

## DIFFERENCES IN THE EXPLOSIVE AND REPETITIVE STRENGTH OF TWELVE-YEAR-OLD SCHOOLCHILDREN WITH DIFFERENT MORPHOLOGICAL CHARACTERISTICS

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### SUMMARY

In this research we attempted to define the procedure which could be used to provide optimally distinct groups of school children in terms of the morphological structure of their bodies, and which could further be used to define the possible differences in explosive and repetitive strength. With this aim in mind, a sample of 269 school children aged  $12 \pm 6$  months were included in a study where three of their morphological measures were taken (body height, body mass, skinfolds) and five motor tests for the evaluation of explosive and repetitive strength carried out. First the K-means cluster analyses were used to define three distinct groups of participants in each individual morphological segment, with low, average, and high values. On the basis of the maximal number of possible combinations of previously defined groups from the overall sample of school children, three groups with different morphological structures of the body were determined, including: 104 school children with low values, 113 school children with average values and 52 school children with high values for all three morphological measurements. These defined groups of school children were used to determine the possible differences in the tests of explosive and repetitive strength.

On the basis of the obtained results we can conclude that the group with low values of morphological indicators (height, body mass, skinfolds) achieved the best results on the test for the evaluation of repetitive strength of the arms (MSKL), the group with average values on the tests for the evaluation of explosive strength (MSDM and MT20V), while for the rest of the tests there was no statistically significant difference between the distinct groups.

The definition of the potential possibilities for the manifestation of certain motor skills, on the basis of these morphological indicators for each age category of school children, would be made possible through the application of a small number of anthropometric measures. The classification of a certain child into a suitable (appropriate for his affinities) group would enable the realization of a special work program which would enable the most effective improvement of his qualities.

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**Key Words:** explosive and repetitive strength, distinct groups, morphological structure.

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### INTRODUCTION

As part of the curriculum for physical education classes, the evaluation, that is, the definition of the levels of physical characteristics and the abilities of school children represents one of the more important preconditions for the realization for adequate curricular content. Depending on the extent of the manifestation of the individual qualities, it is necessary to

predict and realize the adapted curricular content which would have the most optimal effect. Experts in the field of physical education methodology (Анастасовски, Клишчаров, & Анастасовски, 2000; Findak, 2003; Matic, 1978; among others) point out that the evaluation of special segments of the morphological and motor status of the school children should be used for gaining insight into the abilities and skills of school children, and on the basis of real indicators

which are manifested by the school children, for gaining access to a differentiated (individual) approach during the realization of the curriculum itself.

Physical education classes play an important part in the education of an individual, and have as their aim to, through adequate physical activities, contribute to the optimal development of the abilities of an individual, his growth, physical and psycho-social features (Hardman, 2007). Being familiar with the principles and guidelines of the abilities of school children in the manifestation of certain motor skills is one of the primary needs of every physical education teacher. Considering the specific nature of a child's body (International Life Sciences Institute, 2000; Тодоровска, 1997), it is possible to define and implement suitable curricular content (Šukov, Živković, Šukova-Stojmanovska, & Klinčarov, 1998) in order to achieve the desired effects.

The determination of the relations between certain anthropometric measures and motor skills has been the focus of a lot of attention, and the significant interdependencies in the case of various groups of the population have been defined (Клиничаров, 2003; Клиничаров & Христовски, 2003; Klinčarov & Stojanović, 2001). In the period of the growth and development of a child's body (Kuczmarski et al., 2000) these interdependencies are individually expressed and inevitably must be taken into consideration during the realization of physical education classes. The guidelines defined in the principle of individualization and the availability of the classes should represent the starting point for the application of impulses which will have a positive influence on transformation. The monitoring and valuing of the physical features of school children must lead to determined scientific views on the relationships between anthropometric characteristics and motor skills, which are specific for each age group, developmental group and gender category.

In this research, we have analyzed the prediction of the general ability for the manifestation of explosive and iterative qualities of strength among school children aged 12, as well as the attempts to define the procedure which would determine the distinct groups with optimally different manifestations in terms of morphological indicators, with the aim of homogenizing the groups in the classroom, for the purpose of the optimization of the effects of physical education on the development of psycho-somatic characteristics of school children, as the basic subject matter of this research.

The development of iterative and explosive strength of school children, as the two general abilities which

are to be found at the core of the realization of human movement in sports (Verhošanski, 1979), requires an individual approach to their training. In order to provide optimal conditions during physical education classes, for the application of an individual approach to the development of these abilities and the uniformity of the load on the school children, it is necessary to define the procedure of group homogenization, which is the subject matter of this research.

The aim of this research was to use these results to facilitate the procedure of group differentiation of students with the same and similar abilities for physical education teachers in schools, so as to enable the planning of in-class load, which would be optimal for each individual child.

The assumption behind the research (hypothesis) is that the differentiation of the homogenized groups of school children, based on their morphological measures, will project statistically significant differences between distinct groups in terms of explosive and iterative strength, so that the group with high morphological measures will have significantly smaller results in comparison to the remaining two groups.

## METHODS

### Sample of participants

The sample of participants was extracted from a population of school children, fifth-graders, all males, with a chronological age of 12 ( $\pm$  6 months), who at the time of the research took part in their regular physical education classes, who satisfied all of the health criteria, and who regularly attended physical education classes. The sample included 269 school children, fifth-graders from elementary schools in the Paraćin region.

### Sample of measuring instruments

The following morphological characteristics and motor tests were included:

- Body height (AVIS)
- Body mass (AMAS)
- Skinfolds (upper arm - triceps surae) (KNNL)
- Standing depth jump (MSDM)
- Triple standing jump (MTRS)
- 20 meter run with a high start (MT20V)
- Push-ups (MSKL)
- Torso lifts on a vaulting box (MDTK).

The morphological characteristics were measured by specialists of sports medicine, and according to the recommendations of the International Biological Program (Weiner & Lourie, 1969). Measuring body

height was carried out by using a standardized anthropometer based on Martin with an accuracy of .1 cm, the measuring of subcutaneous fatty tissue was carried out with a caliper of the »John Bull« type with a measuring span of 0 to 40 mm (the pointer goes two rounds around a scale calibrated 0 to 20 mm), with a standard pressure with which the grippers of the instrument press the skin and the subcutaneous fatty tissue of 10gr/mm<sup>2</sup> and an accuracy of .2 mm, while body mass was measured using the Body Composition Analyser scales (Gaia Jawon 357), with an accuracy of .1 kg. The motor tests were carried out by the authors according to the recommendations of Kurelić et al. (1975).

## Procedure and statistical analysis

For the determination of the optimally distinct groups in the determined segment of morphological space, by applying the cluster analysis in the space of the participants, with the aim of the decrease in the variability within groups and a maximization of the variability between groups (K-means clustering), with the added condition of the existence of 3 groups (Number of clusters = 3), groups with low, average and high values of certain morphological characteristics were defined. Through the application of combinatorics, on the basis of all of the possible permuta-

tations with repetitions, following two iterations (Number of iterations = 2), three groups with different values in all three measures were defined.

On the basis of these kinds of various morphological types of participants, with the aim of the extraction of distinct groups, three groups were extracted with low, average and high values in terms of body height, body mass and skinfolds of the upper arm. Between these groups of participants differences were determined in the manifestation of the analyzed motor skills of explosive and iterative strength by using a multivariate analysis of variance (MANOVA), a univariate analysis of variance (ANOVA) and the last significant differences test (LSD - test).

All of the statistical analyses were carried out using the STATISTICA for Windows 8.0 statistical package.

## RESULTS

First by using the cluster analysis (K-means clustering), groups with various manifestations of all the measured morphological measures were defined, where groups with low (G-N), average (G-P) and high (G-V) manifestations OF the variables of body height, body mass and upper arm (triceps surae) skinfolds were determined (Table 1).

**TABLE 1**

*Arithmetic means of the morphological characteristics of distinct groups.*

Variables	G-N ( <i>n</i> = 104)		G-P ( <i>n</i> = 113)		G-V ( <i>n</i> = 52)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
AVIS	141.02	3.55	149.75	4.01	151.35	5.12
AMAS	32.22	3.26	38.73	3.21	51.72	4.12
AKNN	11.97	3.23	13.92	3.76	20.51	3.75

Legend: **G** - Group; **N** - Low; **P** - Average; **V** - High; **n** - Number of respondent (; **M** - Mean; **SD** - Standard deviation; **AVIS** - Body Height; **AMAS** - Body mass; **AKNN** - Skin-folds (upper arm - triceps surae).

On the basis of the applied cluster analysis of the overall sample of participants, 104 participants were included in the group with low values of morphological characteristics, whose mean values for height, body mass and skinfold thickness were AVIS ( $M = 141.02$ ;  $SD = 3.55$ ), AMAS ( $M = 32.22$ ;  $SD = 3.26$ ) and AKNN ( $M = 11.97$ ;  $SD = 3.23$ ), 113 participants were included in the group with average levels, whose means had a value of AVIS ( $M = 149.75$ ;  $SD = 4.01$ ), AMAS ( $M = 38.73$ ;  $SD = 3.21$ ) and AKNN ( $M = 13.92$ ;  $SD = 3.76$ ), while the group with high valu-

es of morphological characteristics consisted of 52 participants, whose means had a value of AVIS ( $M = 141.02$ ;  $SD = 3.55$ ), AMAS ( $M = 32.22$ ;  $SD = 3.26$ ) and AKNN ( $M = 11.97$ ;  $SD = 3.23$ ).

The noted differences in the analyzed motor space between these extracted groups, were determined using a multivariate analysis of variance (MANOVA), univariate analysis of variance (ANOVA) and the last significant differences test (LSD - test) for variables where a difference was determined between groups

**TABLE 2***Arithmetic means of the motor skills of distinct groups.*

Variables	G-N ( <i>n</i> = 104)		G-P ( <i>n</i> = 113)		G-V ( <i>n</i> = 52)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
MSDM	166.17	1.75	170.88	1.68	148.29	2.48
MTRS	482.22	4.37	474.24	4.20	474.60	6.18
MT20V	4.28	.04	4.12	.04	4.42	.06
MSKL	11.72	.66	10.35	.63	5.73	.93
MDTK	7.17	.45	6.46	.43	5.44	.63

Legend: **G** - Group; **N** - Low; **P** - Average; **V** - High; **n** - Number of respondent; **M** - Mean; **SD** - Standard deviation; **MSDM** - Standing depth jump; **MTRS** - Triple standing jump; **MT20V** - 20 meter run with a high start; **MSKL** - Push-ups; **MDTK** - Torso lifts on a vaulting box.

**TABLE 3***Differences in the variables of explosive and iterative strength between the distinct groups at the multivariate level.*

$\Lambda$	<i>F</i>	Effect - <i>df</i>	Error - <i>df</i>	<i>p</i>
.743	8.39	10	524	<b>.000</b>

Legend:  $\Lambda$  - Wilks' lambda – the value of the coefficient of Wilks' test for the equality of group centroids; **F** - Value of the coefficient of the F-test for testing the significance of the differences; **df** - Degrees of freedom; **p** - Probability.

**TABLE 4***The differences in the variables of explosive and iterative strength between the distinct groups at the univariate level.*

Variables	Group			<i>MS</i>	<i>MSE</i>	<i>F</i> ( <i>df</i> <sub>1,2</sub> ) 2.226	<i>p</i>
	G-N	G-P	G-V				
MSDM	166.17	170.88	148.29	9271.00	320.00	28.96	<b>.000</b>
MTRS	482.22	474.24	474.60	1978.00	1989.00	.99	.371
MT20V	4.28	4.12	4.42	1.78	.18	9.67	<b>.000</b>
MSKL	11.72	10.35	5.73	634.99	45.33	14.01	<b>.000</b>
MDTK	7.17	6.46	5.44	52.53	20.84	2.52	.082

Legend: **G** - Group; **N** - Low; **P** - Average; **V** - High; **MSDM** - Standing depth jump; **MTRS** - Triple standing jump; **MT20V** - 20 meter run with a high start; **MSKL** - Push-ups; **MDTK** - Torso lifts on a vaulting box; **MS** - Mean square; **MSE** - Mean square error; **F** - Value of the coefficient of the F-test for testing the significance of the differences; **df** - Degrees of freedom; **p** - Probability.

for certain motor variables, and are shown in tables 3, 4, 5, 6, and 7.

By analyzing these tables we can conclude that the groups displayed statistically different manifestations in the variables for the standing depth jump (MSDM), the 20 meter run with a high start (MT20V) and push-ups (MSKL). From the analyzed differences between the pairs of groups by using the LSD – test, it was concluded that the participants with average

values for all of the morphological variables (group G-P) have a significantly pronounced manifestation of explosive strength, but in comparison to the participants from the groups with pronounced low manifestations, this difference is statistically significant only for the 20 m run with a high start test.

The group with pronounced low manifestations in all of the morphological variables (group G-N) had statistically better results in the manifestation of

iterative strength than the group with high values of morphological characteristics, but this was not the case in comparison to the group with average values. This difference is pronounced for the push-ups test, while for the torso lift on the vaulting box test it was not statistically significant.

## DISCUSSION

These results can be accounted for in a logical way, considering that in the manifestation of iterative strength, greater body mass and subcutaneous fatty tissue represent a ballast weight, and as such decrease the ability of school children for any long-term repetition of movements which are not aided by the effects of gravity, which in turn increases with body mass. It is also important to point out that the extent of the load force velocity hinders the manifestation of iterative strength, and that in such cases of greater velocity, greater muscle strength will be needed to establish a greater force momentum in comparison

to the load momentum, which is necessary for overcoming mechanical work which could overcome it [ $F_m \cdot f > G \cdot q$  (where  $F_m$  – muscle force,  $f$  – its velocity,  $G$  – gravity,  $q$  – its velocity)]. Thus, we can conclude that the participants with greater longitudinal measures and greater body mass will need greater muscle force to overcome the resistance of the load which acts upon the greater velocity, and thus the duration of the repetitive work in that case will be significantly shorter than in the case of participants with low values of morphological measures, due to quicker muscle force expenditure.

In order to explain the mechanisms for long-term repetitive work, it is necessary to explain the relationship between relative strength and body mass, considering that by definition the concept of relative strength is bound to overcoming the resistance of one's own body mass. From the definition itself it can be understood that the participants with the same muscle force and smaller body mass will have greater relative strength, and that the mechanical work of the

**TABLE 5**

*LSD test for variable MSDM.*

Group	G-N (166.17)	G-P (170.88)	G-V (148.29)
G-N		.054	<b>.000</b>
G-P	.054		<b>.000</b>
G-V	<b>.000</b>	<b>.000</b>	

Legend: **G** - Group; **N** - Low; **P** - Average; **V** - High.

**TABLE 6**

*LSD test for variable MT20V.*

Group	G-N (4.28)	G-P (4.12)	G-V (4.42)
G-N		<b>.007</b>	<b>.044</b>
G-P	<b>.007</b>		<b>.000</b>
G-V	<b>.044</b>	<b>.000</b>	

Legend: **G** - Group; **N** - Low); **P** - Average; **V** - High.

**TABLE 7**

*LSD test for variable MSKL.*

Group	G-N (11.72)	G-P (10.35)	G-V (5.73)
G-N		.136	<b>.000</b>
G-P	.136		<b>.000</b>
G-V	<b>.044</b>	<b>.000</b>	

Legend: **G** - Group; **N** - Low; **P** - Average; **V** - High.

muscles which overcomes the resistance of the load of the bodies of these participants will last longer in the case of participants with a smaller relative strength (greater body mass).

Explosive strength primarily depends on the possibility of manifesting maximal strength in as short a period of time as possible. Considering that in the manifestation of explosive strength, the relationship between strength and speed is primarily defined by the extent of the outer resistance when performing explosive movements, we should point out that explosive strength of the speed kind is characterized by the extent of relative muscle strength and the maximum speed of movement performance, where the external resistance is minimal.

The relationship between body mass and maximal strength is significantly high if the dependence refers only to the maximal strength of the muscles, and not to the speed of its manifestation. If we take into consideration the speed of the manifested strength, then the connection between body mass and the manifested strength significantly decreases, that is, has no significant importance, or to be more precise, has no significant effect on the exercises of the explosive type, especially jumping exercises (Verhořanski, 1979).

Force and strength can also significantly influence muscle architecture (Blazevich, Cannavan, Coleman, & Horne, 2007), that is, the relationship between the length of muscle fibers and the surface of their physiological cross-section. The length of the fibers especially has an effect on the extent of the movement which a muscle can perform, with a maximal speed of the reduction, as well as the relation of force-extent (Knežević & Mirkov, 2011). This can be explained by the example of the determination of the muscle torque force, when the muscle is viewed in natural conditions. Thus, muscle force momentum can be manifested in the production of a tangential (active) component of muscle force and the distance between the center of the joint and the center of the mobile muscle connection. This fact leads us to the conclusion that under the conditions of equal muscle force, its momentum increases with the increase in the length of the lever, that is, the athletes with the same muscle force and longer levers will manifest a greater force momentum in relation to athletes with shorter levers, under the conditions of muscle work without external resistance, which is the case in the manifestation of explosive strength of the speed type. With an increase in muscle momentum, the tangential speed of the distal parts of the lever increases, and thus the product of these two components will be a greater explosive strength in the given movement.

The results of our research are in agreement with the results obtained in previous studies, and indicate the negative influence of increased body mass and subcutaneous fatty tissue on the level of motor skills among male school children aged 12, but also on the positive relations between longitudinal measures and explosive strength. A certain number of studies have confirmed these positive relations (Jarić & Kukulj, 1996; Pincivero, Campy, & Karunakara, 2004).

A great number of studies indicate the increase in obesity among children and adolescents and the great negative influence of obesity and extensive body weight on the health of individuals (Eisenmann, Welk, Wickel, & Blair, 2007; Kovač, Leskošek, & Strel, 2008; Starc & Strel, 2010; Steele, Brage, Corder, Wareham, & Ekelund, 2008). The negative influence of body mass, and especially subcutaneous fatty tissue, on the success in the realization of various motor tasks has been confirmed in a great number of studies (Deforche et al., 2003; Kim et al., 2005; Mota et al., 2002; Strel, 2006). The findings from the national study of the health and diet of 12-19-year-old adolescents of both genders in the USA indicate that the motor skills of adolescents with normal body weight are greater than of those considered overweight individuals (Pate, Wang, Dowda, Farrell, & O'Neill, 2006).

This research is in accordance with previous analyses obtained from research that dealt with the same issue (Клинчаров, 2003; Клинчаров, 2008; Клинчаров, Христовски, & Апески, 2005; Klinčarov & Stojanović, 2005; Klinčarov & Stojanović, 2006), which indicates that in this period of adolescence, in the case of young boys, motor skills were analyzed under the significantly negative influence of body mass and subcutaneous fatty tissue (estimated via skinfolds of the triceps).

In the end, we can conclude that even though the interdependence in the motor space of a school age population were studied further, there is still room for seeking deeper insight into this segment, especially in the period of early adolescence.

## CONCLUSION

With the aim of differentiating groups with low, medium and high values of body height, body mass and subcutaneous body tissue, and thus determining the differences between groups differentiated in terms of explosive and iterative strength, a study was carried out on a population of 12-year-old boys.

The obtained results have confirmed the results from previous studies, and thus we can conclude that

it is necessary, in the realization of the content of physical education classes, to differentiate between homogenous groups of school children with the same or similar characteristics. The definition of homogenous groups on the basis of morphological parameters of the body, as practically the easiest measurable indicators, would enable a more efficient organization of physical education classes. The definition of potential possibilities for the manifestation of certain motor qualities, on the basis of these morphological indicators for each age group of school children would be made possible through the implementation of a small number of morphological measures. This would enable the classification of a certain child into a suitable group and the realization of a special work program, which would enable the most effective improvement in his qualities. In this paper we have attempted to define the procedure which would optimally evaluate the motor qualities of explosive and iterative strength among distinct groups of morphological types of participants.

## REFERENCES

- Анастасовски, А, Клиничаров, И., & Анастасовски, И. (2000). *Теоријата и методологијата на физичко воспитување* [The theory and methodology of physical education]. Скопје, МК: Факултетот за физичка култура Универзитетот »Св. Кирил и Методиј«.
- Blazevich, A. J., Cannavan, D., Coleman, D. R., & Horne, S. (2007). Influence of concentric and eccentric resistance training on architectural adaptation in human quadriceps muscles. *Journal of Applied Physiology*, 103(5), 1565–1575. doi: 10.1152/jappphysiol.00578.2007; PMID: 17717119
- Deforche, B., Lefevre, J., De Bourdeaudhuij, I., Hills, A. P., Duquet, W., & Bouckaert, J. (2003). Physical fitness and physical activity in obese and nonobese Flemish youth. *Obesity Research*, 11, 434–441. doi: 10.1038/oby.2003.59; PMID: 12634442
- Eisenmann, J. C., Welk, G. J., Wickel, E. E., & Blair, S. N. (2007). Combined influence of cardiorespiratory fitness and body mass index on cardiovascular disease risk factors among 8-18 year old youth: The Aerobics Center Longitudinal Study. *International Journal of Pediatric Obesity*, 2, 66–72. doi: 10.1080/17477160601133713; PMID: 17763013
- Findak, V. (2003). *Metodika tjelesne i zdravstvene kulture* [The methodology of physical education]. Zagreb, HR: Školska knjiga.
- Hardman, K. (2007). Current situation and prospects for physical education in the European Union - study. Brussels: Directorate General Internal Policies of the Union, Policy Department Structural and Cohesion Policies, Culture and Education, European parliament.
- International Life Sciences Institute (ILSI) (2000). Overweight and obesity in European children and adolescents: causes and consequences – prevention and treatment. Report prepared by the ILSI Europe overweight and obesity children task force.
- Jarić, S., & Kukolj, M. (1996). Sila (jačina) i snaga u pokretima čoveka [Force, strength in human movement]. *Fizička kultura*, 50(1-2), 15–28.
- Kim, J., Must, A., Fitzmaurice, G. M., Gillman, M. W., Chomitz, V., Kramer, E., .... Peterson, K. E. (2005). Relationship of physical fitness to prevalence and incidence of overweight among schoolchildren. *Obes Res.*, 13(7), 1246–1254. doi: 10.1038/oby.2005.148; PMID: 16076995
- Клиничаров, И. (2003). Одредување на разликите во некои морфолошки и моторни манифестации меѓу учениците од машки и женски пол на возраст 11-14 години. [Determining the differences in certain morphological and motor manifestations among male and female school children aged 11-14]. *Физичка култура*, 2, 22–24.
- Клиничаров, И. (2008). Разлики во базичните морфолошки карактеристики помеѓу дистинктни групи на 12 годишни ученици со различно ниво на физичка способност [Differences in the basic morphological characteristics between distinct groups of 12-year-old school children at different levels of physical abilities]. In S. Tufekčijevski (Ed.), *Стручно научен собир »Програмско-организациска, стручна и научна димензија на училишниот спорт«* (pp. 276–281). Скопје, МК: Федерација на училишен спорт на Македонија.
- Клиничаров, И., & Христовски, Р. (2003). Разлики во некои морфолошки и моторички манифестации меѓу ученичките на 11-14 годишна возраст [Determining the differences in some of the morphological and motor manifestations among female school children aged 11-14]. *Физичка култура*, 2, 69–71.
- Клиничаров, И., Христовски, Р., & Апески, А. (2005). Влијание на висината, тежината на телото, трицепс кожениот набор и бодимас

- индексот врз успешнота во манифестација на одредени моторички квалитети кај ученици на 12 годишна возраст [The influence of height, body weight, skinfold thickness of the triceps and the BMI on the success in the manifestation of certain morphological qualities of 12-year-old school children]. *Физичка култура*, 2, 35–39.
- Klinčarov, I., & Stojanović, T. (2001). Utvrđivanje razlika motoričkih manifestacija kod maksimalno distinktnih grupa sa različitim morfološkim pokazateljima [Determining the differences in the motor manifestations of maximally distinct groups with different morphological indicators]. In N. Živanović (Ed.), *Osmi međunarodni simpozijum FIS komunikacije 2001 u fizičkom vaspitanju, sportu i rekreaciji* (pp. 219-223). Niš, RS: Fakultet sporta i fizičkog vaspitanja.
- Klinčarov, I., & Stojanović, T. (2005). Predikcija generalne motoričke sposobnosti za manifestaciju dugotrajnih eksplozivnih kvaliteta sile kod učenika muškog pola uzrasta 13 godina [The prediction of general motor abilities for the manifestation of the long-term explosive quality of force among male school children aged 13]. In N. Živanović (Ed.), *Nacionalni naučni skup sa međunarodnim učešćem FIS Komunikacije* (pp. 191-195). Niš, RS: Fakultet sporta i fizičkog vaspitanja.
- Klinčarov, I., & Stojanović, T. (2006). Uticaj težine, kožnog nabora nadlaktice i bodimas indeksa na uspesnost u manifestaciji dugotrajnih eksplozivnih kvaliteta sile kod 12 godišnjih učenika oba pola [The influence of weight, skinfold thickness of the upper arm and the BMI on the success in the manifestation of the long-term explosive quality of force among 12-year-old school children of both genders]. *Glasnik Antropološkog društva Jugoslavije*, 41, 367–373.
- Knežević, O., & Mirkov, D. (2011). Sila i snaga mišića opružača u zglobu kolena [The force and strength of extensor muscles in the knee joint]. *Fizička kultura*, 65(2), 5–15.
- Kovač, M., Leskošek, B., & Strel, J. (2008). Overweight and obesity trends in Slovenian boys from 1991 to 2006. *Acta Universitatis Palackianae Olomucensis*, 38(1), 17–25.
- Kuczumski, R. J., Ogden, C. L., Grummer-Strawn, Flegal, K. M., Guo, S. G., Wei, R., ... Johnson, C. L. (2000). CDC growth charts: United States. Advance data from vital and health statistics; no. 314. National Center for Health Statistics.
- Kurelić, N., Momirović, K., Stojanović, M., Šturm, J., Radojević, Đ., & Viskić-Štalec, N. (1975). *Struktura i razvoj morfoloških i motoričkih dimenzija omladine* [The structure and development of the morphological and motor dimensions of the young]. Beograd, RS: Institut za naučna istraživanja Fakulteta za fizičko vaspitanje.
- Matić, M. (1978). *Čas telesnog vežbanja* [Physical exercise classes]. Beograd, RS: NIP Partizan.
- Mota, J., Guerra, S., Leandro, C., Pinto, A., Ribeiro, J., & Duarte, J.A. (2002). Association of maturation sex and body fat in cardiorespiratory fitness. *American Journal of Human Biology*, 14, 707–712. doi: 10.1002/ajhb.10086; PMID: 12400030
- Pate, R. R., Wang, C. Y., Dowda, M., Farrell, S. W., & O'Neill, J. R. (2006). Cardio-respiratory fitness levels among US youth 12 to 19 years of age. *Archives of Pediatrics & Adolescent Medicine*, 160(10), 1005–1012. doi: 10.1001/archpedi.160.10.1005; PMID: 17018458
- Pincivero, D. M., Campy, R. M., & Karunakara, R. G. (2004). The effects of rest interval and resistance training on quadriceps femoris muscle. Part II: EMG and perceived exertion. *Journal of Sports Medicine & Physical Fitness*, 44(3), 224–232.
- Starc, G., & Strel, J. (2011). Tracking excess weight and obesity from childhood to young adulthood: a 12-year prospective cohort study in Slovenia. *Public Health Nutrition*, 14, 49–55. doi: 10.1017/S1368980010000741; PMID: 20392312
- Steele, R. M., Brage, S., Corder, K., Nicholas J., Wareham, N. J., & Ekelund, U. (2008). Physical activity, cardiorespiratory fitness, and the metabolic syndrome in youth, Invited review. *Journal of Applied Physiology*, 105, 342–351. doi: 10.1152/jappphysiol.00072.2008; PMID: 18369096; PMCID: 2494842
- Strel, J. (2006). Correlation of physical characteristics and general endurance: A comparison of 7- to 19-year-old pupils between 1983, 1993 and 2003. *Anthropological Notebooks*, 12(2), 113–128.
- Šukov, J., Živković, V., Šukova-Stojmanovska, D., & Klinčarov, I. (1998). Taksonomizacija latentne morfološke strukture ispitanika kao kriterijum za optimalizaciju nastavnih planova i programa fizičkog vaspitanja u osnovnim školama [The taxonomy of the latent morphological structure of participants as the criterion for the optimization of curricula and physical



- education programs in elementary schools]. In G. Bala (Ed.), *Prvi međunarodni simpozijum fizičke kulture*. Novi Sad, RS: Misl.
- Тодоровска, Л. (1997). *Антропометријски параметри за одређивање на степенот на исхранетост кај деца* [The anthropometric parameters for the determination of the extent of obesity among children]. Unpublished master thesis, Univesity of Skopje, Faculty of Medicine.
- Verhošanski, J. I. (1979). *Razvoj snage u sportu* [Developing strength in sport]. Beograd, RS: Partizan.
- Weiner, J. S., & Lourie, J. A. (1969). *Human biology: A guide to field methods*. Oxford- Edinburgh, UK: Blackwell Scientific..

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