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ASPECTS OF MOTOR DEVELOPMENT IN CHILDREN WITH CEREBRAL PALSY

Erna Žgur

Abstract
Child’s motor development is not an isolated process but it rather involves numerous other developmental aspects, such as cognitive and conative. The research is focused on defining the developmental principles of motor abilities and skills in children with prominent motor deficits who were diagnosed with cerebral palsy (CP). The research compares the motor maturity between two groups of children with CP; the younger group (up to 10 years of age) and the older group (10 – 16 years of age). The research included 78 primary school children with different forms of CP (diplegia, hemiplegia, mixed forms), aged between 6 and 16. The discriminant analysis used in the research showed that there is a statistically significant relationship between age and motor maturity in children with CP. The structural matrix confirmed the different hierarchical representation of the motor components (strength, coordination, precision and graphomotor skills) for the selected motor model, in relation to children’s age. The function of explosive strength showed significant differences between younger and older children as regards their motor maturity. We can conclude that there is a significant developmental difference between the groups of younger and older children with CP, in relation to their motor maturity (different hierarchical representation), with the most obvious difference in motor ability of explosive strength.

Keywords: children with cerebral palsy, motor abilities and skills.

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Introduction
Due to irregular brain development, people with CP usually manifest different forms of motor system dysfunction. A disorder can be mild, manifested as rigidity and clumsiness related to movement or individual elements of movement. In case of major trauma to the motor areas of the brain, motor dysfunction results more prominent and complex,

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entailing greater movement difficulties or difficulties with numerous, interconnected elements related to movement; difficulties in maintenance of upright position and consequently with more demanding cognitive tasks (process of learning, development of speech and communication, social, and emotional relationship). For inclusion of children in school, a suitable neuro-motor maturity is required for the satisfactory development of cognitive knowledge, gross and fine motor skills (Logar, Jones, Žgur, Andlovec, Groleger, 2014), enabling the completion of visual motor coordination processes which are necessary for the development of wider dimensions of learning (in Žagar, 2012). Children with CP can also have simultaneous multiple deficits (motor, sensory, perceptual, etc.), having thus major difficulties in learning achievement.

**Aspect of learning achievement and learning progress**

For successful learning, children with multiple deficits need a structured, guided teaching (Miller and Bachard, 2006; Ornik Vovk, Murn, Werdoing, 2011). Children with multiple deficits (including children with CP) need more time to develop and suitably maintain their cognitive, motor, work and social communication abilities, through appropriate learning and therapeutic treatment (Žgur, 2014). Incomplete or less developed central nervous system causes immaturity in development of sensory motor abilities, which is reflected in insufficient motor development (Gibson, Blandford, 2005). The latter hinders the process of maturation of gross and fine motor abilities and skills, essential in the process of acquisition of basic school knowledge (Rosenbaum, Rosenbloom, 2012). Children with CP develop less sophisticated sensory perceptual abilities, which, together with the visual motor coordination, represent an important base for the development of focused attention, identification ability, ability to follow the school lessons, etc.; all elements essential for school work. Incomplete neurologic processes cause incomplete and short attention span which consequently influences the insufficient memory formation, needed for retaining knowledge. Excessive excitation of sensory-perceptual system can lead to the low frustration tolerance, which is reflected in school (peer), as well as in wider social relations (social cohesion and acceptance). Immaturity of sensor perceptual processes additionally increases the difficulties in self-perception formation (in Žagar, 2012). These deficits, as well as some other, especially health problems, consequently diminish the possibilities for suitable learning and exercise. Children therefore often remain on the level of incomplete learning strategies which are thus less successful, slower, and less automated. The role of the maturation of motor processes in students with CP is extremely important, whereby it is important to balance the maturity of
both, motor abilities and skills (Dolenc Velicković, 2010, Jekovec-Vrhovšek, Neubauer, 2011). Teachers themselves can help children by giving them more attention, emphasizing the more coherent development of body scheme and visualization. In collaboration with other experts (e.g. physiotherapists, occupational therapists, sports teachers), attention is focused on relational principle, important in understanding spatial relations, orientation relations (body perception, perception of body parts, relations between the body and space, etc.). Complete development of sensory-motor processes enables an optimal insight, perception and internalization of different information, feelings, better intrapersonal and interpersonal interactions, communication, motivation, major lifelong work preparation, which provides more independence in different types of situation learning, in work and in life.

**Motor abilities and skills**

Each human motor action can be divided into different elements of motor abilities or skills. In some cases they are pure motor abilities, in some others pure motor skills. Most human movement presents mixed forms of abilities and skills which are interconnected and complementary (Gallahue, 2010). Motor development is important as it often determines the balance, efficiency and performance. For the purposes of this study, a nomothetic classification of motor abilities was used (Pistotnik, 1999): flexibility, strength, coordination, speed, balance, and precision.

**Cerebral palsy**

Cerebral palsy is a combination of specific signs which indicate disorders affecting child’s motor abilities, posture and balance control (Miller and Bachrach, 2006, Katušić, 2012). It is also a term used to describe motor deficits as a result of brain damage in early childhood. CP is static, unchanged, non-progressive brain disorder, which means that it does not increase and spread to other parts of the brain (Bax and Goldstein, 2005). The term CP indicates a motor disorder, whereby a person can have numerous other accompanying disorders (learning difficulties, hyperactivity disorders, attention deficit, hearing and speech disorder, epilepsy, difficulty of swallowing or chewing, etc. (Baxter, 2006). CP is not a disease, it is not contagious, it is non-progressive, but lifelong.

**Aim and goal**

The research focuses on the differentiation of the incidence of differences in motor development in older and younger students with CP. Additionally, it focuses on hierarchically constructed model of motor functions in individuals with CP. For students with CP, school time
represents, as for other students, period of intensive learning and knowledge acquisition, but also period of motor functions development.

Research hypothesis
In the research we tested the hypothesis that there is a statistically significant relationship between the age of the children with CP and the development of their motor abilities and skills.

Methods
Sample
The sample consisted of 78 children with CP attending 1 to 9 years of primary schools of equivalent educational standards, aged between 6 and 16. It included children with neurological signs of CP, classified into the following categories: hemiplegia, diplegia, other (mixed) forms. 47.5% of children were diagnosed with hemiplegia, 33.8% with diplegia and 18.7% with other (mixed) forms.

The observed variables
The variables were defined in accordance with the theory of CP. For the purposes of this study, a nomothetic classification of motor skills and abilities was used: flexibility, precision, balance, strength, coordination, speed, stability (postural) control, manipulation and locomotion (Table 1).
Table 1 - Observed variables (motor skills and abilities) in the system

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Variable explanation</th>
<th>Description of testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination (4 tasks of coordination)</td>
<td>motor test of coordination</td>
<td>time of task completion, number of points scored</td>
</tr>
<tr>
<td>Balance (2 tasks of balance)</td>
<td>motor test of balance</td>
<td>time of task completion</td>
</tr>
<tr>
<td>Postural control/stability (4 tasks of postural control/stability)</td>
<td>motor test of postural control/stability</td>
<td>time of task completion</td>
</tr>
<tr>
<td>Strength (3 tasks of strength)</td>
<td>motor test of strength</td>
<td>number of points scored</td>
</tr>
<tr>
<td>Speed (5 tasks of speed)</td>
<td>motor test of speed</td>
<td>time of task completion</td>
</tr>
<tr>
<td>Flexibility (4 tasks of flexibility)</td>
<td>motor test of flexibility</td>
<td>time of task completion</td>
</tr>
<tr>
<td>Precision (6 tasks of precision)</td>
<td>motor test of precision</td>
<td>number of points scored, time of task completion</td>
</tr>
<tr>
<td>Locomotion (2 tasks of locomotion)</td>
<td>motor test of locomotion</td>
<td>time of task completion</td>
</tr>
<tr>
<td>Manipulation (2 tasks of manipulation)</td>
<td>motor test of manipulation</td>
<td>number of points scored</td>
</tr>
<tr>
<td>Graphomotor skills (4 tasks of graphomotor skills)</td>
<td>motor test of graphomotor skills</td>
<td>number of points scored, time of task completion</td>
</tr>
</tbody>
</table>

Data analysing methods
The test results were processed with the SPSS statistical software for personal computers. Discriminant analysis was used to determine the differences in the latent structure of motor space. With a linear combination of the manifest predictor variables, one or more discriminant functions were obtained (based on the step-by-step
approach). The size of the sample meets the requirements on statistical reliability in the ratio between the number of variables and subjects included in the study. To verify the hypothesis, we used the method of Canonical discriminant analysis. It confirmed a statistically significant relationship between the age of the children with CP and the development of their motor functions.

Results
The results of the discriminant analysis confirmed that there is a correlation between the age of the children with CP and the maturity of their motor skills and abilities for a selected model. Younger children with CP (up to 10 years of age) differed significantly in the maturity of their motor abilities and skills from the group of older children (over 10 years of age). Comparing the two groups - according to age, we obtained one discriminant function (Table 2) with adequately high proper value and canonical correlation coefficient, indicating a clear distinction between the two groups. Wilk’s lambda was tested by chi-square test, confirming significant statistical differences between the two groups.

Table 2 - Canonical discriminant analysis between the group of children (up to 10 years of age) and the group of children (over 10 years of age),

<table>
<thead>
<tr>
<th>Function</th>
<th>Eigenvalue</th>
<th>% Variance</th>
<th>% Cumulative</th>
<th>CCC</th>
<th>Wilks' Lambda</th>
<th>Chi-square</th>
<th>df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.566</td>
<td>100,0</td>
<td>100,0</td>
<td>.781</td>
<td>.390</td>
<td>54,177</td>
<td>37</td>
<td>.034</td>
</tr>
</tbody>
</table>

Note: CCC - Canonical correlation coefficient

Table 3 shows correlations between the discriminant function and manifest variables of the system. Important variables are those whose value is higher than 0.20. They are classified according to their hierarchical correlation to the discriminant function, from the highest, to the lowest. The results of the structural matrix show that the motor components: strength, coordination, precision and graphomotor skills are significantly correlated with age and motor maturity. All four motor components explain the 4% variance of the system. Coordination, precision and graphomotor skills are negatively correlated with strength. The structural matrix includes motor abilities and skills, indicating their dependence on physical maturity. Younger children (up to 10 years of age) demonstrated lower results in the development of motor skills and abilities. It was an expected result as certain motor components are related to the physiological and neuro-motor maturity. Children over 10 years of age achieved better results at certain motor tests (with more elements of specialised movement). The function was named the
function of explosive strength. Its two key components are two strength components (explosive and repetitive).

Table 3 - Structural matrix of functions

<table>
<thead>
<tr>
<th>Function</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td>.304</td>
</tr>
<tr>
<td>Coordination</td>
<td>-.252</td>
</tr>
<tr>
<td>Strength</td>
<td>.248</td>
</tr>
<tr>
<td>Precision</td>
<td>-.241</td>
</tr>
<tr>
<td>Graphomotor skills</td>
<td>-.212</td>
</tr>
</tbody>
</table>

Group centroids (Table 4) represent mean values of canonical and discriminant variables for the two groups - according to age. The direction of the discriminant function is such that the group which includes children over 10 years of age is positive and the group which includes children up to 10 years of age is negative.

Table 4 - Group centroids

<table>
<thead>
<tr>
<th>Age</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Up to 10 years</td>
<td>-1.267</td>
</tr>
<tr>
<td>Over 10 years</td>
<td>1.204</td>
</tr>
</tbody>
</table>

The selected system of variables demonstrated to be significant in 94.7% of children up to 10 years of age and in 90.0% of children over 10 years of age. General grouping of children, according to the applied system, was significant in 92.3% (Table 5).
Table 5 - Classification results

<table>
<thead>
<tr>
<th>Age</th>
<th>Expected grouping</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up to 10 years</td>
<td>Over 10 years</td>
</tr>
<tr>
<td>Up to 10 years</td>
<td>36</td>
<td>2</td>
</tr>
<tr>
<td>Over 10 years</td>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>%</td>
<td>Up to 10 years</td>
<td>Over 10 years</td>
</tr>
<tr>
<td>Up to 10 years</td>
<td>94,7</td>
<td>5,3</td>
</tr>
<tr>
<td>Over 10 years</td>
<td>10,0</td>
<td>90,0</td>
</tr>
</tbody>
</table>

The research confirmed statistically reliable differences between the group of younger and older children with CP, according to their motor maturity. Their results at individual motor tests were significantly different. Older children with CP (over 10 years of age) achieved better results than expected, their motor maturity was at a higher level. The structure of motor tests included elements of specialised movement. Younger children with CP achieved lower results at these motor tests. Their motor maturity was at a lower level; specialised movement phase had not yet occurred.

Discussion
The research confirms that the motor functions in children with different types of CP are complex and highly structured, but the same in individual elements of motor functions. The study brings a new perspective to the understanding of motor skills and abilities in children with CP. Obtained statistical results correspond to the results obtained by other authors in their studies of individual motor skills and abilities (Miller and Bachard 2006, Gage, 2006, Morris, Kurinczuk, Fitzpatrick, Rosenbaum, 2006). They established that puberty is an optimal period for the development of individual motor skills. These conclusions are particularly relevant to manipulation, locomotion and stability, as well as to the onset of the specialized movement phase, which in the period between 11-14 years of age and beyond represents a key phase in the development of specialized movement (Scrutton, 2004) - a useful and life-long physical stage of the development (Eliasson, 2004). There is also an evident correlation between the age and the perfect execution of motor tasks (Bolling et al. 2013). The onset of the physical phase coincides with the specific age period and starts after 10 years of age. Miller and Bachard (2006) mention that children reach maturity in the development of motor tasks around 6 years of age. They are not yet
ready for more demanding and complex motor tasks, accordingly, their results are poorer, as confirmed for the selected motor model. In the course of their development, maturely different forms of movement patterns occur, in relation to age and motor maturity.

The latter was also confirmed in the study, since suitable forms of motor maturity were observed in much older children with CP, with the prevalence of muscle strength; less as regards coordination, precision and other graphomotor elements. Therefore, research results may help the experts (physical education teachers and sports trainers) studying the population of people with multiple motor deficits (Žgur, 2016). The results of this research can serve as the support for the teachers, who work with children with CP on all education levels. Greater consideration of suitability of motor tasks (optimality of the tasks with regard to the motor maturity) enables and encourages a child's school progress, since it is built on their abilities, taking into account the level of their neuro-motor development.

References
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