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Gross motor function, functional skills and caregiver assistance in children with spastic cerebral palsy (CP) with and without cerebral visual impairment (CVI)

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Abstract

Aim: To determine whether the level of gross motor function and functional skills in children with cerebral palsy (CP) and cerebral visual impairment (CVI) as well as caregiver assistance are lower in comparison with the corresponding group of children experiencing CP without CVI.

Method: Data aggregated from 23 children experiencing CP with CVI were compared with data from children with CP without CVI matched for Gross Motor Function Classification System, mental development and age at testing. Scores for Gross Motor Function Measure-88 (GMFM-88) and the Pediatric Evaluation of Disability Inventory-NL (PEDI-NL) were employed to compare the level of gross motor function, functional skills and caregiver assistance between both groups. The Wilcoxon Signed Rank Test was utilized with a significance level of $p < 0.05$.

Results: Children with CP with CVI, mean (± SD) age 6.4 ± 1.5, scored significantly lower than those with CP without CVI, mean age 6.3 ± 1.6, on all GMFM-88 dimensions and the total score ($p < 0.001$) and on the PEDI-NL in the sections of Functional Skills and Caregiver Assistance as well as in those of domains self-care ($p < 0.001$), mobility ($p < 0.001$) and social functioning ($p < 0.001$). Concerning the modifications scale, the scores for children with CP and CVI were significantly lower regarding mobility (no modification, $p < 0.05$), social functioning (no modification, $p < 0.05$) and social functioning (child-oriented, $p < 0.05$).

Conclusion: CVI contributes to diminished gross motor function and functional skills in children experiencing CP with CVI compared with children with CP without CVI. Children with CP and CVI also require increased support at the level of caregiver assistance. Specific interventions need to be developed for children experiencing CP with CVI in order to improve gross motor function, functional skills and caregiver assistance.

Key words: Neurology, occupational health/ergonomics, pediatrics, population studies
Introduction

Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, which is attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication and behavior, by epilepsy, and by secondary musculoskeletal problems (1,2). Visual disorders including cerebral visual impairment (CVI) are regularly observed in an elevated number (30–100%) of children diagnosed with the various forms of CP (3–9).

CVI can be defined as deficient visual function as a sequel of damage or malformation of the retrogeniculate visual pathways (optic radiations, occipital cortex and visual association areas) and may include deficits in central oculomotor control. CVI is a prominent sequel to premature birth, particularly when the prematurity is extreme. Considerable focus has been directed toward the detection and treatment of retinopathy of prematurity, but less attention tends to be focused on CVI, which can, as a consequence, be overlooked. Dutton et al. (9) focused primarily on profound visual impairment in children experiencing CVI, but CVI ranges in severity from blindness to relatively minor impairments of vision and perception. Perceptual visual dysfunction, reduction in visual fields and disorders of visual attention, often with only minimally reduced or normal visual acuities, are increasingly being recognized as forms of CVI as a sequel of prematurity (9–12).

Children experiencing CVI could incur difficulty at different levels such as: underdeveloped stair or curb climbing, often accompanied by the need to touch the surface with the hand; underdeveloped reaching and knocking over objects; impaired simultaneous perception manifested by an inability to locate an object in a crowded visual field such as toys in a toy box, or a parent in a crowd or difficulty reading; and difficulty seeing moving targets. Underdeveloped movements of the arms and especially the legs are compounded by bilateral inferior visual field defects and any co-existent motor deficits. They could also have problems with route finding in unfamiliar places; forgetting where objects were located; and difficulty recognizing faces, shapes or objects (12–14). More severe visual disorders have been discovered in children with spastic CP and serious motor skill limitations (5,6). However, there is no linear relationship between the presence of visual problems and the compromises in the activity level of a child (15).

Children with CP show increased visual monitoring when performing actions with the affected hand, both at the beginning and during an object transport, and this emphasizes the role of visual perception during motor action (16). CVI in children with CP might be a secondary deficit due to an impoverished environment caused by the motor limitations of the pathology that affects them. These children are significantly disabled in their physical activity, which might reduce their ability to explore their world. In addition, they often have cognitive and attention deficits associated with the motor impairment, which further reduces their experiences in general (sensory, motor, learning and memory) (5). Several studies have reported that CVI plays an essential role in motor, cognitive and emotional development (5,7,8,13). In particular, the influence that severe visual disabilities can have on motor behavior is relevant and complex, and secondary to the impairment of various areas of development. The inability to achieve normal adaptive control of posture is strongly related to maintaining dependence on sensation, mainly vision. Children with CP with CVI have specific problems with mapping between vision and proprioception (17).

Children with visual impairment have an inferior gross motor skill performance and are less physically active than their peers without visual impairment and exhibit poor performance on static and slow dynamic balance tasks (18). They have difficulty in achieving a high level of involvement in physical activity, and the development of independent walking might be more challenging for children with a visual impairment than for their normally sighted peers (18). The presence of visual impairments such as CVI may be associated with a higher Gross Motor Function Classification System (GMFCS) score (5,8). It is suggested that children with CP and CVI develop more slowly in the area of self-care when compared with children experiencing CP and without CVI (7). Although children with CP and CVI are limited in their physical activities, it is not clear to what extent CVI contributes to these limitations. Until now, no specific interventions have been implemented
for children with CP and CVI, and there is insufficient
evidence whether CP with CVI children score lower
on functional skills, though there are indications
that children with CP and CVI experience increased
limitations in gross motor function, functional skills
and caregiver assistance (5,8).

Our hypothesis is that the level of functional skills
and caregiver assistance in a group of children with
spastic CP with CVI is lower compared with a matched
group of children with spastic CP and without CVI.
We also expect that the group of children experiencing
CP with CVI exhibit a more inadequate performance
in gross motor function as laying, rolling, sitting,
crawling, walking, running and jumping.

Methods

Children enduring spastic CP with or without
CVI were recruited from Royal Visio (Center of
Expertise for Blind and Partially Sighted People, The
Netherlands) and from primary care allied health
practices. Inclusion criteria were the presence of
spastic CP and age at testing (GMFM-88 (19) and the
PEDI-NL (20,21) between 4 and 8 years.

Exclusion criteria were the presence of syndromes
(e.g. Down syndrome) in combination with CP and
hearing difficulties. Children with a (corrected) vision
< 0.3 and/or a field of vision < 30° and retinopathy of
prematurity were also excluded.

The study was approved by the Medical Ethical
Committee (METc-2010-137) of the University
Medical Center Groningen (UMCG), Groningen,
and The Netherlands. Written informed consent was
obtained from the children's parents.

The diagnosis of CP and the classification
according to the GMFCS level were aggregated from
the children's medical files and judged by a specialized
child physiotherapist. The study group consisted of
children who had been diagnosed with spastic CP as
was cited in the medical and ophthalmological files.
The diagnosis of CVI was determined based on the
results of ophthalmological, (neuro-) psychological
research and on the assessment data reported by a
developmental coach specialized in working with
children with visual impairments.

Employing a retrospective file search of data
collected between March 2007 and December 2010, we
were able to aggregate the data of 77 children. Based
on the inclusion criteria, data of 23 children with CP
and CVI (n = 11 boys) and 23 children with CP and
without CVI (n = 12 boys) were analyzed (Table I).
The children were matched according to their GMFCS
level and the type of CP (uni- or bilateral), their mental
development according to the Resing & Blok (22)
method, and the age at which the GMFM-88 (19) and
PEDI-NL (20,21) were administered. The tests were
administered by therapists, and we exploited the raw
scores of GMFM-88 (19) and PEDI-NL (20,21).

Based on the possible effect on gross motor
function, functional skills and caregiver assistance,
we also collected data regarding gender as well as
the prevalence of epilepsy and speech/language
development according to the International
Classification of Functioning, Disability and Health
for Children and Youth (23).

At the level of speech/language development, the
collected data were: d330 = speaks; d3350 = uses body
language; d3351 = uses signs and symbols; d3100 =
reacts to human voice; d3101 = understands simple
spoken messages; and d331 = babbles.

Test instruments
The GMFM-88 (19) (used for measuring gross
motor function) and the PEDI-NL (20,21) (used for
measuring functional skills and caregiver assistance)
were both recommended in the CP guidelines of the
Dutch Society of Rehabilitation Physicians (2) and,
therefore, were employed in this study.

GMFM-88 is designed to evaluate change in gross
motor function over time or with intervention for
children with CP (24,25). The 88 in the name of the test
refers to the 88 items that are investigated. They relate
to five dimensions: laying and rolling (GMFM-A);
sitting (GMFM-B); crawling and kneeling (GMFM-C);
standing (GMFM-D); and walking, running and
jumping (GMFM-E). The reliability and validity of
this test are sufficient (19,24,25). The severity of the
impairment in gross motor skills was classified in
accordance with the GMFCS into five different levels
where Level I indicates the least functionally hindered,
and Level V is the most functionally hindered (26).

The PEDI-NL (20,21,27) is a questionnaire that
evaluates the daily skills of children aged 6 months
to 7.5 years. The PEDI-NL is suited to measure both
capability (what the child can do) and performance
Gross motor function, functional skills and caregiver assistance | Chapter 2

(what the child actually does) of daily routine childhood activities in the self-care, mobility and social function domain (20,21,27). The capability of a child can be measured utilizing the three functional skills scales of the PEDI-NL. The performance of a child can be measured using the three caregiver assistance scales and modification scales of the PEDI-NL. The modification scales are measurements of environmental modifications and equipment used by the child in daily routine activities (20,21,27). The reliability of PEDI-NL is sufficient for all three scales on the three domains: self-care, mobility and social function domain (21). The PEDI-NL was developed as a discriminative and evaluative measuring instrument and is capable of recording relevant changes during a 6-month period in children with CP (20,21,27).

Statistical analyses

The partial and total scores of the GMFM-88 and the PEDI-NL were calculated and compared in order to discover (possible) differences between the children experiencing CP with CVI and those with CP without CVI. Since the distribution of the differences deviated extensively from the normal distribution, the Related Samples Wilcoxon Signed Rank Test with a significance level of $p < 0.05$ was utilized to detect possible significant differences between both groups.

Results

Table I exhibits the characteristics of the included children. The two groups were matched on GMFCS levels and mental development according to the Resing & Blok (22) method, and the age at which the GMFM-88 and PEDI-NL were administered. The children could be classified into four of the five GMFCS levels (Table I). The mean ($\pm$ SD) age of the children was $6.3 \pm 1.6$ years for the children experiencing CP without CVI and $6.4 \pm 1.5$ years for those with CP with CVI. The difference in age at testing was 0–7 months. No difference was apparent between 14 pairs concerning epilepsy, but nine pairs displayed a difference in the presence of epilepsy.

At the level of speech/language development, significant differences were evident between the two groups regarding $d330 =$ speaks, $d3350 =$ uses body

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Children with CP without CVI</th>
<th>Children with CP with CVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at testing, mean (SD) (years)</td>
<td>6.3 (1.6)</td>
<td>6.4 (1.5)</td>
</tr>
<tr>
<td>Gender (F/M)</td>
<td>12 / 11</td>
<td>11 / 12</td>
</tr>
<tr>
<td>GMFCS I (n)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>GMFCS III (n)</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>GMFCS IV (n)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>GMFCS V (n)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Speech/language development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICF-CY, $d3100 =$ reacts to human voice (n)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Speech/language development</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>ICF-CY, $d3101 =$ understands simple spoken messages (n)</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>Speech/language development</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>ICF-CY, $d330 =$ speaks (n)</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Speech/language development</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

F, female; M, male; GMFCS, Gross Motor Function Classification System; n, numbers; ICF-CY, International Classification of Functioning, Disability and Health, Child and Youth version (Dutch translation).
language and d3351 = uses signs and symbols. No differences were evident between the two on d3100 = reacts to human voice, d3101 = understands simple spoken messages and d331 = babbles (Table I).

**GMFM-88**

The children with CP and CVI scored significantly lower in all dimensions of the GMFM-88 compared with the children experiencing CP and without CVI. As otherwise stated, there was a significant difference in all gross motor functioning between the two groups. GMFM-88 dimensions: A (laying and rolling, p < 0.001); B (sitting, p < 0.001); C (crawling and kneeling, p < 0.001); D (standing, p = 0.009); E (walking, running, jumping, p = 0.002); Total (A + B + C + D + E, p < 0.001) (Figure 1 and Table IV).

Table II demonstrates that in only one matched pair was the child with CP and without CVI slower to crawl and kneel (GMFM-C) than the child with CP and with CVI.

**PEDI-NL**

The children experiencing CP with CVI scored significantly lower on the PEDI-NL in the sections on Functional Skills and Caregiver Assistance and in the domains of self-care (p < 0.001), mobility (p < 0.001) and social functioning (p < 0.001). Concerning the modifications scale, the scores for children with CP with CVI were significantly lower for mobility (no modification, p < 0.05), social functioning (no modification, p < 0.05) and social functioning (child-oriented, p < 0.05) (Figure 2, Tables III and IV).

**Table II.** Gross Motor Function Measure-88 (GMFM-88): the difference in raw score per pair between (a) children with CP without CVI and (b) those with CP with CVI.

<table>
<thead>
<tr>
<th>Pairs</th>
<th>GMFM-A (laying down and rolling)</th>
<th>GMFM-B (sitting)</th>
<th>GMFM-C (crawling and kneeling)</th>
<th>GMFM-D (standing)</th>
<th>GMFM-E (walking, running, and jumping)</th>
<th>GMFM-Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a-1b</td>
<td>0</td>
<td>3</td>
<td>12</td>
<td>74.4</td>
<td>48.4</td>
<td>31.6</td>
</tr>
<tr>
<td>2a-2b</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>31</td>
<td>20</td>
<td>11.6</td>
</tr>
<tr>
<td>3a-3b</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>41</td>
<td>47</td>
<td>21</td>
</tr>
<tr>
<td>4a-4b</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>8</td>
<td>1.5</td>
</tr>
<tr>
<td>5a-5b</td>
<td>0</td>
<td>3</td>
<td>26</td>
<td>15</td>
<td>0</td>
<td>3.4</td>
</tr>
<tr>
<td>6a-6b</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>7a-7b</td>
<td>6</td>
<td>8</td>
<td>19</td>
<td>7</td>
<td>3</td>
<td>8.6</td>
</tr>
<tr>
<td>8a-8b</td>
<td>14</td>
<td>10</td>
<td>51</td>
<td>12</td>
<td>38</td>
<td>21</td>
</tr>
<tr>
<td>9a-9b</td>
<td>6</td>
<td>30</td>
<td>53</td>
<td>18</td>
<td>10</td>
<td>23.6</td>
</tr>
<tr>
<td>10a-10b</td>
<td>4</td>
<td>25</td>
<td>50</td>
<td>38</td>
<td>8.5</td>
<td>25.5</td>
</tr>
<tr>
<td>11a-11b</td>
<td>2</td>
<td>16</td>
<td>44</td>
<td>44.5</td>
<td>20.5</td>
<td>25</td>
</tr>
<tr>
<td>12a-12b</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>6.5</td>
<td>3.5</td>
<td>4</td>
</tr>
<tr>
<td>13a-13b</td>
<td>64</td>
<td>42</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>27.5</td>
</tr>
<tr>
<td>14a-14b</td>
<td>6</td>
<td>12</td>
<td>26</td>
<td>25.5</td>
<td>9</td>
<td>15.4</td>
</tr>
<tr>
<td>15a-15b</td>
<td>37</td>
<td>62</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15.3</td>
</tr>
<tr>
<td>16a-16b</td>
<td>22</td>
<td>83</td>
<td>98</td>
<td>8</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>17a-17b</td>
<td>15</td>
<td>6</td>
<td>9</td>
<td>7.5</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>18a-18b</td>
<td>51</td>
<td>25</td>
<td>64</td>
<td>15</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>19a-19b</td>
<td>60</td>
<td>6.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>20a-20b</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>21a-21b</td>
<td>6</td>
<td>7</td>
<td>4.6</td>
<td>0</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>22a-22b</td>
<td>29</td>
<td>36.6</td>
<td>14.2</td>
<td>0</td>
<td>0</td>
<td>14.8</td>
</tr>
<tr>
<td>23a-23b</td>
<td>6</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.9</td>
</tr>
</tbody>
</table>

A negative value indicates that a child with CP without CVI received a lower score than the child with CP and CVI.
children experiencing CP with CVI and those with CP (20,21,27).

can be measured using the three caregiver assistance scales of the PEDI-NL. The performance of a child can be measured utilizing the three functional skills function domain (20,21,27). The capability of a child childhood activities in the self-care, mobility and social (what the child actually does) of daily routine child-

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Discussion

The first aim of this current study was to investigate whether the level of functional skills and caregiver assistance in a group of children with one type (spastic) of CP and CVI were lower compared with that of a matched group of children with spastic CP and without CVI. The results of our study indicated that children with CP with CVI scored lower on the PEDI scale in functional skills and caregiver assistance than children with CP without CVI. Our study demonstrated that children with CP with CVI obtained a lower score for self-care, mobility and social functioning. This could account for the limitations observed in daily activities and the slow processing and performance speed of children with CP with CVI.

This present study demonstrated that, based on a comparison of PEDI-NL scores, self-care, mobility and social functioning in the group of children with CP with CVI are significantly more affected than in the group with CP and without CVI and that this difference can be explained by the presence of CVI.

Our study demonstrated that children with CP with CVI clearly achieved lower scores in all dimensions of gross motor function including laying and rolling, sitting, crawling and kneeling, standing, walking, running and jumping (GMFM-A, -B, -C, -D and -E) in the GMFM-88 when compared with children with CP without CVI. For example, children with CP with CVI scored lower in the dimension of crawling and kneeling (GMFM). The crawling and kneeling stage is one of the most important phases in a child’s motor skill development – it is when a child begins to move from one place to another. Reduced visual information probably has significant influence on targeted movement of a child with CP and CVI (18). Lack of visual information processing could result in limited crawling and kneeling (GMFM-C).

Our study is the first study that compared a group of children with spastic CP with CVI with a matched group of children with spastic CP without CVI by exploiting the data of GMFM-88 and PEDI-NL. We

![Figure 1](image1.png)

**Figure 1.** The Gross Motor Function Measure-88 (GMFM-88). X-axis: GMFM-88 dimensions; Y-axis: GMFM-88 mean and SD of raw scores of gross motor function (GMFM-88 SD of raw score CP without CVI 21; GMFM-88 SD of raw score CP and CVI 19). *Significant difference. GMFM-88 dimensions: A (laying and rolling, p < 0.001); B (sitting, p < 0.001); C (crawling and kneeling, p < 0.001); D (standing, p = 0.009); E (walking, running, jumping, p = 0.002); Total (A+B+C+D+E, p < 0.001).

![Figure 2](image2.png)

**Figure 2.** The Paediatric Evaluation of Disability Inventory-NL (PEDI-NL, Dutch version). X-axis = PEDI-NL domains; Y-axis = PEDI-NL raw scores mean and SD of raw scores are presented. (PEDI-NL SD of raw score cerebral palsy (CP) without cerebral visual impairment (CVI) 21; PEDI-NL SD of raw score CP and CVI 9). *Significant difference. PEDI-NL domains; FS-SC (Functional Skills-Self-Care, p < 0.001); SF-M (Functional Skills-Mobility, p < 0.001); FS-SF (Functional Skills- Social Functioning, p < 0.001); CA-SC (Caregiver Assistance-Self-Care, p < 0.001); CA-M (Caregiver Assistance-Mobility, p < 0.001); CA-SF (Caregiver Assistance-Social Functioning, p < 0.001).

At the level of modifications scale, there were no significant differences between the two groups except in mobility (no modification, p < 0.05), social functioning (no modification, p < 0.05) and social functioning (child-oriented, p < 0.05).

Table III indicates that, in five pairs of children, the child with CP and without CVI experiences a developmental delay compared with the child with CP with CVI. Such a delay was discerned in the section on Functional Skills (domain self-care, three pairs; mobility, one pair; social functioning, one pair) and Caregiver Assistance (domain self-care, three pairs).

Discussion

The first aim of this current study was to investigate whether the level of functional skills and caregiver assistance in a group of children with one type (spastic) of CP and CVI were lower compared with that of a matched group of children with spastic CP and without CVI. The results of our study indicated that children with CP with CVI scored lower on the PEDI scale in functional skills and caregiver assistance than children with CP without CVI. Our study demonstrated that children with CP with CVI obtained a lower score for self-care, mobility and social functioning. This could account for the limitations observed in daily activities and the slow processing and performance speed of children with CP with CVI.

This present study demonstrated that, based on a comparison of PEDI-NL scores, self-care, mobility and social functioning in the group of children with CP with CVI are significantly more affected than in the group with CP and without CVI and that this difference can be explained by the presence of CVI.

Our study demonstrated that children with CP with CVI clearly achieved lower scores in all dimensions of gross motor function including laying and rolling, sitting, crawling and kneeling, standing, walking, running and jumping (GMFM-A, -B, -C, -D and -E) in the GMFM-88 when compared with children with CP without CVI. For example, children with CP with CVI scored lower in the dimension of crawling and kneeling (GMFM). The crawling and kneeling stage is one of the most important phases in a child’s motor skill development – it is when a child begins to move from one place to another. Reduced visual information probably has significant influence on targeted movement of a child with CP and CVI (18). Lack of visual information processing could result in limited crawling and kneeling (GMFM-C).

Our study is the first study that compared a group of children with spastic CP with CVI with a matched group of children with spastic CP without CVI by exploiting the data of GMFM-88 and PEDI-NL. We
also compared matched groups at different domains according to their GMFCS level and the type of CP (uni- or bilateral), their mental development according to the Resing & Blok (22) method, and the age at which the GMFM-88 (19) and PEDI-NL (20,21) were administered. Based on the matched control setup, this study demonstrated that CVI, indeed, causes a delay in the development of gross motor function, functional skills and caregiver assistance.

The results of our study and Schenk-Rootlieb et al. (7) and Da Costa et al. (5) demonstrate that children with CP with CVI were significantly more limited in their physical activities than those with CP without CVI. Our study confirms these results but also indicates that gross motor function and functional skills in children with CP with CVI as well as caregiver assistance are more limited compared with children with CP without CVI. The results of our study also support the conclusions of Da Costa et al. (5) and Ghasia et al. (8) that physical activities assisting in the exploration of the environment are limited in children with CP with CVI. Both Da Costa et al. (5) and Ghasia et al. (8) described a relationship between the presence of visual impairment including CVI and the presence of motor function impairment in children with CP and concluded that the presence of visual impairments such as CVI in a group of children with CP and GMFCS Levels III, IV or V is higher than in children with CP and GMFCS Levels I and II. Our study indicates that children with CP with CVI experience difficulty on all of the GMFCS levels, and CVI could occur at all GMFCS levels.

In accordance with the study of Da Costa et al. (5) and Ghasia et al. (8), we included comorbidities such as hearing problems, epilepsy, the level of mental development and speech/language development in our study because they may affect the gross motor function and functional skills in children as well as caregiver assistance for them (5,8). Therefore, we can conclude that there are many aspects of CP that could cause limitation in physical activities and CVI, indeed, could be one of the causes of limited physical activities in children with CP.

Furthermore, the current measuring instruments that are employed in rehabilitation do not consider the presence of CVI in the group of children with CP. Evidently, reliable information cannot be obtained regarding the level of functioning of children experiencing CP with CVI. Therefore, it is important that, in addition to the development of reliable measuring instruments, specific intervention programs should be developed that take into consideration the presence of CVI in children with CP.

Moreover, in the future research, it would be interesting to examine whether current management strategies for CVI would also improve gross motor function and functional skills in these children as well as their caregiver assistance (i.e. does treating CVI also treat gross motor function and functional skills?).

**Limitation**

Our study involved a specific target group, i.e. children with spastic CP who are characterized with an increased level of muscle tension. Previous studies also included children with ataxic and dyskinetic types of CP (6,8). Children with ataxic CP experience a loss of normal muscle coordination, which results in movements with abnormal strength, rhythm and precision while those with dyskinetic CP present with involuntary, uncoordinated and recurring movement including times at rest. Thus, movement patterns of children with either ataxic or dyskinetic CP differ from those of children with spastic CP. Since children with different types of CP possess varying motor performance, the inclusion of different types of CP decreases the ability to generalize research results. For this reason, children with ataxic, dyskinetic and spastic CP cannot be compared in regard to gross motor function, functional skills and caregiver assistance. Despite these results, children with spastic CP in relationship to their visual functioning could be generalized to children with ataxia or dyskinesia in future research. This needs to be investigated in other types of CP as well.

In our study, significant differences in the three levels of speech/language development were evident between the two groups. These differences may be partly responsible for the diminished gross motor function and functional skills as well as increased caregiver assistance of the group of children with CP and CVI. The other reason could be the fact that both groups were not matched at the level of speech/language development which will be significant in future research.
In our study, the presence of epilepsy was not evenly distributed between both groups of children. Epilepsy may have an impact on the visual ability, such as less visual attention, resulting in affects at the level of gross motor function, functional skills and caregiver assistance in children with CP and CVI. Future studies should take this into consideration because it may explain some of the differences between both groups in the outcome of our study.

**Recommendations**

During the treatment and supervision of this type of group of children, it is important to discover which sensory (auditory, proprioceptive, tactile, vestibular) compensation strategies a child utilizes to support his/her visual perception (28). The ability to visually perceive movement is rarely damaged in children with CVI, and it is advisable to include movement as an aid during testing and treatment (28). Additionally, support in the area of the gross motor function, functional skills and caregiver assistance are often hands-off. This group of children would benefit from hands-on and verbal support in a task-oriented environment.

Clinical experience suggests that providing verbal and manual support allows children with CP with CVI to achieve motor development milestones easier and assists them in performing daily activities. Therefore, in order to improve the level of gross motor function, functional skills and caregiver assistance, it is

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**Table III.** The Paediatric Evaluation of Disability Inventory-NL (PEDI-NL, Dutch version): the difference in raw score per pair between (a) children with CP without Cerebral Visual Impairment (CVI) and (b) those with Cerebral Palsy (CP) with CVI.

<table>
<thead>
<tr>
<th>Pairs</th>
<th>Functional skills</th>
<th>Caregiver assistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self-Care</td>
<td>Mobility</td>
</tr>
<tr>
<td>1a-1b</td>
<td>6</td>
<td>35</td>
</tr>
<tr>
<td>2a-2b</td>
<td>-1</td>
<td>14</td>
</tr>
<tr>
<td>3a-3b</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>4a-4b</td>
<td>-3</td>
<td>17</td>
</tr>
<tr>
<td>5a-5b</td>
<td>36</td>
<td>15</td>
</tr>
<tr>
<td>6a-6b</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td>7a-7b</td>
<td>33</td>
<td>19</td>
</tr>
<tr>
<td>8a-8b</td>
<td>30</td>
<td>27</td>
</tr>
<tr>
<td>9a-9b</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>10a-10b</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>11a-11b</td>
<td>35</td>
<td>19</td>
</tr>
<tr>
<td>12a-12b</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>13a-13b</td>
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<td>2</td>
</tr>
<tr>
<td>14a-14b</td>
<td>19</td>
<td>-1</td>
</tr>
<tr>
<td>15a-15b</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>16a-16b</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>17a-17b</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>18a-18b</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>19a-19b</td>
<td>3</td>
<td>14</td>
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<tr>
<td>20a-20b</td>
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<td>2</td>
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<tr>
<td>21a-21b</td>
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<td>0</td>
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<td>22a-22b</td>
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<td>17</td>
</tr>
<tr>
<td>23a-23b</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

A negative value indicates that a child with CP without CVI received a lower score than the child with CP with CVI.
important to use verbal and manual support, e.g. using slow-tempo speech while training a skill, simplifying daily tasks and presenting them in a low tempo, offering structure and predictability, and using rituals can support a child with CP with CVI in optimally performing a task. Furthermore, the use of bright colors, shiny and fluorescent material, a light source, and moving objects can help increase the child’s attention visually.

### Conclusion

Children with CP with CVI appear to be more limited in their gross motor function, functional skills, caregiver assistance and in their level of independence when performing daily activities compared with children with CP without CVI.

Children with CP with CVI clearly achieve lower scores in all dimensions of gross motor function including laying, rolling, sitting, crawling, kneeling, standing, walking and running.

The children with CP with CVI score significantly lower than those with CP without CVI on the PEDI-NL in the sections Functional Skills and Caregiver Assistance in the domains of self-care, mobility and social functioning.

Limitations in physical activities in children with CP could be caused not only by a delay in motor or mental development but also by the presence of CVI.

Therefore, it is vital that physicians, counselors and parents take into consideration that, when a child with CP exhibits a limitation of daily activities and slow processing and performance speed, it may not only stem from a delay in motor and/or mental development. He or she may be experiencing a visual impairment such as CVI.

### Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

### References


