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Comparison of motor development of boys and girls aged 11-17

by

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The motor development of boys and girls attending Slovenian primary and secondary schools was compared. Research was carried out on a representative sample of 517 boys and 807 girls aged 11-17. Twenty-six tests were chosen to evaluate motor abilities. Basic statistical parameters were used to analyze the motor status of boys and girls and classic procedures of factor analysis were used.

In boys, greatest progress is observed between the ages of 13 and 15, whereas temporary stagnation can be noted between the ages of 11 and 13 in muscular strength of the arms and shoulder girdle. Between the ages of 15 and 17 stagnation can be observed in information as well as energy components. In girls, greater positive changes can be observed between the ages of 11 and 13 when girls achieve best results in those procedures that hypothetically cover the energy and information component of movement. The greatest decrement trend can be observed in these procedures in girls aged 15 to 17.

In younger subjects of both genders the structure of the latent motor area is less clearly defined and achievements depend on the simultaneous action of different mechanisms responsible for the energy and information components of movement. Generally, the latent structure of motor area of boys and girls is similar; it differs to the greatest extent at the age of 13. The changes are explained by puberty changes, which girls undergo earlier.

Keywords: motor abilities, latent structures, motor development

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Introduction

The period of puberty is characterized by rapid body growth due to the influence of hormones. The accelerated physical development disturbs the established motor patterns and leads to a temporary stagnation or even regression in the process of the motor development. Physical changes take place earlier in girls, what results from the fact that, the motor development of boys and girls differs in this period (Kondric et al. 1997; Kovac 1999; Kovac and Strel 2000; Strel et al. 1994; Strel et al. 2002; Šturm 1970; Šturm and Strel, 1985; Tanner 1991).

By analyzing the manifest and latent spaces of boys and girls we tried to explain certain changes in motor development of both genders and the changes in the development of both genders in the period before, during and after puberty.

Material and methods

The sample comprised 517 male and 807 female pupils and secondary school students from different parts of Slovenia aged 11-17. The sample was stratified by regions and, within regions, it was chosen randomly. It is representative of Slovenia since the primary schools selected are situated in big and small towns while, among secondary schools, different types of schools were selected. The data was collected in more extensive research carried out by Strel et al. (1996). The sample of this research includes subjects who were not excused from PE classes due to health problems and who agreed to take part in the research.

Based on a hypothetical model by Kurelic et al. (1975) and studies conducted by Šturm (1970,) and Strel and Šturm (1981), a group of 26 tests was chosen to evaluate the motor abilities of the studied sample.

Basic statistical characteristics were calculated for each age group; for determining the latent structure of motor abilities the component model of factor analysis was used. First, an analysis of the dependency on the basic variables (correlation coefficient matrix) was carried out. The extent of the communality of variables was calculated. On the basis of the methods of the main components, the eigenvalues and appertaining eigenvectors of the correlation coefficient matrix were determined; important main components were determined by using the Kaiser-Guttman criterion. Due to the simpler determination of factors as regards the contents, a rotation with the oblimin method was used.

Results

The analysis of correlation matrix shows some striking complexes, indicating medium to high mutual connections and in both sexes indicating the existence of certain latent motor dimensions in each age group.

The extracted factors can explain from 63.9% (in 15-year-old female subjects) to 69.6% (in 17-year-old male subjects) of all information in the system of variables. The biggest proportion in all age groups belongs to the first main component (from 22.2% in 17-year-old girls to 33.2% in 11-year-old boys), which contains the majority of information about the entire system of variables. The other components explain smaller proportions of the total variance.

Table 3 The number of main components, percent of the explained variance and proportion of the first main component in different age groups

Age	Gender	Number of factors	% of the explained variance	% of the first component
11	Boys	7	66.893	33.205
years	Girls	7	64.280	27.375
13	Boys	7	67.321	32.124
years	Girls	9	68.253	25.114
15	Boys	8	68.844	25.710
years	Girls	7	63.930	28.472
17	Boys	9	69.621	22.180
years	Girls	8	68.313	30.941

A survey of the formation of the latent structure of motor space by individual age groups confirms the findings concerning the greater and clearer differentiation of motor abilities in later age groups (Kovac 1999; Kovac and Strel 2000; Planinšec 1999; Strel and Novak 1980; Videmšek and Cemic 1991). The number of extracted factors ranges from 7 to 9. However, their structure is clearer in each age group since the size of the correlation among the oblimin factors decreases with age. In the group of 11-year-olds of both sexes connections of the first factor, whose structure is complex, with several others are obvious, whereas later the number of such connections decreases.

The established structure of motor abilities reveals differences between individual age groups, but confirms the basic structure of motor area proved by some other researches (Gredelj et al. 1975; Kurelic et al. 1975; Planinšec 1999: Simons et al. 1990; Strel 1981; Strel and Šturm, 1981). In younger age categories the variance is explained to the greatest extent by a highly complex factor,

Table 1 The results of the analysis validity markers of specific motor fitness tests

Tests	Strength abilities				Speed abilities		Endurance abilities	
	Absolute strength	Local strength	Relative strength	Anaerobic power	Vmax	Muscle mobilization	Anaerobic capacity VO2max	Muscle resistance to fatigue
1500 m run	0,09	0,02	0,02	0,02	0,07	0,05	0,84	0,18
Shuttle run	0,09	0,29	0,12	0,12	0,18	0,25	0,86	0,17
Cooper test	0,04	0,02	0,06	0,02	0,03	0,04	0,90	0,12
Figure eight run	0,16	0,34	0,20	0,48	0,22	0,40	0,08	0,24
Envelope run	0,16	0,30	0,32	0,23	0,16	0,69	0,21	0,15
300 m run	0,06	0,04	0,02	0,14	0,70	0,15	0,18	0,41
Pull-ups	0,22	0,26	0,68	0,20	0,04	0,12	0,32	0,29
Push-ups	0,10	0,26	0,63	0,13	0,22	0,10	0,26	0,31
Sit-ups	0,12	0,19	0,27	0,48	0,32	0,26	0,17	0,29
Medicine ball forward throw	0,54	0,22	0,23	0,26	0,49	0,01	0,01	0,06
Medicine ball backward throw	0,81	0,18	0,22	0,19	0,20	0,03	0,02	0,07
Standing long jump	0,30	0,17	0,28	0,68	0,77	0,16	0,00	0,06
Handgrip strength	0,39	0,12	0,20	0,38	0,01	0,06	0,02	0,13

Table 2 Volume and intensity of training loads in the I[st] and II[nd] training phase

Group	Endurance abilities			Strength (tons)	Speed abilities				Team sports (h)	Gymna-stics (h)	Compe-tition (km)	Together
	General running endurance	Tempo endu-rance	Speed endu-rance		Short runs (km)	Skipping (amount)	Jumps (km)	Uphill runs (km)				
A	458,0	35,0	21,0	37,0	22,0	14,0	3600	12,00	50,0	33,0	2,0	
B	385,0	37,0	25,0	54,0	24,0	15,0	4200	22,0	46,0	30,0	2,0	
Intensity coefficients	0,35	0,65	0,76	0,65	0,88	0,65	0,65	0,75	0,55	0,45	0,95	
Load in A	160,3	22,7	15,9	24,0	19,4	9,1	234,0	9,0	27,5	14,8	1,9	538,5
Load in B	134,7	24,0	19,0	35,1	21,1	9,8	273,0	16,5	25,3	13,5	1,9	574,0

formed by variables responsible for the energy and information component of movement. More pronounced differentiation takes place in boys at the age of 13 when the factors "agility" and "aerobic endurance" express more clearly, whereas in girls similarly formed factors are not extracted before the age of 15.

In younger children, the variables "endurance", "explosive power" and "co-ordination" have the greatest projections on the first factor. In younger children a greater number of variables belonging to different sub-spaces have projections on the first oblimin factor. Similar findings concerning the complexity of the first extracted factor were confirmed by Strel and Šturm (1981) and Simons *et al*. (1990). The name of this factor is slightly different regarding the dominant influence of the variables of energy and co-ordination types in the formation of this factor: **energy and co-ordination component** (11-year-old boys), **energy component** (11-year-old girls) and **co-ordination and energy component** (13-year-old girls).

In 13-year-old boys and 15- and 17-year-old girls, the first factor is most prominently influenced by the **agility** variables, whereas in 15-year-old boys „**aerobic endurance"** proves to be the first factor of greatest importance and in seventeen-year-old boys this variable is „**co-ordination"**.

In all age groups, only two factors are constantly extracted in both sexes: abdominal strength and flexibility of the hip joint.

The latent dimension „**abdominal strength"**, which has already been interpreted in numerous researches (Gredelj et al. 1975; Planinšec 1999; Strel and Novak 1980; Strel et al. 1996), includes motor tasks of sit-ups, which differ in duration, or the position of arms. A common characteristic is the activity of larger groups of muscles, when it is necessary to overcome resistance by repeating the flexion in the hip joint. All the test tasks with a repetitive character depend on to a large extent on subject's motivation.

Two factors of flexibility were extracted, which most certainly influence the choice of the tests and at the same time confirm the findings of Agrež (1973) concerning the topological division of flexibility. The extracted factors were called „**flexibility of the hip joint"** and „**flexibility of the shoulder girdle"**. Among the chosen flexibility tests, the simultaneous flexibility of several joints (knee joint, lumbar and thoracic vertebrae, hip and shoulder joints) is observed in **„forward bend"** and „touch on the bench" and „forward bend in the sitting position" and, besides that, the test subject must overcome the gravity force in „forward bend" and „touch on the bench". In boys, the factor „flexibility of the shoulder girdle" was not extracted in any age group, whereas in girls it was extracted at the ages of 11 and 13.

Despite the fact that the „handstand on the beam” and „flamingo balance” have, statistically speaking, few connections, the factor **„balance”** is often extracted. Besides the variables mentioned above, this factor is also influenced by the variable „bent arm hang”, as established by Strel and Šturm (1981). The research on younger categories showed a high correlation of balance with the co-ordination of movement (Hošek-Momirovic 1975; Pavlovic 1982; Strel and Šturm 1981). Therefore, some researchers (Ušaj 1996) do not mention balance as an independent motor ability or they classify it as the co-ordination of movement (Haag, 1995).

In boys, the factor **„arm strength”** was extracted in all age groups, whereas in girls explosive strength appears from the age of 13 onwards. The common characteristic of all motor exercises of explosive strength is the activation of muscular force in the shortest possible time. A functional basis for such motor reactions is the alactate anaerobic system (Astrand and Rodahl; 1986; Fox et al. 1981). The movement is also demanding from the information aspect since it is necessary to precisely determine the direction of movement and intensity of the action, but the energy regulation, which dictates the rate in which the force is developed, is decisive. The production of muscular force not only depends on the sum of the forces developed by individual muscular groups, but on the co-ordinated action of these muscular groups.

Up to the age of 17, the **„speed of simple movements”** and **„rhythm”** are developed as independent structurally stable dimensions. These two dimensions have been extracted in many researches (Gredelj et al. 1975; Hošek-Momirovic 1975; Metikoš and Hošek 1972; Simons et al. 1990; Strel and Novak 1980; Strel and Šturm 1981; Strel 1981).

The motor tasks are relatively simple, they are carried out at maximum speed in a particular time sequence. The large number of repetitions in opposite directions in a limited time period demands an extremely precise regulation of nervous and muscular excitation. A timely contraction of antagonists in stopping the movement and in changing direction is of particular importance since the subject should spend as little time as possible on this. The continuous performance of movement and thus the achievement of a better result determine the rhythmic performance of the task. The prevailing influence of the latter is probably the reason that these motor tasks, together with the test of the rhythmic performance of motor structures which are characterized by an extremely good, rhythmically co-ordinated precise movements, form one dimension in 17-year-old subjects, which is called **„speed of simple movements in a particular rhythm”**.

A special factor present in 15-year-old boys and 17-year-old students of both sexes was **„co-ordination of movement of the arms”**, as extracted by Metikoš and Hošek (1972), as well as Strel (1981) and Strel and Šturm (1981).

In younger age groups, the *„600 m run”* and *„sprint”* have high projections on the first factor, whereas at the age of 15 the independent factor **„aerobic endurance”** is extracted. The result in both runs is under the dominant influence of aerobic or anaerobic power and motivation.

In 17-year-old subjects two factors with an endurance character are extracted. In this age group the measuring procedures used do not represent such an aerobic effort for boys, therefore the factors define special muscular endurance. The first factor was called **„upper body endurance”** and the second one „**speed endurance**”.

A comparison of the formation of the structure of motor area of boys and girls at the age of 11 shows a similar character. The motor area of boys and girls forms six similar factors („**energy and co-ordination component**”, „**speed of simple movements**”, „**abdominal muscle**”, „**flexibility of the hip joint**”, „**rhythm**”, „**balance**”). Only the fifth factor in boys that was called „**explosive strength of arm muscles**” and the sixth factor in girls called „**flexibility of the shoulder girdle**” differ.

The structure of the motor area of 13-year-old subjects differs depending on gender. While the first factor in girls is still represented by a widely defined dimension from the point of view of phenomenology, the variables concerning agility have the greatest projections on the formation of the first factor in boys. In boys, a newly formed dimension „**aerobic endurance**” appears, while in girls „**explosive strength**” is extracted for the first time. There are four similarly formed factors in boys and girls, namely „**explosive strength**”, „**abdominal strength**”, „**flexibility of the hip joint**” and „**speed of simple movements**”.

In 15-year-old boys and girls the first factor is formed by different variables, but the structure of the factors is much clearer. In boys, the first factor was called „aerobic endurance” and in girls „**agility**”. Besides five other factors („**speed of simple movements**”, „**explosive strength of the arm muscles**”, „**abdominal strength**”, „**flexibility of the hip joint**”, „**rhythm**”) „**aerobic endurance**” can also be found in girls so it may be concluded that in this period the structure of the motor area of boys and girls is formed by similar dimensions, covering the space of a different size depending on the gender.

The first factor in 17-year-old test subjects is most intensively formed by difficult motor tasks. In boys, the co-ordination tests have the greatest projections, therefore this dimension was called „**co-ordination of movement of the whole body**”. In girls, this is the case with complex motor tasks involving constant sudden changes of direction, therefore it was called „**agility**”. The structure of the motor area of both sexes in this age group is formed by six similarly formed factors („**speed of simple movements**”, „**explosive strength of the arm muscles**”, „**abdominal strength**”, „**flexibility of the hip joint**”, „**balance**”, „**rhythm**”), therefore the same conclusion can be drawn as for 15-year-old test subjects.

It can be concluded that the structure of motor area is better defined in older pupils, and efficiency in individual motor tasks usually depends on different mechanisms that act at both subcortical and cortical levels. The younger the subject the more their achievement depends on the simultaneity of the action of different mechanisms.

In the period of puberty the disturbance of the established motor patterns, fast growth and an increase in body weight and subcutaneous fat are probably conditioned by the relatively complicated structure of the factors. These changes occur in girls at the age of thirteen, and in boys at the age of fifteen. Due to these changes, the latent structure of the motor space of boys and girls differs most at the age of 13, whereas the latent structure of the motor space before and after puberty, with some exceptions caused by morphological differences („**flexibility of the shoulder girdle**” in girls, „**explosive strength of the arm muscles**” in younger boys), is similar.

Discussion

In recent times, the study of motor abilities in children and youth who are not included in special training systems has been less common. The changed morphological characteristics and motor abilities of the young, the changed motivation structure, the different attitudes of society to sport and a healthy lifestyle, along with the increased risk of negative influences and accompanying economic and social conditions of the population, give today’s sport, especially PE, a special place within society (Strel and Kovac 1999; Strel et al. 2002). This is why it is necessary to know the developmental characteristics of the youth, their abilities, needs and motivation since they allow a suitable choice of objectives, contents, methods and forms of work in the PE process (Strel and Kovac 1999).

In general, it can be established that the structure of motor area of boys and girls can be formed by the same dimensions that cover a different size of motor space depending on the developmental characteristics (chronologically, girls reach puberty earlier) and morphological differences (greater muscular mass of boys foregrounds, whereas flexibility of the shoulder girdle is less pronounced).

Sport exercises depend on motor potentials to the greatest extent and it is therefore very important to know their structure and the ways to develop them in order to plan them.

The results show that the complexity of the latent structure makes the performance of individual motor abilities in younger subjects more difficult. Regarding the developmental characteristics of children, it is more important to ensure certain energy and informational potential for the efficient movement in this period by means of motor exercises. Only after the completion of accelerated body growth dictated by puberty changes can we concentrate on the development of individual motor abilities. This is primarily true of the motor abilities that are under the strongest influence of body growth: explosive power, agility, endurance and indirect co-ordination of the movement of the whole body. The level of potentials reached in the earlier period determines the starting point for achieving the absolute values in individual motor abilities later on. Before puberty motor exercises must vary from the point of view of the contents (Strel and Kovac, 1999), primarily regarding the informational aspect, they should take account of the developmental characteristics of children in different psychosomatic areas (less intense physical power, overestimation of one’s own abilities, joining in groups).

Puberty changes dictate the careful planning of motor exercises. Similarly to other researchers (Kondric et al. 1997; Strel et al. 1994; Šturm and Strel 1985; Tanner 1991), we have also found that accelerated body growth disturbs the established motor patterns and leads to temporary stagnation or even regression in the process of developing the motor potential. In girls, this takes place earlier; our research establishes that this happens at the age of 13 and in boys at the age of 15. Reduced motor effectiveness in this period often discourages children from sport, which results in the fact that in this period sports training must often be adapted to an individual due to individual differences in development. Mental changes, different perception of sport and increasingly important influence of other values (health, appearance, success), primarily in girls (Strel and Kovac 1999; Videmšek 1996) call for different pedagogical and didactic approaches on the part of the coaches (Strel and Kovac 1999).

A comparison of the same measuring procedures in the periods before, during and after puberty provides us with data on reliability, validity and homogeneity of tests in the time of puberty, when drastic changes in different sub-spaces of the psychosomatic status take place, while the influence of environmental factors is also extremely significant. The data collected allow us to conclude that the measuring procedures have a different validity and homogeneity in different age groups, particularly those that cover the co-ordination of movement, balance, endurance and strength of the arms and shoulder girdle.

We are aware of certain shortcomings of the research since a greater number of test subjects and measuring variables would give us a clearer picture of the latent structure of motor space. In further researches this will probably be difficult to achieve, since the many legal limitations concerning personal data protection make suitable sampling difficult. The large number of researches on the influence of morphological dimensions on motor space (Blaškovic 1979; Hošek-Momirovic 1978; Karpljuk 1996; Strel 1976; Strel 1981; Šturm and Strel, 1985;) show that it is sensible to establish the structure of motor space after having excluded the influence of morphological variables.

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