13.32995	33.67	8.777807	42.345	4.461844
F6'/i	1032.737	88.78319	1241.497	51.30796	1164.653	225.1082
ATV/f	154.6333	5.96059	161.9267	9.899396	159.0933	9.211679
ATT/f	52.82	16.94279	53.91	16.0177	55.78667	23.30283
AOP/f	23.48	2.384261	23.84333	2.89697	23.49333	3.470884
ITM/f	69.92	28.15989	65.36	31.00237	60.43	32.59048
MTR/f	25.68333	0.930717	27.14333	0.698307	27.4	1.03923
MDS/f	142.3867	9.766096	158.8133	4.354737	157.8033	21.22625
MPN/f	18.91	2.773464	103.6967	154.5401	16.47	4.085841
MPT/f	32.21333	4.030103	36.09667	2.51953	37.88333	1.215003
MPR/f	42.15333	1.710478	43.42333	2.354917	45.43667	5.943503
MIV/f	12.71667	10.3467	24.24333	13.78523	31.04333	9.241939
F6'/f	987.0567	84.28283	1130.59	167.4584	1115.16	109.9417

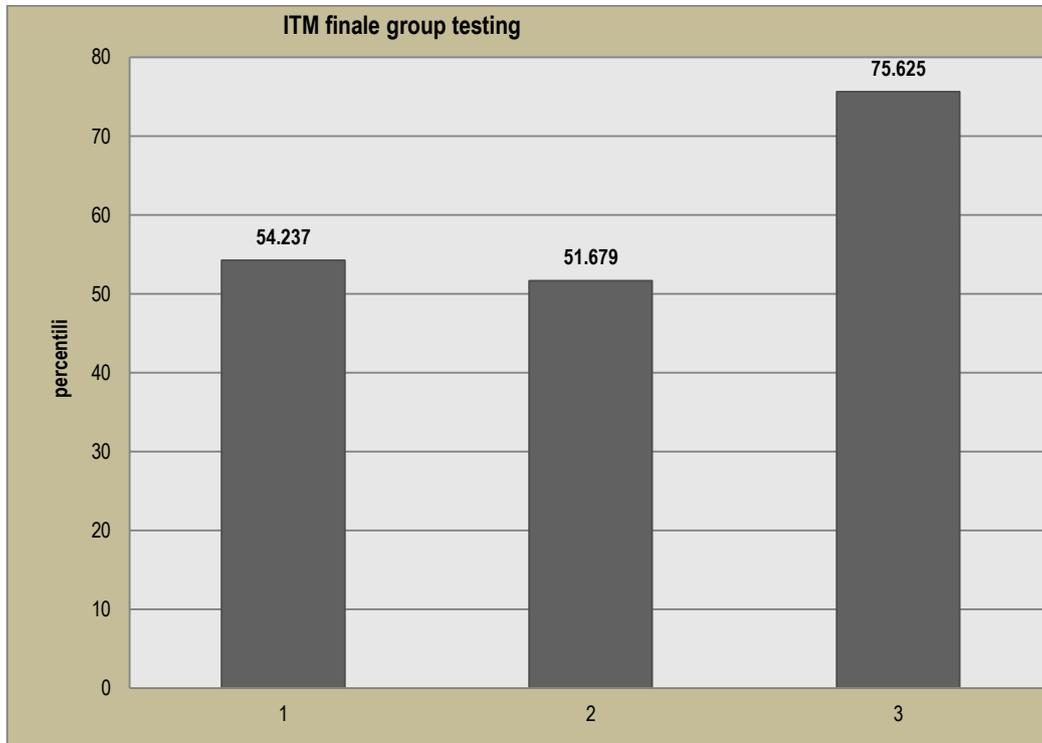
Note: Var. - variable / Per. - measurement period (i - initial, f - final); Mean - arithmetic mean, Std.Dev. - Standard deviation

When the results of the final measurement are analysed according to the degree of nutrition, we can conclude that more than 55% of the non-

athletes have excessive body mass or obesity. Among the athletes engaged in team sport played with ball, obesity on both measurements is

recorded in three football players and one handball player, while among athletes engaged in martial arts only two wrestlers had been obese. One respondent from both groups of athletes (basketball players and karate) is undernourished on both measurements. The average values of nutrition status (Fig. 1) clearly show the difference

between a group of non-athletes and a group of athletes. Benassi et al. (2018) indicate inadequate working conditions and poor selection of coaches as a reason why no significant progress has been made with positive differences between athletes and non-athletes.



Legend: 1 – team sports played with a ball; 2 - martial arts; 3 - non-athletes

Figure 1. Average Values of Body Mass Index (ITM) at the final measurement or all three groups of examinees.

Examinees from the group of athletes engaged in team sports played with a ball and martial arts have mostly normal body masses (Table 3). The same results, that is, that in the pupils non-athletes the highest values of nutrition status are measured

and superiority in the results of all variables in the pupils who are engaged in sports, reached Benassi et al. (2018), Prskalo et al. (2015), Badrić et al. (2015) and Jovanović et al. (2011) in their researches.

Table 3. Data on the nutritional status of all groups of examinees on initial and final measurements.

Groups of examinees	Measures	malnutrition <5 centiles		Normal body mass 5-85 centiles		overweigh 85-95 centiles		Overnourishment (Obesity) > 95 centiles	
		Num.	%	Num.	%	Num.	%	Num.	%
Team sports played with a ball	Initial	6	10	41	68.33	10	6	3	5
	Final	3	5	50	83.33	6	10	1	1.66
Martial arts	Initial	1	3.33	25	83.33	1	3.33	3	10
	Final	1	3.33	26	86.66	1	3.33	2	6.66
Non-athletes	Initial	1	1.75	25	43.86	10	17.54	21	36.84
	Final	1	1.75	24	42.10	11	19.29	21	36.84

Non-athletes on final measurement achieve 20 and more centiles (ITM) higher values than both groups of athletes. Boys who do not even deal with sports have a higher body mass index, and on final measurement it was higher on average for 21 percentiles from those who did team sports played

with a ball and 25 percentiles from those who did martial arts. Although examinees who have only participated in Physical education classes twice a week for 45 minutes during experimental cycle, make progress in almost all variables, yet they make significantly worse results than peers who

have been trained in extracurricular activities for any sport three times a week for at least 60 minutes, and similar results were obtained by Benassi et al. (2018). This is a third hypothesis confirmed; meaning that dealing with any sport significantly and positively influences the body mass index. Since there was no statistically significant difference in changes in anthropometric characteristics, motor and functional abilities between groups of sports, we can conclude that engaging in any kind of sports does not only have a positive influence on motor and functional abilities but also mitigates the negative influence of weight (Sertić et al., 2010, Krstulović et al., 2010.).

Interesting research was carried out by Ørntoft et al. in 2018. Aim of this research was to determine whether the physical condition and the physical composition of children aged 10-12 years old from Denmark, are associated with engagement in sports activities in leisure time in the sports club. The study included 544 Danish students aged between 10 and 12 (269 boys and 275 girls, 11.1 ± 0.4 years). After responding to a questionnaire on leisure activities, the children were divided into four groups: participation in a football club (FC; $n=141$), other ball games (OBG; $n=42$), other sports (OS; $n=194$) and group "no sport connections" (NSC; $n=167$). Children had a range of health and fitness tests including 20-meter sprint test, long jump test, Yo-Yo IR1 test for children (YYIR1C) and body composition test, blood pressure measurement, heart rate at rest (HRrest) and flamingo balance test. The children who were engaged in team sports with a ball (FC and OBG) had higher ($p < 0.05$) non-fat body mass than NSC (FC: 17.5 ± 2.9 ; OBG: 18.4 ± 2.6 ; OS: 16.7 ± 2.9 ; NSC: 16.4 ± 2.8), better results ($p < 0.05$) in the YYIR1C test (FC:

1083 ± 527 , OBG: 968 ± 448 , OS: 776 ± 398 , NSC: 687 ± 378 m), and lower ($p < 0.05$) HRrest after 1, 2 and 3 minutes YYIR1C. Moreover, HRrest was lower ($p < 0.05$) for FC than OS and NSC (FC: 68 ± 9 vs OS: 72 ± 10 and NSC: 75 ± 10 bpm), and lower ($p < 0.05$) for OBG than for NSC (OBG: 70 ± 10 vs. NSC: 75 ± 10 bpm). This research showed that children aged 10 to 12 who were engaged in football and other ball sports had better exercise skills, lower heart rate in the rest and greater muscle mass than children who did not practice sports. It is therefore concluded that participation in club activities in sports played with a ball is of importance for the health of pre-puberty children.

When we compare the results of tests that were conducted at the end with the results of tests conducted at the beginning of test period, we see that there is a significant difference between the parameters for MTR ($p = 0.005$), MSD ($p = 0.007$), MPT ($p = 0.006$), and parameters MPN, MPR, MIV and F6' did not change significantly during the period of measurement. However, no particular interaction between the measurements and the sports group has been observed, and it cannot be said that the parameters of the members of different sports groups have changed at different rates. It is possible that the research period is too short to make such differences significant. Body mass index remained practically unchanged from initial to final measurement and was consistently higher in non-athletes group. Relationships between the performances of sports groups on different tests show the same parameter on initial as on final measurement, with marked differences in achievements between athletes and non-athletes on MSD, MPN, MPT, MIV and F6'tests.

Table 4. Results ANOVA measured variables and correlation coefficient of other variables with a body mass index.

Var.	Sport group	Measurement i/f	Sports group * measurement i/f	Correlation with ITM
ITM	F=51.44 p<2e-16***	F = 0.16 p=0.688	F = 0.103 p = 0.902	-
MTR	F = 3.209 p = 0.04*	F = 7.989 p = 0.00505 **	F = 2.043 p=0.08867	-0.05
MDS	F = 44.740 p< 2e-16 ***	F = 7.168 p = 0.00787 **	F =0.861 p=0.42378	-0.345
MPN	F=0.019 p=0.98119	F=3.271 p=0.07161	F=0.158 p=0.85364	0.096
MPT	F=26.613 p=2.74e-11 ***	F=7.639 p=0.0061 **	F=0.227 p=0.7970	-0.3329
MPR	F=2.762 p=0.0649	F=0.581 p=0.4464	F=0.360 p=0.6980	0.0958
MIV	F=46.522 p< 2e-16 ***	F=3.522 p=0.0616	F=0.047 p=0.9543	-0.479
F6'	F=61.666 p < 2e-16 ***	F=0.419 p=0.518	F=1.152 p=0.318	-0.4509

Conclusion

According to the aim of the research, longitudinal changes of boy's non-athletes, athletes in martial arts and athletes in team sports from age 11 to 13 under the influence of physical exercise as well as the influence of engagement in sports on the

body mass index, in a very interesting age, where very little research was done.

The results of the research show that the sports group has influence on the largest number of

measured parameters, with the members of the group of non-athletes having the worst results on both measurements.

It is commonly known that physical activity has a positive effect on human health and physical condition, and that is certainly an axiom that needs not to be discussed. But if the goal of mankind is to get a new generation of healthy, vital young people, it is necessary to make accurate measurements and to check correlations of specific sports and activities in relation to the development of children of different ages. As stated in the beginning, one of the problems that arise in physical activity research is the absence of uniform, standardized, accurate and reliable test procedures for measuring body function and physical condition of children's, which results in problems with comparison of obtained results.

However, if research is limited to the anthropometric characteristics and functional abilities of boys ages 11-13, grouped by the criterion of engagement in sport, a clear conclusion is undoubtedly drawn - it is not possible to have healthy young people with no physical activity. Prskalo et al. (2015) showed that children with normal body weight had better motor results than overweight and obese children, muscle strength is directly related to the level of stress, optimism and confidence (M. Rodrigues - Aylon et al., 2017).

We see the general superiority of examinees that are athletes compared to non-athletes (Benassi et al., 2018, Ishihara et al., 2018) undoubtedly confirmed that lack of obesity, good physical condition, and lower learning time schedule are a winning combination for better school achievement. Petrić (2009) found that there was a correlation between body mass index and functional abilities, and Faletar and Bonacin (2007) measured the athlete's and non-athletes performance differences

in body mass and hand tapping, in 20 minute run, "lying-sitting" test, triceps skin fold, pull up endurance, grasp in sitting position, and long jump from a stand.

More precisely, Sertić et al. (2010) come to the conclusion that judo in boys aged 10 to 12 causes greater change in anthropological status than engaging in team sports. Schwarzfischer et al. (2018) found correlation between anthropometric characteristics of boys not only in time spent in doing sport, but also in relation to the time spent in the sitting module, concluding that even a higher degree of physical activity would lose its positive influence if the sitting module behaviours are significantly present. Szmodis et al (2018) found a significant difference between the characteristics of boys who are engaged in sports but have a different degree of body fat, showing how strong is the influence of body structure on physical condition. Krstulović et al. (2010) compared the impact of the nine-month of doing judo, football and athletics training program, where all groups showed progress except the control group.

The results of this research show that athletes, a little bit more in martial arts than team sports played with a ball, are in a far better position than non-athletes and we can conclude that Physical education classes in elementary schools cannot guarantee a long-term positive effect on health and anthropological characteristics of the boys.

The results enable us to understand the extent to which sport in general and any sports activity affects the development of individual motor and functional abilities in young athletes and facilitates selection, planning and programming of training in martial arts and team sports played with a ball. The results should point to trainers in which direction they should conduct physical condition training for young athletes considering their body weight.

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