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Human pelvis motions when walking and when riding a therapeutic horse

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A prevailing rationale for equine assisted therapies is that the motion of a horse can provide sensory stimulus and movement patterns that mimic those of natural human activities such as walking. The purpose of this study was to quantitatively measure and compare human pelvis motions when walking to those when riding a horse. Six able-bodied children (inexperienced riders, 8–12 years old) participated in over-ground trials of self-paced walking and leader-paced riding on four different horses. Five kinematic measures were extracted from three-dimensional pelvis motion data: anteroposterior, superoinferior, and mediolateral translations, list angle about the anteroposterior axis, and twist angle about the superoinferior axis. There was generally as much or more variability in motion range observed between riding on the different horses as between riding and walking. Pelvis trajectories exhibited many similar features between walking and riding, including distorted lemniscate patterns in the transverse and frontal planes. In the sagittal plane the pelvis trajectory during walking exhibited a somewhat circular pattern whereas during riding it exhibited a more diagonal pattern. This study shows that riding on a horse can generate movement patterns in the human pelvis that emulate many, but not all, characteristics of those during natural walking.

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1. Introduction

Motor practice and the repetition of cyclic motions are important for the establishment, development, reinforcement, and improvement of neural and motor pathways (Casady & Nichols-Larsen, 2004; Damiano, 2006; Miller et al., 2010; Willoughby, Dodd, Shields, & Foley, 2010). Therapeutic intervention programs that emphasize repetitive practice of skilled activities or cyclic motions such as walking may be helpful for many types of neurological disorders including those associated with cerebral palsy, stroke, spinal cord injuries, and other central nervous system disorders (Damiano, 2006; Ketelaar et al., 2001; Miller et al., 2010; Willoughby et al., 2010). Such therapies may be administered through manual assistance of a therapist (Geiger, Allen, O'Keefe, & Hicks, 2001; Shurtleff, Standeven, & Engsberg, 2009; Tecklin, 2007) or through assistance with various mechanical devices such as exercise machines (Dodd, Taylor, & Damiano, 2002; Miller et al., 2010), treadmills (Damiano, 2006; Miller et al., 2010; Stanger & Oresic, 2003; Willoughby et al., 2010), or even robots (Hogan et al., 2006; Miller et al., 2010; Veneman et al., 2007).

Equine assisted therapy (EAT) is another therapeutic treatment strategy that emphasizes repetitive motion. Also called hippotherapy, these treatment programs are designed by a licensed health professional and include time riding on a horse as part of an integrated intervention strategy (American Hippotherapy Association, 2010). These programs use the cyclic, multidimensional motion of a horse and the resulting patient responses to help achieve functional outcomes for patients with a wide variety of neuromusculoskeletal dysfunctions including cerebral palsy, sensory integration disorders, traumatic brain injury, stroke, and others (American Hippotherapy Association, 2010). There is growing, quantitative evidence in the literature supporting the benefits of EAT for regulating muscle tone and improving range-of-motion, spasticity, muscle symmetry, balance, postural control, and other abilities (Benda, McGibbon, & Grant, 2003; Casady & Nichols-Larsen, 2004; Debuse, Chandler, & Gibb, 2005; Hamill, Washington, & White, 2007; Lechner et al., 2007; McGibbon, Benda, Duncan, & Silkwood-Sherer, 2009; Shurtleff et al., 2009; Silkwood-Sherer, Killian, Long, & Martin, 2012; Silkwood-Sherer & Warmbier, 2007).

The rationale often cited in support of EAT is the theory that the horse induces in the rider's body a repetitive, cyclic pattern of motion that is similar to that of natural human walking (Beinotti, Correia, Christofoletti, & Borges, 2010; Benda et al., 2003; Bertoti, 1988; Biery, 1985; Casady & Nichols-Larsen, 2004; Hammer et al., 2005; McGibbon, Andrade, Widener, & Cintas, 1998; Miller, 2007; Quint & Toomey, 1998; Riede, 1988; Wheeler, 2000). Qualitatively this theory seems reasonable since the rider sits on the horse's back near the pelvis, and the horse's pelvis is driven largely by movement of its hind limbs when walking. Subjectively, simple observation of a person walking and a person riding a horse reveals that both exhibit translations in, and rotations about, the three principal axes. However, scientific studies to quantify similarities between walking and riding motions are scant. Numerous studies have reported on human pelvis kinematics during natural walking (e.g., Lamoreux, 1971; Thurston & Harris, 1983; Whittle & Levine, 1999; Zhao, Zhang, Wang, & Wang, 2005). Other studies have reported human pelvis kinematics during horseback riding, but these tend to involve professional riders during dressage (Münz, Eckardt, Heipertz-Hengst, Peham, & Witte, 2013), trotting (Lagarde, Peham, Licka, & Kelso, 2005), or walking on a treadmill (Byström, Rhodin, von Peinen, Weishaupt, & Roepstorff, 2010). To our knowledge, only Fleck (1992) has measured and compared both walking and riding kinematics in a single study.

Fleck (1992) studied the body motions of 24 healthy children while walking on a treadmill and while riding on a horse that was walking on an equine treadmill. She reported measurement ranges in the sagittal and frontal planes of lateral pelvic displacement, lateral pelvic list angle, and the vertical displacement of the estimated body center of mass. Her results showed similarities between walking and riding for the pelvic tilt angle, the directions of displacements, and the timing sequences of stride, but also showed differences in the magnitudes of displacements. The Fleck (1992) study provides an initial foundation for examining the theory that riding motions are similar to walking motions. However, the study presented only the ranges of a few kinematic measures, and did not look at the temporal characteristics or phase sequencing of those measures. Also, only a single horse was included in the riding trials, and these trials were performed on an equine treadmill (Fleck, 1992).