original scientific article
received: 2010-09-20
UDC: 796.012.1-053.5/.6

MOTOR STRUCTURE AND BASIC MOVEMENT COMPETENCES IN EARLY CHILD DEVELOPMENT

Rado PIŠOT [1], Jurij PLANINŠEC [2]

[1] University of Primorska, Science and Research Centre of Koper, Institute for Kinesiology Research, Slovenia

[2] University of Maribor, Faculty of Education, Slovenia

Corresponding author
Rado Pišot
University of Primorska, Science and Research Centre of Koper, Institute for Kinesiology Research, Garibaldijeva 1, Koper, Slovenia
e-mail: rado.pisot@zrs.upr.si

ABSTRACT

Motor development consists of dynamic and continuous development in motor behaviour and is reflected in motor competences (on the locomotive, manipulative and postural level) and motor abilities (coordination, strength, speed, balance, flexibility, precision and endurance). This is a complex process in which a child acquires motor abilities and knowledge in interaction with inherited and environmental factors. A sample of 603 boys and girls, of which 263 were aged five (age deviation +/– 3 days; 18,5 ± 3,1kg body weight; 109,4 ± 4,3 cm body height) and 340 were aged six and a half (age deviation +/– 3 days; 23, 7 ± 4, 3 kg body weight; 121 ± 4,8 cm body height), were involved in this study after written consent was obtained from their parents. The children's motor structure was established through the application of 28 tests that had been verified on the Slovene population and established as adequate for the study of motor abilities in the sample children. The factor analysis was applied to uncover the latent structure of motor space, and PB (Štalec & Momirović) criteria were used to establish the number of significant basic components. The analysis of the motor space structure revealed certain particularities for each age period. In the sample of 5 year old children, the use of PB criterion revealed four latent motor dimensions, in 6.5 year old children, the latent motor space structure was described with four (boys) and five (girls) factors. Despite the existence of gender differences in motor space structure and certain particularities in each age period mostly related to the factors which influence movement coordination, several very similar dimensions were discovered in both sexes.

Being aware of different approaches to researching motor structure and analyzing basic movement competences in the development process is a special challenge oriented towards discovering adequate and exact instruments, protocols and methods.

Keywords: early childhood, motor development, motor skills and knowledge, motor structure, factor analysis.

STRUKTURA MOTORIKE IN RAZVOJ TEMELJNIH GIBALNIH KOMPETENC V ZGODNJEM OTROŠTVU

IZVLEČEK

Gibalni razvoj predstavljajo dinamične in večinoma kontinuirane spremembe v gibalnem vedenju, ki se kažejo v razvoju gibalnih znanj (lokomotorne, manipulativne in stabilnostne) ter gibalnih sposobnosti (koordinacija, moč, hitrost, ravnotežje, gibljivost, natančnost in vzdržljivost). V tem procesu, s pomočjo katerega otrok pridobiva gibalne spretnosti in vzorce, prihaja do pomembne interakcije med genetskimi in okoljskimi vplivi. V študiji je po podpisanem soglasju staršev sodelovalo 603 otrok; od tega je bilo 263 otrok starih 5 let (SD starost +/- 3 dni, telesna teža 18,5 ± 3,1 kg, telesna višina 109,4 ± 4,3 cm) ter 340 otrok starih šest let in pol (SD starost +/- 3 dni, telesna teža 23,7 ± 4,3, telesna višina 121 ± 4,8 cm). Za oceno gibalnih sposobnosti je bila uporabljena baterija 28 testov, ki so bili predhodno preverjeni na slovenski populaciji otrok in so se kot primerni izkazali tudi na izbranem vzorcu otrok. Za ugotavljanje latentne strukture motoričnega prostora smo uporabili metodo faktorske analize, za ekstrakcijo glavnih component smo uporabili PB-kriterij (Štalec in Momirović). Analiza strukture motoričnega prostora kaže določene značilnosti za vsako starostno obdobje. V vzorcu 5-letnih otrok uporaba PB kriterija razkrije 4 glavne motorične dimenzije, v vzorcu 6,5-letnih otrok pa je latnetni motorični prostor opisan z 4 faktorji pri dečkih in 5 pri deklicah. Kljub razlikovanju strukture motoričnega prostora med spoloma, je nekaj dimenzij zelo podobnih. Največje razlike med spoloma se kažejo pri faktorjih, ki opredeljujejo koordinacijo gibanja. Različni pristopi v raziskovanju motorične strukture in analize gibalnih kompetenc v procesu gibalnega razvoja predstavljajo poseben izziv, usmerjen v raziskovanje in načrtovanje primernih orodij, protokolov in metod.

Ključne besede: zgodnje otroštvo, gibalni razvoj, gibalne sposobnosti in znanje, struktura motorike, faktorska analiza

INTRODUCTION

Motor abilities are crucial for individual motor efficiency on which depends the performance of different motor tasks (Šturm & Strojnik, 1994). These are abilities which cause individual differences in motor efficiency or in human characteristics on the basis of which these differences are explained (Schmidt, 1991). The level of motor abilities indicates the limits of the individual potential to perform certain motor competences (Magill, 1998). Acquired motor skills and developed motor abilities are fundamental factors of a child's motor competence (Pišot, et al., 2010) on the basis of which we can monitor harmony and deviations in a child's motor development.

Motor development consists of dynamic and mostly continuous development in motor behaviour and is reflected in the development of motor abilities (coordination, strength, speed, balance, flexibility, precision) and functional abilities (endurance) and motor competences (on the postural, locomotive and manipulative level) (Gallahue & Ozmun, 2006). This is a complex process in which a child acquires motor abilities and knowledge in interaction with genetic and environmental factors (Latash, 2008).

Genetic factors are crucial for neuromuscular maturation, morphological characteristics (especially in terms of size), dimensions and body composition, physiological characteristics and the pace of growth and maturation (Malina, Bouchard & Bar-Or, 2004). Among environmental factors, previous motor experiences and the acquisition of new motor experiences have the most important influence. Thus a very important segment of motor development is the development of motor abilities which is continuous over a period of time although occasional periods of stagnation and even decline in abilities are typical (Pišot & Planinšec, 2005). Some motor abilities reach their highest level sooner, some later. Early childhood is characterised by a very intensive development of some motor abilities, such as speed and coordination, whereas the development of others such as balance, strength, flexibility and endurance is a bit slower (Malina, et al., 2004; Thomas & French, 1985). It is also typical that significant individual differences occur. Each individual has their own pace of development determined by their "biological clock" (Gallahue & Ozmun, 2006).

Different measurement procedures intended for the study of kinesiology itself and identifying the association with other psychosomatic dimensions are used in order to identify motor abilities. There are different approaches to studying and explaining motor efficiency, thus the existence of more classifications of motor abilities.

Schmidt (1991) states that the study of motor abilities in the USA is based on research from the fifties and sixties in which the method of factor analysis was used to determine the structure of motor abilities (Fleishman, 1964; Fleishman & Bartlett, 1969; adapted from Schmidt, 1991). The number of motor abilities depends mainly on the criteria we consider or on the approach to the study (Schmidt & Lee, 1999). Schmidt and Lee (1999) emphasize that individual motor abilities can be more or less linked to each other, different abilities are often influenced by the same factors, which are extremely difficult to recognize. However, the authors understand motor abilities as relatively independent. They also discovered that there are still some ambiguities regarding the study of human motor efficiency.

One of the possible classifications of the structure of motor abilities is offered by Magill (1998) who mainly originates in the studies of Fleishman (Fleishman, 1972, adapted from Magill, 1998; Fleishman & Quaintance, 1984; adapted from Magill, 1998) and basically assumes the existence of two categories of motor abilities; the first are perceptive-motor abilities (coordination, control of movement – preparation of response and reaction time, …), the others are abilities which relate to the body capacity (strength, flexibility, balance, endurance, …).

Much information so far confirms that the models of motor abilities are hierarchical. The studies of Kurelić et al., 1975; Gredelj et al., 1975; Metikoš et al., 1989; Bös, 1994, explained primarily within the functional and structural models, revealed that there are two massive dimensions of wide range regulation which are dominant in defining the structure of motor space. The first one prevails in all motor activities in which the processes of structure, control and regulation of movement are very important for performing a motor task. Therefore this dimension is probably linked to mechanisms for receiving and processing information. The second dimension is critical to those motor tasks in which energy efficiency is particularly important; it is also linked to various peripheral subsystems and morphological characteristics. This means that any physical / sport activity is regulated by information and energy components which are constantly interwoven and combined (Šturm & Strojnik, 1994; Bös, 1994).

Most studies which have examined the structure of motor abilities on a sample of children suggest that younger subjects show a certain differentiation of motor abilities, but it is far from that measured in adult subjects. The impact of a general factor of motorics is often present which mainly includes the coordination and information component in general. The structure of motor abilities changes with age. The most significant changes apply to those motor dimensions which are under the influence of cortical regulation mechanisms. On the contrary, dimensions which are under the influence of subcortical regulation mechanisms are more stable.

A different approach to studying motor abilities of younger children was used by Planinšec and Čagran (2001). They state that children differ mainly in general motor ability, determined by information and energy component which mostly influences the prevailing motor type.

A study conducted on the sample of four to seven year old children revealed that there may be a potential motor capacity (Bala, 2003). Quantitative differences between sexes showed that boys achieve much better results in tests of explosive power and functional coordination of basic motor abilities, whereas girls achieve better results in flexibility tests.

Eurofit Test Battery (1993) was explored on a sample of five to seven year old children by I. Fjortoft (2000). She found that tests are useful for the indicated age group and that they achieve a suitable level of reliability. She eliminated three factors by using factor analysis and contrary to the research of others, (Oja & Jurimae, 1997) achievements in motor tests did not depend on the body weight and height of the children.

A series of studies of the structure of motor abilities in young children was done by Rajtmajer (e.g. 1992, 1993a, 1993b 1996, 1997b) and later by Pišot (1997, 1999a, 1999b, 2000, 2003, 2005) and Planinšec (1997, 2000, 2001, 2003, 2005). These studies represent the basis of studying motor abilities in young children in Slovenia. Based on this research, a battery of motor tests was done which are suitable for young children.

There are considerable differences in studying motor efficiency in young children and the results of studies are in accordance with some aspects but not with others. However, everything depends on the type of motor tests used. Therefore we still do not have a reliable answer to the question what is the structure of motor abilities in young children.

In our study, in which we analysed the structure of motor space on the sample of five and six and a half year old children using the very sharp PB criterion and the defined factors are real to the largest extent possible, we expect some new answers about present differentiation and peculiarities of the defined motor abilities in children at that age. Taking into account the nature of our research and goals, motor abilities will be presented and explained primarily within the functional (Kurelić et al., 1975, Gredelj et al., 1975) and structural (Metikoš et al., 1989) models.

METHODS

Subjects

The sample of this research consisted of 603 boys and girls, of which 263 were aged five (of which 125 boys and 138 girls; age deviation +/– 3 days; 18.5 ± 3.1 kg body weight; 109.4 ± 4.3 cm body height;) and 340 were aged six and a half (of which 174 boys and 166 girls; age deviation ± 3 days; 23.7 ± 4.3 kg body weight; 121 ± 4.8 cm body height). The age of the sample was precisely defined which allows for qualitative comparisons and identifying changes between different age groups. The children were completely healthy during the measurements. Parents and children were informed in detail and in advance of the procedure of measurements and parents signed a written consent form in order to participate in the study. The study was conducted following the guidelines set by the Declaration of Helsinki.

Measurements

For the assessment of motor abilities, 28 tests were used; all had been standardized on a Slovenian population. The motor tests were created especially for an age group of preschool children and had been thoroughly verified in others studies (e.g., Rajtmajer & Proje, 1990; Rajtmajer, 1993; Pišot, 1994, Planinšec, 1995). The motor tests belong to the following hypothetical dimensions: whole-body coordination (rolling a ball around a hoop - KKOTZO, walking on rungs backwards - KLILEN, walking through hoops backwards - KHOONA, crowling backward - KPOLNA, crawling under a bench - KPLAKL, crawling with a ball - KPLAZO, running after crawling - KTEKOT); hand coordination (circling a ball around the body - KROZOT, rolling a ball around the feet - KKOTZS, leading a ball with two hands in a standing position - KUDARZ, building a tower from big foam rubber cubes – KOCPV7, menaging hollow cubes - KOCKVO, building a tower from small wooden cubes – KOCLM8); agility (stepping sideways - KBOTEK, running with changing directions - KTEKSS, running in a zigzag - KTEKCC); explosive strength (standing broad jump - EXMSDZ, standing triple jump – EXMSD3, standing high jump - EXMSVI); repetitive strength (stepping on a bench - VDMKLO, sideways jumps - VDMBPO, sideways jumps with hand support - VDMBPR); speed of simple movements (hand tapping in two fields – HITAR1, foot tapping - HITTAN, hand tapping in 4 fields – HITAR2); and balance (standing on a block longitudinally - RSLKVV, standing on a block crosswise - RSLKVP, standing on a vertical block - RSPKVA).

Procedure

The measurements of motor abilities were always carried out before noon in specially prepared rooms in the Maribor Pediatric Hospital, Slovenia. The entire testing time of one child did not exceed two hours. The measurements were carried out by qualified experts. The rate of testing was twenty-five children per day. The children carried out three repetitions of each motor test.

Statistics

Data processing was performed with SPSS software. The basic statistical indicators were calculated. The factor analysis model was used to determine the structure of latent space of motor dimensions and PB (Štalec & Momirović, 1971) criterion to extract the main number of important principal components. We used PB criterion, according to which the number of main components stops when the minimal common quantity of valid variance of the system of manifest variables is exhausted.

RESULTS

The analysis of the correlation matrix (Table 1) between individual tests to measure motor abilities in five year old children reveals that almost 85 percent of correlation coefficients are statistically significant at the level of risk $p < 0.05$ (< or = 0,105; at the level of risk $p < 0,01$ < or = 0,138). We can conclude that the set of motor variables is homogeneous, as there are a large number of statistically significant correlations between the tests. Motor variables could be divided into those with very little or low correlations with other tests and those with high correlations.

The first group includes all balance tests, stacking blocks tests and some coordination tests. The second group includes standing broad jump, standing triple jump, side jumps, stepping into a bench, arm plate tapping, leg plate tapping and almost all coordination tests.

The correlation matrix shows that movement coordination (regarding the highest correlations with other measurement procedures) has the most important correlation with the whole motor efficiency at the period of 5 years of age. Among all the tests, especially the crowling backwards test has the highest correlation with others, followed by rolling a ball around a hoop, walk backwards through a hoop, crawling under a bench, standing triple jump and walk backwards on wall bars.

Structure of motor abilities in five year old children

The calculated communalities of motor variables reveal that the range of values extends from the lowest 0.14 to the highest 0.76. The communality of variables is therefore very different. On the average the values are around 0.50. It should be noted that five year old children were measured and that the structure of most motor testes was very complex so the communalities are satisfactory.

That PB criterion (which is very strict and is considered to give the smallest number of important factors aiming towards hypofactorisation) revealed four factors which together explain 45 % of common variance of the system of manifest variables. The first main component explains 28.4 % of system variance which is more than 60 % of all explained variance. The relation of the explained variance shows that the first main component can be defined as a general motor factor. By analysing the factor matrix we found that almost 85 % of all motor variables have the highest projections on the first main component.

Table 2 shows the structures of motor factors which were obtained by applying the criterion PB. This would result from the correlation matrix of motor variables, the matrix of main components, matrix concatenation, the structure matrix and factor cor-

Table 1: The motor variables correlation matrix in five year old children.

	EXMSDZ	EXMSD3	EXMSVI	VDMKLO	VDMBPO	VDMBPR	HITAR1	HITTAN	HITAR2	RSLKVV
EXMSDZ	1.00									
EXMSD3	.746	1.00								
EXMSVI	.349	.292	1.00							
VDMKLO	.336	.320	.292	1.00						
VDMBPO	.389	.373	.157	496	1.00					
VDMBPR	.305	.257	.065	.447	605	1.00				
HITAR1	.324	.358	.121	.398	.456	.404	1.00			
HITTAN	.321	.329	.098	.381	.410	.355	.712	1.00		
HITAR2	.284	.295	.163	.392	.386	.367	.399	457	1.00	
RSLKVV	.201	.220	.141	.226	.263	.225	.204	.202	.134	1.00
RSLKVP	.158	.115	.044	.196	.132	.175	.176	.161	.118	.217
RSLKVA	.214	.155	.099	.109	.168	.187	.166	.123	.049	.404
KROZOT	.259	.227	.144	.409	.360	.406	.509	.390	.325	.106
KKOTZS	.096	.099	.018	.285	.332	.317	.221	.151	.175	.164
KKOTZO	-.271	-.289	-.314	-,374	-.327	-.271	-.321	-.289	-.250	-.153
KOCPV7	-.154	-.173	-.086	-.275	-.188	-.197	-.257	-.233	-.186	-.138
KOCKVO	-.174	-.251	-.081	-.145	-.241	-.273	-.340	-.290	-.205	-.118
KOCLM8	-.242	-.212	-.112	-.336	-.205	-.236	-.293	-.312	-.255	-.143
KLILEN	-.269	-.319	-.275	-.331	-.302	-.280	-.322	-.307	-.266	-.178
KHOONA	-.328	-.348	-.234	-.359	-.236	-.265	-.267	-.279	-.202	-.132
KPOLNA	-.424	-.425	-.244	-.409	-.319	-.364	-.288	-.287	-.275	-.213
KPLAKL	-.339	-.312	-.284	-,408	-.384	-.323	-.193	-.180	-.211	-.235
KPLAZO	-.338	-.340	-.252	-.294	-.285	-.279	-.253	-.263	-.233	-.185
KTEKOT	-.278	-.260	-.212	-.281	-.216	-.232	-.293	-.264	-.244	-.093
KTEKSS	-.334	-.338	-.214	-.366	-.367	-.249	-.332	-.243	-.229	-.043
KBOTEK	-.285	-.231	-.194	-.193	-.309	-.144	-.323	-.269	-.216	-.128
KTEKCC	-.283	-.294	-.166	-.347	-.369	-.253	-.293	-.257	-.252	-.106
KUDARZO	.276	-.273	.150	.304	.407	.399	.350	.316	.242	.144
PPIKZO	.070	.067	.057	.096	.159	.069	.037	019	.103	.049

	RSLKVP	RSLKVA	KROZOT	KKOTZS	KKOTZO	KOCPV7	KOCKVO	KOCLM8	KLILEN	KHOONA
EXMSDZ										
EXMSD3										
EXMSVI										
VDMKLO										
VDMBPO										
VDMBPR										
HITAR1										
HITTAN										
HITAR2										
RSLKVV										
RSLKVP	1.00									
RSLKVA	.168	1.00								
KROZOT	.056	.075	1.00							
KKOTZS	.182	.051	.220	1.00						
KKOTZO	-.207	-.152	-.273	-.259	1.00					
KOCPV7	-.119	-.121	-.212	-.144	.320	1.00				
KOCKVO	-.087	-.113	-.202	-.217	.289	.275	1.00			
KOCLM8	-.032	-.141	-.302	-.158	.341	.512	.264	1.00		
KLILEN	-.143	-.112	-.319	-.280	.449	.144	.146	.220	1.00	
KHOONA	-.143	-.105	-.243	-.203	.405	.220	.337	.316	.393	1.00
KPOLNA	-.204	-.183	-.285	-.274	.483	.261	.322	.320	.440	.799
KPLAKL	-.205	-.206	-.235	-.265	.363	.252	.194	.235	.299	.441
KPLAZO	-.146	-.141	-.178	-.216	.397	.278	.238	.289	.253	.324
KTEKOT	-.166	-.097	-.227	-.074	.308	.250	.241	.248	.268	.410
KTEKSS	-.078	-.051	-.335	-.152	.315	.213	.278	.259	.291	.386
KBOTEK	-.099	-.119	-.203	-.054	.214	.025	.127	.162	.230	.205
KTEKCC	-.088	-.064	-.276	-.204	.324	.233	.206	.234	.383	.340
KUDARZO	.127	.090	.366	.259	-.344	-.134	-.215	-.239	-.156	-.112
PPIKZO	.135	-.034	-.012	.156	-.072	-.107	-.097	-.051	-.099	-.068

	KPOLNA	KPLAKL	KPLAZO	KTEKOT	KTEKSS	KBOTEK	KTEKCC	KUDARZO	PPIKZO
EXMSDZ									
EXMSD3									
EXMSVI									
VDMKLO									
VDMBPO									
VDMBPR									
HITAR1									
HITTAN									
HITAR2									
RSLKVV									
RSLKVP									
RSLKVA									
KROZOT									
KKOTZS									
KKOTZO									
KOCPV7									
KOCKVO									
KOCLM8									
KLILEN									
KHOONA									
KPOLNA	1.00								
KPLAKL	.457	1.00							
KPLAZO	.427	.464	1.00						
KTEKOT	.479	.260	.297	1.00					
KTEKSS	.498	.368	.210	.354	1.00				
KBOTEK	.223	.169	.094	.340	.343	1.00			
KTEKCC	.437	.271	.195	.231	.536	.204	1.00		
KUDARZO	-.194	-.172	-.249	-.189	-.091	.165	.231	1.00	
PPIKZO	-.090	-.128	-.177	-.049	-.102	-.096	-.103	-.084	1.00

relation matrix. The first motor factor was called Motor Coordination, the second factor represents Speed of Alternative Movements, the third factor is Static Equilibrium, and the fourth factor has the characteristics of Coordination of Limb Movement.

Table 2: The most important values from matrix concatenation and matrix structure in five year old children (PB criterion).

Motor factors	Variables	Values from matrix concatenation	Values from matrix structure
Motor coordination	KPOLNA	–0.853	–0.844
	KHOONA	–0.849	–0.784
	KTEKSS	–0.622	–0.653
	KTEKOT	–0.582	–0.595
	KKOTZO	–0.549	–0.639
	KPLAKL	–0.548	–0.614
	KTEKCC	–0.504	–0.573
	KPLAZO	–0.466	–0.551
	KLILEN	–0.470	–0.565
	EXMSVI	0.459	0.442
Speed of alternative movement	HITAR1	0.812	0.799
	HITTAN	0.763	0.747
	KROZOT	0.674	0.678
	VDMBPO	0.662	0.716
	VDMBPR	0.633	0.670
	KUDARZ	0.616	0.599
	HITAR2	0.596	0.616
	VDMKLO	0.455	0.611
Static equilibrium	RSLKVV	0.691	0.697
	RSPKVA	0.630	0.621
	RSLKVP	0.463	0.493
Coordination of limb movement	EXMSDZ	0.492	0.457
	EXMSD3	0.449	0.417
	KOCPV7	0.447	0.458
	KKOTZS	–0.427	–0.452
	KBOTEK	–0.416	–0.406

Table 3: Factors correlation matrix in five year old children - PB criterion.

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
FACTOR 1	1.00			
FACTOR 2	.486	1.00		
FACTOR 3	.250	.202	1.00	
FACTOR 4	-.022	-.029	-.068	1.00

The correlation matrix (Table 3) of motor factors which we received by applying PB criterion reveals that there is a relatively important correlation between variables of motor coordination and the speed of alternative movements. Therefore, both factors are important to perform complex motor tasks efficiently. The balance factor has low correlation with the second and a bit higher, but still low with the first factor. The correlation of coordination limb movement factor with the others are not significant, the only really significant correlation is between the first and the second factor.

Structures of motor space in six and a half year old children

Latent structure of motor space in six and a half year old girls according to PB criterion

Furthermore, we study motor space of girls at the age of six and a half. To get complete information and to facilitate the understanding of individual phenomena in a child's motorics, we present the structure obtained from a very sharp PB criterion (Table 4) and the defined factors are real to the largest extent possible.

The latent structure of motor dimensions is, according to PB criterion, defined by only five latent dimensions. They explain 48.2 % of the common variance of the system. The first proper value explains 21.8 % of the variance, the remaining four from 7.9% to 5.5%. As the first main component exhausted almost half of the explained variance, it represented latent dimension which is responsible for a considerable part of the variability of the system variables. The first motor factor is very complexly structured, therefore we called it the ability to solve spatial problems and explosive power, the second factor is called the speed of alternative movements, the third factor has the characteristics of keeping the balance, the fourth factor represents the ability to realise integrated programs of movement, the fifth represents the coordination of hands.

Table 4: Results of factor analysis in six and a half year old children (girls) PB criterion.

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
EXMSDZ1	0.69653	–0.01563	0.00328	0.02404	0.08110
EXMSD31	0.63322	0.05749	–0.09376	–0.14979	0.04699
EXMSVI1	0.59921	–0.20085	0.01726	–0.00962	0.10521
VDMKLO1	0.17643	0.43737	0.14330	–0.07439	0.04102
VDMBPO1	–0.01780	0.50305	0.22618	–0.12156	–0.36213
VDMBPR1	–0.04272	0.55525	0.33319	–0.01351	–0.06529
HITAR11	–0.00049	0.68907	–0.05014	–0.08858	–0.16239
HITTAN1	–0.00483	0.57486	0.10089	–0.18493	–0.16101
HITAR21	–0.14126	0.31704	0.11605	0.02312	–0.47572
RSLKVV1	0.02312	0.08652	0.74787	–0.07949	0.17906
RSLKVP1	0.06250	–0.05407	0.77070	–0.04775	0.09153
RSPKVA1	0.03793	–0.11370	0.75919	0.01484	–0.16548
KROZOT1	–0.12422	0.66242	–0.04325	–0.09268	0.40520
KKOTZS1	0.05338	0.24142	0.19520	0.02243	0.69034
KKOTZO1	–0.36874	–0.35742	–0.04849	–0.17607	–0.19769
KOCPV71	–0.19080	–0.56108	0.18582	–0.09038	–0.04167
KOCKVO1	–0.09087	–0.12179	–0.02657	0.09946	0.62760
KOCLM81	–0.29061	–0.47654	0.27158	–0.06962	0.08754
KLILEN1	–0.36866	–0.18357	–0.07891	0.24940	–0.09081
KHOONA1	–0.70979	–0.06683	–0.04060	–0.04071	0.01845
KPOLNA1	–0.59580	–0.18182	–0.08358	0.05817	0.02394
KPLAKL1	–0.54196	–0.09026	–0.34902	–0.05412	0.15934
KPLAZO1	–0.58052	–0.01891	–0.22835	–0.16836	0.16320
KTEKOT1	–0.28459	–0.01219	0.09932	0.06989	0.13005
KTEKSS1	0.01971	0.04066	–0.02469	0.88890	–0.00145
KBOTEK1	0.02516	0.01448	–0.08669	0.87742	0.00809
KTEKCC1	–0.40937	–0.15223	0.07741	0.50930	0.10878
KUDARZ1	0.22528	0.26719	0.09181	0.10528	–0.20952

The factor correlation matrix (Table 5) based on PB criterion shows that there are significant correlations only between the first and the second isolated factor (0,33). These are dimensions which are based on the coordination abilities with different manifestations, but certainly with the same or very similar functional basis. Other latent dimensions according to the size of coefficients are obviously not related.

Table 5: Factors correlation matrix in six and a half year old children (girls) PB criterion.

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
FACTOR 1	1.00000				
FACTOR 2	0.33562	1.00000			
FACTOR 3	0.11032	0.16950	1.00000		
FACTOR 4	–0.08129	–0.14482	–0.06669	1.00000	
FACTOR 5	–0.07684	–0.12231	–0.06685	0.07549	1.00000

Latent structure of motor space in six and a half year old boys according to PB criterion

Latent structure of motor dimensions in six and a half year old boys will be determined and analysed on the basis of reasonable grounds which we used to interpret the latent structure of motor dimensions in girls. The structure of motor space in boys is defined according to a stricter PB criterion with only four latent dimensions which together explain 44.2% variance of the system of manifest variables. The main component explains 24.5% variance of the system, which is more than half of the total explained variance, the other three components explain from 8.1 to 5.3%. The first motor factor in boys is called coordination of movement, the second motor factor has the characteristics of speed of alternative movements, the third factor has the characteristics of maintaining the balance, and the fourth factor has more complex structure and is called ability to perform motor structures with legs and hands simultaneously.

Table 6: Results of factor analysis in six and a half year old children (boys) PB criterion.

	FACTOR1	FACTOR2	FACTOR3	FACTOR4
EXMSDZ	0.34705	0.05976	–0.02231	0.53253
EXMSD3	0.32644	0.02098	–0.05688	0.44830
EXMSVI	–0.03108	0.07251	0.13026	0.62755
VDMKLO	0.49172	0.15558	–0.06097	–0.00431
VDMBPO	0.15114	0.61189	–0.15578	0.04357
VDMBPR	0.29591	0.44298	–0.07059	0.12793
HITAR1	–0.13982	0.76912	–0.10303	0.06500
HITTAN	–0.01545	0.71220	0.03719	0.17515
HITAR2	0.03385	0.58320	–0.12635	–0.10190
RSLKVV	0.08580	0.11463	–0.70767	0.00674
RSLKVP	0.12739	0.00876	–0.73093	–0.01436

	FACTOR1	FACTOR2	FACTOR3	FACTOR4
RSPKVA	–0.19702	0.22038	–0.76941	0.03722
KROZOT	0.15684	0.19127	0.29057	0.42580
KKOTZS	0.46997	–0.02026	0.02151	–0.02585
KKOTZO	–0.64545	–0.00203	0.08440	–0.14835
KOCPV7	–0.50378	–0.15300	–0.22667	0.21098
KOCKVO	–0.03098	–0.46204	–0.16326	–0.23793
KOCLM8	–0.59407	–0.15809	–0.08309	0.14392
KLILEN	–0.48591	0.20244	0.07412	–0.25919
KHOONA	–0.39881	0.15782	0.13044	–0.58631
KPOLNA	–0.43735	0.15893	0.05926	–0.54884
KPLAKL	–0.60614	0.03462	0.20521	–0.14618
NPLAZO	–0.43451	0.03397	0.24921	–0.27168
KTEKOT	0.09307	–0.07099	0.10759	–0.60158
KTEKSS	0.11557	–0.02796	0.06507	–0.60787
KBOTEK	0.06781	–0.16108	0.08950	–0.46282
KTEKCC	–0.34813	–0.08827	–0.01080	–0.27835
KUDARZ	0.37333	0.39913	–0.21456	–0.11628

The factor correlation matrix (Table 7), isolated by PB criterion has no high correlations. The first factor has the highest correlation with the fourth factor, slightly lower with the second one. As previous structure factor analysis reveals, there is a link between different forms of coordination with the speed of alternative movements and even more with the explosive power, which we significantly highlighted when interpreting the last factor. Among other dimensions there are no significant correlations.

Table 7: Factors correlation matrix in six and a half year old children (boys) PB criterion.

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
FACTOR 1	1.00000			
FACTOR 2	0.24416	1.00000		
FACTOR 3	–0.09818	–0.12914	1.00000	
FACTOR 4	0.30050	0.18996	–0.18641	1.00000

Comparison of latent structure of motor spaces in six and a half year old girls and six and a half year old boys

After we used PB criterion we isolated one factor less in boys than in girls. On this basis we can conclude that the structure of motor space in six and a half year old girls and boys partly differs, the level of differentiation of motor abilities is much higher in girls than in boys. We believe that the reason for this can be found in faster development of girls who overtake their male peers at this age.

DISCUSSION

The analysis of the motor space structure revealed certain particularities for each age period. In the sample of five year old children, the use of PB criterion revealed four latent motor dimensions. In six and a half year old boys and girls, the latent motor space structure can be described using four (boys) and five (girls) factors. Despite the existence of gender differences in the motor space structure, mostly related to the factors which influence movement coordination, several very similar dimensions were discovered in both sexes.

Among all isolated dimensions, most of them cover the area of different forms of coordination and there is a relatively important link between variables of motor coordination and the speed of alternative movement. The cause of this is that in all motor tasks the speed to perform complex motor tasks efficiently is very important in the first and the second factor and partially in that the motor test tasks for measuring the speed of movement are apparently simple. Similar results and findings were had by Strel and Šturm (1981) and Videmšek and Cemič (1991), who defined the first main component as a general motor factor.

In this paper we analysed and discussed the structure of motor space in children in preschool and early elementary school. The analysis of the structure of motor space showed certain particularities in each age group. Despite the fact that the structure of motor space differs between sexes, certain dimensions are very similar. The differences between sexes appear mainly in the factors that define the coordination of movement. Studies that identify the structure of motor space separated by sex at an early age are very few and of those which we detected (Strel, Šturm, 1981, Morris et al.,1982) gave similar results and the researchers came to very similar conclusions regarding the differentiation of motor abilities in girls and boys. In a study of 3 to 6 year old children, Morris, Williams, Atwater and Wilmore (1982) defined differences between sexes and age group. Seven motor tests were designed to measure motor efficiency in the field of equilibrium, crawling skills, catching, running, standing broad jump and throwing a ball. The analysis of data showed certain differences in equilibrium where girls had better results, and that boys were slightly better in all other tests. They concluded that there are already some small differences in motor efficiency between sexes in early childhood. Taking into account that six and a half year old girls are more receptive to the influences of morphological characteristics than boys (Pišot, Planinšec, 2005) we consider that these differences may affect the determination of the structure of motor space or level of differentiation. Contrary to these findings and the findings of Oja &

Jurimae (1997) in the study of Fjortoft (2000) they found that achievements in motor tests do not depend on the body weight and height of children.

Based on the results of our study, we can conclude that numerous factors, isolated dimensions, are in the space of coordination and cover the area of different forms of coordination. In order to perform a certain complex movement, and from the ages between five and six and a half, even simple movements are still complex as there is a need to formulate motor programs and while performing movement there is a need for feedback information which is integrated into the motor scheme and enables program correction and the creation of appropriate movement responses. Complex motor coordination depends on certain cognitive components which represent different forms of information processing (Tirre & Raouf, 1998). With increasing complexity of movement the demands for intellectual activity before and during movement performance also increases (e.g., Planinsec, 2002h). For a successful movement structure simultaneous, serial processing of information is required which is also important during intellectual activity ((Schmidt & Lee, 1999, Horga, 1993; Pisot & Planinsec, 2005). This is also consistent with the findings of Lurija (1976), suggesting that the development of motor centres in the central nervous system in young children is aimed at forming secondary zones and the function of integration at the level of tertiary zones is only in its origin (perhaps the age limit shifted slightly down). The overall motor efficiency of children in the studied age depends to its greatest extent on the quality of the functioning of motor centres in secondary and tertiary zones of the central nervous system.

CONCLUSION

Following the number of isolated dimensions and on the basis of their structure we point out that in the treated sample of children, a certain level of differentiation of motor abilities is already present and it is more significant in girls. The reason for this may be attributed to the faster development of girls who partly overtake their male peers at this age. Certainly, various morphological characteristics which take part in the manifestation of different motor abilities and motor efficiency in general influence the structure of motor space to differ according to sex. Consequently, it can be concluded that the period of early childhood motor regulation is characterized by some specific features which distinguish the motor space of children from that of adults.

This study contributes in the understanding of developmental characteristics of children, particularly within the dimension of motor space. To confirm these assumptions, further studies will be necessary to clarify outstanding issues about motor and morphological space of children. The more we know about children, his particularities and needs, the more positive development incentives provided by physical/sport activity we can offer. It is very important not to miss this optimal period when a child is most receptive to the various results which can be achieved during the training process. Later it is not possible to compensate for the losses resulting from unsystematic and irregular physical/sport activity.

Acknowledgements

This study was partly funded by the Ministry of Higher Education, Science and Technology of the Government of the Republic of Slovenia. We are grateful to professors D. Rajtmajer, P. Praper and K. Kancler, MD (Faculty of Education and the Pediatric Hospital Maribor, Slovenia) for leading a broader research project "Structure and relations of psychomotor and cognitive abilities of preschool children" and for supporting this study. We are thankful to all researchers and collaborators for their help and to our subjects and their parents for their willingness to participate in this study.

REFERENCES

Bala, G. (2003). Quantitative differences in motor abilities of pre-school boys and girls. Kinesiologia Slovenica, 9 (2), 5–16.

Bös, K. (1994). Differentielle Aspekte der Entwicklung motorischer Fahigkeiten. In J. Baur, K. Bös, V. J. Baur, K. Bös, & R. Singer (eds.): Motorische Entwicklung. Ein Handbuch (pp. 238–254). Schorndorf: Verlag Hofmann.

Eurofit. (1993). Eurofit Tests of Physical Fitness, 2nd Edition. Strasbourg: Council of Europe Publishing and Documentation Service.

Fjortoft, I. (2000). Motor fitness in pre-primary school children: The EUROFIT motor fitness test explored on 5–7 year-old children. Pediatric Exercise Science, 12 (4), 424–436.

Fleishman, E. A. (1964). The structure and measurement of Physical Fitness. New York: Prentice-Hall, Engelwood Cliffs.

Gallahue, D. L., & Ozmun, J. C. (2005). Understanding motor development: infants, children, adolescents, adults. New York: McGraw-Hill Higher Education, London: McGraw-Hill.

Latash, M. L. (2008). Neurophysiological basis of movement. Champaign, IL: Human Kinetics.

Gredelj, M., Metikoš, D., Hošek, A., & Momirović, K. (1975). Model hierarhijske strukture motoričkih sposobnosti. Rezultati dobiveni primjenom jednog neoklasičnog postupka za procjenu latentnih dimenzija. Kineziologija, 5 (1–2), 11–81.

Kurelić, N., Momirović, K., Stojanović, M., Šturm, J., Radojević, D., & Viskić-Štalec, N. (1975). Struktura i razvoj morfoloških i motoričkih dimenzija omladine. Beograd: Institut za naučna istraživanja, FFV.

Lurija, A. R. (1976). Osnovi neuropsihologije. Beograd: Nolit.

Magill, R. A. (1998). Motor learning: concepts and applications. Dubuque: McGraw-Hill.

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). Growth, maturation, and physical activity. Champaign: Human Kinetics.

Metikoš, D., Hofman, E., Prot, F., Pintar, Ž., & Oreb, G. (1989). Mjerenje bazičnih motoričnih dimenzija sportaša. Zagreb: FFK.

Oja, L., & Jurimae, T. (1997). Assessment of motor ability of 4 and 5 year old children. American Journal of Human Biology, 9 (5), 659–664.

Oja, L., & Jurimae, T. (2002). Physical activity, motor ability, and school readiness of 6 year old children. Perceptual and Motor Skills, 95, 407–415.

Pišot, R. (1997). The Structure of morphological characteristics of six and a half year old boys. In M. Pavlovič (ed.). Third International Symposium Sport of the Young, Bled, Slovenia, (pp. 188–194). Ljubljana: Faculty of Sport.

Pišot, R. (1999a). Latent structure of six and a half year old girls' motor space after partialisation of morphological characteristics. In V. Strojnik, A. Ušaj, & B. Jošt (eds.). Theories of human motor performance and their reflections in practice, (pp. 277–280). Ljubljana: Faculty of Sport.

Pišot, R. (1999b). Latent structure of six and a half year old boys' motor space after partialization of morphological characteristics. 4th Annual Congress of the European College of Sport Science –"Sport Science'99 in Europe: Proceedings book. Rome: University Institute of Motor Science.

Pišot, R. (2000). The Analysis of the structure of six and a half year old children's motor space in the light of its development as a whole. Acta universitatis carolinae – kinanthropologica, 36 (1), 67–78.

Pišot, R. (2003). Children's motor space in the light of its development as a whole - convergencies between motor activities and early teaching of foreign languages'. In Moloda sportivna nauka Ukraini: zbirnik naukovih prac' z galuzi fizičnoi kul'turi ta sportu. Tom 2, Periodične vidanja: Vipusk 7 (pp. 127–132). Lviv: NVF Ukrains'ki tehnologii.

Pišot, R., & Planinšec, J. (2005). Motor space structures in early childhood. (In Slovenian.) Annales, University of Primorska, Science and Research Centre, Institute for Kinesiology Research.

Pišot, R., Šimunič, B., Šarabon, N., Cankar, G., Jelovčan, G., Plevnik, M., et al. (2010). Motor competences for healthy and thriving children. In J. Dolinšek (ed.). Child and Sport (pp. 15-26), Maribor: University Medical Centre Maribor, Clinic for Paediatrics.

Planinšec, J. (1997). Classification of pre-school children with different cognitive status based on their motor competence. In: J. Bangsbo, et al. (eds.). Second Annual Congress of the European College of Sports Science, Copenhagen, Denmark. Book of abstracts: poster presentations. 2, Sport science in a changing world of sports (pp. 844–845). Copenhagen: European College of Sport Science.

Planinšec, J. (2000). Some characteristics of coordination development of a child's motion. R. Pišot, & V. Štemberger (eds.). A Child in Movement: proceedings (pp. 540–548). Ljubljana: Faculty of Education.

Planinšec, J. (2001a). Development of some motor abilities in preschool and primary school period. In B. Škof, & M. Kovač (eds.), Innovations in school physical education: proceedings (pp. 306–313). Ljubljana: Zveza društev športnih pedagogov Slovenije.

Planinšec, J. (2003). Assessment of physical activity of young children. (In Slovenian). Zdravstveno varstvo, 42, 58–65.

Planinšec, J., & Čagran, B. (2001). Determination of the motor types of younger children by classification into groups. Kinesiologia Slovenica, 7 (1–2), 37–43.

Rajtmajer, D. (1992). The Motor Abilities Structure of the 5 to 5.5 year old girls. Educa, 2, 147–158.

Rajtmajer, D. (1993a). Psychomotoriche Fähigkeiten der jungeren Kinder. Maribor: Faculty of Education.

Rajtmajer, D. (1993b). Comparative analysis of psihomotor strukture of 5 to 5.5 year old children. Sport, 41 (4), 36–40.

Rajtmajer, D. (1996). Struktura a hodnocení motorických schopností děti ve věku do 6 let. In M. Krobotová (ed.), Sborník z 6. konference o současných celosvětových otázkách alternativního školství (pp. 244–249). Olomouc: Universitatis palackianae Olomucensis, Facultas paedagogica.

Rajtmajer, D. (1997b). Psychomotor abilities of the youngest: theory, research, information system. Maribor: Faculty of Education.

Rajtmajer D., & Proje S. (1990). Reliability and factor structure of composite tests for evaluation of early child motor development. Sport, 1–2, 48–51.

Schmidt, R. A. (1991). Motor learning & performance. Champaign: Human Kinetics Books.

Schmidt, R. A., & Lee T. D. (1999). Motor control and learning: A behavioral emphasis. Champaign: Human Kinetics.

Strel, J., & Šturm, J. (1981). Reliability and structure of some motor abilities and morphological characteristics of 6.5 year old children. Ljubljana: Institute for Kinesiology, Faculty of Physical Culture.

Štalec, J., & Momirović, K. (1971). Ukupna količina valjane varijance kao osnova kriterija za određivanje broja značajnih glavnih komponenata. Kineziologija, 1 (1), 77–81.

Šturm J., & Strojnik V. (1994). Introduction to anthropological kinesiology. Ljubljana: Faculty of Sport.

Thomas, J. R., & French, K. E. (1985). Gender differences across age in motor performance: A meta-analysis. Psychological Bulletin, 98 (2), 260–282.

Videmšek, M., & Cemič, A. (1991). Analysis and comparison of different motor abilities models in 5.5 year old children. Masters thesis. Ljubljana: Faculty of Sport.