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# GENDER DIFFERENCES IN THE MORPHOLOGICAL CHARACTERISTICS AND MOTOR SKILLS OF CHILDREN AGED 7 TO 11

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**Abstract**. *A sample of 655 participants (348 boys and 307 girls), schoolchildren aged 7 to 11, was included in a study of a system of 10 variables (4 morphological and 6 motor variables), with the aim of applying a multivariate analysis of variance and a canonical discriminant analysis to determine the statistical significance of the differences in the means between the genders in terms of morphological characteristics and motor skills. The obtained results indicated a statistically significant difference between the genders in the entire system of applied variables, at the p=.00 level, an univariately, that the boys, probably as a result of increased body weight (p=.01) and forearm volume (p=.00), had better results in motor skills as well, including explosive strength (the standing long jump, p=.00), body coordination (the polygon backwards, p=.00), repetitive strength (sit-ups, p=.00) and force (hyperextensions, p=.00), while the girls had better values only for flexibility (deep pull-up hang on the bench, p=.00). By using a canonical discriminant analysis, we isolated a single discriminant function (p=.00) whose structure is made up of seven variables, six of which belong to the boys, and only one of which (deep pull-up hang on the bench) belongs to the girls. In accordance with the obtained values, it is necessary to consider the development (extensive changes) in the morphological characteristics and motor skills of both boys and girls equally in physical education classes. These changes are ones which are not genetically limited, that is, ones which are still susceptible to change, so as to be able to perform optimum planning and programming and the operationalization of physical education classes based on the obtained indicators, as well as the control of the ontogenetic development of these relevant anthropological characteristics, under the influence of the programmed contents according to gender at this age.*

**Key words**: *age 7-11, gender differences, morphology, motor skills, multivariate analysis.*

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## INTRODUCTION

Recent extensive scientific research and practical experience have shown that the optimum programming of physical education classes at an age of 7 to 11 (first to fourth grade elementary school children) can significantly transform the morphological and motor skills of children, which actually means that through the timely programmed instruction in a purposeful and optimum manner we can focus, operationalize and change the structure of the personality in the desired (Pejčić, Malacko & Muvrin, 2014; Mraković, 1992).

Among academic circles, there is an opinion that due to an insufficient weekly number of classes, there is superfluous content in the curriculum, which usually leads to the one-sided favoring of the educational component at the expense of developing relevant anthropological characteristics, especially motor-functional abilities. Authors also consider that the one-sided focusing of instruction on learning, or acquiring a greater amount of motor knowledge and skills, which today is found in a great number of schools, does not guarantee that this will lead to the desired transformation of the relevant anthropological characteristics and abilities of children, which should be the ultimate goal of education.

A study into the structure and transformation of the effects of relevant anthropological characteristics and abilities of children by applying various types of content within physical education and/or training in the development of certain anthropological characteristics of children represents one of the high priority projections in education and sport (Gredelj, Hošek, Metikoš & Momirović, 1975; Stojanović, Momirović, Vukosavljevic & Solarić 1975; Metikoš, Gredelj & Momirović, 1979; Rajtmajer, 1997; Strel & Šturm, 1981). It takes place based primarily on previously constructed desired states (models), the current state of the participant (diagnosis) and longitudinal transformation (planning, programming, operationalization) and the analysis of the effects of the instruction and/or training technological process (Mraković, 1994; Findak, 1998; Findak, 1999, Pejčić, 2002; Malacko, 2002; Malacko & Pejčić, 2009; Milojević & Stanković, 2010, Stanković & Malacko, 2011; Doder, Malacko, Stanković & Doder, 2013).

This precisely means that it is almost impossible to apply an adequate technological process (transformational procedure) of exercise or training if the kinds of anthropological features, abilities and motor knowledge which take part in the success of a certain educational or sports activity are not known beforehand. In addition, their importance should also be known, and their hierarchical influence on achieving success, which are used to determine which program content, methods and load can be developed in the most optimum manner over a certain period of time, as well as which measuring instruments they can be measured and controlled with and how (Malacko & Rađo, 2004; Pejčić, Malacko & Tomljenović, 2008; Malacko, 2011; Malacko, Pejčić & Tomljenović, 2014).

The development of certain relevant anthropological feaures and abilities among children as a part of the education process, whose success depends primarily on the selection of suitable program content, their application and load, should not be focused on aimless exercise, especially in the case of selection of children for certain sports activities, which means that the unfocused development of certain anthropological features and abilities outside of any particular goal, that is, achieving a desired aim is futile (Pejčić, 2002).

The technology of instruction on certain movement structures (technical elements) in today's educational or sports activities is still being carried out in accordance with tradition, experience and intuition, and very little of it is based on newly-constructed, selected and empirically verified experimental treatments focused on achieving the greatest and quickest

effects in learning (education) of certain situational movement elements, in as short a period of time as possible, and with the least amount of frequency (the number) of optimal structures.

Through empirical verification, we determined that the program content of exercise and/or training sessions, which are focused on the development of relevant anthropological abilities have to be constructed or selected so as to enable a change under the influence of the previously adopted (trained, automatized) movement structures (exercises). At the same time it is well-known that there is an empirical rule that irrespective of the basis of the program content, a greater advantage of education will be determined for content which has greater complexity, that is, which can be used to achieve a greater number of goals simultaneously (Malacko & Popović, 2001).

In addition to the information on the content which is used to solve certain issues, information on the extent and manner in which we should apply that content is necessary, as well as what kind of load should at the same time be used in certain time intervals. It is clear that these contents, methods and loads cannot be studied, analyzed and applied in isolation, and instead should be solved as inter-dependent conditioned elements while constructing, composing, programming and operationalizing some educational or training process.

Generally speaking, what this precisely means is that we need to take into consideration, on the one hand, so-called internal (endogenic) factors, which are primarily determined by the genetic potential of the children (Malacko, 2009), and on the other hand, the external (exogenic) factors, which primarily include class organization, but also the purposeful, proper and optimum educational content. In the case of internal factors, we should primarily take into consideration the variable nature (genetic limitations) of anthropological features and abilities, the so-called 'critical periods' (Gužalovskij, 1984), especially during that phase of ontogenetic development when influence is possible, considering that the development of precisely these characteristics determines the later adaptation to modern conditions of working and living. As far as external factors are concerned, it is necessary to point out that in addition to the available exercise time and material conditions for work, special attention should be paid to age and gender.

Numerous facts collected to date indicate that ontogenetic development actually represents the "unified results of joint action of both the genetic nature of man and environmental conditions, where the internal nature of the human body, during various stages of ontogenesis (Pejčić & Malacko, 2005), and probably to various extents, reflects the influence of the social-ecological environment, so that to an uneven extent is susceptible to the various environmental conditions" (Karsajevskaja, 1970).

In accordance with the aforementioned, we can logically conclude that detailed knowledge on the limiting factors and critical (sensitive) periods (Koprivica, Arunović & Radisavljević, 1994), as well as the dynamics of the development of morphological characteristics and motor skills within and between genders, which mostly manifest the general regulations of ontogenesis, are a necessary assumption and precondition for the proper and effective management of the transformation processes in education and sport, which to an equal extent refers to all the other personality dimensions.

In this kind of approach, analysis of research carried out so far, information which is being discovered daily, confirmed and applied in that sphere, the aim of this research was to use a representative sample of participants, aged 7 to 11, to determine the statistically significant differences in the means determined for the boys and girls in terms of morphological characteristics and motor skills, so that we could use the obtained indicators to perform further strategic and applicative planning, programming, and operationalization of physical education

classes, as well as to control the ontogenetic development of relevant anthropological values under the influence of programmed content based on age and gender.

## THE METHOD

### The sample of participants

The overall sample consisted of 655 participants of both sexes (348 boys and 307 girls), aged 7-11 (first to fourth grade children).

### The measuring instruments

The sample of variables consisted of 10 variables, of which 4 were variables of morphological characteristics and 6 variables of motor skills.

| Test | Latent variables | Measuring unit |
|---|---|---|
| **Morphological variables** (Stojanović, Momirović, Vukosavljevic & Solarić, 1975)**:** | | |
| **ABH** - body height | *longitudinal skeleton dimension* | mm |
| **ABW** - body weight | *the weight of the body* | kg |
| **ACF** - forearm volume | *body volume* | cm |
| **AUS** - upper-arm skin fold | *subcutaneous fatty tissue* | cm |
| **Motor variables (**Gredelj, Hošek, Metikoš & Momirović, 1975)**:** | | |
| **MHT** - hand tapping | *the speed of movement frequency* | fr |
| **MLJ** - the standing long jump | *explosive strength* | cm |
| **MPB** - the polygon backwards | *body coordination* | sec |
| **MSU** - sit-ups | *repetitive strength* | fr |
| **MPH** - deep pull-up hang on the bench | *flexibility* | cm |
| **MFB** - hyperextensions | *force* | sec |

### Data processing method

In order to determine the difference in the means of the applied variables between the boys and girls, we used the statistical methods of analysis, the multivariate and univariate analysis of variance (MANOVA/ANOVA). The multivariate testing of the null-hypothesis which states that the group centroids were equal to the common centroid (GENERAL MANOVA) was carried out using $\lambda$ - Wilk's Lambda test, the F - test and p - the level of statistical significance ($p > .05$). The univariate statistically significant difference between the arithmetic means of the values obtained for the boys and girls was calculated using the F - test and p – level of statistical significance ($p > .05$).

In order to determine the statistical significance of the structural differences between the boys and girls in the applied system of morphological and motor variables, as well as the individual determination of variables which contributed most to the differences between the groups based on their correlations with the discriminant function (FUNC-1) a canonical discriminant analysis was the applied. Based on the multivariate parameters, we calculated the correlation coefficient (R), Wilk's lambda ($\lambda$), Chi-square ($\chi^2$) and the significance for the entire system of variables ($p > .05$), as well as the group centroids for the boys (C1) and girls (C2).

## RESULTS

Based on the data obtained from the multivariate analysis of variance (MANOVA/ ANOVA) shown in table 1, we can clearly see that in the entire applied system of (multivariate) morphological and motor variables there is a statistically significant difference (p=.00) between the arithmetic means of the boys and girls (Mb-Mg).

Univariately, the statistically significant differences in the individual morphological variables can be found in body weight (p=.01) and forearm volume (p=.00) in favor of the boys. Thus it can be assumed that they had increased body mass, primarily at the expense of the increased volume (mass) of the muscles, considering that they were almost equal with the girls in terms of body height and subcutaneous fatty tissue. It is quite probable that this increased muscle mass among the boys caused them to achieve better and statistically significant differences (p=.00) in arithmetic means for the motor skills of explosive strength (the standing long jump), body coordination (the polygon backwards), repetitive strength (sit-ups) i force (hyperextensions), while the girls were only better at flexibility (deep pull-up hang on the bench).

**Table 1** Univariate and multivariate statistical differences between the sexes in morphological and motor variables

| Variables | ANOVA / MANOVA | | | | Canonical discriminant analysis |
|---|---|---|---|---|---|
| | Mb | Mg | F | p | Func - 1 |
| ABH - body height | 1451.66 | 1455.15 | .46 | .49 | -.04 |
| ABW - body weight | **390.79*** | 374.92 | .47 | **.01*** | .15* |
| ACF - forearm volume | **211.19*** | 205.51 | 12.36 | **.00*** | .22* |
| AUS - upper-arm skin fold | 9.21 | 8.70 | 3.37 | .06 | .11 |
| MHT - hand tapping | 24.11 | 23.92 | .18 | .66 | .02 |
| MLJ - the standing long jump | **159.57*** | 141.40 | 10.38 | **.00*** | .20* |
| MPB - the polygon backwards | **181.94*** | 218.16 | 50.06 | **.00*** | -.46* |
| MSU - sit-ups | **34.42*** | 30.77 | 33.71 | **.00*** | .37* |
| MPH - deep pull-up hang | 48.77 | **51.30*** | 7.59 | **.00*** | -.18* |

Legend:

Mb - arithmetic mean of boys
Mg - arithmetic mean of girls
F - F-test
$\lambda$ - Wilk's Lambda test
$\chi^2$ - Chi - square test
p - the level of statistical significance (p > .05)

$\lambda$ =.73
$\chi^2$ = 21.15
p = .00

R = .51
$\lambda$= .73
$\chi^2$ = 20.01
p = .00

Centroids:
C1 = .56
C2 = - .63

From the presented data obtained from the canonical discriminant analysis (shown in the same table) we can clearly see that there are also statistically significant structural differences in the entire system of applied morphological and motor variables (p=.00) between the boys (C1) and girls (C2).

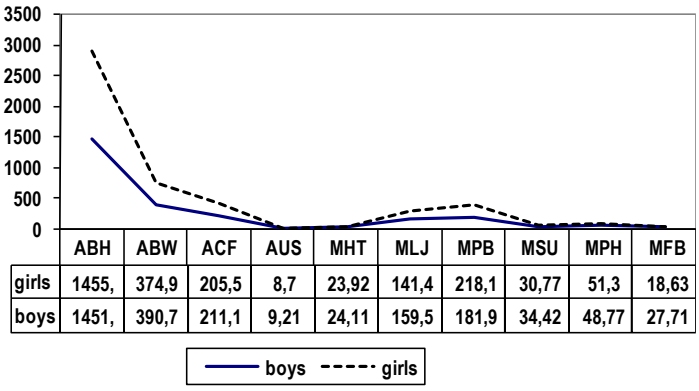
The structure of the discriminant function (FUNC-1) is defined by the motor variables (marked with a *) of explosive strength (the standing long jump), body coordination (the polygon backwards), repetitive strength (sit-ups) and force (hyperextensions) and flexibility (deep pull-up hang on the bench) as well as the morphological variables of the weight of the body (body weight) and body volume (forearm volume), so that it can be interpreted as an integral morphological-motor discriminant function.

By analyzing the results of the canonical discriminant analysis from the viewpoint of centroids of the boys (C1 = .56) and girls (C2 = -.63), that is, their deviation from the discriminant function (FUNC-1), we can clearly see that of the seven morphological and motor variables, which make up the structure of the discriminant function, the boys achieved better results on a total of six variables (body weight, forearm volume, the standing long jump, the polygon backwards, sit-ups and hyperextensions), and the girls on only one of the variables (deep pull-up hang on the bench).

## DISCUSSION

In this study we expected to determine a statistically significant difference in the arithmetic means between the genders, both in the entire system (multidimensionally) and in some of the individual variables (univariately), considering the already mentioned differences in the development of children of both genders at this age.

From this analysis of morphological variables, which refer to the weight of the body and body volume (ABW - body weight and ACF - forearm volume), we can clearly see that they, in accordance with the usual genetic projections, along with the aforementioned fact, this development is more intense among the boys. By analyzing the motor variables, we can also determine that the boys achieved better results in the variables of explosive strength (MLJ - the standing long jump), body coordination (MPB - the polygon backwards), repetitive strength (MSU - sit-ups) and force (MFB - hyperextensions), while the girls were only better in the variable of flexibility (MPH - deep pull-up hang on the bench).




| | ABH | ABW | ACF | AUS | MHT | MLJ | MPB | MSU | MPH | MFB |
|---|---|---|---|---|---|---|---|---|---|---|
| girls | 1455, | 374,9 | 205,5 | 8,7 | 23,92 | 141,4 | 218,1 | 30,77 | 51,3 | 18,63 |
| boys | 1451, | 390,7 | 211,1 | 9,21 | 24,11 | 159,5 | 181,9 | 34,42 | 48,77 | 27,71 |

**Graph 1** Trajectories variables of morphological characteristics and motor abilitis

Based on the results obtained in this study (Graph 1), we can clearly determine that the influence of physical education was greater on the applied variables of relevant morphological characteristics and motor skills among boys of this age (the trajectories should be studied separately, since they were presented in such a way so as to be analyzed in more detail), with the only possible conclusion that this is partly the result of a genetically conditioned increase in the weight of the body (body weight) and body volume (forearm volume), which directly more favorably influenced the increase in the values of explosive, repetitive and force, and indirectly coordination skills.

If the results obtained in this research were to be compared with the results obtained in certain previous studies carried out in other countries, we could note certain similarities. Pejčić and Malacko (2005), working with a sample of 4429 first through fourth grade participants of the Primorje-Gorski Kotar County, 2202 boys (first graders $N_1$ = 566, second graders $N_2$ = 561, third graders $N_3$ = 561 and fourth graders $N_4$ = 514) and 2227 girls (first graders $N_1$ = 575, second graders $N_2$ = 543, third graders $N_3$ = 569 and fourth graders $N_4$ = 540), applied a standard battery of measuring instruments numbering a total of 11 anthropometric and motor variables (body height, body weight, underarm volume, upper arm skinfold, hand tapping, the standing depth jump, the backwards obstacle course, torso lifts, hyperextensions, deep pull-up hang on the bench and the three-minute run), which is being used in the school system of Croatia. The battery was used with the aim of, on the one hand, determining the ontogenetic development of individual anthropometric and motor variables based on gender and within individual grade groups, and on the other, determining the kind of differences that can be determined in the development of anthropometric and motor variables between the two genders within the age groups. The results are indicators that the anthropometric and motor variables at this age equally and progressively develop based on age (first through fourth grade of elementary school), according to the usual genetic potentials of endogenic factors) and under the influence of the applied curricular content (exogenic factors), along with the relatively well-known fact that the development is more intense among the boys. In the case of the girls, we noted increased flexibility values only in the case of the anthropometric variable of subcutaneous fatty tissue and the motor variable of flexibility.

In addition, in the research of Pejčić, Malacko and Muvrin (2014), carried out on a sample of 148 male and female school children (73 boys and 75 girls), aged 7-11 (attending the first through fourth grade), a battery of measuring instruments consisting of 11 variables was used, 4 of which were morphological variables and 7 variables of motor skills, with the aim of determining gender differences. The results showed that between the boys and girls in the system of morphological and motor variables there are multivariate statistically significant differences in the arithmetic means at the level ranging from p= .001 to p= .017. Of the 4 morphological and 7 motor variables, the first-grade boys showed signs of increased values of two morphological and four motor variables, the second graders in one morphological and six motor variables, and third graders in four morphological and six motor variables and fourth graders in one morphological and five motor variables. The first-grade girls has better values for two morphological and three motor variables, the second graders in three of the morphological and one motor variable, third graders for one morphological and only one motor variable, and fourth grade girls in three of the morphological and two motor variables.

In the research of Trajkovski-Višić, Malacko and Tomljenović (2011), involving a sample of 393 participants (169 girls and 224 boys) preschoolers aged 4, 5 and 6 from the area of the Primorje-Gorski Kotar County (attending kindergartens in Fužina, Kostren, Delfin, Delnice, Zamet, Maestral, Krnjevo and Galeb), a system of 43 variables were used, 14 of which morphological and 29 were motor, with the aim of determining the univariate and multivariate statistical significance of the differences between preschool boys and girls. The results indicated that between the genders in the system of applied variables there is a multivariate statistically significant difference at the p= .00 level. Based on the obtained univariate values we can conclude that the boys differ in a statistically significant manner in the arithmetic means of morphological variables with a decreased amount of subcutaneous fatty tissue and increased transversal dimensionality of the skeleton, as well as increased values for body height and weight. They achieved better results in the motor variables of

explosive strength of the legs, partial body coordination, flexibility in a lying position and endurance (the three-minute obstacle course), which is shown by the statistically significant differences in the arithmetic means and better values of heart rate prior to and following activity. Girls with increased morphological values of soft tissue voluminosity achieve better results in the force arm and force shoulder, repetitive strength of the torso, flexibility of the hamstrings, flexibility of the hip and endurance – running across "a sliding obstacle course" for a period of three minutes.

Recent conclusions, opinions and analyses, and thus the ever stricter warnings of the scientific, professional and wider audiences regarding the intolerably low effectiveness of physical education classes, especially among girls this age, represent the basic motivation for further and focused strategic research, which will be marked by the basic dilemma, whether and to which extent greater effects are caused by the existing official curriculum or special program content of movement structures for children of both genders.

Exercise, the improvement and adoption of desired and purposeful movement structures (sports-technical elements, motor information), it is necessary to determine whether it is highly selected, a performed choice or a new construction of certain specific (situational) movement structures (warm up exercises, interim exercises, exercises proper), which according to their form, character, structure and load most closely remember situational (mostly competitive) movement activity. At the same time, as the final outcome, we should bear in mind that with smaller structural movement elements we can achieve faster and greater effects when exercising and adopting relevant movement structures, which can be used in an optimum manner to develop (alter) relevant anthropological characteristics and abilities, which are in the function of the most optimum outcome (success) in some educational and/or sports activity.

The technology of teaching certain movement structures (technical elements) in today's practical educational or sports activity is still being carried out in the traditional manner, based on experience and intuition, and with the addition of only slightly newly-constructed, selected and empirically verified treatments focused on achieving fast and extensive effects in teaching (offering instruction on) certain situational movement elements within a very short period of time, and with as little frequency as possible (number of repetitions) of optimum structures.

Since the effects of the application of movement structures (motor content) depends on the exercise methods and/or training, for each structure of exercise it is important to, in advance, know how much each content should be consumed for a particular purpose, and how it should be implemented. What this practically means is that some content in its complexity can be suitable for the realization of a certain goal, and that it is still not being realized due to some inadequate training (the content application method), which could lead to adverse effects.

For these reasons, in addition to the information regarding what is solved through the use of certain content, we also need information on the extent and manner this content should be applied in, as well as what kind of load to introduce at certain time intervals. It is clear that the content, methods and load cannot be studied, analyzed and applied in isolation, and instead should be dealt with as interdependent and mutually conditioned elements when constructing, composing, programming and the operationalization of some educational or training process.

## CONCLUSION

In this research, we confirmed the expected existence of statistically significant differences in the means between children of both genders, both in the entire system of (multivariate) applied variables (p=.00), and in certain individual variables (univariate). The results obtained by applying the multivariate analysis of variance (MANOVA/ANOVA) have shown that the boys, most probably, at the expense of increased body weight (p=.01) and forearm volume (p=.00), scored better results on motor skills such as speed of movement frequency (hand tapping, p=.00) explosive strength (the standing long jump, p=.00), body coordination (the polygon backwards, p=.00), repetitive strength (sit-ups, p=.00) and force (hyperextensions, p=.00), while the girls were only better in flexibility (deep pull-up hang on the bench, p=.00). Viewed from the aspect of the position of the centroids of the group of the boys (C1 = .56) and girls (C2 = -.63), the results of the canonical discriminant analysis, that is, their distance from the discriminant function (FUNC-1), clearly indicate that of the seven morphological and motor variables which make up the structure of the discriminant function, the boys achieved better results in six of the variables, and the girls only on one. As a result, in physical education classes, children aged 7 to 11 (first to fourth grade elementary school students), of both genders, it is necessary to equally pay attention to the development (changes) of morphological characteristics and motor skills which are less genetically limited, that is, which enable changes under the influence of programmed physical education classes, so as to, on the basis of obtained indicators, we could perform optimum planning, programming and operationalization, as well as the control of the ontogenetic development of anthropological characteristics under the influence of programmed content in accordance with gender.

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# POLNE RAZLIKE U MORFOLOŠKIM KARAKTERISTIKAMA I MOTORIČKIM SPOSOBNOSTIMA DECE STAROSTI 7-11 GODINA

*Na uzorku od 655 ispitanika (348 dečaka i 307 devojčica), učenika i učenica od I-IV razreda osnovne škole, bio je primenjen sistem od 10 varijabli (4 morfološke i 6 motoričke), sa ciljem da se primenom multivarijantne analize varijanse i kanoničke diskriminacione analize utvrdi statistička značajnost razlika u aritmetičkim sredinama između polova u morfološkim karakteristikama i*

*motoričkim sposobnostima. Dobijeni rezultati su pokazali da u celom sistemu primenjenih varijabli postoji statistička značajnost razlika između polova na nivou p=.00, a univarijantno, da su dečaci, vrlo verovatno na račun povećane telesne težine (p=.01) i obima podlaktice (p=.00), imali bolje rezultate i u motoričkim sposobnostima eksplozivne snage (skok udalj iz mesta p=.00), koordinaciji tela (poligon natraške, p=.00), repetitivnoj snazi (podizanju trupa, p=.00) i sili (izdržaj u visu, p=.00), dok su devojčice imale bolje vrednosti samo u fleksibilnosti (pretklon trupa, p=.00). Primenom kanoničke diskriminacione analize izolovana je jedna diskriminaciona funkcija (p=.00), čiju strukturu sačinjavaju sedam varijabli, od kojih šest pripadaju dečacima, a samo jedna (pretklon trupa) devojčicama. Shodno dobijenim vrednostima, neophodno je da se u nastavi fizičkog vaspitanja u ovom uzrastu kod oba pola mora u podjednakoj meri voditi računa o razvoju (većim promenama) morfoloških karakteristika i motoričkih sposobnosti, koji nisu genetički ograničeni, odnosno kod kojih su moguće promene, kako bi se na temelju dobijenih pokazatelja moglo vršiti optimalno planiranje, programiranje i operacionalizovanje razredne nastave fizičkog vaspitanja, kao i kontrola ontogenetskog razvoja ovih relevantnih antropoloških karakteristika pod uticajem programiranih sadržaja po polovima u ovom uzrastu.*

Ključne reči: *uzrast 7-11 godina, polne razlike, morfologija, motorika, multivarijantna analiza*