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# Wii$^{TM}$-habilitation of upper extremity function in children with Cerebral Palsy. An explorative study

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**Abstract**

*Objective:* Commercially available virtual reality systems can possibly support rehabilitation objectives in training upper arm function in children with Cerebral Palsy (CP). The present study explored the effect of the Nintendo Wii$^{TM}$ training on upper extremity function in children with CP.

*Methods:* During six weeks, all children received twice a week training with the Wii$^{TM}$, with their most affected arm. The Melbourne Assessment of Upper Limb Function and ABILHAND-Kids were assessed pre- and post- training. In addition, user satisfaction of both children and health professionals was assessed after training. Enjoyment in gaming was scored on a visual analogue scale scale after each session by the children.

*Results:* Fifteen children with CP participated in the study. The quality of upper extremity movements did not change ($-2.1$, $p > 0.05$), while a significant increase of convenience in using hands/arms during performance of daily activities was found ($0.6$, $p < 0.05$).

*Conclusion:* Daily activities seem to be easier performed after Wii$^{TM}$ training for most of the included children with CP.

**Keywords:** *Cerebral palsy*, *virtual reality*, *upper extremity function*, *paediatric*, *rehabilitation*, *gaming*

## Introduction

Cerebral Palsy (CP), a neurodevelopmental disorder, is the most common cause of physical disabilities in children in Western countries [1]. CP is characterized by abnormal muscle tone, reflexes, motor development and coordination. Complementary to the motor constraints, other disabilities may occur such as sensory-related deficits, visual and hearing deficits, eating difficulties, cognitive function impairments, and emotional impairments. Besides problems related to postural control and lower limb function, one of the key motor impairments of children with CP is the deficit affecting their upper arm function. Limited upper-arm function means a limited ability to perform various activities in daily life independently [2].

Because of the heterogenic clinical presentation of children with CP, there are mainly general guidelines for treatment and rehabilitation [3]. According to the theory of motor control and motor learning [4] physical and occupational therapy for children with CP uses motivating, repetitive, purposeful, and task-specific training. Furthermore, it is important to integrate play and leisure aspects in therapy to support the development of children with disabilities [5]. Appealing therapy might even stimulate the transfer of therapy into daily life tasks and activities.

New technologies, like virtual reality (VR) and gaming, can play an important role in training function and functional performance. They offer possibilities for intensive and motivating training, have access to many interactive environments and are able to provide multisensory feedback. At this, VR meets important conditions for motor control and motor learning and offers play and leisure to children [6]. Using VR and gaming also invites therapists to train children together and might offer possibilities to train at home. Holden [6] stated that people with disabilities are capable of motor learning in virtual environments (VE) and that the movements learned in VE can be transferred to real world

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equivalent motor tasks in most cases. Support for the use of VR in pediatric rehabilitation was also reported in two reviews, performed by Galvin et al. [7] and Parsons et al. [8]. Galvin et al. included five studies using VR to improve hand and arm skills in children with CP [7]. Generalization of findings was limited by inconsistencies in outcome measures. Parsons et al. stated that VR treatment as rehabilitation tool is most effective for use in children with CP compared with children with autism and attention deficits [8]. Recently, in another review on VR systems with gesture-based interaction (e.g., the Eye Toy and IREX) presented the use of VR in children with CP [9]. Wang et al. [9] concluded that despite the heterogeneity in study designs, outcome measures, training intensities, and the small sample sizes, the included studies [10–17] supported the use of VR training of upper arm function in children with CP.

Commercially available VR systems, which are primarily designed for leisure, are widely used at home by children at present. Riley [18] stated that one in four children own a video game console at home, such as the Nintendo Wii™ or Sony PlayStation®. However, at this moment, it is unknown if low-cost, commercially available VR systems are applicable for achieving rehabilitation purposes, since these systems are originally developed for the healthy population. To date, the majority of studies using commercial available technologies were performed in the adult stroke population [19].

To our knowledge, the effect of training the upper arm function in children with CP using the Nintendo Wii™, has not been reported in literature until now. With exception of Deutsch et al. [20], who reported about a case study using the Wii™ as a therapeutic tool in a 13-year-old child with CP to determine the feasibility of gaming to achieve the patient's goals.

The present study examined the effect of training the upper extremity function in children with CP using the Wii™ sport games boxing and playing tennis as an intervention. The first aim was to examine the effect of Wii™ training on the quality and use of upper extremity movements during the performance of mostly bimanual daily activities. The second aim was to evaluate the user satisfaction and usability of the Wii™ computer games for, respectively, the participants and health professionals. The third aim was to observe if enjoyment in gaming persisted during the period of training.

## Methods

### *Study design*

For this explorative clinical trial, with a pre- and post-measurement, 15 children with CP were approached out of the CP population at the Roessingh Rehabilitation Centre (RRC) in Enschede. The inclusion criteria were aged between 6 and 15 years, a Melbourne assessment score of 11% and higher, being able to hold the game controller belonging to the Wii™, have normal or corrected to normal vision and hearing and being able to understand the instructions for using the Wii™. During the study, other therapies, for instance walking therapy, continued. Only if improvement of upper extremity function was a current goal for rehabilitation, this therapy was stopped during their participation. In addition, participating children were not allowed to play with the Wii™ at home during the study. The study protocol was approved by the local medical ethics committee and the parents gave their informed consent before participation.

### *Intervention*

During six weeks, children attended training with the Wii™ home video game console Sports twice a week at the RRC. Each session took 30 min in which they played both boxing and tennis for 15 min holding the controller in their most-affected arm. Two physical therapists trained all children and each child was trained by the same therapist during all sessions. The children were in a sitting or standing posture, depending on their ability. Posture was kept constant during all sessions. While playing boxing, during which both controller and nunchuck had to be used, the nunchuck was held by the physical therapist in a neutral position.

### *Primary outcome measures*

*Melbourne assessment of unilateral upper limb function.* The Melbourne Assessment, with a test–retest variability of 0.96 and inter-rater reliability of 0.95, was developed to quantify the quality of upper-limb function in children with CP aged between five and 15 years old [21–23]. The Melbourne has to be assessed and videotaped by a trained therapist after which the video has to be scored. It consists of 16 items which examined reach, grasp and release of manipulation of the affected upper limb and was assessed pre-and post training. The individual scores were summed to obtain a raw overall score after which was converted into a percentage score. At baseline, the participants were divided on practical availability of participants and time of the therapists, among two experienced independent therapists, who assessed the Melbourne and were not further involved in the training. After the training the same therapists assessed the Melbourne by the same children. The scoring of all pre- and post-videotaped Melbourne Assessments was performed by another trained and independent therapist, who also was not involved in the training.

*ABILHAND-Kids.* The ABILHAND-Kids is a functional scale developed to measure how easily daily activities are performed by children with CP (aged between 6 and 15 years old), scored by their caregivers [24, 25]. Reliability was reported 0.94 and the reproducibility over time 0.91 [24]. The ABILHAND-Kids was assessed pre- and post-training by sending the questionnaire to the caregivers, who were informed and asked to fill in and return the questionnaire. The scale consists of 21 mostly bimanual items of which the individual raw scores were transformed into measures expressed in logits. The ABILHAND-kids is significantly related to school education of the children, type of CP and gross motor function ($r = 0.91$) [24, 25].

*Secondary outcome measures*

*User satisfaction questionnaire.* The user satisfaction questionnaire was filled in at follow-up. This post-experience questionnaire for children with disabilities was developed by Jannink et al. [12] to assess user satisfaction with VR exercise games. It contains statements concerning attitudes and feelings towards VR exercise games and clarity of several aspects of VR games. It consists of 24 questions that children can answer according to a five-point Likert scale, ranging from completely disagree (1) to completely agree (5). The 24 questions are classified in presentation, level of difficulty of the games, in motivation, cognitive capability and physical effort of the player. After the last training the physical therapist asked the children the questions and noted the answers. Three questions of the original questionnaire were left out in the present study, because they were too specific about another VR game.

*Health professional usability questionnaire.* The health professional usability questionnaire is an user-centered, expert guidelines-based questionnaire based on the same VE and game heuristics as the questionnaire described above [26–28]. It contains 70 questions concerning computer experience of the health professionals, the Wii™ computer in general, menu of the Wii™, information and explanation of the games, the Wii™ computer exercise games and it offers the opportunity to make recommendations for improvements for the Wii™ computer. Most questions had to be scored on a Visual Analogue Scale (VAS), but also multiple choice and some open questions were used. It was filled in at follow-up by the physical therapists who trained the children with CP. They were asked to answer the questions with children with physical disabilities as users in mind in contrast with the healthy children.

*Visual analogue scale.* After each training session, the children scored on a VAS [29, 30], their perceived enjoyment of playing boxing and tennis, with a continuum between "no enjoyment" (score 0) and "very much enjoyment" (score 10).

*Statistical analysis*

All statistical analyses were performed with SPSS software, version 14.0. The significance level was set at 0.05 for all tests. Descriptive statistical methods were applied for patient characteristics. For both the Melbourne Assessment and the ABILHAND-Kids the two-tailed paired *t*-test was used to assess changes after training. For the ABILHAND-Kids, the raw scores were converted into a linear measure of manual ability according to the Rasch model. The user satisfaction questions were grouped in presentation, level of difficulty, motivation, cognitive abilities, and physical effort and presented in frequencies for both games. The answers on the health professional usability questionnaire were described. The experienced enjoyment, measured with the VAS, was presented at weekly mean values of all children.

## Results

*Study population*

Table 1 shows the characteristics of the participants and the differences between pre- and post-measurements on the Melbourne and the ABILHAND-Kids. Fifteen children with CP, 12 boys and three girls with a mean age of 8.9 years, participated in the study and were trained for 6 weeks. Fourteen children were diagnosed with a spastic CP type of which eight children were spastic bilateral and six children spastic unilateral diagnosed. One child was diagnosed as an atactic CP type. While most participants had Gross Motor Function Classification System (GMFCS) level I, four children had GMFCS level III. All children followed special need education of which nine children were known with learning disabilities. Seven children had a Wii™ at home.

*Upper arm function*

The mean quality of upper arm movements measured by the Melbourne Assessment was somewhat changed after the training ($-2.1$, $p = 0.112$), however not significant. Two-handed daily activities measured by the ABILHAND-Kids were significant more easily performed by the children according to their caregivers ($0.6$, $p = 0.046$). Measurements on

Table 1. Population characteristics ($n = 15$), Melbourne Assessment and ABILHAND-Kids difference and pre- and post-measurement.

| Child | Age (years) | Type CP[1] | GMFCS[2] | MACS[3] | Wii™ at home | Melb Ass[4] (%) Pre | (%) Post | (%) Δ | AB-kids[5] (logits*) Pre | Post | Δ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.11 | Spas. Bilat | III | II | Yes | 81.1 | 69.7 | −11.4 | 1.758 | 1.410 | −0.36 |
| 2 | 9.0 | Spas. Bilat | II | II | No | 79.5 | 79.5 | 0 | 0.661 | 0.852 | 0.19 |
| 3 | 13.9 | Spas. Bilat | I | I | No | 86.9 | 82.0 | −4.9 | 3.440 | 3.900 | 0.46 |
| 4 | 8.6 | Spas. Unilat | I | II | Yes | 87.1 | 78.4 | −8.7 | 0.882 | 1.384 | 0.50 |
| 5 | 8.11 | Spas. Bilat | III | II | No | 96.7 | 87.8 | −8.9 | 3.512 | 6.684 | 3.17 |
| 6 | 6.8 | Spas. Unilat | I | II | Yes | 77.0 | 76.2 | 0.8 | 1.384 | 2.395 | 1.04 |
| 7 | 8.10 | Spas. Unilat | I | II | Yes | 77.9 | 82.0 | 4.1 | 0.492 | 1.384 | 0.89 |
| 8 | 7.7 | Spas. Bilat | III | I | Yes | 71.3 | 73.8 | 2.5 | 1.203 | 0.509 | −0.69 |
| 9 | 9.7 | Spas. Unilat | I | II | Yes | 82.0 | 87.7 | 5.7 | 2.172 | 1.449 | −0.72 |
| 10 | 13.6 | Spas. Unilat | I | II | No | 86.9 | 86.9 | 0 | 1.923 | 2.894 | 0.97 |
| 11 | 14.6 | Spas. Unilat | I | I | No | 84.4 | 87.7 | 3.3 | 2.172 | 3.183 | 1.01 |
| 12 | 10.1 | Atactic CP | I | II | Yes | 91.8 | 87.8 | −4 | 1.838 | 3.512 | 1.67 |
| 13 | 9.11 | Spas. Bilat | III | II | No | 96.7 | 92.6 | −4.1 | 3.397 | 2.395 | −1.00 |
| 14 | 8.0 | Spas. Bilat | I | I | No | 89.3 | 82.8 | −6.5 | 1.384 | 2.395 | 1.01 |
| 15 | 7.5 | Spas. Bilat | I | I | No | 65.6 | 65.6 | 0 | 0.004 | 0.852 | 0.85 |
| $N = 15$ | Range 6.8–14.6 | | | | | | | Mean (SD[6]) −2.1**(5.2) | | | Mean (SD[6]) 0.6***(1.1) |

Notes: [1]Cerebral Palsy.
[2]GMFCS.
[3]Manual ability classification system.
[4]Melbourne assessment.
[5]ABILHAND-Kids.
[6]Standard deviation.
*logits = natural logarithm of the odds of success (the pass/fail probability ratio).
**$p > 0.05$.
***$p < 0.05$.

the ABILHAND-Kids also showed that three of the four children with a GMFCS level III scored less after training.

*User satisfaction*

Table 2 shows the answers of the user satisfaction questionnaire. Both boxing and tennis games were easily understood and attractive for all children. Playing tennis was experienced as difficult by four children and boxing was reported as difficult by two other children. Seven children found boxing and playing tennis too easy, while all 15 children were motivated for playing boxing and tennis together with other children. Eleven children had more fun playing boxing and 13 children experienced more fun playing tennis compared to their regular therapy. Fourteen children wanted to continue playing boxing and tennis. Eleven children sensed more physical effort during boxing and nine children during playing tennis compared to regular physiotherapy.

*Health professional usability*

Both physical therapists involved in the training sessions were experienced in using a computer and knew the games Wii™ Sports. At the questions about the Wii™ computer in general they stated that Wii™ games could be used best and was most desirable for training arm and trunk movements and balance, whereas training of hand movements seems less obvious. The therapists suggested that besides training the children with CP, the Wii™ could be used also for training children with neuromuscular diseases and developmental coordination disorders. The Wii™ could be used both in therapy and at home according to both therapists. The service of the Wii™ computer cannot be tuned to an individual level, which would be especially preferable for the velocity and the predictability of the game. They were positive about the feedback of the game during playing and both therapists mentioned that it would be desirable to have the possibility for children to play together. The menu of the Wii™ was easy for the professionals and less easy, but still possible, for the children. Also, it was mentioned that the game instructions would be better understandable if they were readable in Dutch instead of English. For the explanation of the games they both preferred a virtual therapist, who should demonstrate the game and react on the performance of the player. The games seemed to involve the children easily, had auditive and visual moderate feedback, seemed easy to learn and were average to win, but of the two

Table 2. User satisfaction questionnaire: answers in frequencies ($n = 15$).

| | Boxing | | | | | Tennis | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| *Wii ™: presentation* | | | | | | | | | | |
| I could see all things in the game very well | – | – | – | 2 | 13 | – | – | – | 2 | 13 |
| I found the moving things/objects in the game very interesting | – | – | – | 3 | 12 | – | 1 | – | 1 | 13 |
| The things I saw in the game were very attractive | – | – | – | 2 | 13 | – | 1 | – | – | 14 |
| The game reacted good on my movements | 1 | 4 | – | 1 | 9 | 2 | 1 | 1 | 3 | 8 |
| I could hear all sounds very well | 1 | 1 | – | 1 | 15 | – | – | – | 1 | 14 |
| The sounds I heard out of the game were very attractive | – | 3 | – | 4 | 8 | – | 1 | 1 | 4 | 9 |
| I could not hear where all sounds out of the game did come from | 11 | 1 | 1 | 1 | 1 | 8 | 4 | – | 1 | 2 |
| *Wii ™: level of difficulty* | | | | | | | | | | |
| The game was too hard | 12 | 1 | – | 1 | 1 | 10 | 1 | – | 4 | – |
| I still must learn a lot, before I can play this game very well | 14 | – | – | – | 1 | 7 | 2 | – | 1 | 5 |
| I had the feeling I could win | – | – | – | 1 | 14 | – | 1 | – | 3 | 11 |
| The game was too easy | 5 | 2 | 1 | 1 | 6 | 2 | 6 | – | 3 | 4 |
| *Player: motivation* | | | | | | | | | | |
| I would find it nice if I could play the game together with more children at the same time | – | – | – | – | 15 | – | – | – | – | 15 |
| I liked it that the game was getting more difficult | 1 | 1 | 1 | 4 | 8 | 1 | – | 1 | 4 | 9 |
| The game was so attractive that I lost all count of time | 2 | 1 | 1 | 4 | 7 | – | 3 | 1 | 1 | 10 |
| I would not like to play this game more often | 10 | 4 | – | – | 1 | 13 | 1 | 1 | – | – |
| Wii™ training is less fun than regular physiotherapy | 8 | 3 | 2 | 1 | 1 | 10 | 3 | 1 | 1 | – |
| *Player: cognitive capability* | | | | | | | | | | |
| This game was easy to understand | – | – | – | 3 | 12 | – | – | – | – | 15 |
| This game was easy to play | 1 | 1 | – | 3 | 10 | 1 | 2 | – | 7 | 5 |
| It was very logical playing the game by moving my arm/hand | – | – | – | 2 | 13 | – | – | – | 1 | 14 |
| My experience with playing the game looks like real life playing | 5 | 1 | – | 1 | 8 | 5 | 1 | – | 1 | 8 |
| *Player: physical effort* | | | | | | | | | | |
| I found it hard to play the game by moving my hands | 9 | 1 | – | 5 | – | 6 | 2 | – | 6 | 1 |
| I became more tired from this game than from the regular physiotherapy | 3 | 1 | – | 2 | 9 | 4 | 2 | – | 2 | 7 |
| By playing the game, I learned new movements | 7 | 1 | – | 3 | 4 | 7 | 1 | – | 2 | 5 |
| I think I could learn new movements, by playing the game more often | 6 | 1 | – | 2 | 6 | 6 | – | – | 1 | 8 |

Notes: 1 = completely disagree.
2 = slightly disagree.
3 = neutral.
4 = slightly agree.
5 = completely agree.

games playing tennis took more time to understand and learn. Tiredness of the children seemed for both therapists equal to regular physical therapy.

*Enjoyment*

Figure 1 shows the weekly mean VAS scores of the perceived enjoyment of the children during the 6-week intervention period. The mean VAS scores of all children were high (>8) and stayed high during the six weeks of training. Occasionally, some children experienced less enjoyment during gaming.

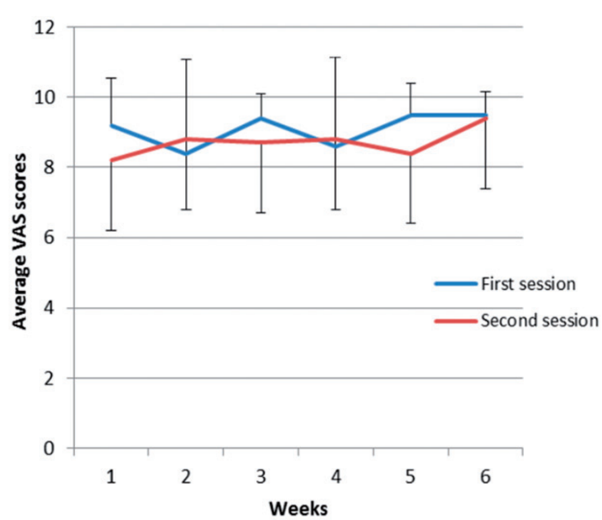


Figure 1. Average VAS scores of experienced enjoyment with error bars positive for the first session and negative for the second session.

## Discussion

The primary aim of this study was to examine the effect of Wii™ training on the upper extremity function in children with CP. A significant increase of convenience in performance of daily activities was found. The secondary aim was to evaluate user satisfaction and usability of the Wii$^{TM}$ computer games by both participants and health professionals and the third aim was to evaluate the perceived enjoyment by the participants in gaming. Both participants and health professionals were mainly positive about playing boxing and tennis with the Wii$^{TM}$. All children showed a high level of enjoyment, which persisted during the period of training.

No change of upper extremity function in some of the participants on the Melbourne was mentioned in the EyeToy® study of Jannink et al. [12]. Also in the present study, no change in mean score on the Melbourne Assessment was found. To be able to play the Wii$^{TM}$ games for therapeutic purposes, participants needed both a minimal score of 11% on the Melbourne Assessment and the possibility to hold the game controller. However, relatively high Melbourne scores were found at baseline, which made it more difficult to improve upper extremity function. When looking at the results, seven of the 15 included children with CP showed a worsening on the Melbourne Assessment. All these subjects showed a relatively higher score on the Melbourne Assessment at baseline ($>80\%$). Children with CP with a much-affected upper extremity function, indicated by a lower Melbourne Assessment score at baseline, showed an improvement of their upper extremity function after training. So it seems that children with CP who are more disabled are more appropriate for training their upper extremity function with a commercial available gaming device.

A significant positive development in performance of daily activities of the children was identified. This supports the idea that playing boxing and tennis with the Wii$^{TM}$ meets requirements for motor learning and motor control. The children with CP who had a Wii$^{TM}$ at home mentioned that they played the games mostly with their less disabled arm. This study indicates that playing games with the most disabled arm benefits the performance of daily activities. In spite of the significant result found on the ABILHAND-Kids, four of the 15 children with CP showed a reduced score after training. However, no trend was found in the data as was found for the Melbourne Assessment.

The significant relation of the ABILHAND-kids with type of CP and gross motor function [24, 25] predicts that performance of daily activities is getting more difficult in children with CP with a higher GMFCS level and CP type spastic bilateral. Remarkably, in the present study two children with a higher GMFCS level and spastic bilateral had high ABILHAND-kids scores at baseline. We found no explanation for that. Also remarkable were the decreased scores at the ABILHAND-kids after the training in three of the four children with a GMFCS level III and CP-type spastic bilateral. Possibly a subjective bias may have been involved by filling in the ABILHAND-kids, a self-report questionnaire.

All approached children decided to participate in this study. Reid et al. [31] and Harris et al. [32] already reported about the positive influence of VR on playfulness and motivation of children with CP. The high VAS scores found in this study showed the enjoyment of the children during playing the games (Figure 1). Perceived enjoyment in playing tennis and boxing even kept high in two children with GMFCS level III and spastic bilateral, who had decreased scores after training on the Melbourne Assessment and the ABILHAND-Kids.

The incidental low scores of six of the children on the VAS were due to pain (two children), loss of the game (two children), and having a bad day (two children). During the first sessions of the intervention two children reported pain around their shoulder and elbow while playing boxing. In later sessions, this pain was not mentioned anymore by them. Harrison [33] already mentioned that Wii$^{TM}$ boxing is quite strenuous for those not accustomed to vigorous upper arm exercise.

Evaluation of the user satisfaction showed that most children could win the boxing game; winning the tennis game was more difficult for most of them, which was due to the velocity and fine-tuning possibilities of the game. Although commercially available games are not developed specially for children with CP, they invite children to move, to play, and win. The user questionnaire also showed that all children were motivated to play together with other children the games, what could promote their social interaction. It seems obvious that a child with CP with more (physical) limitations has insufficient possibilities to play commercially available games. Therefore, specially developed games could be preferred for more disabled children with CP. An important application of virtual gaming environments in rehabilitation games is the possibility to adapt the training environment to the individual situation of the child. Additionally, the motivation and attention can be enhanced by applying positive feedback within these rehabilitation games, such as awarding points when a movement has been performed correctly [34].

The sensed physical effort during playing games, which most of the children reported as more than during regular physical therapy, was not in correspondence with the scores given by the physical therapists. This might be due to enthusiasm and motivation of the children what could have made that they sensed more effort. In future studies, it would be interesting to measure physical effort during gaming in comparison to regular therapy. For health professionals, VR and gaming can be a strong motivating rehabilitation tool that also can be used to support therapy at home, to increase intensity of training and a possibility to let children play together during therapy.

## Limitations and future developments

The present study was limited by the absence of a control group and the small sample size, so conclusions have to be drawn with caution. Also, the generalizability is limited since most of the participants were children with CP with a moderate hand function and reasonable upper arm function (GMFCS level I and a MACS II score).

Although clear instructions were given to both the children and their parents about not using the Wii™ at home during their participation to the present study, children were still able to use the Wii™ at home in theory. However, since all children reported to use their non-affected arm during gaming, it was not expected that this would have influenced the present study results.

Recommendations for future research on upper extremity function of children with CP would be a controlled study, in which also children can participate with a more affected upper extremity function. Therefore, commercial available game devices will be necessary without using a controller, like the Xbox 360 Kinect, or specially developed rehabilitation games to train the arm- and hand function.

## Conclusion

The present study supports the use of VR and gaming as a motivating rehabilitation tool for increasing the functional performance of the upper arm of most children with CP. This could stimulate more independent performance, of mostly two-handed, daily activities. The Wii™ Sports, a commercially available technology, motivates to move and seems suitable to support rehabilitation goals in some of the children with CP. In general, the Wii™ does not take the limitations of all children with CP enough into account. Therefore, specially developed rehabilitation games are preferred for more disabled children with CP.

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The ABILHAND-Kids questionnaire and its administration instructions can be downloaded from www.rehab-scales.org in English, French, and Dutch. The website allows raw scores to the ABILHAND-Kids questionnaire to be converted into a linear measure of manual ability according to the Rasch model.

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