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Gross motor function in children with spastic Cerebral Palsy and Cerebral Visual Impairment: A comparison between outcomes of the original and the Cerebral Visual Impairment adapted Gross Motor Function Measure-88 (GMFM-88-CVI)



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ABSTRACT

Purpose: To investigate whether the adapted version of the Gross Motor Function Measure-88 (GMFM-88) for children with Cerebral Palsy (CP) and Cerebral Visual Impairment (CVI) results in higher scores. This is most likely to be a reflection of their gross motor function, however it may be the result of a better comprehension of the instruction of the adapted version.

Method: The scores of the original and adapted GMFM-88 were compared in the same group of children (n=21 boys and n=16 girls), mean (SD) age 113 (30) months with CP and CVI, within a time span of two weeks. A paediatric physical therapist familiar with the child assessed both tests in random order. The GMFCS level, mental development and age at testing were also collected. The Wilcoxon signed-rank test was used to compare two different measurements (the original and adapted GMFM-88) on a single sample, (the same child with CP and CVI; $p < 0.05$).

Results: The comparison between scores on the original and adapted GMFM-88 in all children with CP and CVI showed a positive difference in percentage score on at least one of the five dimensions and positive percentage scores for the two versions differed on all five dimensions for fourteen children.

For six children a difference was seen in four dimensions and in 10 children difference was present in three dimensions (GMFM dimension A, B & C or C, D & E) ($p < 0.001$).

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The adapted GMFM-88 provides a better estimate of gross motor function per se in children with CP and CVI that is not adversely impacted by their visual problems. On the basis of these findings, we recommend using the adapted GMFM-88 to measure gross motor functioning in children with CP and CVI.

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1. Introduction

Cerebral Palsy (CP) represents a large group of permanent disorders of the development of movement and posture, causing activity limitations that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain (Rosenbaum, Paneth, Leviton, Goldstein, & Bax, 2007). Gross motor function of children with CP can be classified into five different severity levels using the Gross Motor Function Classification System (GMFCS), where level I indicates the least and level V the most functional limitation. Generally, children at GMFCS level I walk indoors and outdoors and climb stairs without limitations, children at GMFCS level II walk indoors and outdoors and climb stairs holding onto a railing but experience limitations walking on uneven surfaces and inclines, children at GMFCS level III walk indoors or outdoors on a level surface with an assistive mobility device, children at GMFCS level IV sit on a chair but need adaptive seating for trunk control, and children at GMFCS level V have physical impairments that restrict voluntary control of movement (Rosenbaum et al., 2007). Motor disorders of CP can be accompanied by disturbances of sensation, perception, cognition, communication and behaviour, as well as by epilepsy and secondary musculoskeletal problems (Rosenbaum et al., 2007).

Visual impairment can have a major impact on motor development and skills acquisition. A delayed onset of different motor milestones, such as sitting, crawling, standing or walking, has been reported in visually impaired children (Prechtl, Cioni, Einspieler, Bos & Ferrari, 2001; Levizion-Korach, Tennenbaum, Schnitzer, & Ornoy, 2000). Cerebral Visual Impairments (CVI) is observed in approximately 30% of children diagnosed with various forms of CP (Ghasia, Burnstroom, Gordon, & Tychsen, 2008; Stiers, Vanderkelen, Vanneste, Coene, De Rammelsere, & Vandenbussche, 2002). CVI can be defined as deficient visual functioning, resulting from a sequel of damage or malformation of the retrogeniculate visual pathways (optic radiations, occipital cortex and visual association areas) in the absence of damage of the anterior visual pathways or any major ocular disease (Dutton & Jacobson, 2001; Dutton, Saaed, Fahad, Fraser, McDaid, & McDade, 2004). CVI ranges in severity from blindness to relatively minor impairments of visual perception. Children with CVI exhibit slow, inefficient and highly variable visual performance during daily-life activities (Good, Jan, Burden, Skoczenski, & Candy, 2001). CVI has an impact on all aspects of a child's development, and children with CP and CVI develop more slowly in the areas of self-care, mobility and social function than children with CP without CVI. (Da Costa, Salmao, Berezovsky, De Haro, & Ventura, 2004; Dutton & Jacobson, 2001; Dutton, 2013; Ghasia et al., 2008; Good et al., 2001; Salavati, Rameckers, Steenbergen, & Schans van der, 2014; Schenk-Rootlieb, Van Nieuwenhuizen, Van der Graaf, Wittebol-Post, & Willemse, 1993; Salavati et al., 2015a). Children with more severe CP may have a greater reduction in visual acuity (Da Costa et al., 2004; Fazzi et al., 2002).

The Gross Motor Function Measure-88 (GMFM-88) is a widely used instrument to assess motor capacity in children with CP (Chrysagis, Skordilis, Stavrou, Grammatopoulou, & Koutsouki, 2012; Scholtes et al., 2010). The GMFM does not however account for the presence of visual impairments, which may reduce validity for children with CP and visual impairments. We previously adapted the GMFM-88 for children with CP and CVI. This adapted version (GMFM-88-CVI) takes into account the presence of CVI in children with CP and is reliable for measuring motor functioning in children with CP and CVI (Salavati et al., 2015b). The GMFM-88-CVI supports a specific task without changing the question or instruction of the original GMFM-88. The adaptation of the GMFM-88-CVI for children with CVI is at the level of verbal support/instruction, manual support, types of equipment and environment (Salavati et al., 2015b).

The GMFM-88 consists of 88 items in five dimensions. The reliability and validity of this test are sufficient (inter-rater reliability: ICC = 0.75–1.00; test-retest reliability: ICC = 0.96–0.99) (Engelen, Ketelaar, & Gorter, 2007; Ketelaar, Van Petegem-van Beek, Veenhof, Visser, & Vermeer, 2003). The GMFM-88 is a criterion-referenced instrument constructed to evaluate the development of motor skills in children with CP, and designed and validated for these children by using principles of classical test theory. It is widely used as a clinical and research outcome measure and there is considerable evidence of its reliability, validity and responsiveness (Avery, Russell, Raina, Walter, & Rosenbaum, 2003). Reliability and validity for children with visual impairments such as CVI is unknown for the GMFM-88 (Engelen et al., 2007; Ketelaar et al., 2003). Experts working with children who have both CVI and CP experienced that the GMFM-88 does not account for the presence of visual impairments – that is, the assessment may not be suitable for children with CVI because outcome scores are likely to be negatively impacted by visual impairments. As such, it is a potentially less valid measure to assess motor functioning in children with CP and CVI. These children have an inherent limitation with proper identification and processing of visual information (Haley, Coster, Ludlow, Haltiwanger, & Andrellos, 1992; Salavati et al., 2014). Also, because of visual impairments a child might not be able to show its motor functioning abilities during a standardised assessment of motor development, leading to a possible underestimation of its true motor capacity (Visser, Ruiter, Meulen van der, Ruijssenaars, & Timmerman, 2014; Salavati et al., 2014).

The GMFM-88-CVI for children with CP and CVI (test-retest reliability: ICC = 0.94–1.00; interobserver reliability: ICC = 1.00–1.00; internal consistency = 0.97–1.00) takes into account CVI in children with CP (Salavati et al., 2015b). Evalua-

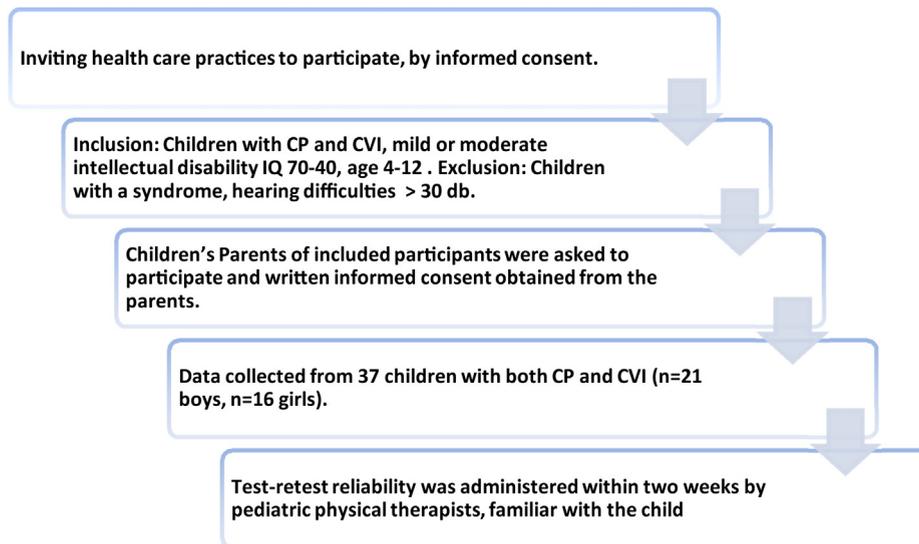


Fig. 1. Procedure for inclusion.

tion with the GMFM-88-CVI enables detection of improvement related to intensive motor training which would possibly be masked by the visual impairment when the original version of GMFM-88 would be used. Based on the importance of visual processing on motor performance we hypothesised that the original GMFM-88 gives an underestimation of the gross motor functioning of children with CP and CVI.

The aim of our study was therefore to investigate whether the GMFM-88-CVI for children with CP and CVI results in a higher score of their gross motor function via a comparison with the original GMFM-88 in the same group of children with CP and CVI.

2. Methods

2.1. Participants

Children with CP and CVI were recruited from Royal Dutch Visio (Centres of expertise for blind and partially sighted people) and allied healthcare practices. Inclusion criteria were presence of any type of CP and CVI, mild or moderate intellectual disability (IQ 70–40), and age at testing between 4 and 12 years. Level of intellectual disability was obtained from the medical files. Children with another comorbid syndrome (e.g. Down syndrome) or hearing difficulties (>30 dB hearing loss), severe or profound intellectual disability (IQ < 40) and (corrected) vision <0.3 and/or field of vision $\leq 30^\circ$ were excluded. Children who had planned surgery (e.g. Lower limb orthopaedic surgery) or other medical interventions (e.g. intramuscular botulinum-A toxin) between the two tests were also excluded. (Fig. 1).

The diagnosis of CP and the classification according to GMFCS level were obtained from the medical files and classified by a rehabilitation physician. The diagnosis of CVI was determined on the basis of the results of ophthalmological and psychological/neuropsychological testing and on the assessment data reported by a developmental therapist specialised in working with children with visual impairments. The following criteria were used: a normal or near-to-normal result on the eye exam (corrected vision >0.3 and/or field of vision >30°) performed by an ophthalmologist; a history or presence of neurological problems; and presence of behavioural responses to visual stimuli that are unique to CVI. This results in strong colour preferences, need for movement to elicit or sustain visual attention, visual latency-delayed responses in looking at objects, visual field preferences, difficulties with visual complexity, light-gazing and non-purposeful gaze, difficulty with distance viewing, and absent or atypical visual reflexes (Dutton & Jacobson, 2001; Stiers et al., 2002). Children with all types of CVI were included in our study and no selection was carried out based on subtypes. Except for the diagnosis of CVI, there was no additional information available about levels of CVI and therefore, subtype analyses for levels of CVI was not possible.

Permission to conduct the study was obtained from the Medical Ethical Committee (METC-2014.438) of University Medical Center Groningen (UMCG), the Netherlands. Written informed consent was obtained from the children's parents.

2.2. Test instrument

2.2.1. The original GMFM-88

The GMFM-88 is a standardised functional assessment tool 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

Table 1
Characteristics of the participants.

Characteristic	Children with CP and CVI
Age in months, mean (SD), min-max	113 (30), 54–144
Gender, <i>n</i> (%) male/ <i>n</i> (%) female	21 (57)/16 (43)
Type of cerebral palsy: <i>n</i> (%) spastic/ <i>n</i> (%) dyskinetic	36 (97)/1 (3)
GMFCS I, <i>n</i> (%)	bilateral 10 (27), unilateral left 1 (3)
GMFCS II, <i>n</i> (%)	6 (16) bilateral
GMFCS III, <i>n</i> (%)	3 (8) bilateral
GMFCS IV, <i>n</i> (%)	7 (19) bilateral
GMFCS V, <i>n</i> (%)	10 (27) bilateral
Speech/language development:	
- ICF-CY, d3100 = reacts to human voice, <i>n</i> (%)	37 (100)
- ICF-CY, d3101 = understands simple spoken messages, <i>n</i> (%)	37 (100)
- ICF-CY, d3102 = understands complex spoken messages, <i>n</i> (%)	27 (73)
- ICF-CY, d330 = speaks, <i>n</i> (%)	21 (57)
- ICF-CY, d331 = babbles, <i>n</i> (%)	16 (43)
- ICF-CY, d3350 = uses body language, <i>n</i> (%)	32 (87)
- ICF-CY, d3351 = uses signs and symbols, <i>n</i> (%)	28 (76)
Level of intellectual disability, <i>n</i> (%) mild/ <i>n</i> (%) moderate	14 (38)/23 (62)
Presence of epilepsy, <i>n</i> (%)	3 (8)
Use of epilepsy medication, (<i>n</i> %)	3 (8)
Percutaneous endoscopic gastrostomy tube feeding, <i>n</i> (%)	4 (11)

GMFCS, Gross Motor Function Classification System; ICF-CY, International Classification of Functioning, Disability and Health, Child & Youth version (Dutch translation).

treatment programs of this population. The GMFM-88 is responsive to changes in motor functioning, and can be used to measure changes in fundamental gross motor skills over time in children with CP and to evaluate physiotherapy interventions (Engelen et al., 2007; Ketelaar et al., 2003). The test consists of 88 items grouped into five dimensions of gross motor functions: lying and rolling (GMFM-A) 17 items; sitting (GMFM-B) 20 items; crawling and kneeling (GMFM-C) 14 items; standing (GMFM-D) 13 items; and walking, running and jumping (GMFM-E) 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 support (walker, crutches and canes) or orthoses (ankle foot control, knee control or shoes). A 5-year-old child with normal motor abilities can accomplish all items (Harries, Kassirer, Amichai, & Lahat, 2004; Russell, Rosenbaum, Avery, & Lane, 2002; Avery et al., 2003).

2.2.2. The GMFM-88-CVI

The GMFM-88-CVI is an appendix to the instruction of the original GMFM-88. Most of the adjustments relate to higher motor skills such as jumping, climbing stairs and cycling. Equipment use in GMFM-88-CVI is colourful, sound-producing and high in contrast in order to get the attention of the child who is to move towards the material (Salavati et al., 2015b).

The test-retest reliability ICCs of dimension scores are 0.94–1.00 and the inter-observer reliability ICCs for the GMFM-88-CVI are 1.00–1.00 for dimension scores. Test-retest and interobserver reliability of the GMFM-88-CVI for children with CP and CVI are excellent. Internal consistency of dimension scores is: dimension A 0.97–1.00, dimension B 0.99–1.00, dimension C 1.00–1.00, dimension D 1.00–1.00, dimension E 1.00–1.00 and Total 1.00–1.00; the dimensions are thus reliable (Salavati et al., 2015b).

2.3. Design

The paediatric physical therapist familiar with the child administered the original GMFM-88 and the GMFM-88-CVI in random order as either first or second test, within a two-week period. We choose to administer the test-retest within two weeks because it is highly unlikely that gross motor function of children with CP will change within such a time period.

2.4. Data collection

Based on the possible effect on motor functioning, we also collected background data on prevalence of epilepsy as well as speech/language development according to the *International Classification of Functioning, Disability and Health, Child & Youth version (Dutch Translation) (2008)*. At the level of speech/language development, the collected variables were: d3100 = reacts to human voice; d3101 = understands simple spoken messages; d3102 = understands complex spoken messages; d330 = speaks; d331 = babbles; d3350 = uses body language and d3351 = uses signs symbols (Table 1). The data of children were registered according to GMFCS level and type of CP (unilateral or bilateral) and level of intellectual disability. In addition, the gender and age at which the GMFM-88 and GMFM-88-CVI were administered was noted. All paediatric physical therapists were familiar with both the original GMFM-88 and the GMFM-88-CVI. The tests were administered by

Table 2
Difference in percentage score between GMFM-88 and GMFM-88-CVI for each child.

Child	GMFM-A (lying & rolling)	GMFM-B (sitting)	GMFM-C (crawling & kneeling)	GMFM-D (standing)	GMFM-E (walking, running & jumping)	GMFM- Total	GMFCS level	Level of intellectual disability ^a
1	12	2	25	10	5	11	1	2
2	10	12	10	7	7	10	1	1
3	9	15	16	10	14	13	1	2
4	9	11	27	14	4	13	1	1
5	3	12	10	5	6	6	1	1
6	14	20	10	2	16	12	2	2
7	8	10	29	5	3	11	2	2
8	23	9	16	2	3	11	3	1
9	5	3	7	7	2	5	3	1
10	14	12	24	10	10	14	4	2
11	12	17	7	12	7	12	4	2
12	9	7	3	5	5	6	4	2
13	8	7	20	1	37	15	5	2
14	3	4	7	3	5	5	5	2
15	12	19	0	3	3	7	1	2
16	18	19	15	11	-1	12	5	1
17	8	7	-1	15	7	6	5	2
18	20	3	7	0	0	6	1	1
19	31	23	3	0	0	11	1**	1
20	8	2	5	0	0	3	1	1
21	17	24	10	0	0	10	2	2
22	20	15	4	0	0	8	4	2
23	26	12	5	0	0	8	5	2
24	1	1	4	0	0	1	5	2
25	6	8	0	0	0	3	1	2
26	0	0	0	3	10	3	1	1
27	0	5	5	0	0	2	2	1
28	0	0	8	3	4	3	2	2
29	6	2	0	0	0	2	2	2
30	0	0	12	8	5	5	3	2
31	0	2	1	0	0	1	4	1
32	0	0	6	6	7	4	4	2
33	20	4	0	0	0	5	5	2
34	33	11	0	0	0	9	5	2
35	30	18	-1	0	0	10	5	2
36	5	0	0	0	0	1	4	1
37	0	0	0	0	3	1	5	1

A positive value indicates a higher score for GMFM-88-CVI. GMFM-88, Gross Motor Function Measure-88; GMFM-88-CVI, Gross Motor Function Measure-88 for children with CVI; CP, cerebral palsy; CVI, Cerebral Visual Impairment; GMFCS, Gross Motor Function Classification System.

^a 1, mild intellectual disability; 2, moderate intellectual disability.

** unilateral left.

trained paediatric physical therapists and the dimension as well as total scores of the GMFM-88 and GMFM-88-CVI for children with CP and CVI were used for further analysis.

2.5. Statistical analyses

Data were analysed using the Statistical Package for Social Sciences (SPSS), v.22 software.

The Wilcoxon signed-rank test is a non-parametric statistical hypothesis test used when comparing two related samples, matched samples, or repeated measurements on a single sample to assess whether their population (pseudo) median differ. In our study, we used the Wilcoxon signed-rank test with a significance level of $p < 0.05$ to compare two different measurements (the original and adapted GMFM-88) on a single sample (the same child with CP and CVI).

3. Results

All children were tested with both tests between November 2014 and February 2015. Mean (SD) duration between the two tests was 10 (6) days. We included data from 37 children with both CP and CVI ($n = 21$ boys and $n = 16$ girls) for analysis. Table 1 provides the characteristics of the included children.

All children showed a positive difference in percentage score on at least one of the five dimensions of the GMFM (Table 2). The percentage scores for the two versions differed on all five dimensions for fourteen children with mild/moderate intellectual disability distributed over all GMFCS-levels (I–V). For six children, a difference was seen in four dimensions and in 10 children a difference was present in three dimensions (A–C or C–E). The children with a difference in four dimensions were

Table 3

Related (paired) Samples Wilcoxon Signed Rank Test. Median (min-max) and Mean (SD) of GMFM-88 and GMFM-88-CVI scores, Z-value, median, and 95% CI of differences. N = 37.

GMFM dimension	GMFM-88		GMFM-88-CVI		Z-value ^a	Median of the differences (95% CI lower-upper)
	Median (min-max)	Mean (SD)	Median (min-max)	Mean (SD)		
A	79 (10–100)	74 (25)	96 (28–100)	85 (21)	–4.79	12.5 (9.0–16.5)
B	77 (2–100)	64 (33)	92 (10–100)	73 (32)	–4.86	10.0 (7.0–13.0)
C	43 (0–100)	44 (39)	56 (0–100)	52 (42)	–4.62	9.0 (6.0–13.0)
D	14 (0–100)	35 (38)	26 (0–100)	40 (39)	–4.02	6.5 (4.5–8.5)
E	7 (0–97)	29 (34)	11 (0–100)	33 (38)	–4.08	6.0 (4.0–8.5)
Total	39 (2–99)	50 (31)	49 (8–100)	57 (32)	–5.31	7.0 (5.5–8.5)

GMFM-88, Gross Motor Function Measure-88; GMFM-88-CVI, Gross Motor Function Measure-88 for children with CVI; CP, cerebral palsy; CVI, Cerebral Visual Impairment. A: lying and rolling; B: sitting; C: crawling and kneeling; D: standing; E: walking, running and jumping; Total (A + B + C + D + E); CI, confidence interval.

^a All corresponding P-values are <0.001.

all classified as GMFCS-level I and children with difference in dimensions C–E, all had a moderate intellectual disability. The children showing different percentage scores between the two versions on two dimensions had varying levels of intellectual disability and GMFCS classification.

The two children who differed in only one dimension were at GMFCS level IV and V with mild intellectual disability. Fifteen children with mild/moderate intellectual disability showed no differences in percentage score on the dimensions D and E. Seven of these children were classified as GMFCS-level I or II, and eight children were classified as GMFCS-level IV or V.

Table 3 shows the comparison between the test outcomes of the GMFM-88 and the GMFM-88-CVI for the separate GMFM dimensions. Significant differences between GMFM-88 and GMFM-88-CVI outcomes on all dimensions as well as on the Total scores were shown by the Wilcoxon signed-rank test ($p < 0.001$). When tested with GMFM-88-CVI, the children scored significantly higher on all dimensions ($p < 0.001$) compared to when they were tested with the original GMFM-88 (Table 3).

4. Discussion

The aim of our study was to investigate whether the GMFM-88-CVI for children with CP and CVI results in a higher score for gross motor function via a comparison with the original GMFM-88 in the same group of children with CP and CVI. Our study showed that the GMFM-88-CVI results in higher total scores for gross motor functioning than the original GMFM-88, hence it is a better test to assess motor capabilities per se for children with CP and CVI. The reason for the higher scores using the GMFM-88 CVI is the adaptation of the instruction of the GMFM-88-CVI. Using the adapted version of GMFM-88 reduces the difficulty of a child with CP and CVI to perform motor tasks, if CVI is present.

Difficulties associated with other impairments may also be anticipated by using the adapted version of GMFM-88. For example, a child with CP and CVI could have difficulty localising an object via vision, e.g. when he or she 'reaching for the toy', (GMFM-88, nos. 6 and 7). This child should therefore be verbally instructed on the toy's location in advance. Also, the paediatric physical therapists need to be conscious of their own body position while they invite the child to move. During motions such as rolling over (GMFM-88, nos. 8 and 9), it is important to be positioned on the side towards where the child will be rolling.

Using the GMFM-88-CVI enables a child with CP and CVI to perform a motor skill and helps the paediatric physical therapist to take more realistic measure of the gross motor function per se that is not confounded by visual impairments. For instance, to enable a child with CP and CVI to 'roll to supine over a side' (GMFM-88, nos. 14 and 15), the paediatric physical therapist used the additional instruction: 'sit on the side the child should roll towards and during the practice phase the paediatric physical therapist uses manual and verbal support (e.g. researcher's voice) to invite the child to roll towards a side'. Also, the paediatric physical therapist 'used toys that have lights, moving parts, produced sound, and/or were fluorescent/high-contrast' (Salavati et al., 2015b). As another example, CVI results in a limitation of depth perception and this causes difficulty performing a task such as 'kicking a ball with the foot' (GMFM-88, nos. 78 and 79) or 'standing on a 15-cm step, jumping off with both feet simultaneously' (GMFM-88, no. 88). The additional instructions, such as verbal and manual support, thus enable the child with CP and CVI to successfully perform the motor skills (Salavati et al., 2015b).

Generally, the additional instruction in the GMFM-88-CVI is based on the amount of manual support (e.g. duration and phase of needed manual support given), verbal support and special equipment (e.g. colourful, sound-producing, high-contrast) needed to obtain the attention of a child with CVI, in order to help the child accomplish a specific skill. The lower score using the original GMFM-88 is thus probably a reflection of visual impairment rather than motor impairment. By using the GMFM-88-CVI, the developmental level of motor performance can be monitored more accurately, which should lead to more realistic planning of appropriate level of motor skills in intervention programs. Interventions can be better adjusted to the needs and capabilities of the child, leading to increased efficacy of such programs. As a consequence, the use

of verbal or manual support by the paediatric physical therapist during the intervention will help the child to describe and accomplish an action that occurs. For example, on the 'walking, running and jumping' dimension, using special material as well as verbal and manual support helps the child accomplish the task. Additionally, a familiar environment can result in successful performance of skills, in contrast to an unknown or less familiar environment. It is therefore important to evaluate a child's level of functioning in the same environment (Salavati et al., 2015b).

The results of our previous study on comparing a group of children with CP with and without CVI (Salavati et al., 2014) showed that children with CP and CVI scored significantly lower ($p < 0.009$) on all dimensions of the original GMFM-88 than children experiencing CP without CVI. The results of our present study comparing both tests show that by using the GMFM-88-CVI children with CP and CVI score significantly higher ($p < 0.001$) on all dimensions of the GMFM-88-CVI.

We found that in all GMFM-88 dimensions the scores of the GMFM-88-CVI were higher compared to the GMFM-88. However, those differences were smaller for dimensions D and E. A possible explanation is that only children at GMFCS levels I and II are able to perform motor tasks on dimensions D and E. Children at GMFCS levels I and II usually have less severe CVI (Da Costa et al., 2004; Ghasia et al., 2008). Cerebral Visual Impairment can lead to different levels of visual acuity, ranging between blindness to relatively minor impairment of visual perception within GMFCS levels. So, it is possible that a child with GMFCS level I may have a better vision than a child with GMFCS level V. These differences in visual competence between children with different GMFCS levels might cause the small differences within the dimensions D and E. In our study, eight children with mild/moderate intellectual disability showed no differences in percentage score for dimensions D and E. These children are classified as GMFCS level IV or V. One possible explanation is that these children always have difficulty to perform motor tasks on dimensions D and E (Da Costa et al., 2004; Ghasia et al., 2008; Rosenbaum et al., 2007). In line with this, Da Costa et al. (2004) and Ghasia et al. (2008) showed that visual acuity was lowest for children at GMFCS level V and improves progressively for children at GMFCS levels IV, III, II and I. In our study, children at various GMFCS levels were represented and 11 (30%) children had GMFCS level I. It is not clear whether the large proportion of children with GMFCS level I is representative for the population. It is well possible that the presence of CVI in children with CP with GMFCS I–V received more attention in recent years and consequently more children with CP in GMFCS levels I are diagnosed of having CVI.

The results from the difference in percentage score between the GMFM-88 and GMFM-88-CVI for each child show that 10 children at GMFCS levels I and II present no or small differences on GMFM-D and GMFM-E. The reason could be that these children have fewer adverse effects from CVI when they perform motor skills such as standing or walking. These motor skills place a high demand on sustained visual attention (Dutton & Jacobson, 2001; Stiers et al., 2002).

On both GMFM-88 and GMFM-88-CVI the mean (SD) score on dimensions C–E are lower than those on dimensions A and B. This might be due to an underrepresentation of children who are able to perform the gross motor tasks needed for dimensions C–E (Table 3).

5. Limitations

The adjustment of instructions in the GMFM-88-CVI could possibly also result in higher scores for children with CP, but without CVI. In future studies, it would therefore be of interest to investigate the original GMFM-88 as well the adapted versions of the GMFM-88-CVI in children with CP without CVI.

In our study only one child with dyskinetic CP was included. This was due to limited availability of children with dyskinetic CP in the participating rehabilitation centers. Children with dyskinetic CP presents with involuntary, uncoordinated and recurring movement including times at rest. Thus, movement patterns of children with dyskinetic CP differ from those of children with spastic CP who are characterized with an increased level of muscle tone (Rosenbaum et al., 2007). For this reason, children with dyskinetic and spastic CP might not be comparable in regard to gross motor function (Salavati et al., 2014). As such, our results with predominantly in children with spastic CP cannot be generalized to children with dyskinesia. It is therefore recommended that the comparison between GMFM-88 and GMFM-88-CVI should also be examined for other motor types of CP.

Cerebral Visual Impairment is quite variable in its range from no light perception to normal visual acuity, and with cognitive visual dysfunction, a disorder of visual processing that leads to misinterpretation of the visual world with respect to either what objects are or where they are (Jane & Rod, 2006). In our study we included all types of CVI. In general, each type of CVI could result in different motor performance and outcome for the GMFM-88-CVI. It is important that future studies notice which type of CVI each included child has, therefore the paediatric physical therapist should take into account which type of CVI is present.

Furthermore, children with CP and CVI also have a lack of visual information, so they use the auditory information to better understand their environment. A highly variable visual performance during daily-life activities could result in different performances on two different testing days. To achieve reliable test results, it is important to repeat measuring motor functioning on different days. Also, a familiar environment will result in successful execution of a particular motor skill.

It is important to use the GMFM-88-CVI for children with CP when a child shows a higher level of motor functioning during the therapy but may not be able to show its motor functioning abilities during a standardised assessment of motor development.

6. Conclusion

Assessment with GMFM-88-CVI results in higher scores in children with CP with CVI that are impacted by visual problems. On the basis of these findings, we recommend using the GMFM-88-CVI to measure gross motor functioning in children with CP with CVI.

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