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A comparison of the upper limb movement kinematics utilized by children playing virtual and real table tennis

Amy Bufton, Amity Campbell, Erin Howie, Leon Straker *

School of Physiotherapy and Exercise Science, Curtin University, Perth, Western Australia, Australia

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ABSTRACT

Active virtual games (AVG) may facilitate gross motor skill development, depending on their fidelity. This study compared the movement patterns of nineteen 10–12 yr old children, while playing table tennis on three AVG consoles (Nintendo Wii, Xbox Kinect, Sony Move) and as a real world task. Wrist and elbow joint angles and hand path distance and speed were captured. Children playing real table tennis had significantly smaller (e.g. Wrist Angle Forehand Real-Kinect: Mean Difference (MD): −18.2°, 95% Confidence Interval (CI): −26.15 to −10.26) and slower (e.g. Average Speed Forehand Real-Kinect: MD: −1.98 m s^{-1}, 95% CI: −2.35 to −1.61) movements than when using all three AVGs. Hand path distance was smaller in forehand and backhand strokes (e.g. Kinect-Wii: MD: 0.46 m, 95% CI: 0.13–0.79) during playing with Kinect than Move and Wii. The movement patterns when playing real and virtual table tennis were different and this may impede the development of real world gross motor skills. Several elements, including display, input and task characteristics, may have contributed to the differences in movement patterns observed. Understanding the interface components for AVGs may help development of higher fidelity games to potentially enhance the development of gross motor skill and thus participation in PA.

* Corresponding author at: School of Physiotherapy and Exercise Science, Curtin University, GPO Box U1987, Perth, Western Australia 6845, Australia. Tel.: +61 08 9226 3634.
E-mail address: L.Straker@curtin.edu.au (L. Straker).

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1. Introduction

Regular participation in physical activity (PA) is important for children's health and development – improving bone mineral density (Janz et al., 2010), reducing the risk of obesity, improving cardiovascular function, providing psychological benefits (Australian Government: Department of Health and Ageing, 2010) and enhancing the development of gross motor skills (McKenzie, Alcaraz, & Sallis, 1998). Reduced participation in PA can lead to poorer gross motor skills which in turn can lead to reduced confidence and motivation to participate in PA (McKenzie et al., 1998), Conversely, poor motor skills during childhood have been associated with physical inactivity in adults (Lloyd, Saunders, Bremer, & Tremblay, 2014), thus creating a vicious cycle of physical inactivity and poor motor skills (Straker et al., 2011). As a result of this symbiotic relationship between motor skills and PA participation, there is an urgent need to develop motor skill proficiency in all children (Barnett et al., 2013). Physical education in schools has traditionally been used to develop motor proficiency in children, though physical education alone may no longer afford adequate opportunities for skill development (Barnett et al., 2013). Thus, alternative opportunities for motor skill development are needed.

Electronic games are played by the majority of children. For example 85% of Australian 5–14 yr olds played electronic games outside of school hours (Australian Bureau of Statistics [ABS], 2012) and 87% of American households owned some form of electronic game (Rideout, Foehr, & Roberts, 2010). American 8- to 18-year olds spend an average of 1 h and 13 min playing electronic games each day (Rideout et al., 2010) and there has recently been a large increase in the time children spend playing electronic games (~300% increase from 1999 to 2009) (Rideout et al., 2010). Traditional sedentary games require only key pressing for game play and there is concern that the substantial and growing exposure to these sedentary games is displacing real world PA and thus contributing to the aforementioned vicious cycle of poor gross motor skill and low PA (Straker et al., 2011). However, a new generation of electronic games requires large body movements during play and may provide an alternative opportunity for motor skill development (Papastergiou, 2009). Active virtual reality games (AVGs), played on commercially available consoles such as Nintendo Wii (Kyoto, Japan), Microsoft Xbox Kinect (Redmond, USA), and Sony Move (Tokyo, Japan) are currently popular. One benefit of AVGs is they are generally accepted as motivational for children, which in turn might lead to regular play and increased repetition of motor skill practice (Levac et al., 2010). It is largely assumed that this AVG training will lead to real world skill improvement (Rose et al., 2000). However, limited research exists on how motor skills during AVG play may transfer to real world skills.

Transfer of learning is a widely utilized principle relating to education, rehabilitation and skill acquisition. Contradictory theoretical interpretations of the cognitive process associated with transfer have been posited (Newell, 1989; Thorndike & Woodworth, 1901). However, in the case of skill acquisition, the importance of 'task constraints' is highlighted across multiple theories (Davids, Button, & Bennett, 2008; Newell, 1989). For example, the dynamic systems theory suggests that motor skill development is a non-linear process, involving movement systems, in response to individual, environmental and task constraints (Davids et al., 2008). In the context of task transfer, as the constraints vary, the performer will adapt their movement in order to achieve the same desired outcome (Davids et al., 2008). One way to assess the similarity of constraints is the individual's resulting behavior (Ackerman & Cianciolo, 2002). Therefore the fidelity of the constraints in an AVG could be assessed by comparing the resulting movement pattern with a real world task.

The specificity of training principle supports that improvement will arise from repetition of a similar movement (Barnett, Ross, Schmidt, & Todd, 1973). It is proposed that performance will be optimal when the task acquisition and later repeated task performance are similar in terms of task constraints (Barnett et al., 1973; Newell, 1989). Several studies have demonstrated that regular use of Wii Fit can improve measures of motor performance in children with balance impairment and cerebral palsy (Jelsma, Geuze, Mombarg, & Smits-Engelsman, 2014; Jelsma, Pronk, Ferguson, & Jelsma-Smit, 2013). It is unknown whether typically developing children may successfully train motor skills using commercially available AVG and the large range of games that currently replicate physical world sporting games. Additionally, no study to date has measured the movement kinematics during AVG play and