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THE ROLE OF THE GENERAL MOTOR FACTOR IN CHILDREN WITH CEREBRAL PALSY

This article is evaluating the motor functions of children with cerebral palsy. The objective of the study was to determine factors of motor development of children with cerebral palsy. The study was conducted on a sample of 80 children 6 to 16 years of age. Only children with cerebral palsy attending primary schools of equal educational standards were included in the study. Motor and rehabilitation components that best reflect their functional status. The results of the factor analysis revealed the principal factor – a latent dimension indicating the specificity of the structure of the motor abilities of the studied sample. One principal factor, defined as a general motor factor that hierarchically include motor skills and motor abilities, was distinguished by the factor analysis. The significant differences of the latent structures of motor skills in children with cerebral palsy were determined by the research, when broader neurological and rehabilitation factors are included in the motor component.

Key words: *cerebral palsy, motor skills, motor abilities, general motor factor*

INTRODUCTION

The school years is one of the most dynamic periods in life a growing child. It is also a period of learning and of acquiring and refining motor skills and abilities. Injuries, illnesses or other factors may lead

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to changes in a child's developmental process. The term 'children with disabilities' refers to children with special needs, and this category also includes those with cerebral palsy (Placement of Children with Special Needs Act, Official Gazette of the Republic of Slovenia, No. 54/00, No. 3/07). Due to the damage to their central nervous system, children with cerebral palsy (CP) exhibit noticeable motor impairments (Baxter, 2006). Their academic and personal success is often conditioned by the level of their motor maturity and the sophistication of their motor system. Children with CP often experience problems related to memorization, attention, orientation, and graphomotor skills which further impede their learning processes (Geralis and Ritter, 1998; Miller and Bachard, 2006). Visual and hearing impairments are present as well (Thomas et al., 2003; Jekovec-Vrhovšek, 2010).

Motor development does not occur as an isolated process, nevertheless it is directly related to the development of cognitive, affective and emotional areas influenced by the internal and external factors (Gallahue and Ozmun, 1998). Motor performance of children with CP is different due to the effects of pathophysiological factors (Gage, 2006). Developmental postural deficits play an important role in the motor development of children with CP.

Motor Abilities and Motor Skills

Motor abilities determine one's motor expression; they are a person's natural endowment (Gallahue and Ozmun, 1998; Durward et al., 1999). They depend predominantly on genetic factors, personal experience and environmental factors, and are relatively stable (Jones and Barker, 1999; Pistotnik, 1999). Moreover they also depend on the functioning of different control systems of the central nervous system, which is severely compromised in the case of CP. A nomothetic classification of motor abilities was used for the purposes of this research: flexibility, strength, coordination, speed, balance, and precision (Pistotnik, 1999).

Motor skills represent the already existing sophisticated skills, or motor knowledge acquired through the process of motor learning and training (Gallahue, 2010; Carr and Shepherd, 2000). Motor skills are defined as the human ability to achieve the result with maximum reliability and minimal consumption of the time and energy. Motor skills could be inadequately developed due to the diminished transmission of sensory and motor impulses and primitive spinal control. They require a high degree of neuromotor control which is impaired in people with cerebral palsy (Scherzer, 2001). Motor behavior can be characterized in terms of the following three categories: locomotion, manipulation and stability (Magill, 1998).

Cerebral Palsy

Cerebral palsy is a general medical term used to describe a variety of neurological signs and is not a disease or illness in the standard medical sense (Siebes, 2001; Dolenc-Veličković, 2010). Brain damage does not grow and/or spread to the other areas of the brain (Scherzer, 2001). It affects the motor system and results in poorer ability of motor coordination and balance, and occurs in the presence of abnormal motor patterns or in a combination of these disorders. Perceivable and unavoidable motor disorders may also be accompanied by other disorders such as epilepsy, hyperactivity, mental retardation, attention deficit disorders, learning disorders, chewing and swallowing difficulties, etc. Mobility in the developmental process of children with CP is restricted by primitive and complex motor patterns affected by abnormalities of muscle tone (Scherzer, 2001).

This study was conducted on a sample of children with different types of CP (hemiplegia, diplegia, athetosis, ataxia, mixed forms). Most children with CP were diagnosed on the basis of the affected body part. The following three categories were used for further statistical procedures: hemiplegia, diplegia, other/mixed forms.

Objectives and hypotheses

The objective of the study was to determine the factors delimiting the motor abilities of children with CP. The research central question attempted to answer was whether there are uniform latent motor abilities of children with CP according to the various types of CP. The hypothesis tested within the study was that there is a difference in the latent structure of the motor abilities of children with CP.

METHODS

Sample and participants

The research included children with CP 6 to 16 years of age. Our sample consisted of 80 children with CP attending primary schools of equal educational standards, grades 1 to 9. A common denominator when creating a research sample was a clinical diagnosis of CP supported by the relevant medical documentation. The sample included children with the CP neurological signs classified into the following categories: hemiplegia, diplegia, other/mixed forms. The sample consisted of 53.8% girls and 46.2% boys; 47.5% of the children were diagnosed with hemiplegia, 33.8% with diplegia and 18.7% with other/mixed forms. 90% of the children have received physical therapy, while 56.3% undergone occupational therapy; most children started talking at the age of 18 months and walking at 24 months of age. The sample size of children with CP is corresponding to the number of selected variables.

The observed variables

The variables were defined in accordance with the theory of CP. The selection of variables included those of motor and rehabilitation components best reflecting the children's functional status. A nomothetic classification of motor skills and abilities was used for the purposes of this research: flexibility, precision, balance, strength, coordination, speed, stability/postural control, manipulation and locomotion. The onset speech and walking are the motor factors which were included as well. The reliability of the motor performance tests was verified by Cronbach's alpha coefficient and their validity was assessed by the factor analysis. The variables included in the statistical data processing reached the levels of interval and ratio scales. The selected tests were based on the CP pathology and on the developed motor performance dynamics.

Table 1 – Observed variables in the system

Variable name	**Variable explanation**	**Description of testing**
Coordination (4 coordination tasks) Walking in a straight line, walking a slalom line, triple jump, long jump	motor coordination test	task completion time, number of points scored
Balance (2 balance tasks) Rolling on an equilibrium board, stand up posture on an equilibrium board	motor balance test	task completion time
Postural control/stability (4 postural control/stability tasks) Standing on the left leg, standing on the right leg, standing up from the back position, standing up from the lap position	motor postural control/stability test	task completion time
Strength (3 strength tasks) Raising the body from the back posture into sitting position, straight leg raise on the back posture, tapping hands	motor strength test	number of points scored
Speed (5 speed tasks) Brisk walking, running, slalom run, sprint	motor speed test	task completion time
Flexibility (4 flexibility tasks) Crawling, rolling, transition from the four leg posture into standing position, walking on four leg position forward and backward	motor flexibility test	task completion time
Precision (6 precision tasks) String of balls-p, string of balls-t, tower assembly, pyramid assembly, lacing overide –p, lacing overide-t	motor precision test	number of points scored, task completion time
Locomotion (2 locomotion tasks) Walk/ jump/ run; jump/walk/jump/run	motor l ocomotion test	task completion time

Variable name	**Variable explanation**	**Description of testing**
Manipulation (2 manipulation tasks) Throw the ball at the target, catch the ball, throw the ball	motor manipulation test	number of points scored
Graphomotor skills (4 graphomotor skills tasks) Tracing four shapes-p, tracing four shapes-t, connecting nine shapes-p, connecting nine shapes-t	motor graphomotor test	number of points scored, task completion time

Note: p-points, t-time

Measurement tools

A variety of observational, measurement and anamnestic instruments were used for the purpose of this research to measure, test and evaluate the motor skills and abilities observed in children with CP. A set of original authorized motor tests was used to determine the level of motor development. Due to the series of neurological and physiological factors, children with CP represent a population which cannot be adequately tested by means of conventional motor tests. A set of motor tests was designed, enhanced and adapted for the purposes of this study to include a wider population of children with the various types of CP. The motor tests were designed in accordance with the recommendations given by Strel and Šturm (1984). Due to the different forms of CP and with the potential medical contraindication, it was necessary to design entirely new motor tasks in order to test all children regardless of the specific form of CP they had been diagnosed with. The battery of tests was a brand new one and represents the beginning of the research into the motor function of children with cerebral palsy.

The Cronbach's alpha coefficients of reliability were calculated for all original authorized motor tests. The following issues were also taken into account in the process of selection and reliability of motor variables: objectivity of testing (the author personally performed the motor tests and gathered the information on children's medical history) and validity (determined analytically through the factor analysis (FA)).

Testing procedures

The study was conducted in several stages and included registration and testing of children in medical centers, private clinics and schools. The data were collected solely for the scientific research purposes and obtained with the permission of the subjects' parents. The study was approved by the National Medical Ethics Committee of the Republic of Slovenia and we were given permission by the Ministry of Education and Sport to view the documentation issued to children with disabilities.

Statistical analysis

The test results were processed with SPSS statistical software programs. The necessary measurement properties were identified for the measurement instruments used in the study (post festum analyses). The data obtained were subsequently analyzed by using the basic statistical procedures: descriptive statistics and FA. FA was used to statistically identify the latent variables of the system which can explain the latent structure of the correlations between the manifest variables. We defined the first, i.e., the principal object to be measured by each instrument separately on the basis of the FA. The Cronbach's alpha coefficient was used to determine the level of reliability of the measurement instruments. Owing to the twofold measurement process in the motor performance tests (completion time and number of points scored) the times and points had to be converted into standardized values. Once a conversion was made in the time data domain, the results were then aggregated and included in the further statistical processing. In certain tasks, a conversion was made due to the occurrence of a negative correlation. All the variables were normalized by means of the Rankit plot and the testing procedure was performed by using the Kolmogorov-Smirnov test. The validity of the use of FA and reliability was checked with the Kaiser-Mayer-Olkin test and the Bartlett test of sphericity. In the correlation matrix of the system, Hotelling's Method of primary components with the Kaisser-Guttman rule was used for the purposes of extracting the relevant factors. The size of the sample meets the requirements for the statistical reliability in the ratio between the number of variables and subjects included in the study.

RESULTS AND DISCUSSION

Table 2 - Descriptive statistics for the entire sample

	M	SE_m	Me	Mo	SD	KA	KS
C	0,000	0,080	0,150	-2,49	0,712	-1,260	2,086
B	0,000	0,103	0,241	0,82	0,922	-0,812	-0,739
PCS	0,000	0,082	0,019	-3,88	0,729	-2,411	10,844
St	0,000	0,093	-0,097	-1,73	0,833	0,312	-0,132
S	0,000	0,104	0,286	-5,56	0,934	-3,881	17,978
F	0,000	0,094	0,198	-4,55	0,837	-3,052	12,094
P	0,000	0,087	0,091	-1,90	0,776	-0,365	-0,514
L	0,000	0,109	0,282	-4,72	0,974	-2,753	9,357
M	0,000	0,091	0,543	0,54	0,817	-2,029	4,449
GS	0,013	0,076	0,237	-2,07	0,670	-1,168	0,768

Note: C- Coordination, B-Balance, PCS- Postural control/stability, St- Strength, S-Speed, F- Flexibility, P- Precision, L- Locomotion, M-Manipulation, GS- Graphomotor skills,

Table 2 shows the values of the principal evaluations of the descriptive statistics parameters for the sample. The variables used were standardized and the results ranged from - 5 to + 5 SD, which is why the arithmetic mean always equals zero. All the selected variables of the system were tested for normality with the Kolmogorov-Smirnov test (Table 3).

Table 3 - Results of Kolmogorov-Smirnov Test

	Kolmogorov-Smirnov Z	p
Coordination	1,150	0,142
Balance	1,914	0,001
Postural control/stability	1,483	0,025
Strength	0,704	0,704
Speed	2,369	0,000
Flexibility	1,916	0,001
Precision	0,741	0,642
Locomotion	1,751	0,004
Manipulation	2,654	0,000
Graphomotor skills	1,397	0,040

Normalization was performed (Rankit Method) since the majority of statistical variables were not normally distributed. The variables were factored with the Hotteling's iterative procedure of principal components. Factor analysis was applied to the sample of 80 children who achieved results in all of the selected tests. The reliability of the system variables was assessed using Cronbach's alpha coefficient for each individual variable of the motor performance and for the entire battery of tests. Cronbach's alpha coefficient was used to determine the amount of total variance explained in the test. The results of Cronbach's alpha coefficient for each variable of the motor performance and for the entire battery of motor performance tests were high (0,936, N=10) and show a high degree of reliability of the selected variables of motor performance. A complete correlation matrix was computed and tested with Kaiser-Meyer-Olkin/KMO (0,916) and Bartlett test (χ^2=574,817, df=45, p<0,000).

The results of the KMO test showed that the selected matrix was positively semi-defined and that the values were suitable for further factorization (0,916). We factorized the correlation matrix and obtained the selected communalities as a final product (Table 4). These products represent the amount of total variance explained by the general and group factors, and signify the lower limit of system reliability.

Table 4 - Communalities

	S	F	L	PCS	P	C	St	GS	M	B
Extracted Communalities	0,799	0,718	0,705	0,699	0,673	0,670	0,666	0,602	0,589	0,561

Note: S-Speed, F- Flexibility, L- Locomotion, PCS- Postural control/stability, P- Precision, C- Coordination, St- Strength, GS- Graphomotor skills, M-Manipulation, B-Balance

The Kaiser-Guttman criterion was used to stop the extraction of factors. According to this criterion (eigenvalues greater than or equal to one), we kept one principal factor explaining more than 63% of the system variance.

Using the Kaiser-Guttman criterion, one principal factor was extracted (factor eigenvalue=6,380), which explains 63,799 percent of system variance. An extracted structure factor matrix was calculated subsequently (Table 5).

Table 5 - Extracted structure factor matrix

	S	F	L	PCS	P	C	St	GS	M	B
Factor 1	0,894	0,847	0,840	0,836	0,820	0,819	0,816	0,708	0,699	0,679

Note: S-Speed, F- Flexibility, L- Locomotion, PCS- Postural control/stability, P- Precision, C- Coordination, St- Strength, GS- Graphomotor skills, M-Manipulation, B-Balance

We defined this extracted factor as a general motor factor (GMF) of children with cerebral palsy, as it shows the significant correlation projections on all the motor performance variables. Since all the system variables were associated with variance, we decided to name a uniform GMF. All motor skills and abilities of the system are highly saturated with GMF. The balanced development of each individual part of the motor subsystem is an essential prerequisite for a well-developed general motor system. The factor matrix (Table 5) shows the highest correlations with the variables of speed, flexibility, locomotion, stability/postural control, precision, coordination, strength, graphomotor skills, manipulation and balance. These variables show a satisfactory general level of motor performance. GMF is formed by the variables constituting the basic human motor function. The magnitude of the basic motor factor effects is shown by the first four variables: speed, flexibility, locomotion, stability/postural control. The variables indicate the presence of the fundamental verticalization elements, with equal representation of abilities and skills. High values indicate a relatively good level of the motor development in the sample of children with cerebral palsy. GMF forms the strongest connection with speed. This is the ability to perform simple motor tasks quickly, which is a reflection of a relatively intact neurological development of children with CP. The placement of speed and flexibility in a top position indicates a satisfactory level of their motor development with the emphasis on the prevalence of basic hereditary components. Following are the locomotion and stability/postural control variables, which also reflect the role of the gross motor function with the emphasis on acquired motor skills for which a certain level of neurological and motor development is necessary. The precision, coordination and strength variables, which are a reflection of the functioning of different neural control systems are right behind them. The lowest values were reached by the graphomotor skills, manipulation and balance variables. We found that the GMF is the least represented by the variables which require a high level of precision, maturity and sophistication. These require sufficient conductivity of the sensory and motor systems, which is often impaired in persons with cerebral palsy. Low values of these variables indicate an important role of the development of the pathology of CP.

The occurrence of GMF, which includes skills and abilities, shows an adequate development of the gross motor system of children with

CP (Scherzer, 2001). Due to their neurological symptoms and the occurrence of pathological patterns, children with CP exhibit a deficit in specialized forms of movement. The selected motor system indicates the crucial role of the central nervous system (integration system), ranging from highly structured functions to simple reflex responses. It is important, however, to bear in mind that the acquired motor system in children with CP is not the same as that of healthy children. Despite having the same laws of development, the motor structure of children with CP is nevertheless different. Various neurological-motor deficits that can be found in CP trigger the use of compensatory mechanisms.

CONCLUSION

The GMF in children with CP indicates the existence of internal and external factors of the neuromotor system with a hierarchical representation of motor skills and abilities. Timely and appropriate physical therapy, which replaces the facilitation of spontaneous and later voluntary movement, sufficiently embeds the mechanisms imitating normal movement (Eliasson et al., 2004). We believe that the emergence of GMF in children with CP occurred due to the selection of a relatively homogeneous population irrespective of the individual types of CP. All children in the sample were physically independent and exhibited a similar level of physical maturity. Physiotherapy enabled the development of the necessary movement mechanisms with gradual integration of the less mature movement patterns into alternative compensatory forms of movement. Therefore, concentrated values of skills and abilities, within the GMF, appear not to be isolated incidences. The gross motor function with verticalization requires a uniform factor structure**.** It includes the skills and abilities constituting the motor nucleus which forms a movement basis**.** A stable movement basis which enables the functional ability of children with CP initiates the occurrence of non-isolated values within the GMF. The variables included represent the necessary motor basis, providing them with a sufficient level of autonomy. The motor system of children with CP has a complex structure, although it is identical in the occurrence of skills and abilities and often includes the appearance of the less mature movement forms. A uniform motor abilities in children with CP is established with a corresponding representation of skills and abilities. The differences which have arisen between them are the result of a more general structure, not only the motor structure. The study confirms a statistically significant difference in the latent structure of all the abilities constituting the motor system of children with CP, in accordance with the type of CP. Children with different types of CP differ in respect of the total motor abilities. The type of CP and the subsequent pathology significantly define their motor system. Despite consisting of identical levels of motor components, the resulting motor abilities in children with CP is different from that of the healthy individuals.

The objective of FA was to determine the proportion of the total variance of GMF for the individual forms of CP. The sample was not large enough to allow the identification of the specific variance for each form of cerebral palsy. Searching for specific variance will be continued by increasing the sample.

In part, the results obtained can be used for further analysis which will enable a more accurate assessment of specific variance (by increasing the sample of participants and homogenization of the sample in terms of age and diagnosis).

The study confirms a statistically significant difference in the latent structure of all the abilities constituting the motor abilities of children with CP, according to the type of CP. In the total motor system, children with different types of CP differ. The type of CP and the subsequent pathology significantly define their motor abilities.

REFERENCES

1. Baxter, P. (2006). Developmental Medicine & Child Neurology. The official journal of the American Academy for Cerebral Palsy and Developmental Medicine, the British Paediatric Neurology Association. In P. Baxter (Ed), *Cerebral Palsy: Synergism, Pathways and Prevention*. (Vol. 48., No. 1., 3-4). London: Press, MacKeith.
2. Carr, J., Shepherd, R. (2000). *Movement Science. Foundations for Physical Therapy in Rehabilitation*. Second edition. Maryland, An Aspen Publication.
3. Durward, B. R., Baer, G. D., Rowe, P. J. (1999). *Functional Human Movement. Measurement and Analysis*. Oxford: Butterworth Heinemann.
4. Dolenc-Velicković, T. (2010). *Neuro-developmental treatment for early intervention, lectures and demonstrations*. In K. Žiberna (Ed).

An open-minded approach to the therapeutic options. Bled: 8-th International Congress on Cerebral Palsy, 19.

5. Eliasson, A. C., Krumlinde-Sundholm, L., Rosblad, B., Beckung, E., Arner, M., Ohrvall A. M., Rosenbaum, P. (2004). *The Manual Ability Classification System (MACS) for children with cerebral palsy*: Scale development and evidence of validity and reliability. Department of Woman and Child Health, Karolinska Institute, Sweden.
6. Gage, J. R. (2006). *The Treatment of Gait Problems in Cerebral Palsy*. Mac Keith Press, Clinical in Developmental Medicine, Cambridge: University Press.
7. Gallahue, D. L., Ozmun, J. C. (1998). *Understanding motor development, Infants, Children, Adolescents, Adults*. Boston: Hill Companies.
8. Gallahue, D. L. (2010). *Levels and stages of movement skills learning: practical implications for parents, teachers, coaches and therapists*. Portorož: The 6th International Scientific and Expert Symposium. Contemporary Views on the Motor Development of a Child, 29-30.
9. Geralis, E., Ritter, T. (1998). *Children with Cerebral Palsy. A Parents' Guide*. Woodbine House.
10. Jekovec-Vrhovsek, M. (2010). *Multidisciplinary Care for Children with Cerebral Palsy and Epilepsy in Slovenia*. In K. Žiberna (Ed), Bled: 8-th International Congress on Cerebral Palsy. An Open-Minded Approach to the Therapeutic Options, 28.
11. Jones, K., Barker, K. (1999). *Human Movement Explained*. Butterworth-Heinemann.
12. Magill, R. A. (1998). *Motor Learning: Concept and Applications*. Dubuque: McGraw-Hill.
13. Miller, F., Bachard, S. J. (2006). *Cerebral Palsy. A Complete Guide for Caregiving*. Baltimore: A Johns Hopkins Press Health Book.
14. Pistotnik, B. (1999). *Osnove gibanja: osnove gibalne izobrazbe. Gibalne sposobnosti in osnovna sredstva za njihov razvoj v športni praksi*. Ljubljana: Fakulteta za šport.
15. Scherzer, A. L. (2001). *Early Diagnosis and Interventional Therapy in Cerebral Palsy. An Interdisciplinary Age-Focused Approach*. Cornell University Medical Center. New York.
16. Siebes R. (2001). Measurement of functional skills in children with cerebral palsy. In *Brain & Development*. Official Journal of the Japanese Society of Child Neurology. (191). Bled.
17. Strel, J., Šturm, J., Ambrožič, F., Krpač, F., Leskošek, B., Strojnik, V. (1984). Ovrednotenje informacijskega sistema za ugotavljanje

in spremljanje motoričnih sposobnosti in morfoloških značilnosti šolske mladine v SRS, 3. faza. Ljubljana, Inštitut za kineziologijo.
18. Thomas, K. T., Lee, A. M., Thomas, J. R. (2003). *Physical Education Methods for Elementary Teachers*. 70 Proven Lesson Plans. Second edition. Iowa State University.
19. Placement of Children with Special Needs Act, Official Gazette of the Republic of Slovenia, No. 54/00, No. 3/07.

ULOGA GENERALNOG MOTORIČKOG FAKTORA KOD DECESA CEREBRALNOM PARALIZOM

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Sažetak

U radu se procenjuju motoričke sposobnosti dece sa cerebralnom paralizom. Cilj istraživanja je definisanje faktora motoričkog razvoja dece sa cerebralnom paralizom. Istraživanje je obuhvatilo 80-oro dece sa cerebralnom paralizom od 6 - 16 godina starosti. Obuhvaćena su samo deca koja su uključena u škole sa ravnopravnim edukacijskim standardom. Faktorskom analizom izdvojen je jedan glavni faktor, definisan kao generalni motorički faktor, koji hierarhijski obuhvata motoričke sposobnosti i motoričku spretnost. Istraživanjem su utvrđene značajne razlike latentnih struktura motoričkih sposobnosti kod dece sa cerebralnom paralizom, kada se u motoričku komponentu uključe širi neurološki i rehabilitacioni faktori.

Ključne reči: cerebralna paraliza, motoričke sposobnosti, motorička spretnost, generalni motorički faktor

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