THE EFFECT OF EQUINE-ASSISTED THERAPY ON GAIT FOR AN INDIVIDUAL WITH A SPINAL CORD INJURY

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Abstract

The purpose of this study was to examine the effects of participation in equine-assisted therapy for an individual with a spinal cord injury. This study examined one male participant (age = 33 years) with an incomplete level C3-C4 spinal cord injury and spastic paresis. The participant completed two therapeutic horseback riding programs, each lasting 6 weeks, with an approximately 5-month break between the programs. His walking gait was analyzed before and after each of two riding sessions, which occurred on a weekly basis during the riding programs. Walking gait was analyzed using Dartfish™ video software before and after each of two separate riding sessions. The variables measured included stride length and width (meters), ankle, knee, and hip angles (degrees) at heel strike and toe-off. All joint angle were measured in the sagittal plane. The results revealed improvements in range of motion for both the left and right ankle angle (15° changes or greater). There was a slight decrease in right hip angle at heel strike (7°) across riding programs, and a decrease in stride length (0.2 m). Based on these results for the current participant, equine-assisted therapy may be used as an effective treatment to maintain mobility and walking gait for some individuals with spinal cord injury.

Keywords: *gait analysis; therapeutic horseback riding; hippotherapy; spinal cord injury*

Introduction

The Professional Association of Therapeutic Horsemanship International (PATH Intl.) uses the term *equine-assisted therapy* to describe all forms of therapy that include the assistance of a horse. One of the most common forms of equine-assisted therapy is commonly referred to as therapeutic horseback riding. Therapeutic horseback riding has been defined by PATH Intl. (2014) as the use of equine-assisted activities to achieve therapeutic goals with a focus on teaching horsemanship skills (Gilliland & Knight, 2012). Bertoti (2003) claims the equine-assisted benefits occur because the gait of the horse replicates the normal human gait for the rider, which involves hip and pelvic rotation, weight shift, and proprioceptive stimulation.

Positive effects on spasticity and muscle symmetry from participation in equine-assisted therapy have been claimed for individuals with spinal cord injury and cerebral palsy (Benda, McGibbon, & Grant, 2003; Lechner, Kakebeek, Hegemann, & Baumberger, 2007; MacKinnon et al., 1995; McGibbon, Benda, Duncan, & Silkwood-Sherer, 2009; Sterba, Rogers, France, & Vokes, 2002). Gilliland and Knight (2012) found therapeutic horseback riding yielded positive benefits to a participant with Friedreich's ataxia. Over the course of two 6-week therapeutic riding sessions, held 5 months apart, the participant with Friedreich's ataxia did not demonstrate the noticeable changes in his gait that would have commonly occured as the disease progressed (Gilliland & Knight, 2012). A recent study reported that therapeutic horseback riding also yielded positive results for a female adult participant with Down syndrome (Coffey, Knight, & Wax, 2015). This current case study was conducted simultaneously with the two previously mentioned studies (Coffey et al., 2015; Gilliland & Knight, 2012) to identify the potential benefits to gait from participation in equine-assisted therapy for an individual with a spinal cord injury. Information from this case study will help determine if the benefits from participation outweigh the potential risks.

This study also used Dartfish video solutions (Alpharetta, GA) to analyze the participants' walking gait as opposed to a traditional three-dimensional motion capture system. Dartfish only requires the use of a single video camera, which makes the set up much easier in a setting such as a riding arena. Dartfish can measure two-dimensional kinematics and is much cheaper than a three-dimensional motion capture system (Khadilkar et al., 2014). It was used by the current authors to measure two-dimensional gait kinematics of a participant with Friedreich's ataxia both before and after therapeutic horseback riding. A recent study measured hip and knee angles in the sagittal plane using Dartfish during a functional lifting task. The authors reported good reliability and stated that the results of the study support the use of Dartfish to measure two-dimensional kinematics in a clinical setting (Norris & Olsen, 2011). Another study examined the walking gait of children with cerebral palsy using both Dartfish and traditional video. The authors reported that the use of Dartfish improved interrater reliability, and that video software such as Dartfish is a useful tool to evaluate gait patterns of clinical patients (Borel, Schneider, & Newman, 2011). Others studies have reported that Dartfish is a reliable motion analysis tool for measuring shoulder kinematics (Khadilikar et al., 2014; Melton, Mullineaux, Mattacola, Mair, & Uhl, 2011). In general, several studies have reported that when compared to more traditional motion capture systems, Dartfish is reliable at measuring both lower and upper extremity kinematics (Borel et al., 2011; Khadilkar et al., 2014; Melton et al., 2011; Norris & Olsen, 2011.), and it is a more cost-efficient option than a high-speed three-dimensional motion capture system (Khadilkar et al., 2014).

Case Study

Method

Participant

This paper presents a single case study of a 33-year-old male with the clinical diagnosis of incomplete C3-C4 spinal cord injury with spastic paresis. He is classified as quadriplegic, but claims to have more right hemiplegic involvement than left. The participant suffered a fracture/dislocation of his C3-C4 cervical vertebrae in July of 1993. His original Abbreviated Injury Scale (AIS-Code) was 5, which indicates a critical injury and a 50% probability of death. The participant underwent a posterior cervical exploration and foraminotomy at the C3-C4 level, and an anterior cervical microdiskectomy and fusion at the C3-C4 level. At the time of injury he was classified as a quadriplegic, but has since shown great improvement. Since his diagnosis, he has been involved in a variety of physical therapies, and has been participating in therapeutic horseback riding for five years. He currently uses a cane to help with walking and balance. Written consent was obtained from the participant for the participation in this study and to have the results and conclusions published. The protocols were developed to conform to the Human Subjects Review Board of the researchers' university.

Study

The data for this study was collected at the same time as the data for two previously published studies examining a participant with Friedreich's ataxia (Gilliland & Knight, 2012) and a participant with Down syndrome (Coffey et al., 2015), therefore the methodology is the same. Similar to those studies, the primary purpose of this study was to analyze the participant's walking gait before and after each riding session, and to analyze any biomechanical changes that may have occurred over the course of two separate six-week riding sessions, approximately five months apart.

Variables

The participant's walking gait was recorded with a Sony™ Handycam™ (Sony Corporation, Tokyo, Japan) digital camcorder and analyzed using Dartfish (Alpharetta, GA) video software solutions. Dartfish is a motion analysis software that is used to analyze motion in two dimensions. The camcorder was set up on a tripod approximately 8 feet behind the walking surface that the participant was going to walk over. Ankle angle, knee angle, hip angle (degrees), and stride length (meters) were all measured. The participant performed two trials (pre- and posttest) per weekly session over a six-week span in both sessions. The participant's gait was recorded prior to and following a 45-minute riding session. Stride length was defined as the distance in meters from left heel strike to left heel strike. The measurement of the ankle angle, knee angle, and hip angle was consistent with the techniques used to measure these angles in previous studies (Coffey et al., 2015; Gilliland & Knight, 2012; Norris et al., 2011). To mark specific anatomical locations, a piece of white athletic tape was placed over the 5th metatarsal head, lateral malleolus, lateral femoral epicondyle, greater trochanter, and acromion process bilaterally. All angles were measured using Dartfish (Figure 1). For the ankle angle, a line was drawn connecting the marker on the lateral femoral epicondyle to the marker on the lateral malleolus (lower leg), and a second line was drawn from the marker on the lateral malleolus to the marker on the 5th metatarsal (foot). The ankle angle was the angle between these two lines. To measure the knee angle, a line was then drawn connecting the marker on the greater trochanter to the marker on the lateral femoral epicondyle (thigh), and a line was drawn connecting the marker on the lateral femoral epicondyle to the marker on the lateral malleolus (lower leg). Knee angle was the angle between these two lines. To measure the hip angle, a line was drawn connecting the marker on the acromion process to the marker on the greater trochanter, and a second line was drawn connecting the marker on the greater trochanter to the marker on the lateral femoral epicondyle. Hip angle was the angle between these two lines. The calculation of these angles can be seen in figure one. Two gait cycles were analyzed with the participant's left leg closest to the camera, and two gait cycles were analyzed with the participant's right leg closest to the camera; both views were in the sagittal plane. These values were then averaged for each trial. All measures were conducted in an indoor riding arena in hard-packed dirt.

Figure 1. An example of calculated joint angles using Dartfish video solutions software

Figure 2. An example of calculated joint angles using Dartfish video solutions software

Experimental Design

The experiment was designed to examine the participant's gait characteristics both before and after each therapeutic horseback riding session, and over the course of two programs. The experimental design was the same as that of the Coffey et al. (2015) and the Gilliland and Knight (2012) studies; for more details, please refer to those studies. Each riding session involved the riding gaits of walk and trot completed as independently as possible for the rider. After the participant arrived at the horseback riding center, his walking gait was recorded prior to his therapeutic riding session. The participant walked a straight line of 20 meters, turned around, and walked back to the starting position. The participant walked across the arena surface, which consisted of hard-packed dirt. The participant was instructed to walk at a self-selected comfortable walking pace. After completing the first gait session, the participant completed a 30- to 45-minute therapeutic horseback riding session. After the riding session was complete, the participant dismounted from the horse and walked back over to the data collection area, which was approximately 20-30 feet from where the riding session occurred. The participant was allowed a short break (up to 5 minutes) after completing the riding session before his second gait trials were recorded, but most days he did not need one. Since this study involved one participant, only descriptive statistics were reported.

Results

The results revealed observed differences (15° or greater) in left ankle angle at heel strike and toe off, with an increase in ankle angle for pre- and posttests of the second riding session when compared to the pre- and posttests of the first riding session for both variables. There were also differences in the second session compared to the first session for the pre- and posttest of right ankle angle at heel strike and toe off, indicated by an increase in ankle angle for the second session pre- and posttests compared to the first. Differences were also seen in right hip angle at heel strike, with a decrease in the angle for both the pre- and posttest of the second riding session compared to the pretest of the first riding session. There was also a noted difference (0.08 m or greater) in stride length, with a decrease in stride length for the posttest of the first session, pretest of the second session, and posttest of the second session when compared to the pretest of the first session. The means and standard deviations are presented in tables 1 and 2.

Application

Individuals with spinal cord injury are commonly caught in a deconditioning cycle, in which physical functioning deteriorates from inactivity and leads to an even greater reduction in physical activity (Washburn & Figoni, 1999). The participant in the current case study became actively involved in his recovery shortly after his accident, and has remained active through participation in therapeutic horseback riding. Increases between 16-23° were made in ankle angle for both the right and left legs across the two riding sessions. This is a positive finding since increases in spasticity are often reported among patients with spinal cord injury (Lechner, Kakebeek, Hegemann, & Baumberger, 2007), and the current participant demonstrated an increase in range

Table 1
Mean (+ SD) stride length during the different testing sessions

Variable	First Session Pretest	First Session Posttest	Second Session Pretest	Second Session Posttest
Stride Length	*0.91 (.02) m	0.83 (.05) m	0.78 (.10) m	0.71 (.07) m

Table 2
Mean (+ SD) stride length during the different testing sessions

Variable	First Session Pretest	First Session Posttest	Second Session Pretest	Second Session Posttest
Left Ankle Angle at Heel Strike	*112.30 (4.40)°	113.66 (8.02)°	128.98 (3.70)°	135.47 (8.85)°
Left Ankle Angle at Toe Off	*131.04 (7.88)°	130.74 (7.43)°	152.84 (9.72)°	150.96 (13.64)°
Right Ankle Angle at Heel Strike	*115.36 (2.92)°	116.62 (5.83)°	130.06 (7.16)°	132.54 (9.08)°
Right Ankle Angle at Toe Off	*121.68 (6.95)°	109.28 (1.62)°	143.98 (9.53)°	135.52 (10.28)°

of motion at the ankle. The participant did demonstrate a decrease in stride length between the pre- and posttests, and between the first and second riding sessions. This decrease in stride length would increase his stability by reducing the amount of time he spends in single leg stance. It would, however, cause a slight decrease in mobility. It is possible that this decrease in stride length occurred for the post riding sessions due to fatigue.

Range of motion only noticeably decreased at the right hip at heel strike. Therefore, therapeutic horseback riding was beneficial in maintaining range of motion at most joints and increasing range of motion at some joints, which would increase mobility for this participant. Through the use of physical activity and therapeutic horseback riding, the participant in the current case study has either regained or maintained his current level of function. The specific cause of this mechanism is not currently known, but should be investigated with future research.

Although the reliability of the kinematic variables measured using Dartfish in the current study were not measured, Dartfish has been proven to be reliable in previous studies (Borel et al., 2011; Khadilkar et al., 2014; Melton et al., 2011; Norris & Olsen, 2011). In the present study, it would have been very difficult to set up a multiple camera motion capture system at the riding arena to collect kinematic data. By using Dartfish, the set up for data collection was much easier, and it allowed the researchers to record the participant's walking gait immediately before and after his horseback riding session. Dartfish also allowed for the analysis of these variables at a much faster rate. Based on this study and previous studies (Borel et al., 2011; Coffey et al., 2015; Gilliland & Knight, 2012; Khadilkar et al., 2014; Melton et al., 2011; Norris & Olsen, 2011), Dartfish can be a powerful tool for conducting a clinical analysis in a nontraditional setting, such as a horse riding arena.

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