

Analysis of Quantitative Changes of High School Students' Morphological-Motor Characteristics under the Impact of Regular Physical Education Classes

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Abstract

The research was conducted on a sample including 166 participants - male students of "Combined Technical High School" from Travnik, who attended physical education classes regularly during the school year. In the research, five variables were used to assess the morphological status, and nine variables to assess the motor status of the participants according to the Eurofit Fitness Test Battery. The main aim of the research was to determine quantitative changes in morphological and motor status of secondary school students during one school year under the impact of programme content of regular physical education classes through a longitudinal study. Quantitative changes in morphological and motor status and analysis of differences between the initial and final measurements were determined by analysis of changes under the model of differences and standard model of multivariate changes (SSDIF analysis, Bonacin, 2004). A hypothetical measurement matrix was defined by projecting the measurement data, and explicating a set of linear shifts on the association matrix, which resulted in obtaining structural vector describing quantitative changes, while taking into account relations of the initial variables. Results of the SSDIF analysis indicate that a one-year curriculum of physical education has caused statistically significant changes at the global level ($p = 0.0000$) in both investigated areas, but the changes that have occurred are mild. Significant quantitative changes in the motor space occurred in body height

and weight, and in the triceps skinfold, as well as in the following variables in the motor space: running 10×5 m (sideways), lifting the trunk from the lying on back position and the hand dynamometry, and the biggest and most statistically significant global quantitative changes occurred in the 20 m test run sideways with progressive acceleration (ŠATL20 0.8439).

Key words: *morphological characteristics; motor skills; physical and health culture; quantitative changes.*

Introduction

Physical and health culture in Bosnia and Herzegovina is a compulsory subject in primary and secondary schools, as it is the most important part of the educational system aimed at improving and strengthening students' health, growth and development. High quality physical and health culture enables proper body growth, development of motor abilities and skills, but also formation of knowledge, attitudes, values, social skills, and self-confidence, necessary for adopting and maintaining a physically active lifestyle, as well as doing sports in leisure time (Findak et al., 2000, 2011). Effects of physical and health culture classes are primarily reflected in their positive impact on the growth and development of a young organism, on the one hand, and increase in motor skills, on the other hand (Blažević & Bonacin, 2006; Milanović et al., 2009; Neljak, 2015; Višnjić et al., 2004). All European countries recognize the importance of physical and health education at school. The education system in Bosnia and Herzegovina is in the process of transition, and schools are going through the process of redefining the role of teachers and position of students in the teaching process. The Council of Europe set it as a priority and called for the launch of pan-European research into the policy and practice of physical and health education in schools every five years. Each member country should set up its own centre for monitoring curricula of physical and health education in schools, education of physical and health education teachers or 'twinning' among sports schools and similar (under the European Union's Sports Support Programme, 2014). New curricula of physical and health education in schools are also being introduced within the education system reform. At the same time, along with their application, attempts have been made to start systematic monitoring of the programmes' effects, with the desire to accomplish not only continuous insight into the course of their implementation, but also their upgrading and improvement based on the experience acquired. In order to be able to act upon a student systematically through physical and health education, i.e. on their physical development, development of a range of their motor skills, their cognitive and connotative dimensions, it is necessary to establish the existing situation and to determine guidelines for their transformation on those grounds. In this sense, a need has emerged for permanent monitoring and testing of students. The Eurofit Fitness Test Battery, proposed by the European Council in 1988, is used for the process of monitoring and testing physical development and motor skills of students in the primary and secondary education systems in Bosnia and

Herzegovina. Application of this test battery has brought certain novelties in relation to the previous method of monitoring physical development and motor skills of students and contributed to the improvement of overall teaching quality of physical and health culture in Bosnia and Herzegovina. However, in the past few years, in the US and some European countries, there has been a completely new perception of the purpose and aim of monitoring physical development and motor skills of students in physical and health education, mainly based on a certain number of studies that point to the link between physical development, motor skills and health of children and young people (Ortega et al., 2008). A question is justifiably posed as to how to respond to changed living and working conditions in a modern society through regular classes of physical and health education (and other extracurricular and out-of-school activities) and how to use comparative advantages of physical exercise in civilized living conditions (Findak, Metikoš, & Mraković, 1999; Milanović et al., 2015). In this respect, systematic and uninterrupted work throughout the school year must be a fundamental requirement that is placed upon the students and teachers of physical and health education.

Therefore, the aim of this research is focused on determining quantitative changes of morphological and motor status of secondary school students under the impact of the current curricula content of regular physical and health culture classes.

Methods

The Participant Sample

The research was conducted on a sample of about 166 participants – male students of 1st and 2nd grades of the “Combined Technical High School” from Travnik, who attended regular classes of physical and health culture in the school year 2016/2017. The total sample of 166 students was not based on any criteria that may be correlated with the manifesting anthropological dimensions. The only criterion by which the students acquired the right to be a part of the sample was to be consistently present during the teaching process and to be completely healthy (all the students who were ill at the time of measurement and testing and attended the classes, were omitted from the sample). The research was carried out during regular classes of physical and health culture.

The Variables Sample

Variables applied for the assessment of morphological and motor status of students were those selected from the Eurofit Fitness Test Battery. Decision to use this test battery resulted from the fact that it is obligatory in the process of monitoring and testing physical development and motor skills of students in elementary and secondary education system in Bosnia and Herzegovina.

Sample of Variables for the Assessment of Morphological Characteristics

The following variables were applied for the assessment of morphological characteristics: body height (AVISTL), body weight (ATEŽTJ), biceps skinfold

(ANABIC), triceps skinfold (ANATRI), back skinfold (ANALEĐ), abdomen skinfold (ANATRB) and lower leg skinfold (ANAPOT).

Sample of Variables for the Assessment of Motor Skills

The following variables were applied for the assessment of motor skills: standing long jump (MFESDM), lying – sit up (MRCDTL), elasticity – mobility of hip joints (MFLPRK), hand tapping (MBFTAP), running 10 x 5 m (sideways), (ŠATL10x5), pull-up (chin-up) endurance test (MSAVIS), flamingo balance (FLAMIN), hand dynamometry (MBFDIN) and 20 m run sideways with progressive acceleration (ŠATL 20).

All variables were measured according to description of tests by Hadžikadunić, Rađo, Grozdanić, and Turković (2000).

Statistical Analysis

Quantitative changes (effects) and analysis of differences between the initial and final measurements were determined by analysis of changes under the model of differences, and based on the programme of SSDIF analysis (Bonacin, 2004). Effects of quantitative changes are analysed by Bonacin-Rađo model (2004), which assumes that quantitative changes are only those changes that lead to identical variables relations and therefore the same factor structures. Hypothetical measurement matrix was defined by projecting the measurement data, and explicating a set of linear shifts on the association matrix, which resulted in a structural vector describing quantitative changes, while taking into account relations of the initial variables.

Curriculum of Physical and Health Culture

Curriculum for regular classes of physical and health culture for the 1st and 2nd grade of Combined Technical High School was conducted for 70 school hours (twice a week for 2 school hours), during the school year 2016/2017. Within planning of regular physical and health culture classes, goals and tasks were defined, as well as time cycles (periodisations) for their accomplishment, and necessary technical and material conditions. Programming of work was focused on determining content, load and methods of work for the development of anthropological characteristics and motor skills of students. Selection of motor skill exercises was made, load dosage and schedule of the curriculum content consistent with the goals and tasks of the programmes content were defined. Performance of programme tasks of regular physical and health culture classes was appropriate for the abilities and characteristics of the students and was carried out within homogenised groups. The structure and content, in the main part of the class, contained the teaching materials of sports games, general physical preparation, sports gymnastics, athletics, dance and social games, as well as additional exercises during the class when the students were waiting for their turn to participate.

Results

Quantitative Changes Analysis

Quantitative changes are the changes that result in general increase or decrease of the accompanying parameters functions, and mathematically they come down to a degree of differences in vectors describing characteristics, abilities or features of the participants (entities) in two or more time points or the difference in vectors describing characteristics of two or more groups of participants described in two or more time points. Recently, a whole set of procedures has been developed that can be used to determine quantitative changes in some of the characteristics, abilities or features of the participants (entities) relatively reliably, but without affecting changes of relations between these control parameters (variables).

Results of the SSDIF Analysis of Quantitative Changes in Morphological Characteristics

Table 1 shows the results of SSDIF analysis of quantitative changes in morphological characteristics created under the impact of curriculum content of physical education. Based on the results presented, it can be seen that quantitative changes at the global level are statistically significant. The Mahalanobis distance between the centroids of the vector of status shows that the difference between the initial and final measurements is statistically significant. The results of SSDIF analysis indicate that global effects have truly been caused, but they are mild and without dramatic changes. There were statistically significant changes in body height (AVISTL 0.7870), body weight (ATEŽTL 0.6737) and in triceps skinfold (ANATRI 0.1780).

Table 1

Results of the SSDIF analysis of quantitative changes in morphological characteristics

Variables	A	D	S	R
AVISTL	22.307	0.4665	12.262	0.7870
ATEZTJ	33.494	0.3829	10.497	0.6737
ANABIC	0.0910	0.0411	0.0375	0.0240
ANATRI	0.5205	0.1484	0.2774	0.1780
ANALED	-0.0807	-0.1202	-0.0264	-0.0169
ANATRB	0.2608	-0.1679	0.0824	0.0529
ANAPOT	-0.3012	-0.1915	-0.1235	-0.0793
M			=	2.4276
H			=	402.9875
F			=	55.4762
DF1			=	7
DF2			=	159
P			=	0.0000

Note. A-differences in arithmetic means, D-discriminant coefficients, S-standardized orthogonal projections, R-structure of factor discrimination, M- the Mahalanobis distance between the centroid of vectors of the initial and final measurements, H-Hotelling's T test, F-test for variance analysis, DF1 and DF2 - degrees of freedom, P - the level of significance, i.e. an error used to assert that there have been significant changes

Table 2 demonstrates partial tests of hypotheses on differences. Based on the results in the given table, it can be seen that partial quantitative changes occurred in the following variables: body height (AVISTL 0.000), body weight (ATEŽTL 0.0000) and triceps skinfold (ANATRI 0.0008).

Table 2
Partial tests of hypotheses on differences

Variables	F	P
AVISTL	24.95973	0.0000
ATEZTJ	18.29104	0.0000
ANABIC	0.2330	0.6356
ANATRI	127,696	0.0008
ANALED	0.1153	0.7344
ANATRB	11,277	0.2898
ANAPOT	25,314	0.1094
DF1 = 1		DF2 = 165

Note. F - test, P - probability

Orientation of Quantitative Changes in Morphological Characteristics

In the further process of the analysis, global directions of development of the aforesaid changes of morphological characteristics have been presented. Table 3 shows the results of SSDIF analysis of morphological characteristics - oblique rotated promax of the measurement differences set gives us information on the orientation of the aforesaid quantitative changes. Based on the results presented in Table 3, it can be seen that the changes of morphological characteristics took course in two global directions, i.e. that morphological mechanisms acted in two directions. The first direction (factor) describes body weight (ATEŽTJ), triceps skinfold (ANATRI), back skinfold (AKNLED), abdomen skinfold (AKNTRB) and lower leg skinfold (ANAPOT). This means that morphological mechanisms acted on the change (reduction) of body mass and subcutaneous fat tissue. The second direction (factor) describes body height (AVISTL 0.8771) and biceps skinfold (ANABIC -0.4850).

Table 3
Results of the SSDIF analysis of morphological characteristics
- Oblique rotated promax of the measurement differences

Variables	PX1	PX2
AVISTL	0.0782	0.8771
ATEZTJ	0.7442	0.3944
ANABIC	0.4393	-0.4850
ANATRI	0.8324	-0.1824
ANALED	0.6730	-0.0044
ANATRB	0.8541	-0.0905
ANAPOT	0.5832	0.0138

Table 4
Promax factor correlation (PX1, PX2) measurement differences set

Factors	PX1	PX2
PX1	1.0000	0.1070
PX2	0.1070	1.0000

It can be seen that morphological mechanisms had the opposite orientation in action on these two measures. There was a loss of body mass and reduction of the biceps skinfold. Also, these changes were followed by other skinfolds that all have negative signs, indicating elongation of the participants. This phenomenon is normal in this age group. This effect is likely to be attributed, to the largest extent, to biological development, but also to the influence of the curriculum content of physical education.

Results of the SSDIF Analysis of Quantitative Changes in Motor Skills

Table 5 shows the results of SSDIF analysis of quantitative changes in motor skills created under the impact of curriculum content of physical education during one school year.

Table 5
Results of the SSDIF analysis of quantitative changes in motor skills

Variables	A	D	S	R
MFESDM	33.936	0.0425	0.2978	0.1092
MRCDTL	11.988	0.2917	0.5379	0.1972
MFLPRK	0.6385	0.0497	0.2222	0.0815
MBFTAP	-0.4187	-0.0323	-0.3614	-0.1325
ŠATL10×5	-0.5440	-0.8669	-0.6276	-0.2301
MSAVIS	19.175	0.0937	0.2973	0.1090
FLAMIN	-0.7831	-0.0561	-0.3424	-0.1255
MBFDIN	14.428	0.2125	0.4936	0.1810
ŠATL 20	13.675	43.138	23.019	0.8439
	M	=	7.4402	
	H	=	1235.0652	
	F	=	130.5759	
	DF1	=	9	
	DF2	=	157	
	P	=	0.0000	

Note. A-differences in arithmetic means, D-discriminant coefficients, S-standardized orthogonal projections, R-structure of factor discrimination, M- the Mahalanobis distance between the centroid of vectors of the initial and final measurements, H-Hotelling's T test, F-test for variance analysis, DF1 and DF2 - degrees of freedom, P - the level of significance, i.e. an error used to assert that there have been significant changes

Based on the results presented, it can be seen that quantitative changes at the global level are statistically significant, as the statistical significance is at the level of $p = 0.0000$. Results of SSDIF analysis indicate that global effects have been caused by the curriculum content of physical education, but they are mild and without dramatic changes. One-year curriculum of physical education has caused statistically significant quantitative changes in the following variables: running 10×5 m (sideways), shuttle run (ŠATL10×5), lifting the trunk from the lying on the back position (MRCDTZ) and hand dynamometry (MBFDIN). However, the largest and statistically most significant global quantitative changes were made in the 20 m running sideways test with progressive acceleration (ŠATL20 0.8439), used for performing the assessment of overall endurance. This fact can point to one thing, namely that the loads during physical education classes were aimed at increasing endurance of the students and this was not in the high training zones.

Table 6 shows partial tests of hypotheses on differences. Based on the results in the given table, it can be seen that under the impact of a one-year programme of physical education curriculum content there were statistically significant partial quantitative changes in all applied general motor variables. Such results may point to one thing, namely that programmed curriculum content of physical education during the school year had a positive impact on the increase in overall motor skills.

Table 6
Partial tests of hypotheses on differences

Variables	F	P
MFESDM	147.208	0.0004
MRCDTL	480.338	0.0000
MFLPRK	81.993	0.0050
MBFTAP	216.766	0.0001
ŠATL10×5	653.745	0.0000
MSAVIS	146.686	0.0004
FLAMIN	194.657	0.0001
MBFDIN	404.456	0.0000
ŠATL 20	879.5696	0.0000
DF1 = 1		DF2 = 165

Note. F - test, P - probability

Orientation of Quantitative Changes in Gross Motor Skills

In the further process of the analysis, global directions of development of the aforesaid changes of general motor skills have been presented. Table 7 shows the results of the SSDIF analysis of motor skills - oblique rotated promax of the measurement differences set that gives us information on the orientation of the aforesaid global quantitative changes. Based on the results presented in Table 8, it can be seen that

the changes of general motor skills took course in five global directions, i.e. that the motor mechanisms acted in five directions.

The first direction (factor) describes explosive power, static strength and overall endurance, as it is most defined by explosive power assessment variables (MFESDM), hand static force assessment variable (MBFDIN) and overall endurance assessment variable (ŠATL20).

The second factor describes static strength of arms and shoulders area, because it is defined by high projection of the variable for the assessment of static strength of arms and shoulders area, endurance pull-up (chin-up) test in elevated position (MSAVIS).

The third factor describes flexibility and agility, as it is most defined by the variables for assessing mobility in hip joints (MFLPRK) and running 10 × 5 m (sideways - ŠATL10 × 5). Flexibility in hip joints was expressed here, because it is necessary to run as fast as possible while changing the motion direction, without reducing the running speed. With higher mobility in hip joints, changes in the motion direction can be performed without reducing the speed of motion and vice versa. Thus, the third factor is high mobility (flexibility), including the possibility of easier change in the motion direction.

The fourth factor describes balance, as it is most defined by the balance assessment test (MFLAMI).

The fifth factor describes repetitive power and frequency of the upper extremity movements, because it is most defined by the variables for the assessment of repetitive trunk power, lifting the trunk from the lying on back position (MRCDTZ) and variable for the assessment of the motion frequency, hand tapping (MBFTAP). The effects just described show that systematic work in physical education classes can have many beneficial effects that remain with the students as a foundation for further developmental phases in life. To what extent the curriculum content will show better effects should be seen through the application of other programmes of curriculum content. Consequently, the effects achieved can certainly be attributed to the impact of physical education curriculum content.

Table 7

Results of the SSDIF analysis of motor skills - Oblique rotated promax of the measurement differences set

Variables	PX1	PX2	PX3	PX4	PX5
MFESDM	0.8663	-0.3015	0.1448	-0.1447	-0.0348
MRCDTL	-0.0913	0.3298	-0.0149	-0.1830	0.4410
MFLPRK	0.0925	0.1442	0.6852	0.1587	-0.3967
MBFTAP	-0.0768	-0.1451	0.0783	0.0241	0.7442
SATL10X5	-0.0329	0.0364	0.7767	-0.0907	0.3083
MSAVIS	-0.1292	0.8924	0.1176	-0.1259	-0.0905
FLAMIN	-0.1740	-0.1679	0.0268	0.9098	-0.1066
MBFDIN	0.5886	0.1512	-0.1409	-0.0855	-0.2959
SATL20	-0.4183	-0.3734	0.0602	-0.3899	-0.3465

Table 8 shows the correlation of oblique rotated promax factors of motor variables. Weak correlation between the promax factors can be seen from the table. More significant correlation can be seen between the first and the second promax factors.

Table 8
Correlation of promax factors (PX1, PX2, PX3, PX4, PX5 = factors)

Variables	PX1	PX2	PX3	PX4	PX5
PX1	1.0000	0.2196	-0.0307	0.1447	-0.0037
PX2	0.2196	1.0000	-0.0695	0.1025	-0.0019
PX3	-0.0307	-0.0695	1.0000	-0.0836	-0.0512
PX4	0.1447	0.1025	-0.0836	1.0000	0.0301
PX5	-0.0037	-0.0019	-0.0512	0.0301	1.0000

Discussion

Based on the obtained results, it can be concluded that the conducted curriculum content of physical and health culture during one school year produced statistically significant quantitative changes of morphological characteristics and motor skills of the students. The effects of physical and health culture curriculum content are visible globally and partially. The results obtained point that the programmed curriculum content of physical and health culture during the school year had a positive impact on the increase in overall motor skills. However, it must be noted that the changes that occurred are mild and not dramatic. To what extent the curriculum content will show better effects, should be seen through the application of other programmes of curriculum content. Many previous studies in the field of physical and health culture (Badrić, 2010; Badrić et al., 2015; Badrić & Gašparić Baniček, 2016; Bajrić, O., Šmigalović, Bašinač, & Bajrić, S., 2012; Bajrić, Šmigalović, Bašinač, & Bilić, 2012; Borčić et al., 2005; Džibrić et al., 2009; Ferhatbegović et al., 2010; Hodžić, 2008; Milenković et al., 2011; Rađo et al., 2003; Selmanović et al., 2008) have shown that effects on the changes in anthropological characteristics of students are greater and more significant when regular classes are combined with additional organizational forms of work in primary and secondary schools (extracurricular and out-of-school activities, elective activities, various forms of supplementary education, school sports societies and other).

Conclusion

The primary aim of this longitudinal study was focused on the tendency to determine quantitative changes in morphological characteristics and motor skills of the students under the impact of the current one-year teaching programme of physical and health culture. The study was conducted on a sample of 166 participants, male students of 1st and 2nd grades of Combined Technical High School in Travnik. Performed measurements were conducted at the beginning and at the end of the 2016/2017 school year using variables according to the Eurofit Fitness Test Battery programme

(5 morphological status assessment variables and 9 motor status assessment variables). The students completed regular classes of physical and health culture in accordance with the existing Curriculum for the 1st and 2nd grades of Combined Technical High School Travnik (70 teaching hours, two 45-minute lessons a week).

Results of the SSDIF analysis indicate that the current one-year curriculum of physical and health culture has caused statistically significant changes at the global level ($p = 0.0000$) in both investigated areas, but the changes that occurred are mild. Quantitative changes in morphological status of the students took course in two global directions, that is, morphological mechanisms acted in two directions with the opposite orientation. This phenomenon is only normal in this age group of participants. This effect is likely to be attributed, to the largest extent, to biological development, but also to the impact of physical education curriculum content.

Quantitative changes in motor skills in which all the applied variables participated positively took course in five global directions, that is, motor mechanisms acted in five directions. Described motor mechanisms point to the fact that programmed and systematic work in teaching physical education can have many beneficial effects with the students. Consequently, the effects achieved can certainly be attributed to the impact of the current curriculum content of physical and health culture.

This is extremely important information, as the students involved were high school students, a population in which biological manifestations are still being formed and the effects described show and point to the fact that systemic and organized-programmed work can have many beneficial effects that remain with the students as the capital for further developmental phases in life.

Generally speaking, the effects of the current one-year physical and health culture teaching programme (70 teaching hours, two 45-minute lessons a week) contributed to the growth of tested morphological characteristics and development of motor skills in the students. The students who regularly participated in the performance of teaching content of physical and health culture during the school year achieved significant progress in some morphological characteristics and all the motor skills. Given that the modern way of life “causes” increasingly lower need for exposing oneself to physical efforts, and along with the fact that the students spend most of their time sitting in school and at work desks, the importance of research of this nature is increasingly bigger. Given the actuality of the issues and reforms through which the education and training system is going, the results of this study should also encourage other researchers to research similar problems, as the results of even partial studies could contribute to the higher quality of planning, programming and monitoring the effects of physical and health culture in its entirety on the changes in anthropological characteristics of the students.

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Analiza kvantitativnih promjena morfološko-motoričkih obilježja učenika srednje škole pod utjecajem redovne nastave tjelesnog odgoja

Sažetak

Istraživanje je provedeno na uzorku ispitanika koji je obuhvatio 166 ispitanika – učenika muškog spola „Mješovite srednje tehničke škole“ iz Travnika koji su u toku školske godine pohađali nastavu tjelesnog odgoja. U istraživanju je primijenjeno 5 varijabli za procjenu morfološkog statusa i 9 varijabli za procjenu motoričkog statusa ispitanika prema programu Eurofit baterije testova. Osnovni cilj istraživanja bio je da se longitudinalnom studijom u jednoj školskoj godini utvrde kvantitativne promjene morfološkog i motoričkog statusa učenika srednje škole pod utjecajem programskih sadržaja redovne nastave tjelesnog odgoja. Kvantitativne promjene morfološkog i motoričkog statusa i analiza razlika između inicijalnog i finalnog mjerenja utvrđeni su analizom promjena pod modelom razlika i SSDIF analizom (Bonacin, 2004). Projekcijom podataka mjerenja definirana je hipotetska matrica mjerenja, a eksplicijom skupa linearnih pomaka na matricu asocijacije dolazi se do strukturnog vektora koji opisuje kvantitativne promjene, uzimajući u obzir relacije inicijalnih varijabli. Rezultati SSDIF analize upućuju na to da je jednogodišnji nastavni program tjelesnog odgoja izazvao statistički značajne promjene na globalnoj razini ($p = 0,0000$) u oba istraživana prostora, ali su nastale promjene blage i nisu dramatične. Do statistički značajnih kvantitativnih promjena u motoričkom prostoru došlo je u tjelesnoj visini i težini, kao i kožnom naboru tricepsa, a u motoričkom prostoru u varijablama: trčanje 10×5 m (tamo-ovamo), dizanje trupa iz ležanja na leđima i dinamometrija šake, a najveće i statistički najznačajnije globalne kvantitativne promjene dogodile su se u testu trčanje na 20 m tamo-ovamo s progresivnim ubrzavanjem (ŠATL20 0,8439).

Ključne riječi: kvantitativne promjene; morfološke odlike; motoričke sposobnosti; tjelesna i zdravstvena kultura.