Changes over Years in Gross Motor Function of 3–8 Year Old Children with Cerebral Palsy: Using the Gross Motor Function Measure (GMFM-88)

Netta Harries BPT, Michal Kassirer BPT, Tali Amichai BPT and Eli Lahat MD

Institute of Child Development and Rehabilitation, Division of Pediatrics, Assaf Harofeh Medical Center, Zerifin, Israel
Affiliated to Sackler Faculty of Medicine, Tel Aviv University, Ramat Aviv, Israel

Key words: children, cerebral palsy, motor function, motor development curves, GMFM test

Abstract

Background: In the developing child the nervous system undergoes a maturation process. The development and organization of any motor ability is the naturally adopted preference among the possibilities and constraints. The motor behavior of children with cerebral palsy is a personal automatic preference based on such constraints. One of the clinical measures designed for measuring the function of children with CP is the Gross Motor Function Measure. Motor development curves for children with CP have been established based on the GMFM instrument and Gross Motor Function Classification System.

Objectives: To examine the change over time in gross motor function for children with CP attending a special education school for handicapped children in Israel.

Method: We conducted a retrospective review of the medical records of children at various ages and with varying degrees of severity who were being treated by a multidisciplinary team. The study population comprised 106 children aged 3–8 years with CP who were attending the school of special education at Assaf Harofeh Medical Center. The GMFM-88 test was performed annually for the study children over a 7 year period (1995–2001).

Results: During the study period the GMFM scores improved significantly. The rate of improvement and top achievements over the years differed according to the severity of the motor impairment. The gross motor development reached a plateau at the age of 6–7 years.

Conclusions: The changes in gross motor development of the study population were similar to the profile of changes in the developmental process of children who develop normally. The nature of the curves of gross motor change for the children with CP should be borne in mind when designing individual treatment goals and strategies for a child.

IMAJ 2004;6:408–411

The human infant learns to walk towards the end of the first year. Ease and economy of gait and adaptability to challenges of the environment are the results of maturation, motor learning and perceptual learning. "Phylogenetic activities," such as lifting the head, rolling over, sitting, creeping and walking, are not influenced by exercises [1]. However, for more specialized activities and the use of tools such as skates and tricycles the child must learn the task in the context of the environment [2].

In the typically developing child the nervous system undergoes a maturation process. This process can be demonstrated by stabilization of gait between the ages of 3.5 and 4 years, as measured by kinematic and kinetic parameters. Growth alone can account for the majority of changes in these parameters that occur during the rest of the growing years [3].

The development and organization of any motor ability is the naturally adopted optimal preferences among the possibilities and constraints, with a functional aim, such as minimizing physiologic cost, asymmetry and the variability of limb coordination. This self-optimization is already fully manifested in the child from the age of 7 years, and remains unchanged through adulthood. By means of a model based upon this approach, it is possible to forecast parameters of walking such as velocity, length of step etc., according to anthropometric data (weight and height) of the individual child [4].

Cerebral palsy is a broad term that refers to a number of neurologic conditions resulting in abnormal development of movement and postural control. It is "an umbrella term covering a group of non-progressive, but often changing, motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of development" [5]. CP has highly variable effects on the neurologic and functional development of the child, effects that impact on the degree of disability and limitations of activity. The main limitations of activity ensuing from CP involve problems in motor function. Gross motor and fine motor function measures provide quantification of the degree of physical disability [6].

It may be assumed that the motor behavior of children with damage to the neuromusculoskeletal system is an optimal automatic choice based on the constraints and abilities of each individual child. These determinants have been defined by physiotherapists in the following order of importance: a) *primary impairments* (muscle tone/movement patterns, distribution of involvement, balance, and sensory impairment); b) *secondary impairments* (range of motion/joint alignment, force production, health and endurance); c) *child personality characteristics* (motivation); and d) *family ecology and healthcare services* (support to the child, family expectation, and support to the family) [7].

The measurement of gross motor function in children with CP is a complex process. One of the clinical measures designed for this purpose is the GMFM-88 [8,9]. The purpose of our study was to identify developmental characteristics for functional gross motor changes in CP children at various ages and with varying degrees of severity, at a special education school for handicapped children in Israel. The children were undergoing treatment by a multidisciplin-

CP = cerebral palsy
GMFM = Gross Motor Function Measure

ary team. Our study matches in many ways the work done by Rosenbaum et al. [10] in community ambulatory rehabilitation programs in Ontario, Canada.

Subjects and Methods

The data were collected from the patients' medical files. The children attending the school come from the community in the area. The school admits handicapped children with learning ability (mild mental retardation and normal intelligence – DSM) for treatment and education. The children stay at the school for a period of 1–6 years depending on their needs.

The study population included 106 children, 67 boys and 39 girls. A pediatric neurologist diagnosed the children as children with CP, according to the standard definition of the types of CP (spastic and non-spastic) and distribution [11]. In this study the tetraplegic children – spastic and dystonic – were grouped together [12]. None of the children had undergone selective dorsal rhizotomy [13], intrathecal baclofen [14] or botulinum toxin injections in the lower limbs [15]. These interventions were not widely used in Israel at the time of the study. During the study period 47 children (44%) underwent orthopedic surgery. The children received treatment in accordance with their individual rehabilitation program at the school. Intensity and frequency of physical therapy were decided accordingly. The physical therapy approach at the Center is an eclectic one based on a neurodevelopmental approach that derives ideas from various sources, such as functional therapy, incorporating motor learning.

The children attended the special education school at Assaf Harofeh Medical Center during the years 1995–2001. As a routine procedure, the children were assessed for their achievements at the end of each school year. All were routinely evaluated with the GMFM-88 test. All children participating in the study were able to understand instructions and to cooperate during the testing procedure. The five physical therapists who administered the test are physiotherapists with pediatric experience and who had worked with handicapped children for at least 3 years (range 3–25 years). They were trained in administering the test by a physiotherapist qualified in the procedure. Their training included a criterion test videotape [16].

Instruments

The GMFM-88 [17] is a standardized functional assessment used by therapists to examine the achievements and limitations of gross motor function of children with CP, monitor progress of the individual child, and evaluate the outcomes of treatment programs for this population. The test has been validated by demonstrating its capability to detect changes over time in gross motor function of children with CP [8,9]. The test was used by Palisano et al. [18] in the process of establishing developmental curves for gross motor function for children with CP. The GMFM was developed especially for children with CP. The test consists of 88 items grouped into 5 dimensions of gross motor functions: a) lying and rolling – 17 items; b) sitting – 20 items; c) crawling and kneeling – 14 items; d) standing – 13 items; and e) walking, running and jumping – 24 items. Each item is scored on a 4-point scale. A percentage score is calculated for each dimension and for the total score of the five dimensions. It is possible to score with or without aids (rollator, walker, crutches, and canes), or orthoses (ankle foot control, knee control, or shoes) [17]. There are no age limits, but a 5 year old with normal motor abilities can accomplish all items [8].

The severity of disability was classified according to the Gross Motor Function Classification System for CP [18,19]. The GMFCS consists of five ordinal levels of motor function based on self-initiated movement with particular emphasis on sitting (trunk control) and walking. The distinction between motor functions at different levels is clinically meaningful and is based on functional limitation, the need for assistive technology, mobility devices, and wheeled mobility.

Procedures

The test was conducted as instructed in the GMFM-88 manual [17], and administered by a different physiotherapist at the end of each year. The scoring of the items was performed and recorded in the testing session. The test was performed without aids. Classification of the child according to severity of disability was done according to mobility ability of the child, into five levels [18,19]. The GMFCS scale determined the severity of disability, taking age into account. In our study, levels I+II were labeled as "mild," level III as "moderate" and levels IV+V as "severe." Mild indicates that the child walks with no aids, moderate indicates that he or she walks with aids, and severe indicates no functional independent mobility.

Statistics

In this study we used the specific program to analyze repeated measures with missing values, incomplete design BMDP 5V – ANOVA (Statistical Software 1993, W.J. Dixon, University of California Press). The study population was divided into three subgroups according to severity of disability.

Results

Altogether, 297 evaluations were performed on the 106 children in the study group over a period of 7 years. No significant differences were found in the results for males and females. The spastic diplegia (43%) and the spastic/dystonic tetraplegia (32%) were the largest subgroups, followed by spastic hemiplegia (16%) and ataxia+athetosis (8%). Forty-eight children (45%) were classified as having "mild" disability, 34 (32%) as "moderate" and 24 (23%) as "severe" [Table 1]. The children underwent between one and six evaluations during the study period. The mean number of evaluations per child was 2.8 (range 1– 6 evaluations, median 3). Table 2 shows the distribution of GMFM evaluations according to the children's age and the severity of disability.

The GMFM evaluation results for the 7 years of the study show a significant improvement ($P = 0.001$) in gross motor function in the whole group over the years. Total scores were as follows: 58.86% for age 3, 64.63% for age 4, 68.4% for age 5, 71.27% for age 6, 72.71% for age 7, and 74.83% for age 8 [Figure 1, Table 3]. Subdivision of the

GMFCS = Gross Motor Function Classification System

Table 1. The study population according to the CP type: distribution and severity of gross motor disability

Diagnosis	Severity of gross motor disability						Total	
	Mild		Moderate		Severe			
Type/distribution	No.	%	No.	%	No.	%	No.	%
Ataxia/athetosis	6		2		0		8	8
Spastic/hemiplegia	16		1		0		17	16
Spastic/diplegia	26		21		0		47	44
Spastic/dystonic tetraplegia	0		10		24		34	32
Total	48	45	34	32	24	23	106	100.0

Table 2. Distribution of the 297 evaluations performed for the three groups of children by age and severity of disability

Age	Severity of gross motor disability						Total	
	Mild		Moderate		Severe			
(yrs)	No.	%	No.	%	No.	%	No.	%
3–4	12		15		13		40	13
4–5	29		21		17		67	23
5–6	33		18		14		65	22
6–7	31		15		13		59	20
7–8	19		15		11		45	15
8–9	11		6		4		21	7
Total	135	46	90	30	72	24	297	100.0

Table 3. The actual mean (%) change in GMFM score of the three subgroups: "mild," "moderate" and "severe" and the score for the whole study population – "total"*

Age (yrs)	Subgroups according to severity of disability			Total
	Mild	Moderate	Severe	
3–4	81.68	54.64	22.03	58.86
4–5	86.81	60.99	26.31	64.63
5–6	88.29	64.84	32.51	68.4
6–7	90.78	67.23	37.12	71.27
7–8	94.89	69.6	36.61	72.71
8–9	92.87	75.95	38.67	74.83

* Change of scores between age 3 and 8 for all and each groups: *P=0.001*

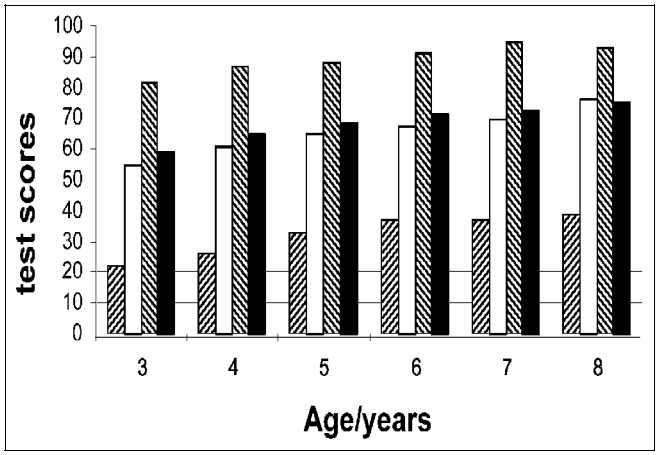

Figure 1. The GMFM test scores (%) for the total study population (in black) and the three subgroups: (from left to right) "severe," "moderate" and "mild"

group according to the severity (mild, moderate, severe) of the motor disability also showed significant improvement ($P = 0.001$) in motor development in each subgroup [Figure 1, Table 3]. The total score for each group, as for the three of them together, demonstrated a slowing down in the acquisition of motor functions after age 6–7 years.

Discussion

In their study addressing the need to classify the gross motor function of children with CP, Palisano et al. [18,19] displayed plots of GMFM total scores of children with CP and of children who developed typically, versus age-produced curves. The outcome is "growth curves" of the motor function. Rosenbaum and colleagues [10] created motor development curves for children with CP, based on the GMFM and GMFCS instruments as a prognostic tool. Their study population came from ambulatory rehabilitation programs in Ontario, Canada.

In our 7 year longitudinal study we observed an "in-rolling" population of 106 children with CP in the school of special education for handicapped children in Israel. These 106 subjects were not the same subjects in all the test points. In many aspects our findings match the conclusions reached by Rosenbaum et al. [10]. We were able to demonstrate a gross motor developmental profile of changes for these 106 children. The developmental process of the children showed no difference between males and females. The curves for the total scores of motor development of each group of children according to severity of disability revealed obvious characteristics for each group.

The improvement in the whole group's GMFM scores demonstrates the natural maturational development of children at that age (3–8 years), combined with the influence of multidisciplinary treatments and interventions. The improvement rate and top scores are different for each group. There was no interaction between the developmental curves of the three groups. In our study population we found that the "moderate" group showed a greater change at the age 7–8 years than the other groups. The "severe" group reached its top scoring at the age of 6 years. The "mild" group reached the top scoring at 7 years in all dimensions. We found that the "severe" and "mild" groups reached their maximum gross motor potential within the period of the study.

Conclusions

The developmental profile of our 3–8 year old children with CP who are under treatment and educational care emphasizes that the gross motor development is slowing down and reaches a plateau at age 6–7. The laws of maturation and acquisition of "phylogenetic motor activities" [3,4] seem to be as valid for them as for children who develop typically.

Treatment targets can be specific skills individually defined for each child, such as sports for children with mild disabilities and motorized wheelchair manipulation for children with severe motor disabilities. The children with moderate disabilities (walking with aids) might need longer direct treatment for the gross motor function in the higher motor dimensions. We suggest a longer follow-up into adolescence of the last group.

Acknowledgments. We are grateful to the physiotherapists in the rehabilitation center for their efforts and dedication; and to Simona Bar-Haim, a friend and colleague, for her support.

References

1. McGraw MB. Growth: A Study of Johnny and Jimmy. New York: Appleton-Century, 1935. Ayer Publishers, 1982.
2. Gibson EJ, Pick AD. The role of perception in development beyond infancy. In: An Ecological Approach to Perceptual Learning and Development. New York: Oxford University Press, 2000:179–86.
3. Sutherland DH, Olshen RA, Biden EN, Wyatt MY. The Development of Mature Walking. Oxford: Blackwell Scientific Publications Ltd., 1988:183–7.
4. Jeng SF, Liao HF, Lai JS, Hou JW. Optimization of walking in children. *Med Sci Sport Exerc* 1997;29:370–6.
5. Mutch L, Alberman E, Hagberg B, Kodama K, Perat MV. Cerebral palsy epidemiology: where are we now and where are we going? *Dev Med Child Neurol* 1992;34:547–55.
6. Russell DJ, Rosenbaum PL, Avery LM, Lane M. Gross Motor Function Measure (GMFM-66 & GMFM-88) User's Manual. London: Mac Keith Press, 2002.
7. Bartlett DJ, Palisano RJ. Physical therapists' perception of factors influencing the acquisition of motor abilities of children with cerebral palsy: implications for clinical reasoning. *Phys Ther* 2002;82:237–48.
8. Russell DJ, Rosenbaum PL, Cadman DT, Gowland C, Hardy S, Jarvis S. The Gross Motor Function Measure: a mean to evaluate the effects of physical therapy. *Dev Med Child Neurol* 1989;31:341–52.
9. Ketelaar M, Vermeer A, Helders PJ. Functional motor abilities of children with cerebral palsy: a systematic literature review of assessment measures. *Clin Rehabil* 1998;12:369–80.
10. Rosenbaum PL, Walter SD, Hanna SE, et al. Prognosis for gross motor function in cerebral palsy: creation of motor development curves. *JAMA* 2002;288:1357–63.
11. Swaiman KF, Russman BS. Cerebral palsy. In: Swaiman KF, Ashwal S, eds. Pediatric Neurology: Principles & Practice. St. Louis: Mosby Inc., 1999:314–18.
12. Aicardi J, Bax M. Cerebral palsy. In: Aicardi J, ed. Diseases of the Nervous System in Childhood. Cambridge: Mac Keith Press, 1998:212–26.
13. Steinbok P. Outcomes after selective dorsal rhizotomy for spastic cerebral palsy. *Child Nerv Syst* 2001;17:1–18.
14. Almeida GL, Campbell SK, Girolami G, Penn R, Corcos DM. Multidimensional assessment of motor function in a child with cerebral palsy following intrathecal administration of baclofen. *Phys Ther* 1997;77:751–64.
15. Yang TF, Chan RC, Chuang TY, Liu TJ, Chiu JW. Treatment of cerebral palsy with botulinum toxin: evaluation with gross motor function measures. *J Formos Med Assoc* 1999;98:832–6.
16. Russell DJ, Rosenbaum PL, Lane M, et al. Training users in the Gross Motor Function Measure: methodological and practical issues. *Phys Ther* 1994;74:630–6.
17. Russell DJ, Rosenbaum PL, Gowland C, et al. Gross Motor Function Measure Manual. Hamilton, Ontario, Canada: Gross Motor Function Group. McMaster University, 1993.
18. Palisano RJ, Rosenbaum PL, Walter SD, Russell DJ, Wood EP, Galuppi BE. Development and reliability of a system to classify gross motor function in children with cerebral palsy. *Dev Med Child Neurol* 1997;39:214.
19. Palisano RJ, Hanna SE, Rosenbaum PL, et al. Validation of a model of gross motor function for children with cerebral palsy. *Phys Ther* 2000;80:974–85.

Correspondence: N. Harries, Institute of Child Development and Rehabilitation, Assaf Harofeh Medical Center, Zerifin 70300, Israel.
Fax: (972-8) 977-9945
email: harriesn@012.net.il