

## DIFFERENTIATION IN MORPHOLOGICAL CHARACTERISTICS, BASIC-MOTOR AND FUNCTIONAL ABILITIES OF HIGH SCHOOL STUDENTS

Adnan Bukvić<sup>1</sup>, Dževad Džibrić<sup>2</sup>, Admir Hadžikadunić<sup>3</sup>, Rijad Novaković<sup>4</sup>

<sup>1</sup>"Rizah Odžekić" Gymnasium, Zavidovići

<sup>2</sup>Faculty of Physical Education and Sport, University in Tuzla

<sup>3</sup>Faculty of Criminalistics, Criminology and Security Studies, University in Sarajevo

<sup>4</sup>Faculty of Teacher Education, University "Džemal Bijedić" in Mostar

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### Abstract

*One of the main accompanying parts of the growth and development of students is their systematic monitoring of certain anthropological dimensions. This research, which is of a transversal character, had a goal to determine differences in morphological characteristics, basic-motor and functional abilities between students from different grades of high school. The population from which the sample of 349 respondents was taken is defined as the population of the first, second, third and fourth grades students from Zavidovići high schools, male, 15 to 18 years old  $\pm$  6 months. The sample of variables consisted of a set of 20 (twenty) tests for the assessment of anthropological dimensions, as follows: morphological characteristics (4 variables), basic-motor abilities (15 variables) and functional abilities (1 variable). A univariate analysis of variance with multiple comparisons was used to determine the differences in the study spaces between students of different grades of high school, with the applied Bonferroni post-hoc test. The obtained results showed that there are statistically significant differences in three of the four morphological variables (body height, body weight and body mass index), in eight of fifteen motor abilities (ball rolling with non-dominant hand, direction switch on training ground, side stepping, figure eight with crouching, running transmission, forward bend on the bench, standing long jump and sit-ups) and one functional variable (1000 m run) between the treated groups at the significance level ( $p \leq 0.05$ ). The obtained results can be subject to a critical analysis of the physical and health education teaching process in order to more efficiently organize and rationalize the teaching of physical and health education. This data may show certain shortcomings of year-round application of funds as part of the realization of the high school plan and program.*

### INTRODUCTION

Physical and health education for many young individuals during the growth and development phase is the only opportunity to engage in organized physical activity. This is why this deduction in today's world dominated by sedentary lifestyle gives this subject an invaluable significance (Petrić et al., 2012). It can already be concluded that compulsory physical and health education must be one of the health basis of the entire population when it comes to mobility for it contributes significantly to the quality development of society as a whole. The health contribution of physical education and health education is mostly manifested and based on ensuring the optimal development of anthropological features of children and youth. Increasing number of researchers daily explore the anthropological features of the school population (Jurak et al., 2015). Monitoring of physical development and the development of motor skills of students within the physical and health education classes has been conducted for relatively long time. In recent years, papers written particularly by American authors have been published, discussing certain issues and questions related to the monitoring of the

anthropological features among children and youth within the framework of physical education and health education classes (Morrow & Ede, 2009; Mahar & Rowe, 2008; Harris & Cale, 2006; Keating & Silverman, 2004).

During high school education, young people go through this period of late adolescence which usually noticeable among boys aged 10 to 22 (Malina & Bouchard, 1991; Pangrazi & Darst, 1997). During adolescence, young people go through bio-psycho-social changes that prepare them for adulthood (Himberg, Hutchinson, Roussell, 2003).

Physical and motor development of boys does not stop in high school. Researches (Strel et al., 2003; Strel, Kovač, & Rogelj, 2006) show that boys grow slightly more than 3 cm and gain about 5 pounds during a period from 16 to 19 years (Strel et al., 2003; Strel, Kovač, & Rogelj, 2006). Boys' motor skills tests are improved as they go through high school (Brettschneider & Naul, 2004; Kondrich, 2000; Kovač, 1999; Strel, Kovač, Rogelj, 2005a).

The main goal of this research is to determine the differences in morphological characteristics, basic-motor and functional abilities among high school students from 1st, 2nd, 3rd and 4th grades.

## METHODOLOGY OF WORK

### Sample of respondents

The research was conducted in 3 high schools in Zavidovići (Gymnasium "Rizah Odžević", Mixed High School and Secondary Technical School). The population from which the sample of 349 respondents was taken was defined as the population of pupils of the first, second, third and fourth grades from Zavidovići high schools, male, 15 to 18 years old  $\pm$  6 months. Only respondents whose health allowed them to attend physical education and health education classes were subjected to the study, and to not show any morphological, motor or psychological irregularities.

### Sample of variables

The sample of variables was comprised of a set of 20 tests for the evaluation of anthropological dimensions, appropriate to the age of the studied population (Neljak et al., 2011). For the assessment of anthropometric characteristics, 4 variables were applied: ATJVIS (body height), ATJTEZ (body weight), APOSMA (percentage of fat), AITJMS (body mass index).

## RESULTS AND DISCUSSION

Before conducting the variance analysis, a procedure for determining the homogeneity of the variance was carried out in order to continue further with the procedure. The Leven test has confirmed that the homogeneity was disrupted at the level ( $p \leq 0.01$ ) in the morphological test body fat percentage, and in open leg forward bend and a high start sprint at 20 m *motor tests*. Since the discrepancy in the assumption of variance equivalence has been established, a more strict alpha level will be used to calculate the significance of the univariate F-test for these variables (Tabachnick & Fidell 2007). A more strict alpha level is ( $p \leq 0.01$ ).

For the assessment of basic-motor abilities, 15 variables were applied: *Coordination* - MKOPLN (training ground backwards), MKOKLR (ball rolling with non-dominant hand), MKOPLO (direction switch on training ground); *Agility* - MAGKUS (side stepping), MAGOSS (figure eight with crouching), MAGPRP (running transmission); *Flexibility* - MFLPRR (open leg forward bend), MFLPRK (forward bend on the bench), MFLPRU (narrow open leg bend); *Explosive power* - MESSDM (standing long jump), MESS20 (high start sprint at 20 m), MESBML - throwing 1kg medicine ball while lying; *Repetitive power* - MRSPTL (sit-ups), MRSPTK (short sit-ups), MRSCUC (squats). For the evaluation of functional abilities, the variable MF1000 (1000 m run) was applied.

### Data processing methods

During the data analysis, the central and dispersive parameters, the arithmetic mean and the standard deviation were calculated. A *univariate analysis of variance with multiple comparisons* was used to determine the differences in the studied spaces between high school students of different grades, with the applied Bonferroni post hoc test.

The analysis of variance revealed the existence of statistically significant differences in three of the four morphological variables (body height, body weight and body mass index), in eight of fifteen motor abilities (ball rolling with non-dominant hand, direction switch on training ground, side stepping, figure eight with crouching, running transmission, forward bend on the bench, standing long jump and sit-ups) and one functional variable (1000 m run) among the treated groups at the significance level ( $p \leq 0.05$ ). The absence of discrepancy was not found in one morphological variable (percentage of fat) and seven motor variables (training ground backwards, open leg forward bend, narrow open leg forward bend, high start sprint at 20 m, throwing 1kg medicine ball while lying, short sit-ups and squats).

**Table 1.** Arithmetic mean  $\pm$  standard deviation (minimum and maximum value); ANOVA (F - test, statistical significance), morphological characteristics, basic-motor and functional abilities between students of different grades

VARIABLES	GRADE 1 (N = 77)	GRADE 2 (N = 101)	GRADE 3 (N = 106)	GRADE 4 (N = 65)	ANOVA	
	AS $\pm$ SD	AS $\pm$ SD	AS $\pm$ SD	AS $\pm$ SD	F	Sig.
ATJVIS	176,55 $\pm$ 9,18 (149,70-196,40)	178,38 $\pm$ 8,71 (154,30-198,70)	<b>180,75 <math>\pm</math> 9,18*</b> (155,20-200,80)	<b>181,27 <math>\pm</math> 7,40*</b> (159,40-203,50)	4,981	,002
ATJTEZ	68,16 $\pm$ 10,41 (41,50-109,40)	68,67 $\pm$ 10,98 (39,40-104,70)	71,38 $\pm$ 10,46 (43,90-105,50)	<b>74,20 <math>\pm</math> 10,42*</b> (46,20-110,50)	5,131	,002
APOSMA	16,34 $\pm$ 6,28 (4,00-38,50)	16,31 $\pm$ 6,10 (4,00-38,80)	17,15 $\pm$ 7,57 (5,00-39,20)	17,76 $\pm$ 9,16 (5,40-37,30)	,718	,542
AITJMS	21,76 $\pm$ 2,01 (18,23-31,85)	21,45 $\pm$ 1,80 (16,96-29,62)	21,70 $\pm$ 1,39 (18,31-27,32)	<b>22,47 <math>\pm</math> 1,88*</b> (18,20-30,15)	4,616	,004
MKOPLN	11,31 $\pm$ 3,78 (5,89-22,91)	11,06 $\pm$ 3,54 (6,15-22,82)	10,75 $\pm$ 3,11 (5,77-21,40)	10,54 $\pm$ 2,99 (5,91-21,49)	,763	,515
MKOKLR	16,96 $\pm$ 3,25 (7,74-26,72)	16,10 $\pm$ 3,83 (7,53-29,83)	15,80 $\pm$ 3,64 (7,78-25,65)	<b>15,29 <math>\pm</math> 3,02*</b> (7,57-26,92)	2,924	,034
MKOPLO	8,06 $\pm$ 2,82 (4,77-17,85)	7,73 $\pm$ 2,51 (4,45-16,54)	7,33 $\pm$ 2,17 (4,33-15,25)	<b>6,87 <math>\pm</math> 2,03*</b> (4,25-14,90)	3,315	,020
MAGKUS	9,38 $\pm$ 1,37 (6,48-13,55)	9,27 $\pm$ 1,06 (6,22-13,44)	9,19 $\pm$ 1,42 (5,83-15,79)	<b>8,60 <math>\pm</math> 1,323*</b> (6,15-13,18)	5,208	,002
MAGOSS	8,99 $\pm$ 1,30 (6,45-13,69)	8,77 $\pm$ 1,17 (6,52-12,95)	8,62 $\pm$ 1,17 (6,40-13,86)	<b>8,43 <math>\pm</math> 1,11*</b> (6,45-13,66)	2,937	,033
MAGPRP	10,74 $\pm$ 1,87 (7,15-17,82)	10,39 $\pm$ 1,52 (7,10-14,98)	<b>10,03 <math>\pm</math> 1,46*</b> (7,39-15,15)	<b>9,97 <math>\pm</math> 1,40*</b> (7,92-14,55)	4,127	,007
MFLPRR	52,93 $\pm$ 13,57 (24,00-102,00)	53,68 $\pm$ 12,69 (25,00-99,00)	52,93 $\pm$ 10,50 (19,00-96,00)	54,69 $\pm$ 12,37 (20,00-98,00)	,344	,793
MFLPRK	39,39 $\pm$ 7,28 (15,00-62,00)	41,27 $\pm$ 9,71 (12,00-67,00)	<b>43,10 <math>\pm</math> 9,92*</b> (13,00-69,00)	<b>45,00 <math>\pm</math> 8,56*</b> (14,00-68,00)	5,187	,002
MFLPRU	43,07 $\pm$ 14,04 (9,00-92,00)	45,05 $\pm$ 13,44 (14,00-87,00)	45,39 $\pm$ 11,39 (13,00-88,00)	46,03 $\pm$ 13,63 (16,00-86,00)	,722	,539
MESSDM	195,24 $\pm$ 27,48 (110,20-262,40)	200,26 $\pm$ 27,74 (105,70-270,60)	204,20 $\pm$ 26,34 (111,30-279,30)	<b>209,39 <math>\pm</math> 26,68*</b> (125,50-277,60)	3,587	,014
MESS2O	3,63 $\pm$ 0,56 (2,69-4,92)	3,57 $\pm$ 0,48 (2,72-4,96)	3,56 $\pm$ 0,46 (2,91-5,18)	3,53 $\pm$ 0,38 (2,88-5,05)	,646	,586
MESBML	114,98 $\pm$ 33,52 (72,00-216,80)	116,43 $\pm$ 33,20 (78,60-225,60)	116,86 $\pm$ 31,24 (75,40-231,20)	117,97 $\pm$ 29,03 (86,50-235,50)	,109	,955
MRSPTL	46,41 $\pm$ 10,93 (12,00-77,00)	48,76 $\pm$ 9,86 (19,00-85,00)	50,00 $\pm$ 10,22 (15,00-79,00)	<b>54,48 <math>\pm</math> 12,04*</b> (25,00-84,00)	7,119	,000
MRSPTK	60,83 $\pm$ 17,72 (15,00-103,00)	63,73 $\pm$ 12,98 (28,00-100,00)	62,97 $\pm$ 13,50 (19,00-105,00)	63,61 $\pm$ 13,70 (25,00-104,00)	,692	,558
MRSCUC	47,88 $\pm$ 10,53 (13,00-73,00)	48,77 $\pm$ 10,48 (12,00-72,00)	49,12 $\pm$ 10,03 (15,00-77,00)	50,07 $\pm$ 9,46 (20,00-76,00)	,567	,637
FT1000	298,78 $\pm$ 110,4 (122,00-750,00)	279,15 $\pm$ 99,25 (187,00-720,00)	275,63 $\pm$ 96,01 (169,00-635,00)	<b>248,37 <math>\pm</math> 66,05*</b> (174,00-520,00)	3,290	,021

\* STATISTICALLY IMPORTANT DIFFERENCES COMPARED TO VALUE OF 1st GRADE;  $P \leq .05$ .

† STATISTICALLY IMPORTANT DIFFERENCES COMPARED TO VALUE OF 2nd GRADE;  $P \leq .05$ .

‡ STATISTICALLY IMPORTANT DIFFERENCES COMPARED TO VALUE OF 3rd GRADE;  $P \leq .05$ .

In order to determine which grades show differences in variables that showed statistical significance of the differences, subsequent tests with the Bonferroni Correction Factor were used.

When it comes to morphological variables, the results obtained show that the students of the third and fourth grades statistically significantly differ in the body height from the first grade students, with the mean values higher between these two grades compared to the first grades. Although there were no statistically significant

differences between the students of the second, third and fourth grades, there is a visible tendency that students in higher grades are higher. Otherwise, the most intense growth among boys is between 13 and 15.5 years, so that boys grow for about 20 cm during that period. (Medved et al., 1987). The results of the research (Prebeg, 1977) show that the average growth of young men definitely ends at 19, although the increase in height after the age of 17 among young men is only minimal.

When it comes to body weight, statistically significant differences can be seen between the fourth grade students and the first and second grade students, with higher mean values among students of older grades, while there were no statistically significant differences between the third grade students with the students from the first, second, and fourth grades. This variable also shows that there is a noticeable tendency of growth among higher grades. The average body mass among boys is constantly increasing until they are 19, with the largest average body mass increase noted between 12 and 14 years (Medved et al., 1987).

When it comes to body mass index, there is a statistically significant difference between the fourth grade students and the students in the second and third grades. Higher mean values are among the oldest students, while there are no statistically significant differences between the first grade students and the second, the third and the fourth grade students, and among second and third grade students.

When it comes to motor variables, the obtained results show that fourth grade students statistically significantly differ from the first grade students in co-ordination estimation variables (ball rolling with non-dominant hand and direction switch on training ground), where the first grade students have higher mean values, which in fact is a worse result in the test because it is a time test where a numerically lower value is a better result.

In terms of agility estimation variables (side step, figure eight with crouching and transmission running) statistically significant differences have been reached in all three tests between first and fourth grade students, where fourth grade students have better results. Fourth grade students are statistically significantly different from the students of the second and third grades in the side step test where they also showed better results. The statistically significant differences between the first and third grade students were achieved in the transmission running test where older students had better results. Although a sensible period for agility development is hard to find in any literature, there are, however, guidelines that determine the long-term approach to its periodization. Agility is the complex ability that belongs to the area of coordination abilities (Beachle & Earle, 2008), and represents the ability of rapid and effective change of direction movement (Brown and Ferrigno, 2008). Therefore, the period before puberty (12-17 years, male) is very favorable for its development. Agility depends largely on dynamic equilibrium and explosive and elastic strength, which can be optimally developed during and after puberty, so it is therefore necessary to develop during those

developmental periods. According to Malin et al., (2004), agility has the same development curve as the maximum running speed. It is also important to note that specific speed and agility are largely dependent on the motion mechanics. The motion mechanics is a prerequisite for the effectiveness of movement to which the emphasized neuro-muscular and energy training speeds (as part of the advancement of specific speed and agility) are upgraded. It greatly influences the advancement of the movement speed (frequency and length of steps) and especially agility (Brown and Ferrigno, 2005).

When it comes to flexibility, in the forward bend on the bench, there were statistically significant differences between the first and third grade students in favor of the older students.

In the assessment of the lower extremities explosive strength, standing long jump, the first grade students were significantly different from the fourth grade students in favor of the older students. The explosive force of the type of horizontal and vertical jump increases linearly from 5 to 18 years for boys (Malina 2004). According to Issurin, (2008), we can affect the explosive power of kinesiological operators by training from 13 to 17 years.

In the test for the evaluation of repetitive strength of the abdominal musculature, sit-ups, the fourth grade students have statistically better results compared to the students of the first, second and third grades. Increasing the level of strength in physical and health education affects the optimal development of internal organs, hormonal and locomotor systems (Hollmann and Hettinger, 2000; Rusch and Weineck, 1998). Therefore, it would be of great benefit for every physical and health education teacher to find places for improvement of this motor skill during their annual program. Despite all of the benefits it has on development of a student body's strength, it is only part of the spectrum of all the motor skills needed to improve the overall anthropological status of the student.

If we look back at the earlier studies related to muscles, in men, 40% of body weight are muscles, and fat in the hands and feet of adolescent boys is reduced, so they are increasingly gaining muscle strength (Medved et al., 1987). Boys show significant uplift in strength, speed and endurance, which continues throughout their teenage years (Berk, 2005). Research has also shown that boys achieve the best results in the area of co-ordination between 10 and 12 years of age and a maximum of 14 years (Fach, 1998).

The differences found in the motor space are also compatible with previous researches (Pelemiš and Stević, 2008; Brettschneider & Naul, 2004; Kondrič, 2000; Kovač, 1999; Strel, Kovač, Rogelj, 2005a).

When it comes to functional abilities, evaluated by a 1,000-meter run test, results obtained show statistically significant differences only among the fourth and first grade students in favor of the older students. Functional abilities are responsible for the level and regulation of the energy transport system, involving numerous internal organs, primarily cardio-vascular and respiratory systems. The oxygen transport system can be changed more efficiently under the influence of cyclical character stimuli. Cyclic activities have an effect on the increase in aerobic capacity; they are easily implemented in all working conditions and a motivational effect on students (Findak, 2001). Physical activity enhances the work of all organs and prevents disorders, so the need for natural forms of movement should not be absent, especially in young people's lives.

## CONCLUSION

The obtained results show that statistically significant differences have been identified between the tested sub-samples. The analysis of variance showed existence of statistically significant differences in three of the four morphological variables, in eight of the fifteen basic-motor and one functional variable between the treated groups at significance level ( $p \leq 0.05$ ). Differences between sub-samples (grades) appeared between the first and fourth grades in three morphological, seven basic-motor and one functional variable. Between the first and third grades in one morphological and two basic-motor variables. Between the second and the fourth grades in two morphological and

two basic-motor variables. Between the third and fourth grades in one morphological and two basic-motor variables.

The occurrence of the difference is not noted between the first and the second, or the second and third grades in variables where statistical significance exists.

During the preparation of the teaching process teachers must make analysis of executive plans and evaluation of the implemented program based on which the information will be obtained about the extent certain teaching contents have been repeated, what kind of methodological and organizational forms of work have been used and whether they have motivated enough students to work. Such analysis will require corrections where the frequency of certain teaching contents will be increased, and attention will be kept on the transfer of motor skills, retrograde inhibition and aim of anthropological changes. More complex methodological and organizational forms of work will be used, which should result in a higher level of motor knowledge as well as the development of motor skills, and greater motivation of children to work (Neljak, 2013).

The results of the analysis confirmed that teachers have to undergo serious planning and implementation of the teaching process, which will be based on scientific principles that arose as a result of practical and theoretical knowledge in the curriculum of physical and health education (Hadžikadunić and Mađarević, 2004; Neljak, 2013). Such an attitude will increase the contribution of physical and health education to the formation of the entire personality, which is also one of the tasks of this subject.

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Corresponding author:

Dževad Džibrić, PhD.

Faculty of physical education and sport, Tuzla University

e-mail: dzevad.dzibric@untz.ba