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ORIGINAL ARTICLE

Identification of structural aspects of motor performance in children aged 7 years.

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Abstract
In order to identify the substance of a complex of motor abilities not only the information on specific elements is important but also on mutual relations between them and their structure. The aim of this study was to analyse and compare differences in the hierarchy of motor and physical indicators in primary school girls and boys. A group of 195 girls and 175 boys aged 7 years were subjected to 16 motor tests measuring condition and coordination abilities. Cluster analysis was applied to find out a hierarchical system of respective motor and somatic indicators. In the examined groups of girls and boys, strength, speed and endurance indicators are characterized by significant differences. On the other hand, indicators of coordination abilities show considerable identity in both groups. Girls differ from boys significantly in higher level of abilities to connect, adapt and rearrange movements. The level of body mass, height and sum of 5 skinfolds was similar in both groups. The hierarchy of somatic and motor variables slightly gender-dependent as early as the primary school age. Physical development affects condition as well as coordination performance independently on sex. On the basis of implemented research objective is possible to verify the position of coordination and condition abilities in the common motor area to the acceptable extent. This knowledge creates the base for the determination of more efficient diagnostic methods and retrospectively for development of individual motor abilities.

Key words: cluster analysis, motor abilities, primary school age

Introduction

The process of childhood growth and motor development can be characterized predictable in terms of universal principles and sequential progressions as children develop higher levels of functioning. However, children show considerable individual variation due to a variety of environmental and hereditary factors, in both the rate and extent of acquisition of these higher levels of functioning (Gallahue & Donnelly, 2003).

Davis (2001) supports that the period between 5 and 8 years of age appears to be a transitional one for the development of motor performance. According to Gallahue and Donnelly (2003), perceptual-motor abilities are rapidly developing and refining fundamental movement skills during this period. Cross-lateral movements often present more difficulty than unilateral movements. Gross motor control is developing rapidly and occurs sooner than fine motor one. However, during this period, movements may become both efficient and coordinated, if appropriate instructions and opportunities for physical activity are provided in educational environments.

On the average, sex differences are generally slight but consistently favor boys for running, jumping, and throwing, while girls perform better in tasks requiring balance, such as hopping. The differences between boys and girls are relatively small and there is much overlap (Malina, Bouchard & Bar-Or, 2004), while the physical growth of them is very similar when they are viewed from a posterior position (Haywood & Getchel, 2005).

Information on attained levels of motor performance is not as extensive for early childhood as it is for adolescence. There is much intra-individual and inter-individual variability in the level of motor abilities among young children. Changes in mean levels of performance with age should be viewed with this variability in mind (Malina, Bouchard & Bar-Or, 2004). As it is stated by Panagopoulou et al. (2008) boys' level of coordination do not differ from those of girls in children aged 6-8 years.

Motor abilities are usually thought to be a relatively stable characteristic or trait and according to Schmidt and Lee (2005), they can be conceptualized as representing limitations on performance, or as defining a person's potential for success. Motor abilities represent a complex of the mutually related dispositions that are integrated on the common biological ground. During the last years coordination abilities have been only marginally in the centre of the scientific community's interest in spite of their emphasized and preferred place among the

other motor abilities. Their significance is connected with their control and regulating function (Starosta, 2003). As a consequence, there is still lack of studies examining the developmental trends of coordination abilities in various groups of population, sexual differences and means of their stimulation.

Although the correlation between physical development and coordinative performance of children indicate possible negative consequences, there are still no distinct research findings regarding the correlations between coordination abilities and physical parameters. Graf et al. (2003) report a significantly higher level of boys' gross motor development than girls' aged 6 -7 years. In the study of Vederhus and Krekling (1996) significant sex differences were revealed in spatial perception, but non-significant difference appeared in spatial visualization in prepubertal children.

A variety of tasks can be used to document levels of motor abilities. Nevertheless, emphasis should be placed on standardized tasks that can be used in the field or school setting, in contrast to those limited to the laboratory. In the studies of motor development in early childhood, various motor tests have been applied. However, their feasibility seems problematic, particularly with respect to the specificity of motor development at that age. That problem stems mainly by the fact that a child is not a small adult. Methodological approaches to motor features are extremely diverse and the results are hard to be compared (Kroes et al., 2004; Ružbarská & Turek, 2007).

The aim of this study was to identify the motor performance of seven year old girls and boys, as well as to analyze and to compare the structure of their motor and physical variables.

Method

Participants and procedure

A group of 195 girls and 175 boys aged 7 years, randomly selected from twelve elementary schools of the East Slovakia Region, participated in the study. The aforementioned participants were drawn from the typical population of children in the first-grade. Data were collected during March, April and May 2005 by the study coordinator and three research assistants during school hours at a time convenient to the schools.

The anthropometric data were assessed together with the tests for coordination abilities in the first testing day. On the following day children underwent the condition motor tests while the endurance shuttle run test was performed at length. This decision was related with the number and demands of the tests. During a two-day testing approximately 20-25 children were tested in all items. The testing procedure occurred at school environment.

The selection of motor tests for this study was accomplished according to the principle that condition and coordination motor abilities represent a complex system and their research should reflect it. In that way children were assessed with the following 16 tests:

1. Flamingo balance (FB) - *static balance,*
2. Plate tapping (PLT) - *frequency speed of an arm,*
3. Sit-and-reach (SAR) - *joint flexibility of a trunk,*
4. Standing broad jump (SBJ) - *explosive strength of lower limbs,*
5. Handgrip (HG) - *a static strength of dominant hand,*
6. Sit-ups (SU) - *dynamic and endurance strength of abdominal, coxal and thigh muscle,*
7. Bent arm hang (BAH) - *static and endurance strength of upper limbs,*
8. Shuttle run 10×5 m (SHR) - *running speed with the change of direction,*
9. Endurance shuttle run (ESR) - *run endurance,*
10. Jump with accuracy (JWA) - *kinaesthetic differentiation,*
11. Turns on a bench (TOB) - *dynamic body equilibrium,*

12. Run for balls (RFB) - *orientation ability*,
13. Ball tracing (BT) - *reaction speed*,
14. Arrhythmical tapping (AT) - *rhythmical ability*,
15. Jump without a swing (JWS) - *movement joining*,
16. Jump back (JB) – *movement adaptation and transfer*

The tests 1-9 were applied and conducted according to EUROFIT instructions (Adam, Klissouras & Ravassolo, 1988) while the motor tests 10-16 were applied according to Hirtz (1985) as well as Raczek, Mynarski, and Ljach (1998). According to those authors, the reliability of the motor tests (JWA, TOB, RFB, BT, RFT, JWS, JB) for children aged 6 – 18 years is 0.7 to 0.9.

In addition, 3 somatic measurements were taken: body mass (BM), body height (BH) and sum of 5 skinfolds (5SF) – triceps, biceps, subscapular, anterior suprailiac and medial calf. Body weight was measured using with a precision of 0.5 kg. The children were barefoot and wore light sportswear. Stature was measured using Martin's anthropometer with a precision of 0.1 cm. Skinfolds were measured using the Harpenden caliper with a precision of 0.1 mm. Then the sum of all 5 skinfolds was calculated.

Statistical analyses

Means and standard deviations were calculated for all variables. An independent *t*-test assessed sex differences. Statistical significance was set at $p < 0.05$. The hierarchy of motor and somatic indicators was established by applying cluster analysis, that enables dividing a group of objects into disjoint internally homogeneous subgroups but heterogeneous to each other (Blahuš, 1999). Since the number of clusters had not been preset, the agglomerative hierarchical clustering was selected from several techniques. This method is based on the cluster formation by determining the distances between objects in multidimensional space, in this case determining Euclidean distance. With respect to the character of the selected technique the gross test score of respective test items was transformed to the standard T – score. As a clustering principle, the Ward's method based on minimization of the intra-cluster sum of squares was applied.

The linkage distance is represented by the horizontal scale which corresponds to the fusion values obtained from the hierarchical cluster analysis. Hierarchical cluster analysis is a statistical method for finding relatively homogeneous clusters of cases based on measure characteristics. It starts with each case in a separate cluster and then combines clusters sequentially, reducing the number of clusters at each step until only one cluster is left. This hierarchical clustering process can be represented as a tree, or dendrogram (Fig. 1, 2), where each step in the clustering process is illustrated by a join of the tree (Hendl, 2004). Data was processed with statistic packages SPSS 16.0 for Windows.

Results

Means and standard deviations together with *t*- test values indicated significant differences between group of boys and girls (Table 1). The results of t-test analysis pointed to a poorer level of condition performance of girls. It was evident that boys performed significantly better in speed, strength and endurance abilities (SBJ, HG, SU, BAH, SHR, ESR), but this tendency was not repeated on tests assessing coordination abilities. Boys dominated significantly only in reaction speed (BT), but on the contrary, girls performed better in movement joining (JWS) and movement adaptation and transfer (JB). These abilities can be regarded as important determinants in motor learning. Level of other abilities was only with slight non-significant distinctions.

Table 1 . Descriptive statistics of the anthropometric and motor characteristics, t-values in the groups of girls and boys aged 7 years

	Girls		*Boys*		*t value*
	Mean	*SD*	*Mean*	*SD*	
Dimension					
Flamingo balance (n) / FB	9.2	5.1	8.8	5.3	0.8
Plate tapping (sec) / PLT	22.6	4.0	22.8	3.7	0.7
Sit-and-reach (cm) / SAR	21.6	5.6	20.7	6.2	1.8
Standing broad jump (cm) / SBJ	104.6	16.5	116.7	17.2	**-5.7 ***
Handgrip (kg) / HG	12.2	3.4	14.8	3.1	**-6.7***
Sit-ups (n) / SU	12.5	3.8	14.7	2.2	**-2.8***
Bent-arm hang (sec) / BAH	12.5	6.0	16.6	9.9	**-3.1***
Shuttle run 10x5 m (sec) / SHR	25.3	2.4	23.6	2.3	**-4.5***
Endurance shuttle run (n) / ESR	17.9	6.5	20.3	9.1	**-2.7***
Jump with accuracy (cm) / JWA	11.8	5,97	12.1	7.2	0.3
Turns on a bench (n) / TOB	4.5	1.2	4.7	1.6	-0.2
Run for balls (sec) / RFB	25.2	3.3	24.1	3.4	0.5
Ball tracing (cm) / BT	160.1	21.7	150.1	20.3	**4.5***
Arrhytmical tapping (n) / AT	6.1	1.7	6.6	1.4	0.6
Jump without a swing (cm) / JWS	21.7	11.8	27.1	11.7	**-3.6***
Jump back (cm) / JB	59.4	16.1	72.1	17.6	**-5.2***
Body mass (kg) / BM	24.1	4.2	25.2	3.2	-1.8
Body height (cm) / BH	123.7	5.2	125.3	6.6	-1.6
Sum of 5 skinfolds (mm) / S5F	42.3	8.2	39.6	7.5	1.7

***** *p < 0.05*

Comparison of physical development indicates similar level in both examined groups, with boys having been heavier, taller, but with lower level of adipose segment. The tests that make up a particular cluster have the property of showing relatively close relations with each other. There were 19 variables, and the cluster analysis grouped them in both groups into 4 clusters. The results of cluster analysis in girls and boys are presented in Figure 1, 2 in a form of a tree diagram.

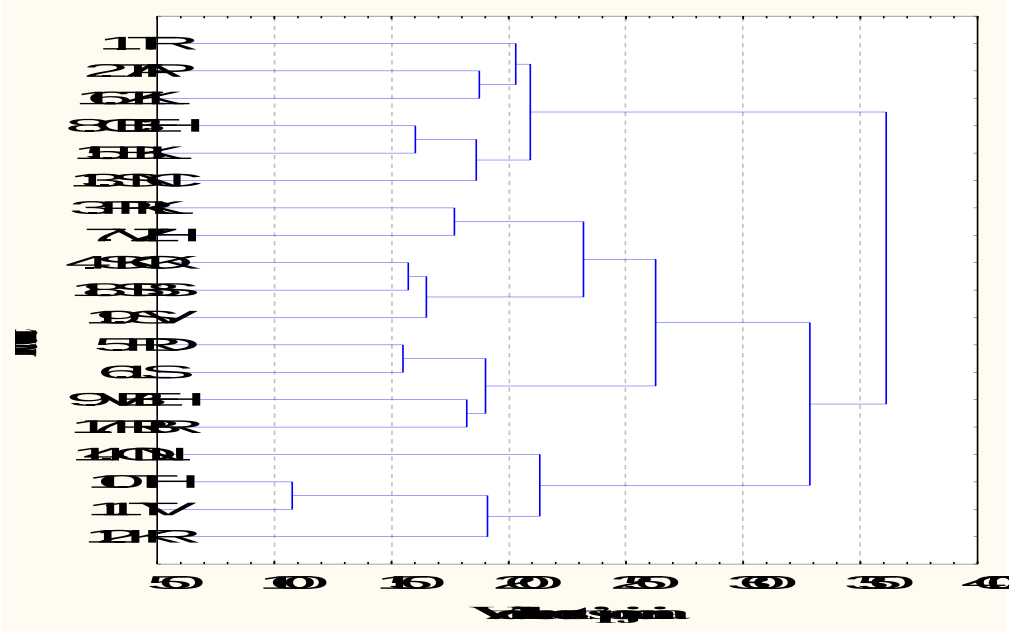

Figure 1. Tree diagram of cluster analysis of motor and somatic variables in girls aged 7 years

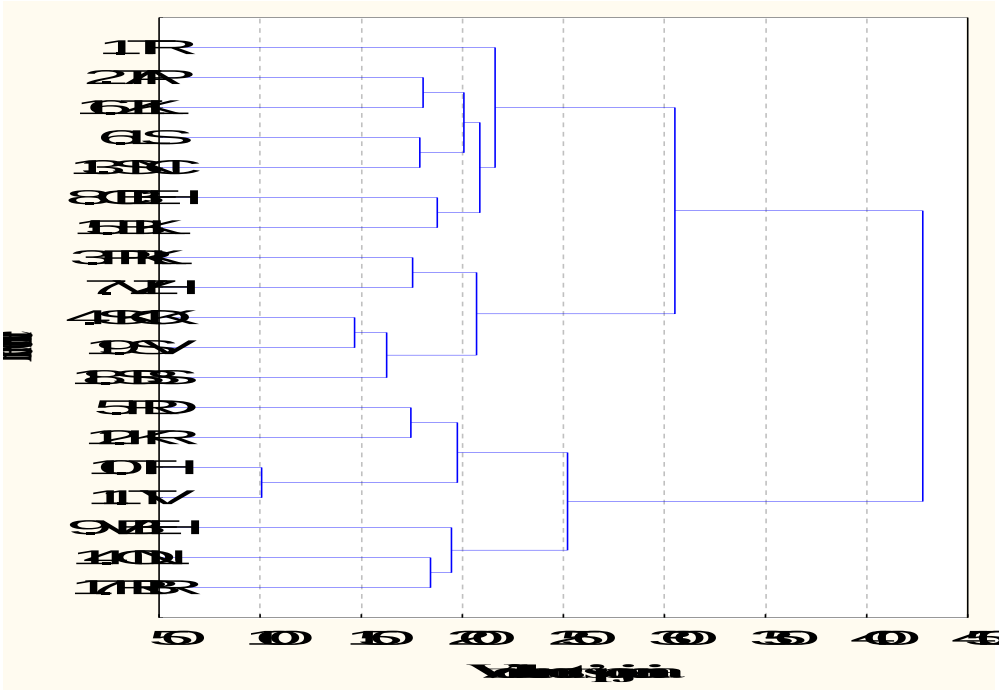

Figure 2. Tree diagram of cluster analysis of motor and somatic variables in boys aged 7 years

On account of a better "readability" the diagrams were transformed into the form of box diagrams (Figure 3).

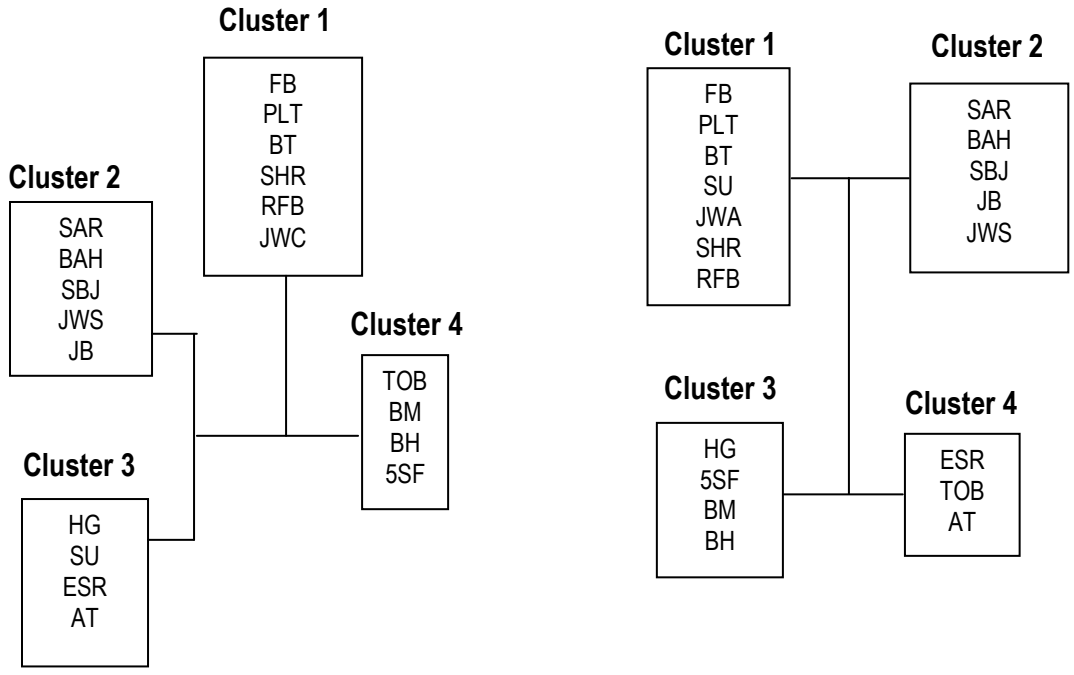

Figure 3. Cluster diagram of somatic and motor variables in girls (left) and boys (right) aged 7 years.
Legend: Flamingo balance (FB), Plate tapping (PLT), Sit-and-reach (SAR), Standing broad jump (SBJ), Handgrip (HG), Sit-ups (SU), Bent arm hang (BAH), Shuttle run 10×5 m (SHR), Endurance shuttle run (ESR), Jump with accuracy (JWA), Turns on a bench (TOB), Run for balls (RFB), Ball tracing (BT), Arrhythmical tapping (AT), Jump without a swing (JWS), Jump back (JB), Body mass (BM), Body height (BH), Sum of 5 skinfolds (5SF)

Coordination and speed sets of indicators (cluster 1) were similar in girls and boys, while there was a separated position of static balance within the cluster 1 in boys. Coordination and speed abilities are in close relation and probably create the basis for motor performance at that age. Explosive power and jumping skills represented identically a basis of clusters 2 in both examined groups. Somatic clusters (4 in girls and 3 in boys) were relatively similar and independent. However, clusters 3 in girls and 4 in boys were more gender-specific. Relation between some coordination abilities grouped in clusters is difficult to explain. Even sex differences of motor performance in this period are generally reported as small, it is obvious that the hierarchy of somatic and motor variables is gender-dependent as early as primary school age. Differences between boys and girls probably reflect the types of activities children participated in, availability of suitable role models for motor skills, and societal expectations for physical activity and motor skill.

Discussion

The results of the present study are in agreement, to some extent, with those of Bala, Sabo & Popovič (2003), who proved that within the motor performance structure of children aged 6 -7 years a factor saturated by fast simple motion plays the main role, maintaining balance and motions which need energetic components. In girls, coordination abilities and flexibility were shown as the key domain of motor space. Cluster analysis showed that coordination abilities, speed and physical factor are probably the key domains determining the motor outcomes in this period of development in both girls and boys. The internal structure of the studied variables proved some distinctions in boys and girls. Such a differentiation can not be detected by applying only partial analyses. While the *t*-test analysis indicated poorer performance of girls in the majority of motor indicators, multidimensional analysis presented that there was only a slight gender-related differentiation in motor performance at that age.

Motor abilities create a basis of the human motor structure. They represent a complex, multilayer and dynamic system of internal relations between miscellaneous elements of the entity. Complex of the same elements in their variant combinations makes the basis of different abilities, and on the other hand, different dispositions create the ground of the identical abilities. Therefore a systemic approach in the research of motor abilities is important. It is difficult to identify the motor abilities as they are latent and manifest only indirectly through the empirical attributes (Ružbarská & Turek, 2007).

Motor performance is influenced, apart from physical characteristics, by motivational factors, opportunity for practice, habitual physical activity, and other factors in the cultural environment. There is a need to consider all these factors during the assessment of motor performance differences. These variables may be particurarly relevant in the context of examining sex performance differences (Malina, 2003). It should be emphasized that during this specific period of motor development children's movement outcomes are evidence of their undergoing biologically-driven growth and intersection of the underlying movement capacity of coordination with the learned performance of motor skills (Miller, 2006).

According to Gallahue and Donnelly (2003) the process of development moves from simple to complex and from general to specific as individuals strive to increase their competence in the motor, cognitive and affective domains of human behavior. Patterns of behavior emerge that may help guide the selection of movement experiences that are typically appropriate for specific age group. All children, however, diverge from typically expected age-group patterns of behavior at one time or another.

The application of multidimensional mathematical and statistical methods allows for more complex identification of the quality aspect of motor performance during ontogenesis.

On the basis of implemented research objective is possible to verify the position of coordination and condition abilities in the common motor area to the acceptable extent. It is obvious that the hierarchy of motor and somatic indicators is characterized by the sexual differentiation as early as in early childhood. The period of early school years is characterised by a considerable variability of the motor behaviour, which is influenced by the physical development. One calendar year can be considered to be a "development stage" in which changes in the child's organism directly influence individual motor acts.

Conclusion

Some attributes of motor performance structure in early school years are difficult to be explained. One of the reasons for that is a lack of studies having examined the relation of condition and coordination abilities as well as their dependence on physical development. Poorer level of condition abilities in 7-years-old girls does not mean the worse disposition of their motor performance. The comparable coordination performance in girls and boys prove their similarity. Therefore, in order the actual status of motor dispositions in children to be identified, the information about not only specific elements but also the mutual relations between them and their structure is considered important. Condition abilities are in a straight continuity with coordination ones and considering their control function, the study of the abilities under the prism of their complexity is necessary. This knowledge creates the base for the determination of more efficient diagnostic methods and retrospectively for the development of individual motor abilities. It is critical, though, the developmental characteristics of children as well as their limitations or potentials to be understood. Only in this way, movement experiences for young children that truly reflect their needs and interests and are within their level of ability can be structured.

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