An exploration of the concept of using the Nintendo Wii for balance training in patients with paraplegia

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ABSTRACT

The objective of this study was to explore whether a patient with a high level and one with a low level of paraplegia could interact successfully with the boxing programme on the Nintendo Wii and whether there would be improvements in their seated functional reach distance when this activity replaced their regular balance training activities. Two participants with spinal cord injuries classified as ASIA A and neurological levels T4 and T12 were trained twice per week for six weeks with the boxing programme on the Wii sport disc. This complemented their regular strength training activities, which were done in fully supported positions (prone, supine or supported sitting). Both participants were able to engage fully in the game with no falls. They both indicated that they enjoyed the interaction. The participant with the T4 injury was unable to reach forward at the start of the training but at the end, he obtained a reach distance of 6.78 cm. The participant with the T12 injury had an initial reach of 8.38 cm and a final reach of 16.94 cm. The boxing game on the Nintendo Wii appears to be a feasible balance training tool for use in the management of patients with both high and low levels of spinal cord injury. The movements that occurred during training were very similar to those that are emphasised with traditional balance exercises. Further investigation with proper controls is required to determine the effectiveness of this type of intervention.

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INTRODUCTION

The incidence of traumatic spinal cord injuries for Western Europe, Australia and North America has been found to range from 15 to 39 per million, with the major cause being collisions involving four-wheeled motor vehicles (Cripps et al 2011). Regaining good-seated balance is important for patients with paraplegia so as to become independent in all transfers and activities of daily living. Early in the rehabilitation process, physiotherapists work on a range of activities, which challenge the patient to maintain an upright posture when the centre of gravity is displaced outside the base of support.

Virtual reality training is a dynamic form of exercise, which allows the users to interact with displayed images, move and manipulate virtual objects, and perform other actions in a way that engenders a feeling of actual presence and immerses their senses in the simulated environment (Kizony et al 2005). This type of training holds significant potential for improving sitting balance in patients with spinal cord injuries in a more interactive and engaging fashion compared to traditional methods.

Betker et al (2007) showed that the use of a centre of pressure controlled video game led to a decrease in falls in two patients with paraplegia and a patient with a traumatic brain injury. The system required the patients to shift their weight until their centre of pressure was aligned with a specific target. This resulted in a reduction in falls and all participants indicated that the exercises were more fun than other balance exercises performed during the rehabilitation process. Kizony et al (2005) explored the use of another virtual reality system on balance in patients with paraplegia during the early rehabilitation period. Participants were engaged in three different gaming activities, all of which encouraged shifting of the centre of gravity outside the base of support. Participants all showed an improvement in response time; however, the correlation between their functional reach scores and virtual reality performance was moderate. All participants indicated a high degree of enjoyment and presence in the virtual environment.

Even though there is limited research related to use of virtual reality systems in spinal cord rehabilitation, studies investigating the use of virtual reality training in other adult and paediatric neurological conditions have shown significant positive improvements on a range of physical outcomes including posture, balance, locomotion, and upper and lower extremity function (Braynton et al 2006, Brüsch et al 2010, Chen et al 2007, Jack et al 2001, Merians et al 2002, Reid and Campbell 2006, Saposnik et al 2010, Sveistrup et al 2003, Viau et al 2004, You et al 2005). In addition to the changes in physical function one study showed virtual reality induced cortical reorganization in patients with stroke (You et al 2005). Improvements in visual-perceptual and spatial function have also been reported (Akhutina et al 2003, Deutsch et al 2008).

Patient motivation is not a fully understood concept in rehabilitation; however, it is thought to be an important contributor to patient outcome (MacLean 2000). Patients with traumatic brain injury who participated in a virtual reality based balance exercise programme expressed a greater degree of enjoyment, more confidence in their functional abilities, a greater degree of awareness of their balance, and more improved self esteem compared to those who participated in an activity based programme (Thornton et al 2005). Children with Spina Bifida, who participated in an ergometry programme augmented with a video game system, indicated that the task

was more enjoyable and provided greater motivation to exercise than regular arm ergometry (Widman et al 2006). Most of the studies reviewed previously also indicated that patients expressed enjoyment of the activity when engaged in virtual training environments.

Much of the research conducted to date has utilized systems that are relatively expensive for individual purchase and for treatment facilities in developing countries. Studies utilizing low cost commercial gaming systems have produced positive results (Deutsch et al 2008, Joo et al 2010). The Nintendo Wii® (Nintendo, Redmond, Washington) is one such device, which offers a wide range of physical activities. Many of the games can easily be played from a seated position and if utilized properly can encourage significant shifting of the trunk to the limits of stability. This study explored whether a patient with a high level (T4) and one with low level (T12) of paraplegia could interact successfully with the boxing programme on the Nintendo Wii and whether there would be improvements in their seated balance. The boxing game on the Wii sport disc was utilized for training since it could be done in sitting and it allowed for active interaction with the gaming software and hardware whilst maintaining balance and coordination, observing cues, adjusting to the situation, and responding to feedback on performance as indicated by the outcome of the matches.

METHODS

A pilot pretest posttest study was conducted at the physiotherapy department of the Sir John Golding Rehabilitation Centre in Kingston, Jamaica after ethical approval was obtained from relevant committees. Training was conducted in a gym setting and the participant with the T12 injury was placed in an unsupported sitting position on a large treatment bed with feet resting flat on the floor. The participant with the T4 injury was placed in a similar position, however a backboard which provided support at an eighty-degree angle from the bed was placed approximately 7.6 cm behind him so he could easily lean back when he needed to rest. A gait belt was placed around the pelvis and a therapist was positioned behind the participants to prevent possible falls resulting from a loss of balance while playing. For additional safety, thick cushions were placed all around the participants. The Nintendo Wii system was connected to a Dell multimedia projector and images were projected onto a large screen that was placed approximately 1.8 metres in front of the participants.

Participants

The first two patients admitted to the rehabilitation facility who met the following criteria were included: had a spinal cord injury at the level of T2 or lower with American Spinal Association (ASIA) Scale classification A to D, was medically stable, had been attending physiotherapy for at least four weeks, and signed an ethically approved informed consent form for participation in the study. Patients with orthopaedic impairments that could hinder upper extremity function were excluded.

The first participant was a 19 year old male who sustained a gunshot wound to the cervical spine. Diagnostic imaging showed a compression fracture at T2. He spent four weeks at an acute care facility after which he was placed on a waiting list for rehabilitation and was discharged to his home environment. While at home, he had no physical therapy treatment. Four months later, he was admitted to the rehabilitation centre where he began his physiotherapy treatment. On admission to the rehabilitation centre, he was classified as ASIA A. His neurological level was T2, with partial preservation of sensation up to T4. His total motor score was 50/100, total pin prick score was 40/112, and total light touch score 44/112.

Participant 2 was a 27 year old male who had sustained gunshot injuries to the left side of the neck and thorax. Diagnostic imaging showed damage to the colon and pancreas in addition to fractures of the T10 and T12 vertebrae. He was managed in an acute care facility for five months, after which he was discharged from hospital. Two months later he was admitted to the rehabilitation centre. On admission to rehabilitation, he was classified as a complete spinal cord injury (ASIA A). His neurological level was T12. His total motor score was 50/100 and his sensory score was 76/112 for both pin prick and light touch. Neither participant had problems with pain or muscle spasm during the training period.

Procedure

The modified functional reach test described by Lynch et al (1998) was used to assess seated balance. The instrument has been shown to have good test-retest reliability in patients with spinal cord injuries (Lynch et al 1998). Participants sat on a narrow treatment bed with 5.08 cm of clearance between the popliteal fossa and the bed. The hips, knees, and ankles were positioned in ninety degrees of flexion, and a backboard was used to support the spine such that the trunk was at an eighty-degree angle from the bed. This backboard also allowed the participants to rest their trunk between trials. A levelled yardstick was attached horizontally to a wall at the height of the participant's acromion. The dominant arm was used as the reaching arm and the ulnar styloid was used as the anatomical landmark to measure reach. The participants were allowed to use the non reaching upper extremity for counterbalance only (no weight bearing or holding on was allowed). They were instructed to raise their dominant arm to ninety degrees, reach as far forward as they could without losing their balance and then return to the start position with their back against the backboard. The reach distance was recorded. Participants were monitored and guarded for safety at all times. The trial was repeated if they required assistance to return to the backboard. Each participant was given two practice trials following which three test trials were conducted. The mean of these three trials were recorded as the initial reach score. After six weeks of training the reach test was repeated. Testing was done by an independent therapist.

Following the baseline assessments participants were familiarised with the use of the Nintendo Wii and testing was done to determine the level of training at which they should start and whether any external assistance was required. The next day training began. Training sessions lasted for forty-five minutes and two sessions were conducted per week for a total of six weeks. Patients were engaged in other upper body strength and endurance training activities; however, these were all done in supported positions (prone, supine, and supported sitting). The training on the Nintendo Wii replaced all balance activities that were part of their routine training. Both participants trained at the beginner's level for the entire duration of the programme.

RESULTS

Both participants were able to interact successfully with the programme and there were no occurrences of falls during the training. Participant 1 (T4 injury) was very cautious while playing the game. Both participants indicated that they enjoyed the training programme. It was noted that participant 2 (T12 level) was more enthusiastic and engaged in the game as opposed to participant 1. On further questioning, he indicated that he liked boxing whereas participant 1 had no interest in the sport. Both participants had a mild degree of soreness in the shoulder muscles from the training, but this was no different from the normal degree of soreness that occurs when engaging in a new level of physical activity. This soreness resolved completely by the fourth session.

Participant 1 (T4 injury) was unable to reach forward at the start of the training but at the end he obtained a reach distance of 6.78 cm. Participant 2 (T12 injury) had an initial reach of 8.38 cm and a final reach score of 16.94 cm.

DISCUSSION

A spinal cord injury results in significant impairment of the proprioceptive input from the joints and this combined with varying degrees of muscle paralysis lead to patients having to develop other methods for maintaining balance. The Nintendo Wii boxing game was a completely new stimuli and training environment for both participants in this study. The system provided both visual and auditory feedback and in addition, there was the added component of drive to win the matches. These factors possibly contributed to the improvements seen in the participants.

It was not surprising that the participant with the higher level injury was more cautious during play since his core muscles were non functional and therefore his stability limits would have been be more constrained. Data from Lynch et al (1998) showed that participants with T1 to T4 paraplegia have significantly lower functional reach scores that those with a T10 to T12 injury when measured at one month into their rehabilitation programme.

At the start of this study, the participants had already completed one month of rehabilitation; however, it was noted that their reach distances were outside of the range reported by Lynch et al (1998) (14.7 - 22.9 cm; mean 22.9 cm SD 5.6 cm for participants T10 to T12) and (7.6 – 21.3 cm; mean 15.5 cm SD 4.3 cm for participants T1 to T4). At the end of training the reach distance for participant 2 was within the range recorded by Lynch et al; however, the values for participant 1 remained slightly outside of this range. Even though both studies recorded data for participants who were one month into their rehabilitation programme, it was unclear how long post injury measurements were done in the study by Lynch et al.

The participants in this study were five and seven months post injury. Neither participant had any rehabilitation treatment during the waiting period for admission to the rehabilitation centre; therefore, generalised deconditioning could explain why their baseline values were outside the range reported by Lynch et al (1998). Participant 1 was not particularly interested in boxing and it was noted that the effort he put into the game was much less than participant 2. This together with the higher level of his injury could account for the lower degree of improvement with training. Even though the concept of patient motivation is not well understood, it does have an impact on rehabilitation outcomes (MacLean et al 2000).

It is not certain what proportion of the improvements in balance was due to the regular strength training programme as opposed to the training on the Nintendo Wii; however, studies have shown that in order to improve balance, treatment activities need to be task specific (Buchner et al 1997, Dean and Shepherd 1997, Schlicht et al 2001). Strength training of the lower limbs in elderly populations did not improve standing balance (Buchner et al 1997, Schlicht et al 2001). In patients with stroke, significant improvements in seated balance occurred when activities were task specific and involved reaching outside of the base of support. Reaching activities that involved no shifting of the base of support led to zero improvements in sitting balance (Dean and Shepherd 1997). In order to improve balance, treatment activities must focus on displacing the centre of gravity and this was done with the use of the boxing game on the Nintendo Wii. All strength training activities in this study were done with the patients in fully supported positions and did not require any shifting outside the base of support.

Clinicians must continually challenge themselves to develop innovative treatment techniques that will result in high compliance, but will also be effective in developing patients' neuromuscular capabilities. Patients become bored with stereotyped routines and once they have particular levels of functioning, the drive to continue begins to decrease. Both participants in this study were highly compliant with the training. One participant liked boxing and it was noted that he was a lot more engaged in the programme than the other participant. This indicates the importance of considering patients' interest when selecting treatment activities. There are a wide range of games for the Nintendo Wii and it would be useful to explore the use of patient selected games on balance. From this study, it was noted that both patients were constantly moving and reacting in a manner that would have challenged their balance systems indicating that the use of the Nintendo Wii could be added to current balance training activities.

Neither of the patients in this study had previous exposure to playing computer games and even though this was not a focus of the study, it was noted that they were both rapidly able to learn to navigate the system with no assistance from the therapist. An added advantage of the Nintendo Wii is that it can allow for multiple users to interact and compete with one another at the same time. With the growing demand to improve patient function in the shortest time possible and reduce length of stay in inpatient facilities, this system could be explored as an option for group training in inpatient settings, community based interventions, and patient self-treatment.

A primary goal of therapy is to facilitate maximal return to function through various means. The results of this pilot study suggests that the boxing game on the Nintendo Wii is a feasible balance training tool for patients with spinal cord injuries; however, well controlled clinical trials need to be conducted to determine whether it is an effective balance training tool. Future studies should also consider the impact on functional outcomes and self-efficacy, and include an objective means of assessing enjoyment.

CONCLUSION

The Nintendo Wii boxing game is feasible for use as a balance training tool in patients with high and low levels of paraplegia, but its effectiveness needs to be investigated.

KEYPOINTS

- Patients with both high and low levels of paraplegia are able to interact successfully with the boxing programme on the Nintendo Wii.
- The Nintendo Wii appears to have the potential to be a useful tool for seated balance training in the patients with spinal cord injuries.
- There is a need for clinical trials to be conducted to determine whether the boxing game on the Nintendo Wii is an effective balance training tool in the early rehabilitation phase for patients with paraplegia.

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