CHANGES IN BIOMOTOR DIMENSIONS OF SCHOOL BOYS AGED 11: EXPERIMENTAL PROGRAMME OF SPORTS GAMES VS STANDARD PE PROGRAMME

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Abstract

On a sample of 252 boys, aged 11 yrs±6 months, divided into the control (CG; N=127 subjects) and the experimental group (EG; N=125 subjects), a system of 33 measurement instruments was applied (12 morphological and 21 motor and functional variables). A goal was to determine changes in morphological characteristics as well as in motor and functional abilities of boys after the annual application of the experimental programme in the EG, composed of the fundamentals of sport games (basketball, volleyball, handball and football), and standard PE programme in CG, based on statistical significance of the differences in arithmetic means of the applied variables between the control and the experimental group in the initial and final measurement. Statistically significant differences between the control (Mc) and the experimental (Me) group in arithmetic means of the applied variables in the initial and the final measurement were determined by means of multivariate and univariate analyses of variance (MANOVA/ANOVA). The computed statistical values made it obvious that in the whole system (multivariate) of the applied variables (12 morphological and 21 motor and functional) statistically significant difference exists between the control and the experimental (Mc-Me) group in the initial and the final measurement at the level of p=.00. The results showed that the subjects of both groups scored better in the initial than in the final measurement in 6 different morphological variables each. In the final measurement, after the experimental programme treatment, the EG had better values in 8 variables (out of which only one at the level of p=.03), whereas the CG was better only in 4 variables. The finding indicated that only the whole system of the applied morphological variables evenly contributed to the differentiation of the groups, both in the initial and final measurements. In the space of motor and functional abilities the subjects in the CG were better in 5 variables in both the initial and the final measurement, whereas the subjects of the EG were better in 16 variables. In the initial measurement 8 individual variables (out of which 2 in favour of the CG and 6 in favour of the EG) contributed to the multivariate statistical significance of the differences in group arithmetic means at the level of p=.00, whereas in the final measurement 14 variables contributed to the statistical significance (out of which one in favour of the CG and 13 in favour of the EG). This indicated that the experimental programme, composed of sport games' movement structures, produced in the EG statistically significant changes in motor and functional abilities as measured in 7 variables assessing leg movement frequency, power (explosive strength) of arms and legs, flexibility of legs and arms, and arm-leg coordination.

Key words: *morphological characteristics, motor abilities, functional abilities, age 11-12 years, boys, exercise effects, experimental programme, sports games*

Introduction

Research in changes of certain anthropological characteristics of children under the influence of various programmes of physical exercise and/or sports training is one of the most important issues in physical education (PE) and sport (van Sluijis, McMinn & Griffin, 2007).These research studies are based usually upon priory constructed, defined desirable final states (models), features of actual states of subjects (diagnostics, control, exercise effect control, genetic limitations) and longitudinal transformation of the states (planning and programming, operational) during the process of physical education (teaching) or sport training (Milanović, 1999; Findak, 1999; Pejčić, 2002). It means it is impossible to design and apply any transformational procedure of physical exercise or sport training if the following is not known: which anthropological characteristics, abilities and motor knowledge and skills contribute to success in any educational or sporting activity; what is their significance and hierarchically defined influence on performance; which programme contents, methods and loads/intensities can optimally develop them within a certain time period; by which instruments can they be measured and how can they be controlled (Malacko, 2008).

The development of children's particular anthropological abilities and characteristics, efficiency of which depends primarily on the selection and application of adequate exercise or sport training contents (programmes) and respective optimal work loads, must not ever assume nature of aimless exercise, especially when the children selected for particular sport events are considered. It means that it is useless to develop individual anthropological abilities and characteristics separately from the actual need, that is, from the desired goal (Kretschmer, 2001; Pejčić, 2002). Additionally, we must always bear in mind that all human capacities and abilities are intervowen, especially in younger ages; they develop according to a certain genetically prescribed order and pace (Ortega, Ruiz, Castillo, & Sjostrom, 2008; Rogers, Fay, Whitfield, Tomlinson, & Grunau, 2005). Therefore, exercise or training programme contents, aimed at development of relevant anthropological abilities and characteristics, should be designed/selected and applied in accordance with the already acquired and automated movement structures. In this the well-known rule of economy reigns: regardless of what is the foundation of the selection, the more functional contents (of a higher complexity) should be preferred, that is, the contents by means of which several goals can be simultaneously accomplished (Mraković, 1992; Malacko & Popović, 2001). According to the above-mentioned, when research studies are conducted, much effort is put in the design of experimental programmes to make them efficient in two areas: (a) in training, mastering and acquiring (automatization) of certain movement structures, on the one hand, and (b) in causing optimal exercise/training effects on particular morphological characteristics and motor-functional abilities, on the other (Kurelić, Momirović, Stojanović, Šturm, Radojević & Viskić-Štalec, 1975; Gredelj, Hošek, Metikoš & Momirović, 1975). Both aspects are mutually related in a very specific way: to change any anthropological characteristic or ability, being responsible for performance in a particular educational or sporting activity, a particular movement structure (situational-technical element), by means of which the transformation is to be caused, has to be previously acquired up to the level of rational, economical and optimal performance. Training, mastering and acquisition of desirable and purposeful movement stuctures (elements of sport technique, motor information) should be based upon carefully selected or constructed specific movement structures which are by their form, character, structure and work load very close to the final movement patterns used in the activity in actual situations. The goal here is to quickly achieve as great exercise effects in acquisition of relevant movement structures with as few elements of the movement pattern as possible. These relevant movement structures are further used in training process to optimally condition (transform) anthropological characteristics and abilities, which are in the function of optimal performance in any educational and/or sporting activity (Malacko & Radjo, 2004). Due to the fact that the effects of the movement structures applied depend also on the methods of exercising and/or training utilized, it is important to know in advance how much each exercise movement structure should be practiced for a particular purpose and how it should be applied. Practically, it means that one exercise structure due to its complexity might be adequate for a particular goal, but the goal is not going to be realized because of inadequate training (volume or intensity). Or, even negative effects may be produced (Mraković, 1994). Therefore, besides the information on the purpose which is to be realized and by which exercise contents, the information is indispensable on how much and in what way the very exercise contents should be applied, as well as what work load is to be implemented within the set time intervals. It is more than obvious that the exercise contents, methods and loads cannot be analysed and utilized seaprately. In the processes of design, programming and operationalization of any educational and/or sport training process they should be regarded as interdipendent and correlated elements (Findak, Prskalo, & Pejčić, 2003). Practitioners of everyday school teaching, especially those who work with children aged 11-12 years, generally consider that the PE curriculum is overreaching and too ambitious, primarily due to the insufficient weekly time allocation. It leads to the one-sided predominance of the educational component over the developmental aspect of teaching PE. The type of PE teaching which is focused on learning, that is, mastering of large body of motor knowledge and skills, what is nowadays typical for the majority of elementary schools, cannot guarantee that these teaching contents will contribute to the desirable development of relevant anthropological characteristics and abilities of children, which should be the main purpose of school PE teaching. Namely, such an approach jeopardizes one of the principal developmental laws of growth and maturation: human characteristics and abilities are most successfully developed within the so called "critical periods", when such a development is objectively possible, meaning during childhood and youth (adolescence). In professional literature (Kuznjecova, 1975; Gužalovskij, 1984) the term "critical periods" is frequently understood as ontogenetic periods. Within their limits and on the basis of natural laws the greatest tempo of the development of certain personal characteristics and abilities is achieved, capacity of adaptation to the environmental factors is enhanced and the most favourable preconditions are created for certain skills and habits development and information acquisition (Harrison et al., 1999). The starting assumption is that, in these periods, the human organism is more than in other periods susceptible to external stimuli (transformations) if they are, by their direction, in accordance with the general tendencies of natural course of morphological,

motor and functional changes. Out of this stems the principal empirical rule: the development of individual physical abilities should start early. Practically, it means that "the greater the genetically determined portion of the variance of the particular anthropological dimension, the smaller the influence of conditioning process on it during life; and vice versa, the smaller the genetically determined portion of the variance, the greater the influence of the process of exercise" (Mraković, 1992). It corroborates the notion that the one-sided favourization of educational component of PE teaching may be, and is, erroneous. Namely, many motor information, skills and habits can be acquired later in life, whereas the environmental influences missed in critical developmental periods can hardly ever be compensated later.

Previous observations, analyses, opinions and statements, as well as ever more serious warnings of professional and wider social community regarding the unacceptably low level of PE teaching efficiency, were a basic drive for commencing the presented research study and its goal orientation. The main issue here is: which programme can, if it can at all, induce greater changes - the standard, mandatory PE syllabus, implemented in standard, control group, or the specially designed programme, consisting of sport-specific movement structures (technical fundamentals), implemented in the experimental group during the same time period. The aim of the present research study was to determine the changes in the development of morphological characteristics as well as motor and functional/cardio-respiratory abilities of school boys in the fifth grade after the annusl application of the experimental PE programme, composed of sport games' fundamentals (basketball, volleyball, handball and soccer). The changes will be determined on the basis of statisticallly significant differences in arithmetic means of the variables between the control and the experimental group in the initial and the final measurement.

Methods

Sample of subjects

A sample of subjects consisted of 252 boys, aged 11 years ± 6 months, who were divided into the control (CG; standard PE programme; 127 subjects) and the experimental (EG; 125 subjects) group.

Sample of variables

The sample of variables consisted of the 33-item test battery which included 12 morphological and 21 motor-functional variables. In the space of morphology the following latent and manifest variables (anthropological measures) were used: *dimensions of the skeleton* – body height (BOH), shoulder width (SHW), pelvic girdle width (PGW), *body mass and volume* – body mass (BOM), forearm circumference (FOC), upperarm circumference (UPC), thigh circumference (THC), calf circumference (CAC), waist circumference (WAC), and *subcutaneous fatty tissue* – upper arm skinfold (UAS), subscapular skinfold (SUS) and abdominal skinfold (ABS). For the assessment of motor and functional abilities the following latent or manifest variables were used: *body coordination* – passing through and jumping over (PTJ), agility in the air (AGA), obstacle course backwards (OCB), *frequency of movement* – hand tapping (HTA), foot tapping (FTA), foot tapping against the wall (FTW), *power (explosive strength)* - standing long jump (SLJ), medicine ball throw from supine lying (MTL), 20m running from the standing start (20R), *strength endurance* – all-out declined sit-ups off the bench (ASB – A subject is sitting on the bench, 10-20 cm off the rim, with the knees bent 90º and the feet locked on the bench by the assisstant. He puts his hands behind the neck and holds a stick with his elbows behind the neck. He has to lie down back until his head touches the padded mat on the floor. From that position he performs all-out sit-ups. The number of properly performed sit-ups is a result.), all-out hyperextension on the box (AHB – A subject, in prone position, extends upper body over the end of the box; the end of the box should be at his hips. A partner locks his legs. He bends down at waist with his hands and a stick behind his neck. He raises his torso straight up until parallel with the upper surface of the box. The number of properly performed back extensions is a result), undergrip chin-ups on the bar (UCB), *flexibility* – bent forward on the bench (BFB), straddle sit-and-reach (SSR), shoulder circumduction backwards with a stick (SBC), *leg-hand coordination* - slalom with three medicine balls (S3B – 10m long route with 5 stands 2 m apart; a subject should roll simultaneously three medicine balls with his legs and hands up and down the route.), slalom by kicking two balls (S2B), hand dribbling (HDR), and *aerobic capacity* – rest heart rate (RHR), vital capacity (VIC) and 1,000 m running (RTM).

Data processing

The multivariate and univariate analyses of variance (MANOVA/ANOVA) were used to determine the differences among arithmetic means of the variables measured in the initial and final measurement between the control (Mc) and the experimental (Me) groups of boys. The multivariate testing of the null hypothesis that the centroids of the groups equalled the common centroid (GENERAL MANOVA) was conducted by means of Λ-relations (Wilks' Lambda test) i Rao's coefficient (Rao's R), as well as their statistical significance (p-level). The univariate statistical significance of the differences (p-level) between the arithmetic means of the groups (Mc - Me) across the variables was compuited by means of F-test.

Experimental programme

The experimental programme of sports games was approved as a pilot programme by the Croatian ministry of Education and Sport.

It was applied two times a week in the scheduled PE classes lasting 45 minutes. The classes were held in a school setting (either indoors, in the gymnasium, or outdoors). The total annual time allocation of 54 experimental PE classes was structured as follows: 37 classes were focused on sports-game-specific work – acquisition of motor (technical) elements (basketball 10, volleyball 9, handball 9 and football 9), whereas 17 classes were aimed at basic motor preparation/physical conditioning (elements of the drills with apparatuses - 7 classes, athletics - 6 classes, and dances - 4 classes). The programme of basic physical conditioning included callinetics (in place and on move), continuous (aerobic endurance) running, various modes of running with medicine balls, jumping over obstacles with balls, sprints up to 10m from various positions and stances, running with changes of direction and pace, carrying each other in pairs and triples, fartlek up to 300m (continuous running of variable paces), combination of a forward roll and a cartwheel, dive over an obstacle into forward roll, rope jumps and hops (one- and two-legged), various obstacle courses, pushing and pulling each other in pairs, movements performed according to certain rhythmical or aesthetic criteria, and others. In the area of specific motor preparation sport-game-specific technical elements were applied such as: moving without the ball; then holding, catching and passing the ball; straightforward and zig-zag dribblings, pivots, runner/extended lay-up shot (2-stride run-up for a lay-up, 3-stride run-up for a lay-up), set shooting and shooting from moving, punching the ball (spikes), feinting in place and while moving, basic steals, kicking the ball, receiving the ball (soccer), head shots, receiving low, intermediate and high passes (soccer), rebounding, block jumps, individual tactics, collective tactics and others. The general goal of the applied experimental programme was, on the one hand, to introduce the boys into the world of sport games, and on the other, to make them fond of any of the introduced sport games so that they would like to continue to train it in any of the sport clubs (extramural activities), according to their aptitudes, inclinations and interests. The partial goals of the applied experimental programme were:

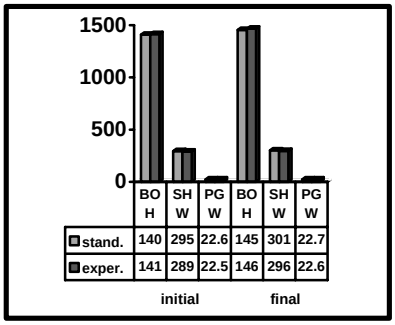
- To adjust the programme to the needs and interests of the boys of the particular age who have decided to engage in programme activities of sport games,
- To implement in the process of teaching/training as simple and understandable sport-game-specific motor structures as possible to provide easy acquisition and application,
- To repeatedly apply the acquired and mastered technical elements of sport games in order to develop particular relevant morphological, motor and functional features,
- To teach particular technical elements with the purpose to introduce the boys to the chosen sport game for the involvement in which they do have the genetical potential,
- To ensure the application of the acquaried rules of sport behaviour and of the rules of the game in actual competition.

The control group attended regular physical education classes with the standard programme contents stipulated for the pupils of the elementary school fifth form.

Results

The obtained statistical values of arithmetic means, presented in Tables 1 i 2, revealed the statistically significant differences at the level of .00 (p=.00) between the control and the experimental group (Mc-Me) in the initial and the final measurement of the entire system (multivariate) of the applied variables (12 morphological - Table 1, and 21 motor and functional - Table 2). In the system of morphological variables (Table 1) it is obvious that in the initial measurement the subjects of the control and the experimental group had better values in 6 morphological variables (the variables are marked with *), whereas in the final measurement the experimental group, after the experimental programme implementation, had better values in 8 variables and the control group only in 4 morphological variables.

Graph 1. Dimensions of the skeletion



In the dimensions of body mass and volume (Graph 2) there were no significant changes in the final measurement. The values of *body weight* (BOM) and *upper arm circumference* (UPC) remained almost the same in both groups. Only the values of *forearm circumference* of the experimental group were better in the final measurement (FOC). There were also no statistically significant differences between arithmetic means of the variables *thigh circumference* (THC) and *calf circumference* (CAC) in the initial and final measurement (Graph 3). Only in the variable *waist circumference* (WAC) certain reduced values (logically, the better result) were obtained in favour of the experimental group, but it was not statisitically significant. Also, no significant difference was found between two groups in the variables of subcutaneous fatty tissue, except for one variable.

Table 1. Multivariate and univariate (MANOVA/ANOVA) significance of the differences (p) between arithmetic means of the control (Mc; N = 127) and the experimental (Me; N = 125) group in morphological variables – the initial and the final measurement

Variables	Initial measurement				Final measurement			
	Mc	Me	F	p	Mc	Me	F	P
BOH	1408.70	**1414.50***	.90	.34	1454.42	**1465.63***	1.88	.17
SHW	**294.63***	289.24	1.00	.31	**301.04***	296.39	.82	.36
PGW	**22.58***	22.46	.03	.84	**22.74***	22.64	.08	.77
BOM	35.94	**36.42***	.86	.35	39.83	**40.75***	1.18	.27
FOC	**205.44***	204.35	.01	.92	209.56	**210.59***	.52	.46
UPC	**213.29***	209.01	.32	.57	**218.59***	214.45	.34	.55
THC	**451.20***	443.66	.16	.68	**465.68***	455.93	.53	.46
CAC	294.09	**295.34***	.11	.73	299.27	300.84*	.20	.65
WAC	**652.88***	656.91	.46	.49	668.86	**662.51***	.00	.95
UAS	8.30	**7.52***	.87	.35	7.96	**6.59***	4.55	**.03***
SUS	6.54	**6.16***	.01	.91	6.15	**5.58***	.59	.44
ABS	8.19	**7.88***	.06	.79	8.65	**7.94***	.16	.68

λ = .88 R= 2.69 p = .00* **λ = .77 R = 5.83 p = .00***

Legend: **Mc -** mean value of the control group, **Me -** mean value of the experimental group, **λ -** Wilks' Lambda, **F -** test, **R** - Rao's R, **p -** significance level ***Morphological variables**:* **BOH -** body height, **SHW -** shoulder width, **PGW -** pelvis girdle width, **BOM -** body mass, **FOC** - forearm circumference, **UPC –** upper arm circumference, **THC -** thigh circumference, **CAC** – calf circumference, **WAC** – waist circumference**, UAS -** upper arm skinfolds, **SUS -** subscapular skinfold, **ABS** – abdominal skinfold

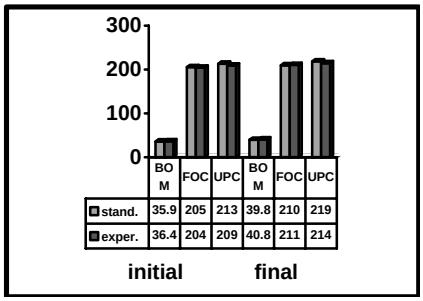
Table 2. Multivariate and univariate (MANOVA/ANOVA) significance of the differences (p) between arithmetic means of the control (Mc; N = 127) and the experimental (Me; N = 125) group in motor variables – the initial and the final measurement

Variables	Initial measurement				Final measurement			
	Mc	Me	F	p	Mc	Me	F	p
PTJ	1650.04	1642.16*	.06	.80	1592.17*	1628.21	.41	.51
AGA	679.26	669.89*	1.83	.17	629.49	608.93*	2.70	.10
OCB	1907.95	1832.28*	2.45	.11	1814.08	1785.72*	.51	.47
HTA	23.42*	22.67	6.84	.00*	23.93*	23.53	2.33	.12
FTA	17.57	18.04*	2.00	.15	18.38	19.06*	6.48	.01*
FTW	16.97*	16.86	.15	.69	17.33	17.77*	3.26	.07
SLJ	140.19	142.27*	2.01	.15	147.68	152.47*	7.58	.00*
MTL	465.80*	463.04	.53	.46	557.68	586.39*	15.33	.00*
20R	403.79	394.31*	1.42	.23	382.98*	391.43	7.19	.00*
DSB	2.67	3.37*	15.35	.00*	3.60	4.09*	6.74	.01*
HLB	12.04	14.64*	17.70	.00*	13.14	15.14*	8.58	.00*
UCB	.67	.95*	13.23	.00*	.74	1.28*	39.33	.00*
BFB	27.25	28.10*	.55	.45	26.59	28.84*	8.49	.00*
SSR	351.82	363.08*	.29	.59	343.03	367.90*	4.00	.04*
SBC	52.79	51.05*	1.64	.20	54.42	50.34*	9.68	.00*
S3B	5521.83	5169.64*	19.46	.00*	5299.16	4982.50*	20.39	.00*
S2B	7529.13	7438.87*	.12	.72	7247.97	7034.25*	3.73	.05*
HDR	1267.06	1098.52*	4.39	.03*	1159.68	1012.69*	44.90	.00*
RHR	73.91*	74.95	6.98	.00*	73.76*	74.11	2.19	.14
VIC	316.24*	311.18	1.18	.27	329.17*	327.48	.23	.62
RTM	377.55	342.18*	21.58	.00*	359.99	34.23*	12.23	.00*

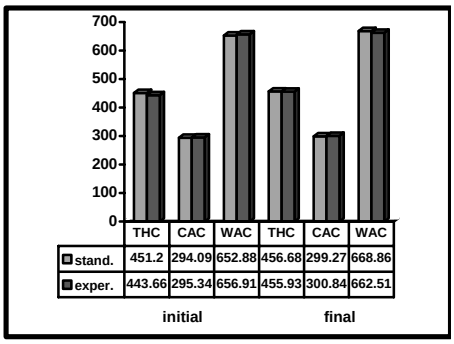
λ = .67 R = 5.34 p = .00* **λ = .49 R = 11.11 p = .00***

Legend: **Mc -** mean value of the control group, **Me -** mean value of the experimental group, **λ -** Wilks' Lambda, **F -** test, **R** - Rao's R, **p -** significance level ***Motor variables**:* **PTJ -** passing through and jumping over, **AGA -** agility in the air, **OCB -** obstacle course backwards, **HTA -** hand tapping, **FTA -** foot tapping, **FTW –** foot tapping against the wall, **SLJ -** standing long jump, **MTL -** medicine ball throw from supine lying, **20R -** 20m runing from the standing start, **DSB –** declined sit-ups on the bench, **HLB** - hyperextension from prone lying on the box , **UCB –** undergrip chin-ups on the bar, **BFB -** bend forward on a bench, **SSR –** straddle sit-and-reach**, SBC –** shoulder circumduction backwards with a stick, **S3B -** slalom with three balls, **S2B -** slalom by kicking two balls, **HDR –** hand dribbling, **RHR** – rest heart rate, **VIC** – vital capacity**, RTM –** 1,000m run

Graph 2. Body mass and circumferences of the arm

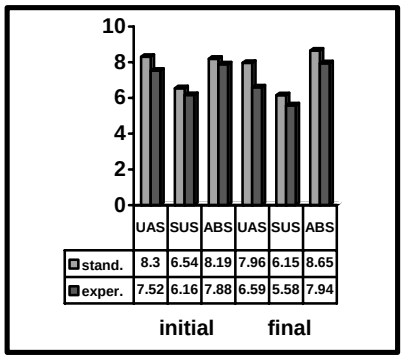


Graph 3. Circumferences of the leg and waist



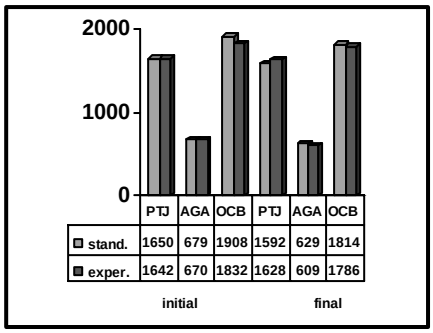
Namely, in both groups the values were being equally reduced (logically, the better result) in *subscapular skinfold* (SUS) and *abdominal skinfold* (WAC). Only in the variable *upper arm skinfold* (UPC) the values were improved and the significant difference was obtained in favour of the experimental group (p = .03) (Graph 4).

Graph 4. Subcutaneous fatty tissue

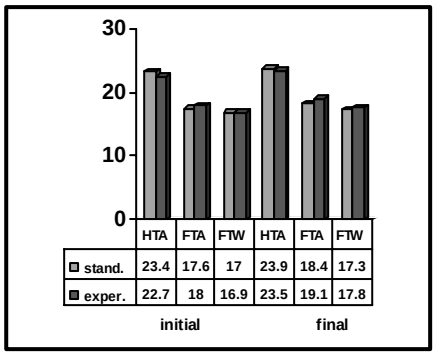


In the Table 2 the results in the system of motor and functional variables are presented. In both the initial and final measurement the control group had better results (the variables are marked with *) in 5 variables, whereas the subjects in the experimental group were better in 16 variables. The contribution of particular variables to multivariate statistical significance of the differences between the two groups at the level of p=.00 was as follows: in the initial measurement 8 variables contributed to the significance (out of which 2 in favour of the control group and 6 in favour of the experimental group), and in the final measurement 14 individual variables (out of which only 1 variable in favour of the control group and 13 variables in favour of the experimental group). Graph 5 displays that in the variables aimed at assessing body coordination – *passing through and jumping over* (PTJ), *agility in the air* (AGA), *obstacle course backwards* (OCB), the results were slightly improved in the final measurement (reduced values mean the better results) in both groups, but with no expected statistical significance in favour of the experimental group. The control group even scored better in the final measurement in the variable *passing through and jumping over* (PTJ).

Graph 5. Body coordination

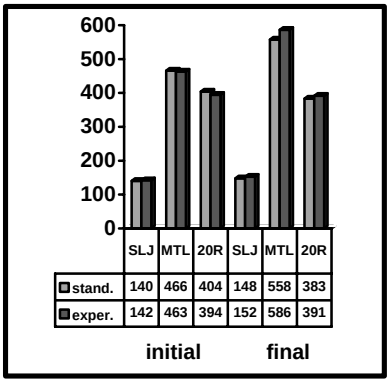


Graph 6. Frequency of movement



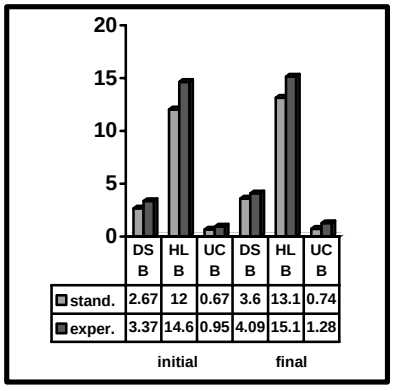
The similar situation is with the motor abilitiy *alternate movement speed (frequency)* (Graph 6): the control group was better in the variable *hand tapping* (HTA) in both measurements, whereas it was better only in the initial measurement in the variable *foot tapping against the wall* (FTW). The experimental group was in the final measurement statistically significantly better (p=.01) in the variable *foot tapping* (FTA). In the test assessing power (explosive strength) (Graph 7) the statistically significant difference in the arithmetic means between the groups (p=.00) was determined in the variable *standing long jump* (SLJ), in favour of the experimental group. Similar is (p=.00) with the variable *medicine ball throw from supine lying* (MTL), but it should be mentioned here that in the initial measurement the control group scored better. In the variable *20m running from the standing start* (20R) the control group achieved better results (reversly scaled), which were significant (p=.00).

Graph 7. Explosive strength



It is obviuos (Graph 8) that the values of all the applied variables assessing motor ability of strength endurance were evenly improved (all-out *declined sit-ups off the bench* - ASB, all-out *hyperextension on the box* - AHB, *undergrip chin-ups on the bar* - UCB and they were statistically significant (p=.01 and =.00) in the initial and the final measurement.

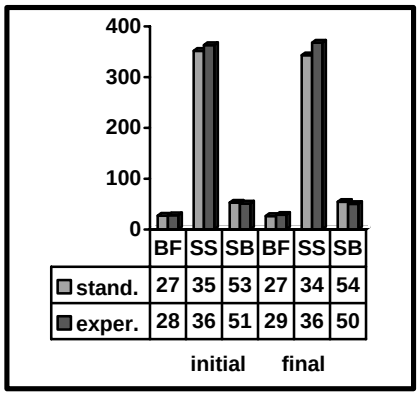
Graph 8. Repetitive strength



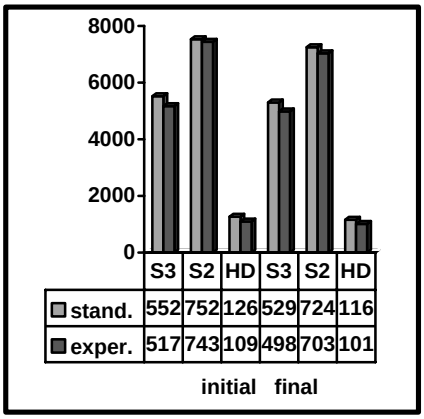
In the motor ability of flexibility (Graph 9) the reults of the experimental group were better in both measurements (*bent forward on the bench* - BFB, *straddle sit-and-reach* – SSR, and *shoulder circumduction backwards with a stick* - SBC), they had the desirable statisitcal significance (p=.04 and p=.00) only in the final measurement and in favour of the experimental group.

In leg-hand coordination (Graph 10), that is, in the variables *slalom with three medicine balls* (S3B) and *hand dribbling* (HDR), the values were reduced (logically, the better result) in both groups in the final measurement. Significant changes occurred only in the variable *slalom by kicking two balls* (S2B). Namely, in the final measurement sigificant difference was obtained between two groups (p=.05) in favour of the experimental group. In the functional ability of *aerobic capacity* (Graph 11) no considerable change was obtained after the application of the experimental programme.

Graph 9. Flexibility

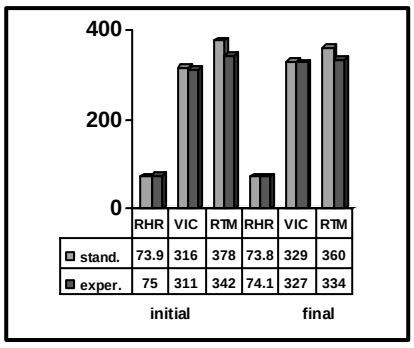


Graph 10. Leg - hand coordination



Only in the variable *heart rate at rest* (RHR) the statistically significant difference (p=.00) in favour of the control group, obtained in the initial measurement, was not maintained in the final measurement (it was transformed in the value at the level of p=.14), due to the reduced (logically positive) values in the experimental group. In the variable *vital lung capacity* (VIC) the values were evenly enhanced in both groups in both measurements, and no statistically significant difference was obtained between the arithmetic means. In the variable *1000 m running* (RTM) the experimental group maintained the the better and statistically significant values level of p=.00.

Graph 11. Aerobic capacity



Discussion and conclusions

It was expected to obtain statistically significant differences in the arithmetic means between the control and the standard group of the boys, elementary school fifth-formers, after the application of the experimental programme based upon sport-specific movement structures (basketball, volleyball, handball, and soccer), in favour of the experimental group both in the entire system of variables (multivariate difference) and in most of individual (univariate differences) morphological and motor and functional variables. The main objective of the research was to utilize multivariate and univariate analysis (MANOVA/ANOVA) in processing of the data collected in the initial and final measurement in order to determine statistically significant differences between the control and the experimental group in arithmetic means of individual variables. Further analysis of the experimental programme should reveal which programme contents induced the greatest changes (differences) in morphological characteristics, as well as in motor and functional abilities, simultaneously having in mind the genetical limitations typical for the children of that age. In the space of morphological characteristics the results indicated that only the entire system of the applied variables contributed equally to the diferentiation between the groups in both the initial and the final measurement, due primarily to the fact that the most morphological variables were under the gene control. From the processed data it is obvious that the experimental programme induced somewhat higher values (although not statistically significant) in the morphological variable *forearm circumference* (FOC), probably under the influence of specific techniques of dribbling, spiking, catching and throwing the ball. The only statistically significant difference in arithmetic means between the two groups was obtained in the variable *upper arm skinfold* (UAS), in favour of the experimental group, at the level of p = .03. The values were reduced (it is logically better rresult) in relation to the somewhat reduced genetical component of subcutaneous fatty tissue, probavly under the influence of the more efficient general exercise activity. In the space of motor abilities the experimental group achieved statistically significantly better results than the control group in the final measurement only in the variables *foot tapping* (FTA), *standing long jump* (SLJ), *medicine ball throws from supine lying* (MTL), *bent forward on the bench* (BFB), *straddle sit-and-reach* (SSR), *shoulder circumduction backwards with a stick* (SBC), *slalom by kicking two balls* (S2B). This means that the experimental programme, consisting primarily of the sport games' movement structures, produced positive changes in the following motor abilities: speed of alternate leg movements, power (explosive strength) of both the upper and lower extremities, flexibility and leg coordination. From the analysis of individual motor abilities it is obvious that the experimental programme had the smallest influence on the transformation of body coordination. Namely, no significant differences were obtained between the two groups in arithmetic means of particular variables either in the initial or the final measurement, and, even more, no significant difference in favour of the experimental group, although expected in this research, was obtained in the final measurement, despite the fact that it is well known that body coordination is under strong genetic control. The finding isa somewhat unexpected because most of the applied sport games' fundamental techniques are inherently composed of coordinated movements, on the one hand, and because, on the other hand, many coordination-type contents were used in the basic motor preparation (combination of a forward roll and a cartwheel, dive over an obstacle into forward roll, rope jumps and hops - one- and two-legged, various obstacle courses, movements performed according to certain rhythmical or aesthetic criteria). Yet, it seems that not enough effort and/or time was dedicated to improvement of this motor abilitiy, very important in sport games. Much more repetitions under the specific and situation-related conditions is obviously neccessary. Statistically significant difference (p=.01) in favour of the experimental group was obtained in the final measurement only in the variable *foot tapping* (FTA), assessing frequency of alternate movements. The improvement in the speed of leg movements was probaly induced by the contents from football, such as kicking the ball, receiving the ball on move, head shot, catching low, intermediate and high passes and others. The biggest and statistically significant differences in the arithmetic means at the level of p=.00 in favour of the experimental group were achieved in the variables *standing long jump* (SLJ) and *medicine ball throw from supine lying* (MTL), used for assessing power (explosive strength) of legs and arms. The differences were probably induced by the following contents: holding, catching and passing the ball; pivots, runner/extended lay-up shot (2-stride run-up for a lay-up, 3-stride run-up for a lay-up), set shooting and kicking and shooting and kicking from moving, punching the ball (spikes), head shots, rebounding, block jumps and others. In the variables *all-out declined sit-ups off the bench* (ASB), *all-out hyperextension on the box* (AHB) and *undergrip chin-ups on the bar* (UCB), which were used to assess strength endurance, the experimental group scored statistically significantly better (p=.01 and p=.00) in both the initial and final measurement. That can probably be attributed to the fact that the mandatory PE contents were applied in both groups (callinetics in place and on move, carrying each other in pairs and triples, pushing and pulling each other in pairs). The greatest changes in the experimental group were achieved in the variables *bent forward on the bench* (BFB), *straddle sit-and-reach* (SSR) and *shoulder circumduction backwards with a stick* (SBC), which were applied to assess motor

ability of flexibility. In the final measurement the significant differences were obtained between the arithmetic means (p=.04, p=.00), due primarily to the application of stretching in the preparatory part of the classes/workouts (warming-up) of the experimental programme. Large changes in favour of the experimental group were achieved in the motor ability of leg-hand coordination, especially in the variable *slalom by kicking two balls* (S2B), because in the initial measurement there was no statistically significant difference between the groups in arithmetic means. The statistically significant differences in the final measurement (p=.05) in favour of the experimental group can probably be attributed to the technical drills consisting of straightforward and zig-zag dribbling and of feinting in place and on move. In the space of functional abilities no significant changes occurred because the statistical significance of the difference between the initial and the final meaurement at the level of p=.00 occurred only in the variable *1,000 m running* (RTM) in favour of the experimental group, probably due to longer (aerobic) running sessions in the introductory part of the classes/training sessions (the so called warming-up), when the subjects were preparing themselves for the main part of a class/training session, as well as due to fartlek up to 300m (continuous running of variable paces), which was a component of the experimental programme. Research results show that the whole system of applied morphological variables has equally contributed to differentiation between standard and experimental groups, due to the fact that most of the morphological variables are genetically controlled. As for the motor and functional abilities, the final measurements in experimental group indicate that experimental program has caused statistically significant changes in motor abilities with seven variables for evaluation of speed of leg movement frequency, leg-arm explosive strength, leg-arm flexibility and leg coordination.

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PROMJENE BIOMOTORIČKIH DIMENZIJA UČENIKA UZRASTA 11 GODINA: EKSPERIMENTALNI PROGRAM SPORTSKIH IGARA U ODNOSU NA STANDARDNU NASTAVU TJELESNOG ODGOJA

Sažetak

Na uzorku od 252 dječaka, starosti 11 godina ±6 mjeseci, podijeljenih na kontrolnu (CG; N=127 subjekata) i eksperimentalnu grupu (EG; N=125 subjekta), sistem od 33 mjerna instrumenta je upotrijebljen (12 morfoloških i 21 motorička i funkcionalna varijabla). Cilj je bio odrediti promjene u morfološkim karakteristikama kao i u motoričkim i funkcionalnim mogućnostima kod dječaka nakon jednogodišnje upotrebe eksperimentalnog programa kod eksperimentalne grupe, sastavljene od osnovnih sportskih igara (košarka, odbojka, rukomet i fudbal), i standardnog TO programa, baziranog na statističkom značaju razlika aritmetičkih sredina upotrijebljenih varijabli između kontrolne i eksperimentalne grupe u početnim i krajnjim mjerenjima. Statistički značajne razlike između kontrolne i eksperimentalne grupe u aritmetočkoj sredini korištenih varijabli početnih i finalnih mjerenja su određene pomoću multivarijantnr i univarijantne analize varijance (MANOVA/ANOVA). Izračunate statističke vrijednosti su dale do znanja da u cijelom sistemu statistički bitne varijacije postoje između kontrolne i eksperimentalne grupe u početnim i krajnjim mjerenjima na nivou od p=.00. Rezultati su pokazali da su ispitanici u obje grupe bolje rezultate ostvarili na početnom nego na krajnjem mjerenju u 6 različitih morfoloških varijabli. U krajnjem mjerenju, nakon eksperimentalnog programa, EG je imala bolje vrijednosti u 8 varijabli (od kojih jedna na nivou p=.03), gdje je CG bila bolja u samo 4 varijable. Rezultat pokazuje da samo cijeli sistem primijenjenih morfoloških varijabli podjednako doprinosi diferencijaciji grupa, i u početnim i u krajnjim mjerenjima. U prostoru motoričkih i funkcionalnih sposobnosti ispitanici u CG su bili bolji u 5 varijabli u oba mjerenja, gdje su ispitanici iz EG bili bolji u 16 varijabli. U početnim mjerenjima 8 individualnih varijabli (od kojih 2 u korist CG i 6 u korist EG), je doprinijelo multivarijantnom statističkom značaju razlika u grupnoj aritmetičkoj sredini na nivou od p=.00, a u krajnjem mjerenju 14 varijabli je doprinijelo statističi bitnoj razlici (od kojih jedna u korist CG i 13 u korist EG). Ovo je pokazalo da eksperimentalni program, sastavljen od strukturalnih kretnji sportskih igara realizovanih u EG, dovodi do statistički značajnih promjena u motoričkim i funkcionalnim mogućnostima izmjerenim u 7 varijabli koje ocjenjuju brzinu rada nogu, eksplozivnu snagu ruku i nogu, fleksibilnost ruku i nogu, i koordinaciju udova.

Ključne riječi: *morfološke karakteristike, motoričke sposobnosti, funkcionalne sposobnosti, 11-12 godina, dječaci, učinci vježbi, eksperimentalni program, sportske igre*

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