Human Movement Science 29 (2010) 1023–1038

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Exploring children's movement characteristics during virtual reality video game play

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ARTICLE INFO

Article history:
Available online 17 August 2010

PsychINFO classification:
2330
3380

Keywords:
Pediatrics
Virtual reality
Motor processes
Motivation
Rehabilitation

ABSTRACT

There is increasing interest in the use of commercially-available virtual reality video gaming systems within pediatric rehabilitation, yet little is known about the movement characteristics of game play. This study describes quantity and quality of movement during Nintendo Wii and Wii Fit game play, explores differences in these movement characteristics between games and between novice and experienced players, and investigates whether motivation to succeed at the game impacts movement characteristics. Thirty-eight children (aged 7–12) with and without previous game experience played Wii (boxing and tennis) and Wii Fit (ski slalom and soccer heading) games. Force plate data provided center of pressure displacement (quantity) and processed pelvis motion indicated smoothness of pelvic movement (quality). Children rated their motivation to succeed at each game. Movement quantity and quality differed between games ($p < .001$). Children with previous experience playing Wii Fit games demonstrated greater movement quantity during Wii Fit game play ($p < .001$); quality of movement did not differ between groups. Motivation to succeed did not influence the relationship between experience and outcomes. Findings enhance clinical understanding of this technology and inform the development of research questions to explore its potential to improve movement skills in children with motor impairments.

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doi:10.1016/j.humov.2010.06.006

1. Introduction

The application of virtual reality systems as therapeutic interventions to improve movement abilities in children with motor impairments is a promising area of research in pediatric rehabilitation (Parsons, Rizzo, Rogers, & York, 2009; Sandlund, McDonough, & Hager-Ross, 2009). Virtual reality is defined as "the use of interactive simulations created with computer hardware and software to present users with opportunities to engage in environments that appear to be and feel similar to real world objects and events" (Weiss, Rand, Katz, & Kizony, 2004). Yet the substantial cost and commercial unavailability of immersive virtual reality systems, which may include head-mounted displays or force feedback gloves, limits the applicability of this complex technology within mainstream clinical practice (Rizzo & Kim, 2005). In contrast, motion-capture virtual reality systems in which the user's image is reflected within the virtual environment, or the user is represented as an avatar within the virtual environment, may offer more promise for integration on a wider scale. Many motion-capture systems have been designed specifically for rehabilitation purposes (Weiss et al., 2004). However, researchers are increasingly investigating the feasibility and effectiveness of lower-cost, commercially available technologies, such as virtual reality video gaming systems, as potential rehabilitation interventions (Chen et al., 2007; Deutsch, Borbely, Filler, Huhn, & Guarrera-Bowlby, 2008; Flynn, Palma, & Bender, 2007; Halton, 2008; Jannink et al., 2008).

The Nintendo Wii and Wii Fit[2] are interactive and movement-based virtual reality video gaming systems that are being used within a variety of rehabilitation settings (Coyne, 2008; LaViola, 2008; Tanner, 2009; The Associated Press, 2008; Zyga, 2007). In these systems, the player is represented through a third person point of view as an avatar within the virtual environment. A hand-held remote measures users' movements, which are translated onscreen; the remote detects changes in acceleration and orientation and the system adjusts feedback accordingly (Deutsch et al., 2008). Wii Sports games such as tennis and baseball involve movement and use of the remote controller in ways that are similar to completing the actions in real life (Deutsch et al., 2008). The Wii Fit is a pressure-sensitive balance board on which players weight shift to control their avatar's movement on screen. The Wii remote provides haptic feedback and games provide abundant visual and auditory feedback, opportunity to compete against multiple players, high quality graphics, and games with a pre-set progression in difficulty levels (Deutsch et al., 2008). Recent advances in Wii technology, such as new movement-based options (Wii Sports Resort, which includes games such as archery, canoeing, and basketball (Nintendo Inc., 2009)) and an addition to the remote (Wii MotionPlus, which increases the accuracy of three-dimensional motion capture (Nintendo Inc., 2009)) suggest that continual upgrades to this gaming system may motivate long-term rehabilitation use.

A 2008 case study in *Physical Therapy* outlining the use of the Wii Sports games in the rehabilitation of an adolescent with CP is the first peer-reviewed report to evaluate this gaming system (Deutsch et al., 2008). This study describes how outcomes of visual perceptual processing, balance, and functional mobility improved after using the Wii in eleven training sessions over a two month period. The authors provide a detailed description of each of the five Wii Sport games and their training modes. They also outline the potential therapeutic uses of the games as well as a qualitative description of movements required by the user during game play (Deutsch et al., 2008).

As these games have only recently been introduced to clinical practice, rehabilitation professionals may still be uncomfortable with the notion of using video games to promote movement abilities in children with motor impairments. Therapists seeking information to support their clinical decisions may benefit from a better understanding of the "active ingredients" of these interventions (Whyte & Hart, 2003). Whyte and Hart (2003) argue that the content and mechanisms of rehabilitation interventions have rarely been objectively defined, and that their active ingredients, which are the essential components of an intervention that are hypothesized to relate to its outcomes or effects, are often poorly understood. Of fundamental interest to therapists are the movement opportunities offered by Wii and Wii Fit game play. The motivational element of including video games within interventions is also of appeal. Therefore, potential active ingredients of use of these gaming systems within motor

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