Balance training using specially developed serious games for cerebral palsy children, a feasibility study

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ABSTRACT

Cerebral Palsy (CP) leads to various clinical signs mainly induced by spasticity. Among these ones impaired balance and posture are very common. Traditional physical therapy exercise programs are focusing on this aspect but it is difficult to motivate patients to regularly perform these exercises. Specially developed serious games (SG) could therefore be an interesting option to motivate children to perform specific exercise for balance improvement. This paper presents a feasibility study including 10 CP children. Patients received 4 sessions of SG included into conventional therapy. Trunk control and balance were assessed using Trunk Control Motor Scale (TCMS) before and after intervention. Children presented a significant improvement in TCMS after interventions (37,6 (8.7) and 39.6 (9.5) before and after intervention respectively, p=0.04). SG could therefore be an interesting option to integrate in the conventional treatment of CP children.

Keywords

Balance, Motor control, Rehabilitation, Cerebral palsy.

1. INTRODUCTION

Balance and posture control are important for functional activities of daily living. Cerebral palsy (CP) children have poor postural balance control compared to typically developing children due to slowed and impaired development of neural motor control mechanisms together with the common secondary musculoskeletal abnormalities (e.g. muscle spasticity, bone deformations…) [1]. Balance training is an important part of rehabilitation of CP children because it has been shown that there is a relation between constraints on balance control and functional limitations of CP children [2]. Specific balance training exercises integrated into rehabilitation programs could therefore modify postural balance by increasing postural muscle control and increasing range of motion of the trunk [2][3]. One of the most frequent reasons cited for patient dropout is lack of motivation [4]. Video games could be an interesting option to introduce new exercises in rehabilitation and therefore fight against patients' demotivation [5]. Commercial video games (e.g. Nintendo Wii Fit™) have been recently tested as a supplementary treatment for CP children with encouraging results on balance and on motivation [6]. However, these games are primary designed for fun and not for rehabilitation, therefore for some patients (heavily disabled) or specific pathologies it is not possible to integrate them in rehabilitation. Specific games must be developed, based on clinical schemes, to be (successfully) used in rehabilitation [7]. The aim of this study was to test if specially developed serious games can be integrated in the treatment of CP children and if they can have an influence on the balance.

2. MATERIAL AND METHOD

Ten CP children (10 ± 3 years old, GMFCS 1.7 (0.8), 4 girls) participated in this study. Participants were included in this study if they were diagnosed with spastic CP, aged between 5 and 15, GMFCS I to III and having sufficient cognitive level to understand how to play the games. Exclusion criteria were having a trunk support, behavioral disorders, orthopedic interventions or botulinum toxin injections in the last six months, intrathecal baclofen. This study was approved by local ethical committee and informed consent was obtained from parents and children.

Five specific games have been developed (Fig. 1, movies of the games can be seen on http://www.youtube.com/ict4rehab). All these games are controlled with a Nintendo Wii Balance Board (WBB) linked to computer via Bluetooth. One game (Balls see Fig. 1D) is controlled with a WBB and a Kinect sensor. Patients played all games seated on the WBB (see Fig. 2). These games are based on relevant clinical schemes and highly configurable. It is thus therefore possible to adjust games' setting in order that every patients, regardless the severity of the disability, is able to control and play the games [8].

Four sessions of games (once a week) were integrated into conventional physical therapy. Children played each game for 3 minutes with two minutes rest between. The duration of the session, including installation, was about 30 minutes what is the average duration of a physiotherapy session.

Two different approaches are available to assess balance (e.g. diagnosis, evaluation of a treatment): quantitative evaluation using force plates [9] or qualitative evaluation using a clinical scale [10]. Balance assessment before and after interventions were done using the Trunk Control Measurement Scale (TCMS) [10].

This scale was chosen because it allows to study balance in sitting position. TCMS is subdivided into three categories: static sitting balance, dynamic sitting balance and dynamic reaching.

Wilcoxon signed-rank test were computed to compare scores.

PervasiveHealth 2014, May 20-23, Oldenburg, Germany

DOI 10.4108/icst.pervasivehealth.2014.255332

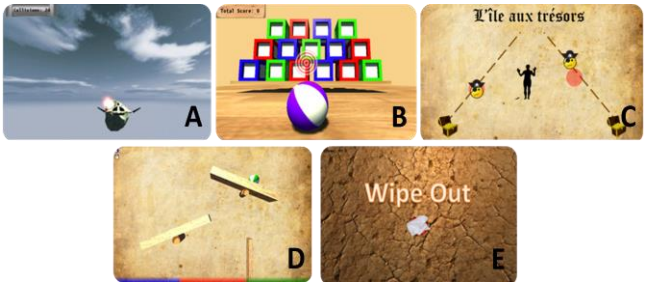

Figure 1. Specially developed games. A: Flight simulator (lateral translation of center of pressure (CoP)), B: hit the boxes (lateral translation of CoP), C: Follow me (oblique translation of CoP), D: Balls: (lateral translation of CoP), E: Wipe out (translations in all direction of CoP).

3. RESULTS

Results of the TCMS and statistics before and after interventions are presented in Table 1.

Table 1. Mean (std) TCMS before and after intervention. P-values are the results of Wilcoxon signed-rank test.

TCMS	Before	After	P-value
Static sitting (/20)	16.8 (3.4)	17.7 (3.4)	0.031
Dynamic sitting (/28)	12 (6.2)	13 (6.9)	0.156
Dynamic reaching (/10)	8.8 (1.3)	8.9 (1.3)	1
TOTAL (/58)	37.6 (8.7)	39.6 (9.6)	0.047

Significant improvements were found for static sitting (increase of 0.9 points (out of 20) after intervention, p=0.031) and for total score (2 points (out of 58) after intervention, p=0.047). No difference was found for dynamic sitting (p=0.156) nor for dynamic reaching (p=1).

4. DISCUSSION

The first aim of this study was to see if it is possible to integrate specially developed balance games into conventional treatment of CP children. All ten children who participated in this study had 100% attendance for the 4-weeks period. This study indicates that these games can be used in rehabilitation of CP children with GMFCS levels I to III.

We observed a statistical significant overall change of 2 points (3.5%) on the TCMS following the 4-week training period. The TCMS is separated into three different categories: we observed significant changes (increase of 5%) only in the static sitting subsection although the games required dynamic control of the trunk. For the dynamic sitting we observed an increase of 8% but this difference was not significant (p=0.156). Contrariwise the games and/or the protocol used in this study seem to have no effect on the dynamic reaching.

Results of this study are difficult to compare with previous ones because it appears that the methodology used (number and duration of the session) and the different type of games played (commercial one or specially developed) varied significantly between studies. Eight studies [11][17] were found in the literature about the use of Nintendo Wii Fit™ (commercial solution) in the treatment of CP children, the number of sessions varied from 1 to 24! The outcomes: balance (scale or score), GMFCS, physical activity level… and the results (from significant improvement to no effect) are also different. There are less papers about the use of specially developed games for CP children. One study has tested an intensive program (5 consecutive days of training, 90 minutes a day) with CP children classified GMFCS I. The authors observed significant improvement in mobility and function and these results were maintained one month after the intervention [18]. Only four subjects were included in this study, therefore results have to be interpreted carefully.

This is a feasibility study, therefore major limitations of this study were the small number of subjects included in the study (10) and the relative small number of sessions (4 sessions of 30 minutes). Due to the absence of a control group, it is not possible to say if the observed changes are due to the games or due to the increase of training (two hours of supplementary training).

Future works is needed in order to evaluate the potential of this new approach. A lot of questions have still to be answered: what type of patients (e.g. hemiplegic, diplegic…) will the most benefit from this support? What is the best frequency and duration of the session? What is the best use of the WBB (some potential uses are presented in Figure 2)? Are there any adverse effects (compensations)?

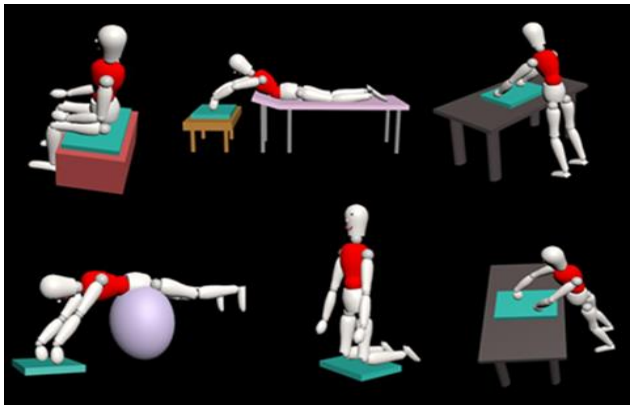

Figure 2. Different potential uses of the WBB during the games (configuration used in this study is sited on the WBB [upper left corner])

5. CONCLUSION

The presented method including a series of mini-games seems to be an interesting supplementary method to be added in the treatment of CP children. Patients enjoyed playing and did not experience any difficulties to play the games because those games are specially adapted for this pathology. It appears that even after only four sessions the presented method has a beneficial impact on the posture of CP children.

6. ACKNOWLEDGMENTS

This study is a part of the ICT4Rehab project (www.ict4rehab.org). This project is funded by Innoviris (Brussels Capital Region). Thanks to Miss Anna Mavriki for the picture.

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