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STRUCTURE OF STUDENTS MOTOR SPACE

Abstract

In recent years the population of students is increasingly subject of study of a number of subsystems in which the subsystem of motor skills has a significant position, especially when it comes to the structure of the motor space. In the different age periods we record significant changes in motor skills. On the basis of their structure, we can conclude the level of development of certain motor skills, that is of those skills which in the greatest extent determine the certain population. The study sample consisted of 200 students of both sexes, aged 15-16 years. The main objective was to identify the latent dimensions of the motor space applied on the basis of a set of manifest variables. The factor analysis obtained results showed that in the students exist eight latent dimensions of the motor space defined by the phenomenological model.

***Key words**:* motor skills, latent dimensions, students, factor analysis.

INTRODUCTION

Interest in the study of motor skills began at the beginning of the twentieth century, although more intensive attention to this kind of research was devoted only in the forties of the last century, and studies based on scientific knowledge and experiences of other sciences (psychology, sociology, biomechanics, physiology, anatomy, etc.) occur in the period after World War II. First, so far registered, the motor space research was carried out by D. A. Sargent, in 1902. He designed the first battery of six tests under the title *Universal test of strength, speed and endurance of the human body* (Kurelić et all.1975). Studies of the factor structure of motor abilities, dating, by Gredelj et all. (1975), starting around 1934, when Mc Cloy analyzed situational motor tests battery and determined factors: strength, speed and coordination.

Larson (1941) with identical motor tests as Mc Cloy performed factor analysis and also isolated three factors, but those factors differentiated on dynamic and static power, he defined speed as motor explosiveness, and coordination he differentiates on coordination with agility of the whole body and motor educational function. Fleishman (1964) conducted a very extensive and important research in the field of motor skills. The study was conducted on a sample of 2000 students of both sexes aged 12-18 years from 45 U.S. cities. The study applied the 30 measurement tests to assess areas of strength and 30 measurement tests for assessing the speed, agility, balance and coordination. Motor space research was conducted on different populations with different age. At first it was a fundamental research on the population of young people aged 19 to 27 years. Among them are very important researches of Kurelića et all. 1975 who proposed and defined a hypothetical model of latent structure of basic motor dimensions, which Gredelj and assoc. (1975) verified by the application of battery of 110 motor tests on a sample of 693 male respondents. The results showed that the structure of this model has three levels (primary, secondary and tertiary factors). Tertiary factors on the second and third levels, are defined as the neuro-physiological mechanisms that are mutually arranged hierarchically. Factors of the second order form mechanisms for structuring movement, synergistic regulation and the regulation of tone, excitation intensity and duration of the excitation control, while the third row factors are the mechanism for the regulation of movement and the mechanism of energy regulation. Hoffman (1980) explores the structure of psychomotor speed in order to isolate the primary factors of speed and determine their relation, and the relation of measures to assess the speed of movement with other measures of motor skills. The study was conducted on 674 male subjects. It was applied 13 variables to assess the speed and 7 to estimate the speed of simple movements and 6 to assess the frequency of movements. Other motor area that is defined by 21 hypothetical factor was estimated from the 97 motor tests. At the end of verified canonical analysis the author concludes that the structure of the first pair of canonical factors indicates the importance of the general factor of speed of movement in the realization of other motor skills.

Initially, the entire motor area was studied with a view to its reduction to a smaller number of latent dimensions that characterize it (Zara, 1972; Opavsky, 1975; Zaciorski, 1975), and very often only one segment of the motor space (for example, strength, endurance, speed, etc.). Very often the subject of motor space encompassing a population of students (Hosek and Metikoš 1972, and Mraković Metikoš 1976, Jankovic, 1981; Milanovic, 1981; Metikoš, Prot, Hofman, 1982). Certain studies have studied the motor area of physical education students (Furjan, 1987; Pavlovic, 2004; Trivun and Pavlovic, 2004; Pavlovic, 2005). All these studies were conducted in order to enable the existence of primary motor factors that characterize a defined population. Differences were observed in terms of gender, activities involving subjects, etc… Based on these results we can with some certainty define the primary motor factors for a population. The interesting and very important researches, which are closely tied to the survey, that were conducted on a population of students. As a fundamental research is the study Kurelića and assoc. (1975) in a sample of 3423 respondents of both sexes from 11, 13, 15 and 17 years, performed factor analysis of 37 motor tests and the final results were published 1975 in the monograph, “The Structure and Development of morphological and motor dimensions of youth." The assumed hierarchical model in the first level was based on phenomenological studies of the factor structure of motor abilities of Fleishman and Ismailia. The primary factors were not isolated, at least not such that would have a logical significance of latent dimensions of the first order. In the space of second-order factors were obtained as defined in Gredelj et all. Connection of isolated factors in the space of a higher order factor indicates the existence of central control of movement, while the third and fourth correlation factor indicates that there are factors of the movement of energy regulation comprising of the third kind order. For the variability of motor manifest abilities responsible are four factors mentioned in whose grounds are the physiological mechanisms. Interesting research conducted Sturm (1970), with measurements carried out in 28 tests of physical abilities of students of both sexes of 8 and 12 years of age from Ljubljana elementary schools, and report on the reliability and factor analysis of these tests he published in 1970. Factor analysis extracted four factors in all groups of respondents: explosive strength, repetitive strength, repetitive strength of the body, speed. In addition to these factors in a 12-year-old boy appeared the primary factor that the author called factor OF „sprint“, and IN the 8-year old boys and girls appeared a special factor of balance. Malacko and Ropert (1977) examined the latent motor structure on a sample of 312 boys age between 10-12 years. With the method of factor analysis they condensated the latent dimensions as a three-dimensional model of speed power, speed of reaction and speed of individual movements without much load, based on which the common variance was explained of the applied motor variables.

Some authors have studied the younger school years. Babic (1985) investigated the factor structure of motor abilities of students aged10 years, where the application of 15 motor tests, using factor analysis for the goal of the explication of the common variability of motor abilities, latent dimensions were extracted and interpreted as a two-dimensional model of explosive power and flexibility. Malacko (1991) investigated the factor structure of motor space on a sample of 103 boys aged 11 years. Using the battery of 18 motor tests, factor analysis condensed latent dimensions were interpreted as six dimensional model of repetitive strength, frequency of movement, speed of alternative movements, speed of the hands and feet, body coordination and explosive strength with which was explained the mutual variance of manifest variables. Wolf-Cvitak and Furjan-Mandic (1999) tested 32 girls, aged 10-12 years with 9 composite motor tests in order to determine the structure of the motor space, with isolated and defined 3 factors: agility, balance and coordination. The obtained factors, the authors argue, are saturated by the explosive force, as found by other researchers using a sample of this age. Kukolj et all. (2001) for the purpose of longitudinal studies had interconnectedness of motor abilities during sensible periods. This study included 235 students and 214 students from first to third grade of elementary school. The authors come to the conclusion that the development of motor skills of students tends to constant improvement. The results of this study can serve as an objective basis for selection of specific content of training in the absence of functional tests (running from 1500 to 5000m).

Samardzic (2009) on a sample of 124 students aged 7 years in Novi Sad, conducted a research with the aim of determining the hierarchical structure of the motor dimensions and their relationships. Applied are a total of 17 variables on a functional model, by application of factor analysis were extracted five factors, which are defined as latent dimensions. Interesting researches are of motor area in secondary school age who were of interest to some authors. Gajic et all. 1981st on a sample of 608 students and 670 female students aged 11-15 years of age with 30 motor tests were analyzed the explosive force of the lower extremities, with eight latent dimensions identified for all ages: ability to manifest power with explosive movements of the body and projecting of the body into the distance, explosive flexor muscle strength of legs , ability to perform frequent movements with lower extremities, the explosive force of impact character, ability to rapidly develop force for movement of the lower extremities, the ability to perform upper limb movements, structuring the movement of explosive character, the ability to sprint. The authors concluded that there are specific differences of these factors in relation to age and sex of respondents. Doder (1998) investigated the factor structure of motor space on a sample of 177 students, aged 11-14 years. Using the system of 12 motor measuring instruments using factor analysis were extracted the four basic factors: coordination, repetitive static strength, explosive strength and flexibility. Dragaš (1998) in a sample of 153 students, aged 15-16 years examined the factor structure of motor abilities. Using the battery of 19 motor tests the existence of five latent dimensions was determined, defined as a five dimensional general model of coordination, explosive strength, frequency of movement, precision shooting and precision targeting.

Based on the results of previous studies was defined the scope of this study which included motor skills of older pupils of school age in order to determine and establish a model of latent motor dimensions that determines the best-defined population of students.

METHOD OF WORK

The sample respondents

The population from which is the sample of respondents, was defined as the population of high school students from Prijedor, Prnjavor, Banja Luka and Doboj ages 15-16 years. The total sample size was 200 students, a sixth of the sample consisted of female respondents.

The sample of measuring instruments

In the selection of measurement instruments it was taken into account their reliability, objectivity and validity. For the purposes of this study a sample of 32 motor variables was identified:

Variables for assessing explosive strength: The long jump from standing point - MSDM, Triple jump from standing point-MTRS, Sargent jump-MSAR, throwing medicine balls lying on back (2kg)-MBMD;

Variables for assessing repetitive strength: push ups- MSKL, raising body-MDTK, Pushing up rear on horizontal bar -MZGV, deep squat (20kg against the wall at 30")-MDCO;

Variables to assess the static strength: hold in knuckle the- MVIS, flexing with hands (20kg)-MFLE, hold in half squat (20kg)-MPOČ, hold abs-MDTI;

The variables for the estimation of the velocity: 20 m flying-M20L, hand tapping-MTAP, foot taping- MTAN, a 20m high start-M20V;

Variables for assessing the flexibility: depth reach on bench-MDPK, flex stick-MISP, lateral split-MSPA, forward bend in sitting position feet apart-MRAS;

Variables for evaluation of coordination: keeping the ball around the stands-MVLS, agility in the air-MOZ, dribbling around the stalks with MVLSN, Coordination with stick-MKOP;

Variables for estimation of endurance: run 100m-M100, run 400m-M400 run, run 800m -M800, run 1000m- M1000;

Variables to assess the factors of balance: standing on one leg on the longitudinal beam MSUOO-open eyes, standing on one foot on the beam cross-MSPOO eyes open, standing on one foot transversely to the beam-closed eyes MSPZO, flamingo-MFLA. The applied set of motor variables are taken from research Kurelić, Momirović, Stojanovic, and Sturm-Viskić Štalec, 1975; Ivanić i Ivanić, 1999.

RESULTS AND DISCUSSION

In factor analysis of a set of motor skills was applied GK normalization procedure, with the selected method of principal components (Varimax normalization). All the obtained latent dimensions are defined by the principle of the phenomenological model (Table 1, 2). A set of 32 manifest motor skills was explained with 51.26% of common variance. Eight factors has been identified, defined as latent dimensions that determine the total variance of the motor system of the analyzed subjects.

Table 1. Eigenvalues; Extraction: Principal components

	Eigenval	% total Variance	Cumul. Eigenval	Cumul. %
Factor 1	5,10	15,95	5,10	15,95
Factor 2	2,15	6,73	7,26	22,68
Factor 3	1,85	5,79	9,11	28,47
Factor 4	1,75	5,45	10,85	33,92
Factor 5	1,55	4,84	12,40	38,76
Factor 6	1,43	4,48	13,84	43,24
Factor 7	1,30	4,07	15,14	47,31
Factor 8	1,26	3,95	16,40	**51,26**

Legenda: Eigenvalues-typical root; %total Variance-variance single factor; Cumul.Eigenval-sum root; Cumul.%-of the total variance

Table 2. Load factor (Varimax normalized)

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	h
MSDM	.40	-.16	**.58**	.04	.03	.23	.01	.07	.44
MTRS	.45	.09	**.55**	.21	-.05	.09	-.18	.31	.55
MSAR	-.06	.15	-.25	-.12	**.48**	.22	.01	.11	.61
MBMD	.19	-.05	**.53**	-.26	-.14	.03	.19	-.08	.53
MSKL	.18	-.09	.14	.02	**.66**	.02	.33	-.00	.72
MDTK	.12	-.14	-.07	.34	**.56**	.06	.01	.17	.63
MZGV	.24	.04	.10	-.06	.03	**.44**	.44	.10	.81
MDČO	.34	.00	.13	.05	-.07	**.55**	-.13	.17	.63
MVIS	.22	.09	.16	.02	.33	**.50**	.18	.09	.69
MFLE	.20	.06	-.27	.07	-.23	**.49**	.33	-.03	.64
MPOČ	-.12	.02	-.35	-.16	-.01	.01	**.76**	.13	.74
MDTI	.27	-.06	.16	.40	-.05	-.02	.09	.42	.54
M20L	-.21	-.00	**.84**	-.03	-.18	.01	-.02	-.07	.56
MTAN	-.01	.01	.04	**.69**	-.02	-.01	-.10	.01	.69
MTAP	-.05	.03	-.00	**.71**	-.23	.20	-.16	-.08	.65
M20V	-.37	.06	**.80**	-.06	-.18	.03	.06	.01	.70
MDPK	.36	-.12	.11	.37	.13	-.12	-.13	.19	.80
MISP	.05	.05	-.28	.01	-.34	.33	.07	-.14	.48
MŠPA	.06	-.01	-.23	.19	**.54**	.06	.21	.01	.30
MRAS	.32	.20	-.08	-.25	**.48**	-.07	-.08	-.25	.55
MVLS	.08	-.00	-.06	.19	-.07	-.25	.30	**.64**	.52
MOZ	.11	-.01	-.05	**-.64**	.32	-.05	.15	-.17	.56
MVLSN	-.01	.03	-.10	-.04	-.01	-.09	.12	**.74**	.64
MKOP	.03	-.19	-.20	**-.51**	.17	.47	-.26	.14	.11
M100	**.63**	-.14	-.39	-.06	-.13	.05	-.04	-.04	.74
M400	**.68**	-.09	-.30	.05	.09	.02	.11	.13	.69
M800	**.78**	-.01	-.08	.15	.20	.10	.04	-.07	.76

M1000	**.78**	.02	-.14	.15	.19	.07	.09	-.11	.79
MSUOO	-.29	**.76**	-.07	.03	-.12	.08	-.14	.06	.74
MSPOO	-.05	**.83**	.04	-.04	-.08	-.08	-.03	.09	.73
MSPZO	.12	**.74**	.04	-.01	.25	-.04	.11	-.14	.65
MFLA	.02	-.48	.22	.05	.19	.23	.24	-.13	.56

The largest contribution to the saturation of the first factor have made the running variables (100m, 400m, 800m, 1000m) defined as variables of aerobic and anaerobic endurance with total 16 per cent in the explanation of mutual system variance with eigenval. 5.10, which indicates a high saturation of the vector in the coordinate system. In addition to endurance variables contribution to the total variance of the first isolation of factors also enabled the variables of the explosive power, jump out from the spot and the triple jump from the spot with a slightly smaller impact. Such saturation of the first factor that plays a key role in explaining the common variance of the system lies in the fact that the isolated variables are dominant in endurance activities that respondents exercise, running, jumping in athletics and also in sports and some individual sports. These variables are controlled by mechanisms of energy and central regulation and movement and partly genetically predetermined and some are not particularly on longer routes, where have some influence physiological mechanisms. However, variables that are most responsible for the extraction of the first factor are responsible for the aerobic-anaerobic endurance. There fore, this factor can be interpreted as a latent dimension of *aerobic and anaerobic endurance* of the respondent.

Another factor in the Varimax rotation define the variables of balance which showed a high homogeneity of the group: transverse standing on a bench with eyes open (MSPOO .83), standing along the bench with open eyes (MSUOO .76), standing cross-bench with eyes closed (MSPZO .74), flamingo (MFLA -.48) with a smaller projection which is the smallest holder of the variability. This factor is exhausted 6.73% of common variance of the system with eigen value (2.15) that is greater than zero, and reserves the right to extraction. The values of the factor determination and communality values are of high projections. It is obvious that this set is positioned close to the largest number of manifest variables which passes next to his stack. Such is the position of the coordinate system and the behavior of this factor as a secondary what in relation to the first determines the highest measure of common variability of the extracted factors (latent dimensions). Other variables in the defined area made insignificant vector strengths and they and their values are small and almost zero which further positions the value of the extracted variables balance. Regarding that in other factor were isolated variables by which the balance of the body was estimated, the second extracted factor can be interpreted as a latent dimension of *balance*.

The third latent dimension define two latent motor variables with projections of more than>.70. as follows: running a 20m high start (M20V .80) and running 20m flying start (20ml .84) as the main proponent of variability of this factor. Statistically significant screening variables explain 5.79% of the common variance of the system with the retained net value greater than zero (eigen.=1.85). Extracted significant variables whose projections are of vector >.70 describe the sprint speed tests. Communalities of extracted variables are of significant projections. An interesting fact is the behavior of variables of explosive strength, standing long jump, triple jump and medicine ball throw which by their positioning in the coordinate system contributed to a better extraction of factors. Their values range from (MBMD .53) (MTRS .55) to (MSDM .58). From this it can be concluded that their projections define the third factor as a latent dimension of sprint speed and explosive power.

Analysis of projections in the fourth isolated growth factor reveals important values of variables of segment speed hand tapping (MTAP .71) and taping the foot (MTAN .69). Both manifest variables are from in the velocity space and are influenced by mechanisms of central control of movement with significant values of communality and variance of 5.45%, with eigenvalue 1.75. Another variable that has allowed a better extraction is variable from space coordination agility in the air (MOZ -.64) and coordination of bat (MKOP -.51). These two variables define the coordination of the whole body. Based on these indicators, the fourth factor defines latent dimension of *segment speed and body coordination*.

The fifth factor carries information not contained in the preceding. It exhausted 4.84% of total variance of the motor space of the system with the relevant value of the characteristic roots. Manifest measures set by the independent extraction of this factor are from the space of repetitive power that are push ups (MSKLE .66), raising body (MDTK .56) as the main carriers of the total variability. Also, the flexibility of the pelvis variables (MSPA .54) and the reach of the sitting (MSRAS .48) by their slightly smaller projections contributed to the extraction of this factor. Beside them is a variable explosive strength of high jump from standing (MSAR. 48). That their projections are significant show values of communality. This factor could be defined as the dimension of *repetitive power and flexibility of the pelvis.*

In space defined by the sixth factor it was explained a smaller part of the common variance of the system which included the participation of three manifest variables of static strength and a variable of repetitive force. Although their projections <.70 retained the right to extract given the eigen value that is greater than zero (1.43). The main carrier of the variability to the sixth factor is the variable deep squat with a load(MDČO .55), then hold in the knuckle (MVIS .50) and hold of load in the flexion of hands (MFLE .49). These three variables are very close together in the coordinate system of the motor space. Also, communalities of extracted variables are of satisfactory values. The variable that contributed to its position in the extraction of this factor is pull-ups (MZGV.44). With four extracted variables it was explained a total of 4.48% common variance of the system. Based on the vector saturations sixth factor can be defined as the dimension of the *static strength of arms and shoulders*.

As the penultimate seventh factor that independently took part in defining the structure of the motor space of defined population of respondents is the factor that is defined with only one variable of static strength, and, as such, explained 4.07% of total common variance of motor space. The variable hold of load in hold half squat (MPOČ .76) retained a higher value of .70 and significantly different from zero (Eigen.1.30). which has acquired to it the right to self-extraction. Such facts speak in favor of it that it is a heterogeneous sample where we do not have a good relationship between the variables in the same space or some variables were too easy or too difficult for respondents. The seventh factor is defined as the latent dimension of *static leg strength*. It's variance gave the contribution of less than 13% in explaining the common variance of the overall system.

As the last eight extracted motor space factor is a factor which is defined by two variables of coordination. Their share in the common variance of the system amounts to 3.95% with a still satisfactory eigen. value (1.26). Although still a small enough variance for independent extraction of the motor space. The main carrier of the variability is variable dribbling between the stands with legs (MVLSN.74) and guiding the ball between stands with hands (MVLS .64). The values of the factor determination and communality values are of high projection (h=.52 - .64). It is obvious that this set is positioned close to the largest number of manifest variable swich passes next to his stack. This position in the coordinate system is also behavior of this factor as a secondary what in relation to the previous seven sets also determines the greatest measure of common variability of extracted factors (latent dimensions). Since in the eighth factor are isolated variables which assessed coordination of arms and legs. This extracted factor can be interpreted as a latent dimension of *coordination of limbs***.**

Table 3. Correlation factors

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Factor 1	1,00							
Factor 2	-,14	1,00						
Factor 3	**-,54**	,06	1,00					
Factor 4	,11	-,00	-,14	1,00				
Factor 5	**,37**	,10	**-,46**	-,06	1,00			
Factor 6	**,34**	-,06	-,03	,09	,18	1,00		
Factor 7	,18	-,08	-,17	-,01	,19	,13	1,00	
Factor 8	,07	,04	-,14	**-,24**	-,05	-,16	,**28**	1,00

By the inspection of the correlation matrix of isolated motor factors (Table 3) correlation of the first factor were observed (Factor 1) with the third, fifth and sixth, that is endurance to sprint speed and explosive power where is a negative correlation (Factor 3=-.54) but significant , A positive correlation with the repetitive power (Factor 5=.37) and static strength (Factor 6=.34) with mean values. The third factor (Factor 3) has established a negative correlation with the fifth factor, that is sprint speed and explosive and repetitive strength and flexibility (Factor 5=-,46). Factor 4 and Factor 8 and also made a small negative correlation (-.24) and with Factor 7 Factor 8 positive correlation (.28). Almost zero correlation was achieved between the other factor balance with all the other. Here you can spot the links within the variable mechanism of energy regulation which are mostly positive and the central control variables which are generally negative. Since it is about a lack of homogenity of the motor space. When it comes to basic manifest variables in the common set, then this correlations are justified.

This study is similar to previous studies that have treated the issue of regulation of motor areas of the student population (Gajic et al. 1981; Doder, 1998; Dragaš, 1998). The results obtained enabled the interpretation of the motor space from the perspective of phenomenological models which is very common in research in physical education. It is possible, however, small differences between this sample and sample of previous research are the consequences of certain endogeno-exogenous factors that have significant influence in the formation of motor habits in students. Also the existence of motor factors depends from development and condition of the population, that is age of respondents. It is known that motor skills exercise achieve trend of growth in individual life ages of respondents, when their development can be much more influenced and achieve better results (Kukolj, 2001; Pavlovic, 2010). Also directed physical activity is very important in the formation of the motor model that would characterize a population. In our research we have a situation that a number of students (½) are involved in physical activities out of school, training in sports clubs, and their motor structure is the result of physical activity and motor skills that are most represented in the implementation of physical activity.

CONCLUSION

After processing the data and the results obtained using factor analysis in a defined motor behavior was isolated a smaller number of latent dimensions based on the applied of the actual manifest variables in the group of patients. In the area of motor skills, factor analysis revealed the existence of eight different factors defined as the latent dimensions of aerobic-anaerobic endurance, balance, sprint speed and explosive power, segment speed and coordination of the body, repetitive power and flexibility of the pelvis, static strength of arms and shoulders, static leg strength, coordination of limbs. Here is the phenomenon of integration of variables within a single mechanism of central regulation of energy or movement. Which indicates a certain independence of the variables defined subspace within motor space. n the motor space is clearly defined eight different latent dimensions. That have stood out as unique to this population of respondents, which formed a common model motor space, which is best defined study population, age 15-16 years of age.

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