Assessment of motor function score according to the GMFM-88 in children with cerebral palsy after postoperative rehabilitation

Azra Delalić[1], Suada Kapidžić-Duraković[1], Husref Tahirović[2]

[1] Department of Physical Medicine and Rehabilitation,University Clinical Centre Tuzla, Tuzla, Bosnia and Herzegovina
[2] Department for Research and Education, University Clinical Centre Tuzla, Tuzla, Bosnia and Herzegovina

Corresponding author:
Azra Delalić
Department of Physical Medicine and Rehabilitation,
University Clinical Centre Tuzla,
75000 Tuzla,
Bosnia and Herzegovina
azradelalic@hotmail.com
Tel.: +387 35 303 135

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Objective. To determine the outcome of rehabilitation treatment after orthopedic-surgical treatment of the lower extremities in relation to motor function and degree of disability in children with cerebral palsy. **Subjects and methods.** An historical-prospective study included 44 treated children with CP from May 2000 until June 2009 at the Department of Physical Medicine and Rehabilitation University Clinical Centre Tuzla. The main criteria for entering the study were diagnosed CP and performed orthopedic-surgery of the lower extremities during rehabilitation treatment. Assessment of the motor function score was performed according to the Gross Motor Function Measure 88 (GMFM-88), and classification of the degree of disability was developed based on the scale of the Gross Motor Function Classification System (GMFCS). **Results.** In our study, motor functions were improved, so that the median value and interquartil range (IQR) of the total GMFM score before surgery was 35.7 (IQR from 22.9 to 57.2), and after postoperative rehabilitation 58.6 (IQR from 31.2 to 85.2) with a high statistical significance ($p<0.0001$). Median value GMFCS scores before surgery ranged around 5 (IQR from 4 to 5), and after postoperative rehabilitation ranged around 3 (IQR from 2 to 5), which shows a highly statistically significant reduction in the degree of disability ($p<0.001$). **Conclusion.** Surgical intervention performed on the lower extremities in children with cerebral palsy may improve motor function in all developmental stages and reduce the degree of disability with intensive rehabilitation.

Key words: Cerebral palsy, Operation, Motor function.

Introduction

Cerebral palsy (CP) is usually present as a pediatric neurological problem in physiotherapy. The clinical chart is dominated by motor function disturbances due to abnormal muscle tone that leads to impairment of posture and movement, but there may also be vision, hearing, speech, seizures, behavioral or swallowing disorders (1). The first description of a child with motor disorders resulting from premature childbirth and asphyxia was published in 1862 by Mr. Little (2). In recent years dealing with severe ce-

rebral palsy has intensified, and so has the establishment of special organizations such as the "Surveillance of cerebral palsy in Europe" (SCPE) dealing with standardization, monitoring and registration of children with CP in Europe, and according to its data, the prevalence of CP in Europe is 2-3/1000 live births (3). According to the SCPE due to the volatility of the motor development the final diagnosis and classification of CP is recommended at age 3-5. SCPE proposes division on the basis of neurological disorders such as the spastic (bilateral and unilateral), dyskinetic (dystonic and horeoatetonic) and ataxic form, and the rough division of motor function or the Gross Motor Function Classification System (GMFCS) at five levels of functional disability, so that the first level represents the least and the fifth level represents the highest level of damage to motor functions. In the majority of children with CP, neuroradiological brain damage is proven, and clinical syndromes occur as a result of that, followed mainly by motor disturbances (4). Spasticity and dystonia represent a major problem in children with CP, because the hypertonic muscles shorten and thus lead to contractures and bone-articular deformity. Spasticity increases in children with CP until the age of four, and thereafter gradually decreases until the age of twelve, which is essential for clinical practice and treatment planning (5). Hypotherapy or horseback riding therapy helps postural balance in a sitting position and improves gross motor function in children with neurological disabilities (6).

Application of botulinum toxin, in combination with kinesitherapy reduces spasticity and improves motor function in spastic diplegia (7). Twenty years after selective dorsal rhizotomy, all patients showed improvement of locomotor functions compared to preoperative status (8). In children in whom treatment was delayed or inadequate eventually secondary musculoskletal deformations occurred that could lead to the deterioration of the existing clinical condition. Orthopaedic surgery has an important role in the treatment of children with CP in the sense of passive mobility enhancement, correction of deformity, or in extreme cases, blocking joints in a functional position (9). Improvement of the functional abilities of children who undergo surgery over a short or long period of time after surgery was significantly better than in children who did not undergo surgery (10). Selective percutaneous tendon extension of the lower extremities is a minimally invasive method, it does not create more scarring, and contributes to the improvement of functional status in all operated patients (11). According to Zergollern et al. (12) and Bortona (13) in their research in operated children with CP there was an improvement of motor function, and Mathur et al. (14) reports better mobility and improved activities of daily life in children with spastic diplegia after postoperative rehabilitation combined with orthotics.

The aim of this study was to determine the outcome of rehabilitation treatment after orthopedic-surgical treatment of the lower extremities in children with cerebral palsy, in relation to motor function and the degree of disability.

Subjects and methods

The research was conducted historically-prospectively from May 2000 to June 2009 at the Department of Physical Medicine and Rehabilitation University Clinical Centre Tuzla. The study included 44 (24 males and 20 females) children with CP, at the average age expressed as a median of 4.3 years at the time of surgery (range 1.6 to 9.4). According to the clinical chart 37 children had a bilateral spastic form, 6 had unilateral spastic form and only one child had an ataxic form of CP. Most children (39) had preserved the

ability of understanding spoken or written linguistic information and the possibility of verbal or nonverbal expression, three children had problems with verbal expression, whereas only one child had severe cognitive disorders without the ability to communicate. The main criteria that would satisfy inclusion in the study were that the child was diagnosed with CP and had been subjected to orthopedic-surgery of the lower extremities during rehabilitation treatment.

All subjects underwent rehabilitation of varying duration and intensity prior to the research, and at least six months before surgery rehabilitation treatment was continuous with mandatory parental education for passive and active-assisted stretching of the shortened muscles, relaxation of the spastic muscles and strengthening their antagonists to stimulate the child's functional abilities depending on the degree of disability, while the orthoses were used for proper positioning of the extremities.

Orthopedic-surgical procedures were performed on one or more levels, using various techniques such as elongatio tendinis, tenoplastica, tenotomia subcutanea, trasposition tendinis, desinsertio musculi, fibrotomia and neurectomia.

After postoperative immobilization with or without a plaster splint in the period required by a postoperative protocol, postoperative rehabilitation was conducted for at least 6 months according to an individual program, which depended on the maturity, mental maturity of the child and his functional abilities. Orthoses were used for positioning the operated limb during the night or during the days after exercises. Exercises were relaxing in the beginning, followed by passive and active-assisted exercises in order to improve mobility and strengthen the weaker muscles, such as thigh abductors, lower leg extensors and foot dorsal flexors. After that, exercises in a sitting balance, a four-legged stance, standing, and walking with compliance were applied, and in the end walking with apparatus and if possible independent walking.

Education of parents was required to use the same program of exercises and positioning in order to continue implementing it in the home setting. Evaluation of motor function and degree of disability for each participant was done by the same physiatrists and physical therapist before surgery and one year after the postoperative rehabilitation. Evaluation of specific gross motor function before and after postoperative rehabilitation was performed according to the score of the Gross Motor Function Measure 88 or GMFM-88 (15). It is a questionnaire that examines 88 motor activities, classified into five developmental stages, namely: GMFM-A (lying and turning), GMFM-B (sitting), GMFM-C (crawling and kneeling), GMFM-D (standing) and GMFM-E (walking, running and jumping). Each motor activity is evaluated from 0 to 3. The grade 0 means that the child neither starts or performs the activity, grade 1: the child may begin the activity, grade 2: the child partially executes the activity; grade 3: the child fully executes the activity. GMFM scores can be represented as the total sum of points or according to certain developmental stages, expressed as a percentage, so that the normal score is 100%. The child is tested minimally dressed, without shoes and supplies, so that the person who is doing the test could be considered undisturbed whilst observing the child. The child is allowed a maximum of three attempts to perform any task, except when the child refuses to perform an action that we feel it can at least partially execute, we can put a label "not tested". Necessary equipment in the testing room are two marked straight lines, 6 m long with 20 cm distance between them, then a straight line 2 cm in width and 6 m in length and a circle with a diameter of 60 cm marked on the floor. It requires a small bench up to 1 m in length,

a large bench, stopwatch, a stick, a large ball and five stairs. Assessment of the degree of disability was performed according to the Gross Motor Function Scale Classification System (GMFCS) (16). The scale is based on the ability to perform motor activities divided into five levels of disability, so that the first shows minimal motor deviations, and the fifth shows complete inability to perform motor activities that are variously described by chronological maturity, for the period up to 2 years, 2-4 years, 4 -6 years and 6-12 years.

Statistical analysis

Since no features of normal distribution were found in the groups examined with the Kolmogorov-Smirnov test, data are presented as median and interquartile range and statistical analysis was performed using the non-parametric the Wilcoxon test. Level of significance was defined with $P < 0.05$. In the analysis, we used the statistical package Arcus QuickStat Biomedical version (17).

Results

Specific gross motor function evaluation was performed according to the values of the GMFM 88 score. The median total GMFM score before surgery amounted to 35.7 (interquartile range 22.9 to 57.2), and after postoperative rehabilitation it amounted to 58.6 (interquartile range 31.2 to 85.2) with a high statistical significance of $p < 0.0001$. A graphic representation of the differences is given in Figure 1.

A comparison of individual values of the GMFM score, according to the motor activity at a certain developmental stage, is given in Table 1. As seen, the present value increases in almost all of the developmental stages of the postoperative rehabilitation, which was statistically significant.

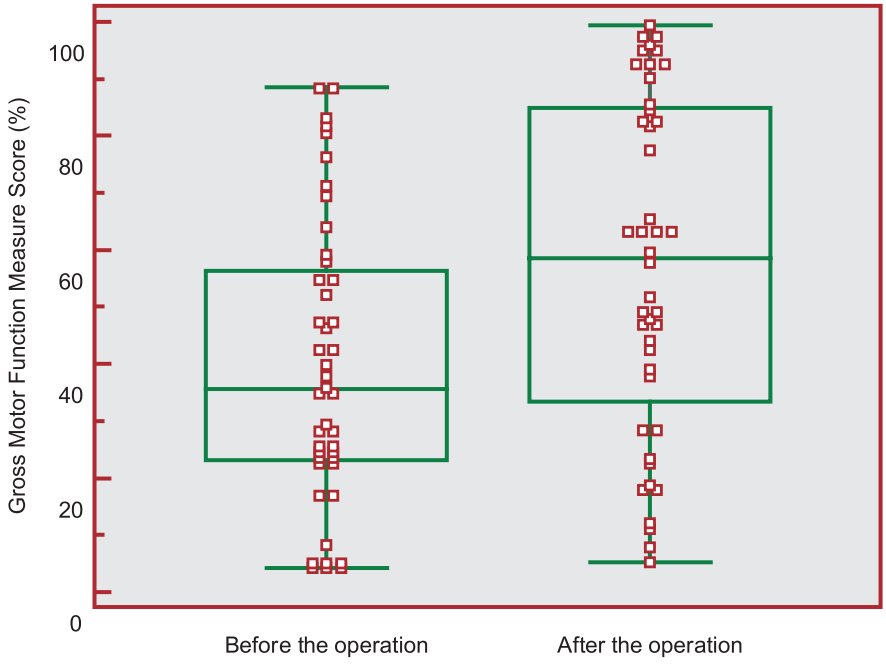

Figure 1 Average values of total motor functions according to GMFM score before and after postoperative rehabilitation

Table 1 Median of motor functions of individual developmental phases according to GMFM score before and after postoperative rehabilitation

Segments of GMFM	Period of measuring		p
	Before operation (Median; IQR*)	After rehabilitation (Median; IQR*)	
GMFM-A (lying and rolling)	84.3 (66.7-92.2)	93.2 (76.5-96.1)	< 0.0001
GMFM-B (sitting)	45.8 (22.1-80)	85.8 (45.4-96.7)	< 0.0001
GMFM-C (crawling and kneeling)	40.5 (0-71.4)	78.6 (35.7-92.8)	< 0.0001
GMFM-D (standing)	2.6 (0-37.8)	23.1 (0-78.8)	< 0.0001
GMFM-E (walking, running, jumping)	0 (0-20.8)	16.7 (0-71.2)	< 0.0001

*IQR= Interquartile Range.

Values of the degree of disability were compared according to the GMFCS scale before and after postoperative rehabilitation. Median values on the GMFCS scale before surgery amounted to 5.0 with an interquartile range from 4.0 to 5.0. Following postoperative rehabilitation, the median value of the GMFCS scale was 3.0 with an interquartile range from 2.0 to 5.0. This decrease in value was highly statistically significant ($p < 0.001$) with 23 (52%) patients who had decreased levels, 21 (48%) patients were without change and no patients with increased levels on the GMFCS scale. The obtained results suggest that prior to operative treatment 75% of respondents had level four or a lower level of disability, while 25% had level five, or the most severe level of disability. After the postoperative rehabilitation the patient's mobility improved, so that 75% of patients had a level two or lower level of disability, and 25% had level five of disability. A graphic representation of this comparison is shown in Figure 2.

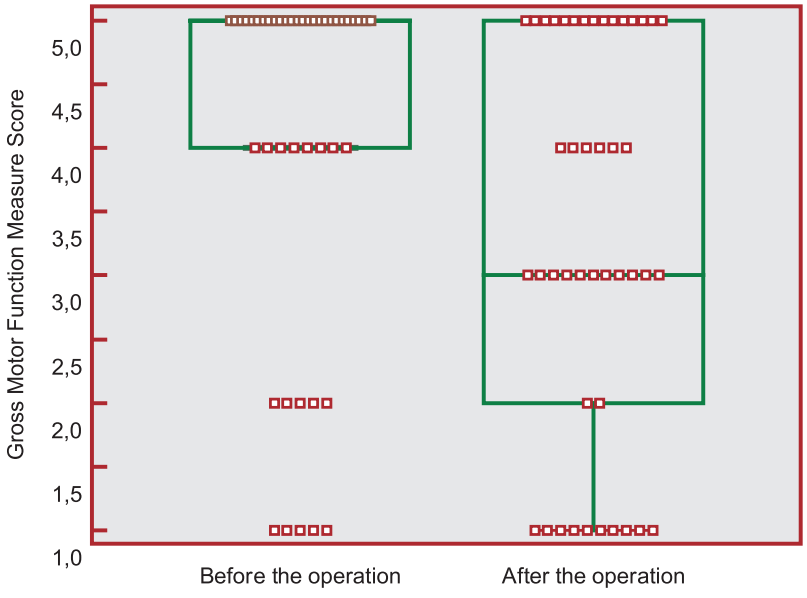

Figure 2 Individual values of disablement level according to GMFCS before and after postoperative rehabilitation

Improvement of motor functions resulted in better mobility and a reduction in the degree of disability. Before surgical treatment 10 patients were able to walk independently with difficulty outside the home and for longer distances (GMFCS I and II), 8 subjects were using a wheelchair to move around (GMFCS IV) and 26 subjects moved with difficultly by using a wheelchair (GMFCS V). The postoperative rehabilitation increased the number of mobile children, so that 12 subjects walked without aids (GMFCS I and II), 11 patients walked with mobility aids (GMFCS III), 6 patients moved with the help of a wheelchair (GMFCS IV), while in 15 cases movement was very limited even with the aid of a wheelchair (GMFCS V).

Discussion

In this study, improvement of motor function and reduction of the degree of disability in children after postoperative rehabilitation was achieved. Motor activity was enhanced after completion of postoperative rehabilitation and the assessment done by GMFM score indicates an increase in the value of the total sum for all the developmental stages as well as the values of certain developmental phases, with a highly significant statistical significance. These changes in motor skills can be explained by the increased range of motion of joints of the lower extremities after surgery, which enabled the further course of continuous and intensive rehabilitation to achieve, in a short period of time, not only improvement of walking, but better stability in sitting and walking on hands and feet.

The validity of the GMFM scores has been demonstrated in a number of studies and has found wide application in clinical practice for assessment of the effect of applied therapy in children with CP, such as botulinum toxin treatment (18). Trahan and Malouin (19) analyzed the effect of applied therapy for eight months for spastic forms of CP showing modifications of GMFM scores, especially with spastic diplegia. GMFM score with a clinical form of CP can be a prognostic indicator of quality of life in this population in adulthood, as Nieuwenhuijsen (20) stated in his research, indicating a high risk of non-active lifestyle in adulthood in children with bilateral spastic CP and low values of GMFM scores.

With proper selection of children for surgery, based on clinical examination and gait analysis, and evaluation of the same children three years later, the operation has been proved to improve spastic muscle function (21). Orthopedic-surgery done on several levels in older children and adolescents who have difficulty moving in a type of squat, brought relief to the knee extensor muscles, reduced pain and improved functional ability and independence (22). Improving the gross motor function resulted in a decrease in the degree of disability estimated according to the GMFCS score before and after postoperative rehabilitation. The median value of the degree of disability according to the GMFCS has been reduced from 5 to 3 which is statistically highly significant, so that in 23 children it reduced the degree of disability, in 21 it remained the same, and no increase in the degree of disability was recorded in any of the examined children. Changes in the degree of disability in the GMFCS score, and functional status after surgical treatment of children with CP as stated by Zorer et al. (23) analyzing 23 operated children, of an average age of 6.3 years, with clinical forms of diplegia, quadriplegia and hemiplegia, in whom a decrease in postoperative contractures was found in all joints of the lower extremities, were improved posture, sitting, walking, and better hygiene, while the degree of disabilities by GMFCS score significantly changed from 3.045 to 1.864. All children with disabilities achieved walk improvement after surgery according to GMFCS I, II and III, while the

functional improvement of 15.7% occurred at GMFCS II, III and IV (24).

The achieved level of motor activity by GMFM score varies with the individual degree of disability, which was investigated by Beckung et al. (25) by testing the achieved GMFM score after five years of life in 317 children with different clinical forms of CP, so that the children achieved the GMFCS I and three quarters of children reached Level II 90%, GMFCS III 80%, 30% GMFCS IV and GMFCS V 20% of GMFM scores. Spinal deformities such as scoliosis in children with CP are correlated with the degree of disability, and the progression of scoliosis is more evident in children with a greater degree of disability, that is in children with GMFCS level V (26). Kinesitherapy has a significant effect on motor function and degree of disability. A significant reduction in the degree of disability according to the GMFCS was noticed after intensive rehabilitation treatment (27). Improvement in gross motor function in children with CP was achieved after applying kinesitherapy treatment for a period of 16 weeks, but significant improvement was noticed in the group of children who exercised five times weekly rather than those who exercised twice a week (28). With intensive and early rehabilitation treatment, we can reduce the degree of disability in children with CP, which means that children with clinical and neuroradiological signs of CP should be included as soon as possible in early rehabilitation (29). Aging of children with CP with a lesser degree of disability leads to reducing the walking speed and increasing knee flexion, while in those with higher levels of disability aging is not associated with a reduction in walking speed and increased knee flexion (30).

As for the operated children, a study that analyzed the operated children with spastic diplegia four years after surgery showed that the walking pace is higher in children that underwent surgery earlier, had fewer surgeries and were walking faster preoperatively, while knee flexion while standing was considerable in patients with multiple surgeries, and lower preoperative knee extension (31). Türker and Lee (32) report increased hip instability, which occurred several years after the aductor tenotomy, while Zwick et al. (33) report improvement in foot mobility, gait speed and support improvement in the phase of movement due to the improved functional abilities of the hip, by analyzing the gait of operated children with diplegia.

Conclusion

Orthopedic-surgical treatment of the lower extremities with the application of kinesitherapy in the complex rehabilitation treatment of children with cerebral palsy, can significantly improve motor function in all developmental stages, such as turning, sitting, crawling, standing and walking, and can significantly reduce the level of disability.

Conflict of interest: The authors declare that they have no conflict of interest. This study was not sponsored by any external organisation.

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