

Lewandowska Renata, Krajewski Stanisław, Kucharczuk Magda. Evaluation of functional performance and locomotion of children with cerebral palsy. *Journal of Education, Health and Sport*. 2018;8(9):247-259. eISSN 2391-8306. DOI <http://dx.doi.org/10.5281/zenodo.1346602> <http://ojs.ukw.edu.pl/index.php/johs/article/view/5825> <https://pbn.nauka.gov.pl/sedno-webapp/works/873837>

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part b item 1223 (26/01/2017).
1223 Journal of Education, Health and Sport eissn 2391-8306 7

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The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 28.07.2018. Revised: 28.07.2018. Accepted: 16.08.2018.

Evaluation of functional performance and locomotion of children with cerebral palsy

Renata Lewandowska^{1,2}, Stanisław Krajewski^{3,4}, Magda Kucharczuk^{3,5,6}

¹ Center of Rehabilitation Neuron in Bydgoszcz, Poland

² Oncology Centre, Bydgoszcz, Poland

³ Neurosurgery Unit, 10th Military Research Hospital and Polyclinic, Bydgoszcz, Poland

⁴ Bydgoska Szkoła Wyższa, Bydgoszcz, Poland

⁵ Surgery Unit 10th Military Research Hospital and Polyclinic, Bydgoszcz, Poland

⁶ Department of Physiotherapy, Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Toruń, Poland

Corresponding author:

Mgr Renata Lewandowska

e-mail: renatanycek@onet.eu

Abstract

Purpose. Demonstration of the author's motor assessment questionnaire as a tool allowing detailed evaluation of movement dissociation disorders in children with cerebral palsy and damaged pyramidal system.

Material and Methods. The study included 19 children with cerebral palsy aged 4 to 16 years. Mean age: 8 years old (SD = 3.53). The research was performed in the Neuron Rehabilitation

Centre in Bydgoszcz. A motor assessment questionnaire was used to examine the possibility of changing position from the lowest, i.e. lying back, to the highest, i.e. standing and walking. Based on the Gross Motors Function Classification Scale (GMFCS), children were qualified to specific functional levels from I to V. The Functional Mobility Scale (FMS) scale was used to examine the capability of locomotion at three distances: 5m, 50m and 500m. Total examination - using the motor assessment questionnaire, the GMFCS scale and the FMS scale - was used to determine dysfunctions and current skills of the subjects and predict their functioning and locomotion.

Results. The range of points scored by children according to the motor assessment table was 7 to 46 out of 48. Based on the GMFCS scale, the subjects were qualified to levels from I to V, and according to the FMS scale - to eight groups depending on the locomotion capabilities. The results obtained by the study group in individual scales were compared.

Conclusions

1. The general functional performance of a child expressed by GMFCS level is significantly affected by factors not related to motor activity itself. This is confirmed by the lack of a close relationship between the motor skills assessment and GMFCS level.
2. Scores obtained in the motor assessment test in most cases are adequate to the capability of independent upright mobilization.
3. Scores obtained in the motor assessment test always determine the capability of walking on three distances according to the FMS scale.
4. Independent walking with the use of orthopedic support is possible for children, who obtained at least 30 points out of 48 in the motor assessment test.
5. It has been shown that the author's motor assessment questionnaire is useful for the motor assessment of children with cerebral palsy.

Keywords: dissociation, motor disorders, locomotion

Introduction

In the functional diagnostics, there are simple and objective ways of evaluating motion parameters such as strength or range. A greater problem is the objectification of muscle tone disorders. However, the greatest difficulty is the assessment and description of disorders of complex movements, such as those performed by people during all activities - whether related to movement or self-care, related to work, art and other aspects of physical activity. It is difficult to measure and evaluate coordination disorders, which are imposed by involuntary movements, accompanied by paresis with increased or decreased muscle tone. Therefore, it is

difficult to assess the progress of rehabilitation as well as predicting the possibility of achieving progress in the future in patients with such disorders [1,2,3,4]. There are scales assessing general motor skills of patients and it is possible to classify patients in various ways. However, the assessment of minor changes in motor skills is difficult, although it does not immediately affect overall fitness, but allows to see progress in improvement, which in turn may be significantly prognostic [5,6,7]. The authors present a proposal for a detailed assessment of the child's motor skills based on the study of individual dissociations. Dissociation is a separation, which leads to development of selective movements, a correct relationship between mobility and stability (distal parts have the ability to move when proximal parts are in fixed, stable connection with the distal one).

In children with cerebral palsy, dissociations develop incorrectly. Pathological compensations are created that block normal motor development. Stiffening is created, which is the cause of improperly developing dissociation. Dissociations affect individual movement patterns, and a correct reciprocal innervation is the basis for the development of all dissociations.

Dissociation improves if development of the antigravity mechanism is correct. Normal postural tension, inhibition of reflex activity and separation of muscle synergy are also important [8,4].

Purpose

The aim of this study was to demonstrate the use of author's motor assessment questionnaire as a tool allowing detailed evaluation of movement dissociation disorders in children with cerebral palsy with damaged pyramidal system. This detailed scale allows to detect even small changes in movement capabilities of children over, for example, one rehabilitation period. It can also be useful in predicting improvements. It is not a better method of assessment, but it seems to be complementary with scales assessing general motor skills.

Material and method

The study included 19 children (9 girls and 10 boys) with cerebral palsy aged 4 to 16 years. The mean age was 8 years old (SD = 3.53), the median was 7. Three children had left-sided hemiplegia, one had right-sided hemiplegia, five had a diplegia and eleven - tetraplegia. They were found to have the pyramidal system damaged - a part of the nervous system responsible for posture and arbitrary movements. In the majority of cases, the symptoms were

manifested by a significant spastic tension of lower limbs, reduced locomotion and increased independent general functioning.

The research was carried out in the Neuron Rehabilitation Centre in Bydgoszcz. After the interview, an important element of the study was observation of the patient's spontaneous behavior, his problems, the capability of changing positions, irregularities and their analysis. The motor assessment questionnaires were used to examine the capability of changing position from the lowest, i.e. lying back, to the highest, i.e. standing and walking. Therefore, it was possible to make a motor evaluation of the subject, his mode of functioning, including upright mobilization and the ability to walk. An evaluation was made without scoring, but with description in three positions: lying in supine position, sitting straight and standing.

The remaining elements of the table, in which the way of moving from the starting position to the end position was assessed, were scored:

- 0 - no performance,
- 1 - movement with considerable support,
- 2 - movement with assistance,
- 3 – unaided movement.

Sixteen items were evaluated by the above scoring. The maximum score for a child was 48. All remarks that occurred during the assessment were included in the relevant column below (Table 1).

Tab. 1. Child motor assessment questionnaire

Position and change of position	Independently 3 points	Support 2 points	Significant support 1 point	Inability to perform - 0 points	Comments
supine position – evaluation					
supine position → right side lying					
prone position → left side lying					
supine position → prone position					
prone position → supine position					
supine position → right side sitting					
supine position → left side sitting					
supine position → sitting straight					
Sitting straight - stability assessment					
Sitting straight → supported tall kneeling - crawling					
Crawling - assessment of movement					
Sitting straight → supported tall kneeling					
Tall kneeling (with support at the rehabilitation bench) → half kneeling (on left lower limb)					
Tall kneeling (with support at the rehabilitation bench) → half kneeling (on right lower limb)					
Tall kneeling → half kneeling (on left lower limb)					
Tall kneeling → half kneeling (on right lower limb)					
Tall kneeling → upright position					
standing position – stability assessment					
Walking					
TOTAL					

Based on the Gross Motors Function Classification Scale (GMFCS), children were qualified to specific functional levels from I to V. Level I concerns the lightest disturbances, level V with severe form of cerebral palsy. According to the scale, a division was made in the following age ranges:

- before 2nd birthday,
- between 2nd and 4th birthday,
- between 4th and 6th birthday,
- between 6th and 12th birthday,
- between 12th and 18th birthday.

The Functional Mobility Scale (FMS) was used to investigate the capability of moving in three distances: 5m, 50m and 500m. The evaluation was made according to the scoring:

- 6 - the child is independent on all surfaces,
- 5 - the child is independent on level surfaces,
- 4 - the child moves using a walking stick or canes,
- 3 - the child moves using crutches,
- 2 - the child moves using a walking frame or a walker,
- 1 - the child moves using a wheelchair.

The assessment was made at all three distances and the subject walked the distance without the support of the other person. If necessary, the subjects could use orthopedic support, i.e. canes, crutches, a walking frame, a walker, a wheelchair. Children who use lower limb orthoses on a daily basis, walked the distance in orthoses, but completely alone. If the patient crossed the distance crawling, it was marked with the letter "C". If it was not possible to walk the distance with the rehabilitation aids, it was marked with the letter "N".

The total examination - using the motor assessment questionnaire, GMFCS scale and FMS scale - was used to determine the dysfunction, but also the current skills of the subjects, make a prediction of their functioning and locomotion.

Results

Based on the patient interview, observations, scores from the author's motor assessment questionnaire and scores from the FMS scale, the examined children were qualified for specific GMFCS levels (Table 2):

Tab. 2. Division of the studied group into GMFCS levels

Levels	Number of children
I	4
II	1
III	4
IV	6
V	4
TOTAL	19

The motor evaluation of the subjects was presented with division into groups according to GMFCS levels (Table 3). The motor assessment questionnaire was used. The maximum score to gain was 48. No child has scored this number. The mean score in the study group was 27 (SD = 13.59), and the median was 26. Children in level I of the GMFCS obtained from 42 to 46 points in the motor assessment. Subject in level II GMFCS obtained 40 points. Children in

level III obtained from 30 to 41 points, children in level IV obtained from 21 to 24 points, and children in level V from 7 to 9 points.

Tab. 3. Motor assessment of children from particular GMFCS levels

Motor assessment points	4 6	44	43	42	40	41	40	30	30	26	24	21	21	21	18	9	8	8	7
GMFCS levels	I			II	III				IV				V						

Scores in the FMS scale were analyzed at distances of 5m, 50m and 500m. Points from the motor assessment were assigned to them appropriately. Table 4 shows the FMS points for individual distances and the motor assessment points for individual subjects.

Tab. 4. Motor assessment of children in the FMS scale

Motor assessment points	4 6	4 4	4 3	4 2	4 0	4 1	4 0	3 0	3 0	2 1	2 6	2 4	2 1	2 1	1 8	9	8	8	7
FMS scale – 5m	6			4	2			C	N										
FMS scale – 50m	6			3	2		1	N											
FMS scale – 500m	6	5	6	5	3	2		1	N										

Caption - functional capabilities of children according to the FMS scale

N – no movement,

C - crawling,

1 - movement using a wheelchair,

2 - movement using a walking frame or a walker,

3 - movement using crutches,

4 - movement using a cane or a walking stick,

5 - the child is independent on level surfaces,

6 - the child is independent on all surfaces.

Children who scored less than 27 points in motor assessment did not walk a distance of 5 meters in any possible way, except for one child (21 points), who walked this distance crawling. The subjects who scored 30 points and higher walked a distance of 5 m: four children with motor points from 30 to 41 walked it with a walking frame or a walker, 1 child who scored 40 points in motor assessment walked this distance with a cane, 4 subjects with 42 to 46 motor points did not use any orthopedic support to walk this distance. Analyzing the capability of walking a distance of 50 meters, it has been shown that 10 children did not walk this distance in any way (<27 points in motor scale). One child with 30 motor assessment

points moved with the aid of a wheelchair, 1 child with the same score moved with a walking frame, 2 children with a motor score of 40 and 41 points walked with the aid of a walker or a walking frame, 1 child with the score of 40 points moved using crutches, the remaining four subjects walked the distance without difficulties. The number of children who did not walk a distance of 500 meters is also 10 (motor assessment points from 7 to 26). Two subjects with 30 motor assessment points were in a wheelchair, two subjects with 40 and 41 points moved with the aid of a walker, one child with 40 points walked a distance of 500 meters with crutches, two subjects with 42 and 44 points walked the distance alone without orthopedic support, but with little difficulty, and two subjects with 43 and 46 points managed to walk this distance without a problem.

The FMS scale is used to assess methods and capabilities of locomotion. A group of 10 children did not walk independently even with the use of orthopedic support: sticks, crutches, walker, walking frame, wheelchair. The second group - 9 subjects - were children walking independently with the use of orthopedic support.

Using the motor assessment questionnaire, the child's upright mobilization can be analyzed (Table 5). Thirteen subjects did not stand independently, and 2 of them were not assisted by their parents. One child had a contraindication to upright mobilization (the physician's decision, due to recent hip surgery). Six children stood independently unaided. Table 5 - 6 present the relationship between the number of motor assessment points and the upright mobilization and walking ability. In both tables the results of motor assessment test were assigned to groups according to GMFCS and FMS scales.

Tab. 5. Number of motor assessment points vs. upright mobilization

Upright mobilization	Number of children	Motor assessment points	GMFCS	FMS
Independent	6	40 - 46	I - III	2 - 6
Non-independent	13	7 - 41	III - V	N - C - 2
without upright mobilization	2	9, 18	IV, V	N

Tab. 6. Motor assessment points, number of children, walking function

Walking function	Number of children	Motor assessment points	GMFCS	FMS
Non-walking	10	7-26	IV - V	N - C - 1
Walking	9	30-46	I - III	2 - 6

The number of motor assessment points was also evaluated in children with various forms of paralysis: left and right hemiplegia, diplegia and tetraplegia [9]. The group of children with

tetraplegia received the least number of points. It was the largest group (10 subjects) with a mean of 17.6 points. The group with the highest number of points scored in the motor assessment test was five children with diplegia. They obtained a mean of 38.8 points while four children with hemiplegia received a mean of 33.75 points. Thus, the result of motor assessment test is associated with the form of cerebral palsy. This especially applies for children with tetraplegia, who received significantly less points than the others. Statistical analysis with a one-way ANOVA showed that the quantitative motor assessment of the examined children with different forms of cerebral palsy was significantly different ($p = 0.017$).

An analysis of the motor assessment was also carried out, depending on age of the subjects. There was no statistically significant relationship between these two variables ($p = 0.811$).

Discussion

The GMFCS system (Gross Motors Function Classification Scale) was established in 1996. It evaluates the motor functions of children with cerebral palsy. It is based on five levels, in five age ranges. This scale is not used to assess changes in the motor functions or motor capability of the child. It is also not used to assess the effects of physiotherapy. It is dedicated for physiotherapists and physicians to determine general motor abilities depending on age. The method of use is not difficult and the scale is readable [10].

The scale can predict changes in motor activity of examined subjects. It can be used, for example, to predict changes in the hip joint. If the child is standing, running (level I), it will not probably be at risk of changes in the hip joint, but children in level V in 90% will be at risk of those changes. Children in level II and III due to tension of the adductor muscles are at risk of the hip joint dysplasia. Subjects in level IV and V most often have a serious problem due to incorrect structure of the hip and therefore may dislocate this joint. The system allows predicting the functional level, motor development and is characterized by high clinical usefulness when it comes to predicting. Age of the subject and locomotion abilities with the use of rehabilitation equipment is taken into account. The system allows to determine the level of development of gross motor function in the child's future. It is a tool through which therapy can be defined and planned. Therefore, it is important that physiotherapy cannot change in functional levels defined by the scale but it is part of a global approach to the patient, in order to improve or maintain independence and comfort of life.

An example of functional assessment of a child aged 6-12 according to the GMFCS scale:

Level I - the child jumps and runs, independent, motor coordination slightly disturbed.

Level II - the child has difficulty in running and jumping, requires the use of a railing to walk up and down stairs, it is difficult for him to move on uneven terrain.

Level III - the child walks with crutches, orthopedic walking sticks, walks up the stairs using a handrail, and uses a wheelchair for further and foreign routes.

Level IV - the child usually moves on a wheelchair and achieves self-mobility using a powered wheelchair.

Level V - the child does not move independently, has significant functional limitations, some children are able to operate a powered wheelchair.

The highest number of children were in level IV, the least in level II, the equal number of children were in level I, III and V. Level IV describes subjects who have limited activity. They are transported in wheelchairs, they can move on short distances crawling, can move in a walking frame assisted by other person. Children in level I walk without limitations. This group consisted mainly of children with hemiplegia. The smallest group was represented by level II patients which contained children who walk without any orthopedic equipment, but with little support; they are unable to jump and run. Level III group described patients who were able to walk with orthopedic equipment and during sitting with pelvis support.

Assigning the scores in motor assessment of individual children from particular GMFCS levels, it was found that the group of children in level V was the least heterogeneous. Their score ranged from 7 to 9 points. The level III group was the most heterogeneous and the scoring ranged from 30 to 41 points. Two children from this level received the same score and one of them had one point higher than a child in level II. These children had high capabilities when it comes to low positions, unfortunately one child due to mental retardation and other due to impairment of hearing and visual function, could not function like subjects in level II and therefore they were qualified to a lower level. They could not function in higher positions, as it would be expected based on high results of the motor assessment. They did not gain independence in the function of gait. This means that the score from the motor assessment test is not always adequate to the GMFCS level. This has been confirmed by authors of many studies, stating that additional disorders such as epilepsy, vision and hearing disorders, deep retardation, and also family conditions may be a clear obstacle to gain higher skills [11,8,12].

In case of children described above, there is a chance for more independence and a changing the GMFCS level. The patient interview showed that the boy with a trauma after Achilles tendon surgery, which he underwent in 2016, walked before surgery, so it is possible that effective rehabilitation and time will be beneficial for him. Another child will soon undergo cochlear implantation surgery, which will significantly affect communication and its motor functions.

Children in level I and II do not have problems with locomotion, which is reflected by results of the FMS scale and motor assessment. Children in level IV walk with limitations, use powered wheelchairs, and children in level V don't walk independently even with orthopedic equipment. Children in level III according to the FMS scale are able to walk using orthopedic support. This is consistent with the GMFCS classification that is based on analyzing the form of movement, the position of sitting and its stability.

Most of the examined children were unable to stand upright on their own, a small percentage of children were could not stand at all. Children who stood upright scored high points in motor assessment. It was 40 or more points. Score in the motor assessment test is connected with the capability of independent standing. However, the mentioned boy after Achilles tendon surgery, who obtained a high score of 41 in the motor assessment test, needed physical assistance to stand upright.

The FMS (Functional Mobility Scale) scale is very useful for assessing the mobility of a child at home and outside. It is used for current assessment of motor activity, but it can also be used to assess changes that occur after surgical interventions [12]. An example: a child who walks without orthopedic support at home, uses orthopedic crutches at school and walks long distances with a walker, will obtain following FMS scores: 5, 3, 2, where:

- 5 - score on a distance of 5 meters,
- 3 - score on a distance of 50 meters,
- 2 - score on a distance of 500 meters.

The analysis was based on the relationship between the motor assessment scores and the capability of movement. Using the FMS scale, the capability of moving at three specific distances was evaluated, and the results of the motor assessment test were assigned to FMS results. Children with a low motor score (≤ 25 points) did not have the capability to walk on any of the three distances. One child could walk the shortest distance (5m) but crawling. An

independent walk with the use of equipment such as sticks, crutches, walkers, walking frames was only possible for children with a score of 30 points and more.

Walking is not an easy form of movement for children with motor disorders. It requires upright mobilization, proper coordination, dissociation between particular segments, and maintaining balance. Ten of the 19 children examined did not walk unaided. It is important that not every child will achieve this function. Many authors focus on the fact that a child who did not walk alone before its 8th birthday, will not achieve this despite continuous work to improve this function. It is important to modify the goals and treatment plan for such children [13,14].

The FMS scale allowed to draw conclusions regarding the capabilities and ways of locomotion. Children in level I and II in GMFCS did not have problems with locomotion, which is reflected in the FMS results. On the other hand, children in level IV and V are almost completely deprived of independent movement function, even with orthopedic support.

Conclusions

1. The general functional performance of a child expressed by GMFCS level is significantly affected by factors not related to motor activity itself. This is confirmed by the lack of a close relationship between the motor skills assessment and GMFCS level.
2. Scores obtained in the motor assessment test in most cases are adequate to the capability of independent upright mobilization.
3. Scores obtained in the motor assessment test always determine the capability of walking on three distances according to the FMS scale.
4. Independent walking with the use of orthopedic support is possible for children, who obtained at least 30 points out of 48 in the motor assessment test.
5. It has been shown that the author's motor assessment questionnaire is useful for the motor assessment of children with cerebral palsy.

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