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Original empirical article

THE DEVELOPMENT OF MOTOR ABILITIES OF YOUNGER ADOLESCENTS

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Aleksandar Milojević, Veroljub Stanković

University of Priština, Teacher Training Faculty in Leposavić, Serbia

Abstract. *The aim of this research was to apply a battery of 11 tests of motor abilities based on the structure of motor abilities model by Kurelić et al. (1975), on a sample of 123 subjects aged 14 to 15. The research was carried out with the purpose of gaining information regarding the development of motor abilities of younger adolescents. This work represents a longitudinal study which lasted for a period of one year. The results of this investigation obtained by the method of quantitative change analysis show that there are some small differences in the results of the tests of motor abilities during development between the ages of 14 to 15. Six statistically significant differences related to the test for the assessment of coordination, flexibility, explosive strength, force and repetitive strength were obtained. These results are the consequence of genotype influence on the development of motor abilities, but also of the educational and extracurricular systematic influence in schools. The increase in motor abilities at this age can optimally be predicted by the results of speed tests.*

Key words: *adolescents, motor abilities, quantitative change analysis, motor development.*

INTRODUCTION

Tracking of the development of motor abilities among children and youths is of vital importance for teachers, pedagogues and psychologists. In our country there are numerous research activities involving the motor abilities in children and youths, and using the transversal method. The longitudinal method implies a longer time interval which is probably the main reason for its scarce use in practice.

The development of motor abilities is a constituent part of the overall development of the personality. Their development depends on the creation of the conditional-reflexive

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Corresponding author: Aleksandar Milojević
University of Priština, Teacher-Training Faculty in Leposavić, Serbia, Dositeja Obradovića bb, 38218 Leposavić
Tel: +381 (0)28 84 601 • E-mail: aleksandar.milojevic@pr.ac.rs

networks in the central nervous system (Zaciorski, 1975). Barow & Mc Gee (1975) claim that the motor ability is one of the basic factors for all movements, i.e. that it enables further movements such as running, jumping, throwing and the like. According to Bernstein (1967), movement in children and adults is not just the product of the central nervous system, but of the biomechanical and energy characteristics of the body, environmental support and the specific conditions of the task itself. The relationship between these components is not a hierarchical, but a permeating one. Therefore, concludes Bernstein, actions must be shaped on an abstract level since it is not possible for the CNS to program the interaction of all these factors in advance.

Farfel thoroughly analyzes the development of motor abilities in his physiological theory. His approach towards the development of motor abilities is based on the physiological parameters. He emphasizes biochemical and physiological processes that are fundamental for the development of motor skills and he concludes that the motor analyzer and all other CNS functions develop in accordance with chronological age. The intensity of the development of the motor analyzer depends on the quantity and versatility of the movements performed daily. Ismail (1976) have found that the development of the physical abilities of pupils aged 8 and over is improving during the maturation process, until the ages of 18 to 19. Acceleration of growth is emphasized between the ages of 9 and 11. The physical abilities of schoolgirls change over age, they improve until the ages of 12 to 13 when they reach their maximum and afterwards stagnate, and two years later decrease, so that 19 year-old girls equal 11 to 12 year-old girls' physical abilities. Acceleration of growth can be found among girls before the age of 10. Most research was concerned with the structure of motor abilities. Fleishman's work (1975) is considered fundamental in this area regardless, of its drawbacks, followed by the work of Vandervael (1964), Kurelić et al. (1975), Ismail (1976).

METHOD

The research was conducted on a sample of 123 subjects, first grade high school male students aged 14. All of the participants were subjected, under the same conditions, to a battery of 11 tests of motor abilities. The testing was administered at the end of their second term as first graders and was repeated after precisely one year on the same sample of participants, with the use of the same tests at the end of their second term as second graders. The sample of motor variables was not designed to enable extraction of motor factors but only to give a global estimation of the motor abilities. In order to estimate motor abilities and the model of the structure of motor abilities (Gredelj et al., 1975; Metikoš et al., 1982) the following manifest variables were applied: explosive power – 1. the standing long jump (SDM); repetitive power – 2. push- ups (SKL); force – 3. the pull up hang (VIS); speed– 4. 20 meter run with a high start (20V), 5. 4x5 meter with a high running start (45V), 6. hand tapping (TAP); flexibility – 7. hyperextensions (DPK); balance – 8. the one leg stand along the balance beam (SUK); coordination – 9. coordination with a baton (KOP), 10. the three-medicine-ball slalom (S3M), 11. the backward polygon (PNA).

The hypothesis that changes in the development of motor abilities are significant during adolescence was tested by multivariate methods for the analysis of quantitative changes, using a DDIFFG algorithm to test the significance of differences in the quantitative changes of two independent samples, and in this research the results of the second measurement can be treated as two independent samples of data (Momirović, 1987).

RESEARCH RESULTS

The obtained results are shown in Table 1 with the results of the univariate analysis of the qualitative changes between the results from the first and the second measurings of motor abilities that are treated as two sets of data.

Table 1 Univariate tests of differences of the arithmetic means

	pr1	pr2	vpr	vvst	zd	ftst	sigd
TAP	23.52	24.35	-.82	2.59	-.31	12.28	**.00***
45V	8.39	8.27	.12	.87	.13	2.35	.12
20V	3.98	3.91	.06	.39	.16	3.32	.07
PNA	12.45	12.47	-.01	2.99	-.00	.00	.94
KOR	7.37	6.67	.69	3.54	.19	4.76	**.03***
S3M	26.44	26.25	.19	5.64	.03	.14	.70
SUK	29.66	30.34	-.67	28.30	-.02	.07	.79
DPK	8.39	11.17	-2.78	6.33	-.43	23.72	**.00***
SDM	213.65	221.75	-8.09	28.00	-.28	10.28	**.00***
VIS	48.00	57.39	-9.38	24.76	-.37	17.65	**.00***
SKL	16.94	18.56	-1.61	7.95	-.20	5.09	**.02***

It is evident that there are six significant differences in the quantitative measures of motor abilities ranging from .00* for the tests of frequency velocity (TAP), flexibility (DPK), explosive strength (SDM) and force (VIS) to .02* for the test of repetitive strength (SKL) and .03* for the test of coordination (KOR). None of the tested motor abilities have shown a significant decrease in the results, while in five of the tests there are no statistically significant differences between the first and the second measurings (Table 1). The results of the univariate differences show that the biggest changes occurred in the force increment (VIS), explosive strength (SDM) and increase in flexibility (DPK) followed by an increase in segmentary speed (TAP), repetitive strength (SKL) and coordination (KOR). Small but statistically significant differences between the first and the second measuring of some motor abilities were expected because of the systematic influence of the teaching activities between the first and the second measuring and the non-systematic influence of all of the remaining factors. These results are completely congruent with the results of other authors (Kurelić et al., 1975), who have obtained similar results, i.e. that during adolescence, until the ages of 17-18 in the case of men, one can notice the relatively steady development of motor abilities.

Table 2 gives correlation of the differences in the measurements. The biggest correlations between the differences were obtained between the tests for explosive strength (SDM) – the standing long jump and the test of speed (20V) – the 20 meter run with a high start (-.48*). Further on there are significant correlations between the test of power (VIS) - endurance in the hanging position and the test of explosive strength (SDM) – the standing long jump (.36*), which correlate with the test of speed (45V) – the 4x5 meter run with a high start (-.28*), the test of force (VIS) - endurance in a hanging position and test of coordination (PNA) – the backward polygon (-.22*), the test of repetitive strength (SKL) – push-ups and balance (SUK) - standing on a balance beam (.21*) and flexibility (DPK) - hyperextensions with the test of frequency velocity (TAP) - hand tapping (-.21*). What can be concluded from the table of correlations is that the increase in running speed in both tests of speed, (20V) and (45V), is in functional sense connected with the decrease in explosive strength test (SDM), and that the increase in force follows the increase in explosive strength and that the increase in coordination follows the increase in speed.

Table 2 Correlation of differences

	TAP	45V	20V	PNA	KOR	S3M	SUK	DPK	SDM	VIS	SKL
TAP	1.00	.06	-.04	-.16	.19	-.03	-.06	-.21	.04	.13	.20
45V	.06	1.00	.21	.29	-.05	-.02	-.08	.20	-.28	-.12	-.08
20V	-.04	**.21***	1.00	.10	-.00	.18	-.10	.07	-.48	-.16	-.05
PNA	-.16	**.29***	.10	1.00	.02	.11	-.00	.07	-.14	-.22	.05
KOR	.19	-.05	-.00	.02	1.00	.11	-.03	-.01	-.04	-.13	-.03
S3M	-.03	-.02	.18	.11	.11	1.00	-.06	-.02	-.13	-.05	-.14
SUK	-.06	-.08	-.10	-.00	-.03	-.06	1.00	.05	.08	-.12	.21
DPK	**-.21***	.20	.07	.07	-.01	-.02	.05	1.00	.01	.17	.05
SDM	.04	**-.28***	**-.48***	-.14	-.04	-.13	.08	.01	1.00	.36	.11
VIS	.13	-.12	-.16	**-.22***	-.13	-.05	-.12	.17	**.36***	1.00	.03
SKL	.20	-.08	-.05	.05	-.03	-.14	**.21***	.05	.11	.03	1.00

Table 3 shows the results of the multivariate analysis that has given one discriminant function tested by the Hotelling test of significance and Mahalanobis distance, significant at the level of .00 (sigt=.00).

Table 3 Mahalanobis distance and Hotelling test of significance

dsq	tsq	hot	nv	hotdf	sigt
.60	74.69	6.23	11.00	112.00	**.00***

Table 4 The discriminant coefficients and the structure of discriminant factors

	beta	fmat
TAP	**-.20***	-.40
45V	**.34***	.17
20V	**.18***	.21
PNA	-.06	-.00
KOR	.08	.25
S3M	-.00	.04
SUK	.00	-.03
DPK	-.09	-.56
SDM	-.00	-.37
VIS	-.00	-.48
SKL	.00	-.26

The structure of the discriminant factors (Table 4) shows that at the top of the table of discriminant variables we find the tests of speed: the 20-meter run with a high start (20V), the 4X5 meter run with a high start (45V) and hand tapping (TAP). Having in mind the obtained results, one can conclude that predictive function is Y = 45V*34 +

TAP*-.20 + 20V*18. Hence, the increase in motor abilities can be predicted based on the results of the speed tests.

Table 5 The reliability of the discriminant function and global measure of differences

rel	gen
-.11	.05

DISSCUSION

Since the sample of motor variables was not designed to enable the extraction of motor factors, but only for a global evaluation of motor abilities for a relatively short, year-long period of development, i.e. a period between two measurings, the obtained results matched those found in previous research programs.

Based on a number of studies in the area of sports genetics, one can conclude that motor abilities are still in the phase of empirical investigations and that it is hard to reach safe conclusions (Wolansky, 1986; Malacko, 2000). In addition, following the opinions on the influence of genotypes on the development of motor abilities, the following prevails: speed (H2=.90-.95), explosive strength, coordination, balance and accuracy (H2=.80.-.85). These are highly dependent on genetic factors, while repetitive strength, force and flexibility (H2=.50) are only dependent to a smaller degree, meaning they can be changed. Motor speed is thus an ability of a dispositional type.

Almost all of the measured motor abilities have been enhanced, i.e. there are differences between the values from the first and the second measuring, meaning that the six tests showed a statistically significant improvement. The development of motor abilities can be thoroughly explained by the tests of speed. The data show that between the values which characterize the level of any speed function under different conditions, remarkably significant correlational relations can be found. For example, significant correlations were found between the latent periods of simple sensory-motor reactions and between the maximum speed of movement of different body parts.

A factors analysis was applied to reveal the factor of "reaction speed" responsible for 3/4 of the variability in the latent period of reaction, while 1/3 of the variability depended on the specificity of the signal and movement of the body part or the body as a whole. A significant correlation was found between the speed of different single movements. No significant correlations were found between the speed of the movement, frequency of the movement and reaction time. In other words, a man can react quickly and not have rapid movements (Stanković, 2007; Stanković & Malacko, 2008). In addition, some research results indicate a transfer of speed features when we take into account the structure of movement having a common coordination basis (jumping speed, throwing speed, start speed), and the fact that there is no correlation between such movements as a skip and sprint. However, running speed shows a high correlation with explosive strength and repetitive strength. Hence, we conclude that men's abilities in regards to speed are quite specific and complex (Malacko & Rađo 2004).

CONCLUSION

The hypotheses claiming that changes in the development of motor abilities during adolescence are remarkable ones were tested by multivariate methods for the analysis of quantitative changes using a DDIFFG algorithm for the testing of the significance of a change involving two independent samples. In this research the results of the first and the second measurings can be considered two independent data samples (Momirović et al. 1987). These results show the greatest changes occurred in the force increment (VIS), explosive strength (SDM) and increase in flexibility (DPK) and are followed by differences in the increase in segmentary speed (TAP), repetitive strength (SKL) and coordination (KOR). Also the obtained results show that the increase in motor abilities is predictable by means of the speed tests results.

All anthropological characteristics, especially motor ones, can be changed qualitatively and quantitatively. It should be mentioned that both types of changes are simultaneous but it is also possible to use an adequate distribution of kinesiological contents, modalities and volumes so as to lead to a significant influence on the type of changes. Knowing the laws which govern these quantitative changes in the body is a deciding factor for the efficient programming and control of kinesiological transformational procedures, which directly depends on the level of mutual relations between anthropological characteristics (Milojević et al., 1988). One has to bear in mind that the total effects of the quantitative changes can be expected only on the condition that an optimal relation between corresponding abilities, features and knowledge is established. Naturally, the influence of the genotype on the development of motor abilities prevails, which means a greater number of single motor abilities are highly influenced by genetic ones, while a smaller number is not as influenced by them. Thus, one should expect a greater possibility of change in them. The use of motor speed to predict the increase in motor abilities is of a dispositional type.

Systematic activities during the school year were implemented through the introduction of extra-curricular activities. In such an environment, the systematic influence of physical education and extra-curricular activities, uniform for all the schoolchildren, less systematic influence which was adjusted to suit each pupil, and the non-systematic influence of the remaining factors brought about an entire array of changes in the motor status of each participating pupil. The results of this research are congruent with the conclusions of Kurelić et al. (1975), who claimed that the development of physical abilities of pupils aged 8 and over improves steadily and gradually over the years the ages 18 to 19.

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RAZVOJ MOTORIČKIH SPOSOBNOSTI MLAĐIH ADOLESCENATA

Aleksandar Milojević, Veroljub Stanković

Cilj istraživanja je bio da se na uzorku od 123 ispitanika muškog pola, starosti 14 i 15 godina primeni baterija od 11 testova motoričkih sposobnosti prema modelu strukture motoričkih sposobnosti Kurelića i saradnika (1975) radi dobijanja saznanja o razvoju motoričkih sposobnosti kod mlađih adolescenata. Rad predstavlja istraživanje longitudinalnog karaktera u trajanju od godinu dana. Rezultati istraživanja, dobijeni metodom kvantitativne analize promena, pokazuju da postoje male razlike u postignuću na testovima motoričkih sposobnosti u toku razvoja od 14-te do 15-te godine ali je dobijeno i šest statistički značajnih razlika i to kod testova za procenu koordinacije, fleksibilnosti, eksplozivne snage, sile i repetitivne snage. Ovakvi rezultati su posledice kako uticaja genotipa na razvoj motoričkih sposobnosti tako i sistematskog uticaja nastavnih i vannastavnih aktivnosti u školama. Porast motoričkih sposobnosti u ovom uzrastu optimalno se može predvideti rezultatitima testova brzine.

Ključne reči: *adolescenti, motoričke sposobnosti, kvantitativna analiza promena, motorički razvoj*