

THE EFFECTS OF THERAPEUTIC HORSEBACK RIDING ON BALANCE

by

Susan Keel Anderson

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Director of Thesis: Dr. David Loy, LRT/CTRS

Major Department: The Department of Recreation and Leisure Studies

The purpose of this study was to determine the effects of therapeutic horseback riding as a therapeutic intervention to improve the balance of thirty individuals who participated in a Professional Association of Therapeutic Horsemanship International (PATH) therapeutic riding member program. The study lasted ten weeks, with each participant receiving the intervention for thirty minutes, once a week. The Multi-Directional Reach Test (MDRT) (Newman, 2001) was used as an instrument to quantify balance before and after the first intervention, the beginning of the second intervention, and after the last intervention. The therapeutic riding program began with active arm movements to encourage stretching, and required two forms of external perturbations involving at least three transitions, and the completion of at least one figure eight to challenge balance of riders with disabilities. This quasi-experimental study used a one-group pretest-posttest design to examine the effects of therapeutic horseback riding on balance. Paired t-tests and repeated measures ANOVAs were used to examine a relationship between therapeutic horseback riding and balance. The discussion presents practitioner applications and research implications.

THE EFFECTS OF THERAPEUTIC HORSEBACK RIDING ON BALANCE

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by

Susan Keel Anderson

East Carolina University

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Susan Keel Anderson

APPROVED BY:

DIRECTOR OF THESIS:

David P. Loy, Ph.D., LRT/CTRS

COMMITTEE MEMBER:

Megan Janke, Ph.D., LRT/CTRS

COMMITTEE MEMBER:

Clifton Watts, Ph.D.

COMMITTEE MEMBER:

Amy Gross McMillan, Ph.D., PT

COMMITTEE MEMBER:

Linda Moran, PT

CHAIR OF THE DEPARTMENT OF RECREATION AND LEISURE STUDIES:

Debra Jordan, Re.D.

DEAN OF THE GRADUATE SCHOOL:

Paul J. Gemperline, Ph.D.

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SECTION I: MANUSCRIPT

Introduction

Children and Adults with Disabling Conditions

Approximately 54 million people in the United States are living with a disabling condition, which equates to one in every five people (US Department of Health and Human Services, 2013). Disabilities can be caused by birth, an accident, or age (US Department of Health and Human Services, 2013). Physical inactivity is a common problem among individuals with a disabling condition (Shih, Chen, & Shih, 2012) and increases the risk for limitations and secondary health issues (Rimmer, 2007). Rimmer (2007) suggested that physical activity is low for individuals with disabilities as a direct result of their disabling condition and the barriers presented by the environment. Furthermore, Rimmer, Riley, Wahg, Rauworth, and Jurkowski (2004) suggested that access to physical activities remains a limiting barrier among individuals with disabilities.

More importantly, individuals with disabilities may lose function as a result of inactivity (Rimmer, 2007) and this may ultimately decrease independence (Shih, Chen, & Shih, 2012) and balance abilities (Silkwood-Sherer, 2012). Impaired balance can often lead to greater physical disability, and problems with activities of daily living (Edgren et al., 2013). Balance is equally an issue among individuals in wheelchairs who are unable to perform activities that are pertinent to their everyday lives without the ability to achieve sitting balance (Petrofsky, 2006). Balance affects an individual's task performance and mobility as it is involved in all levels of tasks that humans engage in from infancy to adulthood.

While partaking in tasks, humans are presented with balance challenges. Balance challenges are activities that cause the balance system to work. To improve the success rate of

the balance system, balance can be practiced and should be considered a skill. Because most skills take practice to develop (Hale, 2004), balance challenges presented by physical activity enable balance practice and training. Balance can be modified through an effective balance training program (Hale, 2004), and balance training has been shown to improve balance (Wang & Change, 1997). Therefore, it is important to find interventions that are effective in presenting an opportunity for balance to be challenged and practiced, in turn enhancing individual's functional balance. Children and adults with disabilities who face balance deficits would benefit from activities that promote improved balance and ultimately provide opportunities to become more independent and more physically active (Silkwood-Sherer, 2012).

Balance

Balance is essential to daily functioning, as any task involving movement requires the balance control system to work properly (Huxham et al., 2001). The term *balance* describes the dynamics of body posture through a balance control system (Winter, 1995). This control system is comprised of postural control and equilibrium that can be challenged by task constraints, the environmental context in which a task is performed, and perturbations (i.e., any disturbance to balance). Postural control works to counterbalance any movement that alters the projection of the body, while equilibrium maintains stability of the body (Massion & Woollacott, 1996). A task is any activity that requires movement of the body, and the environment is the setting where the task is performed (Car & Shepherd, 1998). Perturbations to balance refer to external or internal forces that cause the body to recover and return to its previously balanced state (Shkuratova, Morris, & Huxham, 2004). Both postural control and equilibrium are determinants of balance and work together as a team to enable an individual to balance successfully (Huxham et al., 2001).

The determinants of balance, as seen in Figure 1, can be practiced. The nervous system contributes inputs gained from the visual, vestibular, and somatosensory systems, which work together to control the determinants of balance (Hale, 2004). With practice, the capability of the nervous system to contribute inputs can improve nervous system function and lead to greater motor problem solving ability that incorporates all of the determinants of balance successfully. More importantly, the determinants of balance translate to all activities of daily life, as they are a part of all movement (Huxham et al., 2001).

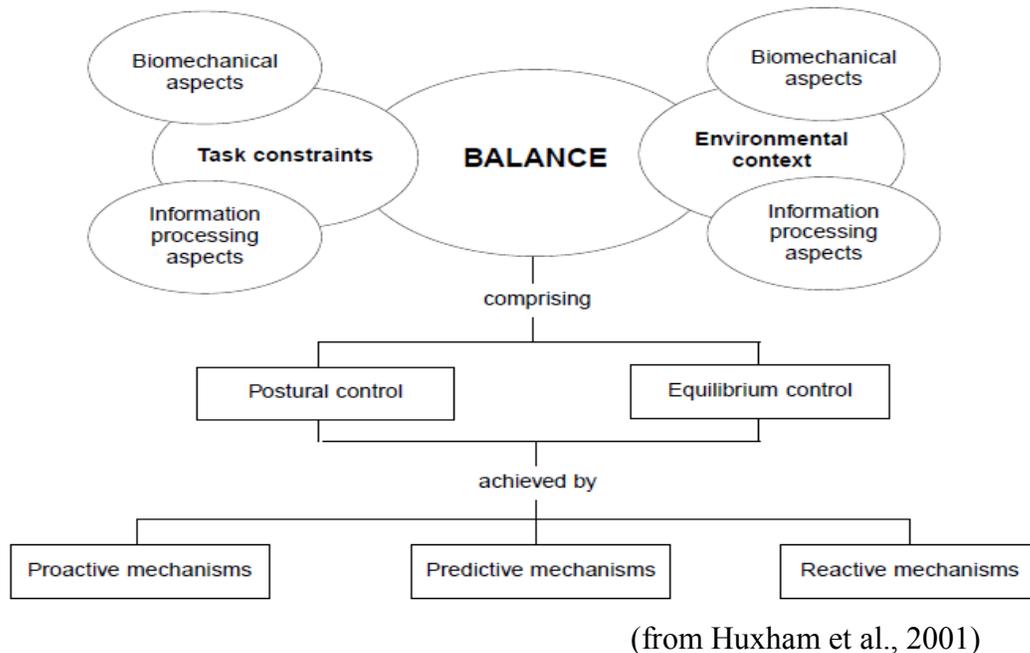


Figure 1. Functional Determinants of Balance

The task, environment, and the perturbations present determine the combination of postural control and equilibrium needed to achieve balance (Huxham et al., 2001). The body reacts to task, environment, and perturbations using proactive, predictive, and reactive mechanisms. Proactive mechanisms *counteract* opposing forces acting on the body (Patla, 1997),

predictive mechanisms are *learned* balance behaviors, and reactive mechanisms *respond* when proactive and predictive mechanisms fail (Huxham et al., 2001). Proactive mechanisms are developed through the vision system, and evaluate the external task and environment (Patla, 1997). Visualizing obstacles and other impediments creates an ability to adjust to the task and environment, therefore maintaining balance. Predictive mechanisms maintain stability between inter-segmental components of the body and the surface. Learned awareness of the relationship between balance and body movement enables predictive mechanisms to anticipate adjustments that the body must make to maintain balance. Reactive mechanisms are relied upon if either proactive or predictive mechanisms fail, or if a perturbation is unexpected. Reactive balance consists of postural reflexes that bring the body back to balance (Nashner, 1980). The balance control system uses proactive, predictive and reactive balance to counteract against the challenges of task, environment and perturbation to remain balanced (Huxham et al., 2001).

Balance is considered an integral component of all functioning and is the basis for undertaking all activities that make up our everyday lives (Huxham et al., 2001). Balance is involved in all levels of tasks that humans partake in from infancy to adulthood (Hale, 2004), and it is an integral part of a person's ability to interact with the environment (Silkwood-Sherer, 2012). Impaired balance often leads to physical disability and greater problems with activities of daily living (Edgren et al., 2013). While it is evident that balance is critical to the independence of individuals with disabilities (Silkwood-Sherer, 2012), those interventions most appropriate to address balance should include a wide variety of therapeutic options (Hale, 2004). Therapeutic horseback riding may be one such alternative.

Therapeutic Horseback Riding and Balance

Therapeutic horseback riding requires complex changes within the balance control system (Huxham et al., 2001), leading to a functional improvement in balance (Fox, Lawlor, & Luttgies, 1984). This type of horseback riding requires varied changing aspects of balance determinants to be practiced, therefore developing motor problem solving capabilities (Zandikar & Kastrin, 2011). The benefit of balance training is that balance and motor problem solving skills learned through training can translate to other activities of daily life (Huxham et al., 2001). Wingate (1982) studied seven children and found that they reported improved posture, less falling, better sitting, more head control, and improved gait. Fox et al., (1984) also concluded that balance improved by 18.6% from pre to post riding session testing. Similarly, Bertoti (1988) found that therapeutic horseback riding was vital in increasing posture control in children with cerebral palsy. Biery and Kauffman (1989) also found that during riding sessions, balance and coordination skills improved for eight children with intellectual disabilities after a year of therapeutic horseback riding as the intervention facilitated the rider's muscles in activation and relaxation, improving balance. Finally, Drnach et al. (2011) demonstrated an increase in balance due to the child's ability to improve upon complex patterns of movement while riding a horse. The rhythmical pattern of the horse's gait, the warmth, and three-dimensional shape of the horse contribute to improvements in balance (Zandikar & Kastrin, 2011; Whalen & Case-Smith, 2012).

Evidence suggests that balance improves due to therapeutic horseback riding interventions. Past research regarding children and adults with disabling conditions has examined the effect of participation in a therapeutic horseback riding program on balance. However, little research has evaluated the effects of therapeutic horseback riding on participants' balance

throughout the intervention period to determine when balance change occurs. Therefore, the purpose of this study is to examine the relationship between balance and a therapeutic horseback riding intervention, examining the possible short term, carry over, and program effects of the intervention.

Methods

Research Questions

This study examined the effects of therapeutic horseback riding as an intervention to improve the functional balance of participants with disabilities. The research questions for this study were:

1. Does therapeutic horseback riding provide positive short-term therapeutic effects on balance of individuals with disabilities after a *single session*?
2. Does therapeutic horseback riding have positive programmatic therapeutic effects on balance of individuals with disabilities after a ten-week therapeutic riding program?
3. Does therapeutic horseback riding provide any short-term *sustained* programmatic effects after the program has ended?

Participants

The study sample size was 34 participants, including 32 children and 2 adults, who were selected from a therapeutic riding program in eastern North Carolina. Participants were recruited based on the following criteria: (a) children (aged three and up) or adults who could stand or sit independently, (b) consent from participants and/or parents/guardians, (c) registered participants in the cooperating therapeutic horseback riding agency, and (d) participants capable of following simple instructions. To encourage participation, all participants who completed the study were entered into a drawing to win a therapeutic riding helmet. The director of the participating

facility granted permission for the researcher to collect data at this riding program (see Appendix F). The researcher assigned each participant an identification number to ensure confidentiality.

Research Design

This research study applied a quasi-experimental design using the one-Group pretest-posttest design to determine changes in functional balance in participants of a therapeutic horseback riding intervention. A pretest baseline measurement was taken, followed by a post-test after the first treatment, a second post-test at the conclusion of the intervention, and a follow up test three weeks following the conclusion of the intervention. Similar to other studies on therapeutic horseback riding (Gabriels & Agnew, 2012), this study was implemented for 10 weeks.

Setting

The therapeutic horseback riding sessions were conducted at a Professional Association of Therapeutic Horsemanship (PATH) member barn in eastern North Carolina. PATH acts as the voice of the equine assisted therapy industry as it contains more than 3,500 instructors and 800 centers serving 48,000 children and adults around the world (Path, n.d.). This organization ensures that member centers are operating under approved standards of practice for therapeutic riding programs and certifies instructors to teach therapeutic horseback riding. The site of this research study was a PATH member barn and all standards of practice were implemented. The participating agency has a total of 11 instructors who were all PATH certified in knowledge and skills in areas including instruction, teaching methodology, disabilities, horsemanship, and equine management.

The organization has 10 horses and serves nearly 100 children, offering services of hippotherapy, equine facilitated learning, interactive vaulting, and therapeutic horseback riding

to individuals ages three and up. The horses in the program are trained to work with children and adults with disabilities. Students participated in weekly lessons that involved individualized lesson plans to address their specific goals. This organization typically serves persons with a variety of diagnoses, including brain/spinal cord injury, multiple sclerosis, cerebral palsy, spina bifida, autism, psychiatric and behavioral disorders, cancer, and stroke.

Independent Variable

The agency's instructors led the therapeutic horseback riding sessions to ensure consistency in each session. Sessions began with the participant putting on a helmet and a belt with security loops before getting on the horse. With the help of the PATH instructor, the participant mounted the horse and adjustments were made so that the participant was sitting properly. The participant was then led into the riding ring where the therapeutic horseback riding took place. To address balance, each session included several perturbations, or disturbances, to balance that required one to react and recover to a steady state (Shkuratova et al., 2004) and recover one's balance (Mansfield, Peters, Liu, & Maki, 2007). To encourage naturally occurring perturbations, the session began with arm stretches that required participants to reach up to the sky as far as possible for 10 seconds and out to the left and right for 10 seconds. The session continued to include two different external perturbations to balance. The first included the participant being required to make at least three transitions. A transition included stop to walk, walk to fast walk, or walk to trot. The second perturbation required the participant to partake in the completion of at least one figure eight pattern in the ring. Data were collected pre- and post-sessions to determine if therapeutic horseback riding had an effect on balance.

Dependent Variable

In this study, balance was measured using the *Multi-Directional Reach Test (MDRT)* (Newton, 2001). Each participant's balance was measured and recorded before and after the first session to establish if there is a significant short-term effect on balance, following the last session of the 10 week program to examine comprehensive program effects, and three weeks after the program ended to determine if there is a carry-over effect on balance. Figure two details the data collection schedule.

Schedule															
Week:	1			2	3	4	5	6	7	8	9	10	11	12	13 (End of 3 rd Week)
Test:	Pre-Test (M1)	X	Post Test (M2)	X	X	X	X	X	X	X	X	X	Post Test (M3)	No Riding	Balance Test (M4)

Figure 2. Data Collection Schedule

The *Multi-Directional Reach Test* (Newton, 2001) was created as a modification to the *Functional Reach Test (FRT)* (Duncan, Weiner, Chandler, & Studenski, 1990). This tool tests the limits of stability (balance) in four directions, and quantifies a person's balance abilities (Newton, 2001). The MDRT uses a yardstick placed at the participants' acromion process and horizontal to the floor to provide a measurement of how far the individuals can reach forward, backward, left, and right outside of their base of support in a standing position (Newton, 2001). Past evidence demonstrated that postural stability can be accurately measured by the lateral reach ability (Brauer, Burns, & Galley, 1999) supporting that the left and right reach measurements of the MDRT are good indications of balance. Furthermore, the MDRT was selected for this study because it can be administered by practitioners with different training backgrounds and regardless of participants' ambulatory status (Petrofsky, 2006).

The MDRT shows evidence of reliability and validity. Newton (2001) found that the test displays evidence of convergent validity when comparing the MDRT with the Berg Balance Test (BBT) (Newton, 2001) and the Timed Up & Go Test (TUG) (Newton, 2001). MDRT scores are significantly and positively correlated with the front reach ($r = 0.476$), back reach ($r = 0.356$), right reach ($r = 0.389$), and left reach ($r = 0.390$) similar to findings regarding the BBT. The further the participants reach on the MDRT, the better their balance score on the BBT. Evidence of convergent reliability was provided when Newton (2001) found that TUG scores were inversely related to reach scores on the MDRT. Newton (2001) also provided evidence of construct validity of the MDRT when she noted a strong correlation ($p < 0.001$) with each direction of the MDRT. There is some evidence ($\alpha = 0.84$) that the MDRT instrument displays internal consistency, and demonstrates reliability when measuring an individual's balance (Newton, 2001).

Procedure

A demographic survey was completed prior to data collection to determine age, height, wheelchair use, leg length, and arm dominance. As part of the demographic survey, participants were asked about the number of hours a week they participated in other forms of therapy (Occupational Therapy school/after school, Physical Therapy school/after school), or other after school activities. This acted as a way to collect and possibly control confounding variables to potential balance improvements. Participants were asked if they were taking any medications related to muscle tone during this study, which may have acted as another confounding variable. The first measurements were taken before and after the intervention occurring in the first session. This determined the immediate effect of therapeutic horseback riding. The next measurement was taken after the tenth (last) session to examine the overall treatment effects of therapeutic

horseback riding. The last measurement occurred three weeks after the program was completed to determine if there were any program effects after the intervention ended. Each reach measurement was taken twice in two consecutive trials to ensure accurate measurement, and the best score was recorded (Newton, 2001). Participants were asked to place their feet flat on the floor and shoulder width apart. For participants that were unable to stand without assistance, the length of their leg was measured from the greater trochanter to the knee joint. Sixty percent of this length was placed on a bench in which the participant sat. The feet of each participant were four to six inches off of the ground to prevent participants from touching the ground for added balance. This enabled the study to measure the same point of balance for all sitting participants each time. The greater trochanter and the knee joint landmarks enable this study to deal with the differences in each individual. These landmarks are in the same place regardless of height or weight, ensuring consistent measurement across all sitting subjects (Mares, 2003). If the participant grasped their legs around the seat, or held the chair with their hands, the MDRT (Newton, 2001) was considered invalid, and the measurement was re-taken (Newton, 2001). Per Mares (2003), the previous motions are mechanisms that aid balance, which would have shown an inaccurate score on the MDRT. For persons who can stand without assistance, the test took no longer than 10 minutes and no longer than 15 minutes for persons who performed the MDRT sitting. The MDRT was conducted in a grooming stall at the barn, on a floor with rubber mats, each time.

Data Analysis

Data analyses included univariate analyses that examined patterns and out of range data in the dataset and progressed to bivariate and multivariate analyses that explored research questions. Frequency statistics were used to determine the characteristics of the demographics of the participants. Mean scores were compared over multiple time points. To address research question one, paired t-tests were completed to examine possible short-term effects on balance associated with a single therapeutic riding session. The average reach data from therapeutic horseback riding session one pre (M1) and post measurements (M2) were averaged and compared.

Research question two examined the ten-week effect of the program on balance. To address this research question, a paired t-test was used to compare mean baseline (M1) and end of program measures of balance (M3). Baseline measures occurred before the first session, while end of program measurements took place after the final session of riding.

Research question three examined short-term sustained program effects on balance associated with the therapeutic riding program. To address research question three, a repeated measures ANOVA compared mean differences from baseline to end of program (M3), and end of program to three-week follow up to examine the short-term sustained program effects (M4).

Results

The findings presented here are the results of data collection and statistical analysis of participant demographic information and the balance measurements of 34 participants collected throughout four time points of the ten-week therapeutic horseback riding intervention. Functional balance scores were interpreted by testing for significant differences between the group means of each time point in the MDRT (Newton, 2001) (anterior, posterior, left, and right) reach scores.

Descriptive statistics of the participants are presented in the figures below. The mean age for all participants was 13.70 years old ($SD=11.51$; range=60), the oldest was 66 yo and the youngest 6 yo. This sample included 15 female and 19 male participants who were diagnosed with a variety of diagnoses including, but not limited to stroke, autism, seizure disorders, Cerebral Palsy, ADHD, Down Syndrome, intellectual disability and developmental delay. The majority of diagnoses were of a cognitive nature ($n=25$), while the remaining were of a physical nature ($n=7$). The researcher performed bivariate correlations to determine if the balance changes could be attributed to the number of years previously ridden. The correlations were not significant ($p>.05$); therefore, there was no need to control for this variable.

Additionally, the sample size of the study was too small and created variation that was too great in the number of hours of outside therapy, and medication received. This made it impossible to categorize the data and the variation was so great it was not meaningful (Belsom, 1997). Therefore, this study did not control for outside hours of therapy and medication received, as detecting effects would be statistically limited. A correlation was performed to determine if any missed sessions in the 10-week intervention due to rain or absence had any effect on the changes in participants balance, and there were no significant results. Figure 3 shows the average mean changes throughout each measurement period of this study.

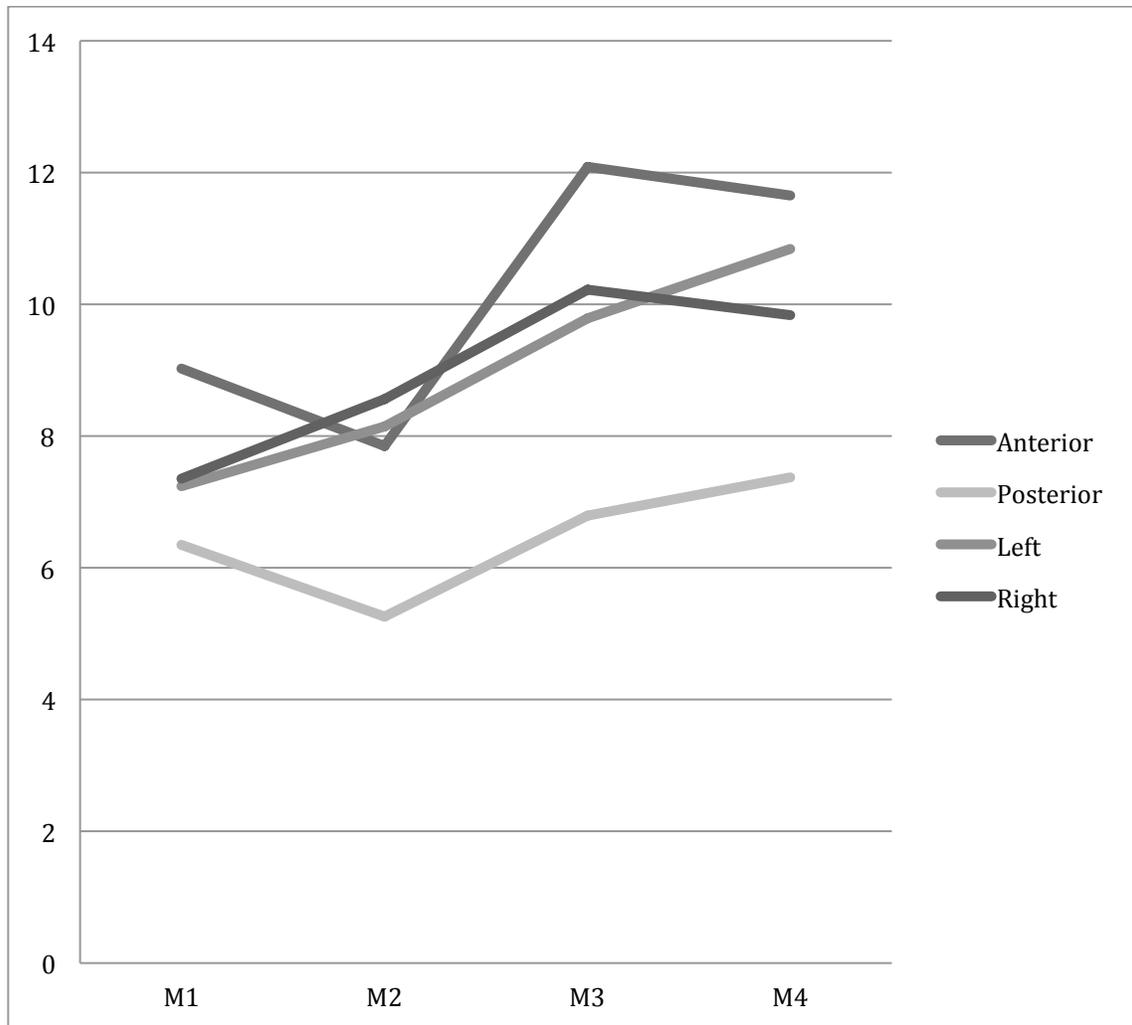


Figure 3. Average Mean Reach M1, M2, M3, and M4

Daily Session Effects of THR on Balance (RQ1)

To address research question one, paired samples t-tests were used to test for significant differences between the means of the baseline balance assessment at measurement one (M1), and the means of the balance assessment at measurement two (M2) of each direction of reach of the MDRT (Newton, 2001). The following table is a summary of the t-test results.

Table 1

Summary of T-Test Comparing Within Session Balance Changes (RQ1)

		<i>M</i>	<i>n</i>	<i>SD</i>	<i>t</i>	<i>p</i>
Anterior	M1	9.03	34	4.82	1.16	0.25
	M2	7.85	34	4.43		
Posterior	M1	6.35	34	3.45	1.99	0.05
	M2	5.26	34	2.66		
Left	M1	7.24	34	3.77	-1.55	0.13
	M2	8.15	34	4.43		
Right	M1	7.35	34	4.07	-1.89	0.07
	M2	8.56	34	4.36		

Anterior Reach

The results of the anterior reach balance assessment ($N=34$) failed to reveal a statistically significant difference ($p>.05$) between the anterior baseline measurement (M1) ($M=9.03$, $s=4.82$) and measurement two (M2) ($M=7.85$, $s=4.43$), indicating no statistically significant change in balance ($t(33)=1.16$, $p=.25$). There was a negative change (mean change= -1.18 inches) in balance from the mean at measurement one ($M=9.03$) to measurement two ($M=7.85$), as seen in Figure 3, but the decline was not statistically significant ($p =.25$).

Posterior Reach

The results of the posterior reach balance assessment ($N=34$) showed a statistically significant difference ($p=.05$) between the posterior baseline measurement (M1) ($M=6.35$, $s=3.45$) and measurement two (M2) ($M=5.26$, $s=2.66$), indicating a change in balance ($t(33)=1.99$, $p=.054$). The mean from measurement one ($M=6.35$) was reduced at measurement two ($M=5.26$), as seen in Figure 3, with a change in a non-therapeutic direction (mean change = -1.09 inches).

Left Reach

The results of the left reach balance assessment ($N=34$) showed no statistical difference ($p>.05$) between the left baseline measurement (M1) ($M=7.24$, $s=3.77$), and measurement two (M2) ($M=8.15$, $s=4.43$), indicating no change in balance ($t(33)=-1.55$, $p=.130$). The mean from measurement one ($M=7.24$) was lower than the mean at measurement two ($M=8.15$), as seen in Figure 3, indicating an increase (mean change= +0.91 inches) in balance in a therapeutic direction, but was not statistically significant ($p = .130$).

Right Reach

The results of the right reach balance assessment ($N=34$) showed no significant statistical difference between the right baseline measurement (M1) ($M=7.35$, $s=4.07$), and measurement two (M2) ($M=8.56$, $s=4.36$), indicating no change in balance ($t(33)=-1.90$, $p=.07$). The mean from measurement one ($M=7.35$) slightly increased in a therapeutic direction at measurement two ($M=8.56$), as seen in Figure 3, but the positive change (mean change= +1.31 inches) was not statistically significant ($p = .07$).

Comprehensive Balance Changes Post 10-Week Intervention (RQ2)

To address research question two, paired samples t-tests were used to test for significant differences between the means at the baseline balance assessment at measurement one (M1) and measurement three (M3) of each direction of reach of the MDRT (Newton, 2001), once the intervention was over. The following table is a summary of t-tests results.

Table 2

Summary of T-Test Comprehensive Balance Changes Post 10-Week Intervention (RQ2)

		<i>M</i>	<i>N</i>	<i>SD</i>	<i>t</i>	<i>p</i>
Anterior	M1	9.00	33	4.89	-2.51	0.02
	M3	12.09	33	5.29		
Posterior	M1	6.39	33	3.49	-0.69	0.50
	M3	6.79	33	3.00		
Left	M1	7.27	33	3.82	-3.60	0.00*
	M3	9.79	33	4.52		
Right	M1	7.38	32	4.16	-3.27	0.00*
	M3	10.22	32	4.23		

Note: *less than .01

Anterior Reach

The results of the anterior reach balance assessment ($N=33$) revealed a statistically significant difference between the anterior baseline measurement (M1) ($M=9.00$, $s=4.89$) and measurement three (M3) ($M=12.09$, $s=5.29$), indicating a change in balance ($t(32)=-2.51$, $p=.02$). The mean change in anterior reach balance from measurement one ($M=9.00$) was lower than the mean at measurement three ($M=12.09$), as seen in Figure 3, indicating a change in a therapeutic direction (mean change= +3.09 inches).

Posterior Reach

The results of the posterior reach balance assessment ($N=33$) failed to show a statistically significant difference ($p>.05$) between the posterior baseline measurement (M1) ($M=6.39$, $s=3.49$) and measurement three (M3) ($M=6.79$, $s=2.99$), indicating no change in balance ($t(32)=-0.69$, $p=.50$). While the mean balance change at measurement one ($M=6.39$) was lower than the mean at measurement three ($M=6.79$), as seen in Figure 3, indicating an improved posterior reach (mean change= +0.04 inches), the difference was not statistically significant ($p = .50$).

Left Reach

The results of the left reach balance assessment ($N=33$) indicated a statistical difference between the left baseline measurement (M1) ($M=7.27$, $s=3.82$) and measurement three (M3) ($M=9.79$, $s=4.52$) indicating a significant change in balance ($t(32)=-3.597$, $p=.00$). The mean at measurement one ($M=7.27$) was lower than the mean at measurement three ($M=9.79$), as seen in Figure 3, indicating a significant therapeutic change (mean change= +2.52 inches) in left reach.

Right Reach

The results of the right reach balance assessment ($N=32$) revealed a statistically significant difference between the right baseline measurement (M1) ($M=7.38$, $s=4.16$) and measurement three ($M=10.22$, $s=4.23$) indicating a significant change in balance ($t(31)=-3.274$, $p=.00$). Once again, the mean at measurement one ($M=7.38$) was lower than the mean at measurement three ($M=10.22$), as seen in Figure 3, indicating positive change (mean change= +2.84 inches) in right reach balance after the horseback riding intervention.

Programmatic Carry-Over Balance Effects Post Intervention (RQ3)

To address research question three, a repeated measures ANOVA was used to compare the group means at each balance measurement point to determine whether there was a change in balance three weeks after the intervention was completed. Tests of within-subjects contrasts were used to compare the total change from the pre-intervention baseline balance assessment (M1) to end of intervention balance assessment (M3) at the last session, which indicated the long-term programmatic effects of therapeutic horseback riding with measurement four (M4). This measurement (M4) was collected three weeks after the participants had stopped therapeutic horseback riding. Each direction of reach in the MDRT (Newton, 2001) was considered.

Balance measurements for the post intervention assessment only included nineteen of the participants as this assessment was gathered following the therapeutic horseback riding program semester, and required the individuals to return to the riding center during non-lesson periods. This caused some attrition (44.1%) in the final data collection point. Paired t-tests were analyzed to determine if there was any significant difference between the distance the participants lived from the barn between the participants who came for the last measurement and those who did not. While the means for those who did not come were slightly higher, there was no statistical difference ($p > .05$). It should be noted that this data collection at M4 was close to Thanksgiving and people could have been out of town. The smaller sample size created some statistical difference from the results in the paired t-tests; however the data still indicated therapeutic changes in balance three weeks post-intervention. The following table is a summary of results.

Table 3

Results of Sustained Programmatic Effects (RQ3)

Reach Direction	Source	SS	df	MS	F	p	η^2
Anterior	M1 vs. M3	304.20	1.00	304.20	4.21	0.05	0.18
	M3 vs. M4	18.05	1.00	18.05	0.45	0.51	0.02
Posterior	M1 vs. M3	0.84	1.00	0.84	0.11	0.75	0.01
	M3 vs. M4	15.21	1.00	15.21	1.61	0.22	0.08
Left	M1 vs. M3	195.84	1.00	195.84	12.28	0.00	0.41
	M3 vs. M4	17.05	1.00	17.05	1.43	0.25	0.07
Right	M1 vs. M3	296.06	1.00	296.06	9.97	0.01	0.37
	M3 vs. M4	16.06	1.00	16.06	0.67	0.43	0.04

Anterior Reach

The tests of within subjects contrast revealed a statistical change ($p = .05$) from the anterior baseline balance measurement (M1) to the end of the intervention comprehensive program measure at time three (M3). When looking at the change from the comprehensive program measure (M3) to the change in balance means at measurement (M4) (e.g., three weeks

following completion of the intervention), there was no statistically significant change in the balance assessment from measurement three (M3) to measurement four (M4), [$F(1,19)=0.45$, $p=0.51$]. This indicates that there was no negative change to the participants balance; meaning that the anterior reach balance score was sustained once the intervention was complete and the participants were no longer riding.

Posterior Reach

The tests of within subjects contrast revealed no statistical change ($p>.05$) from the posterior baseline balance measurement at time one pre intervention (M1) to the end of the comprehensive programmatic intervention at time three (M3). When looking at the change from the programmatic balance score (M3) to the change in balance means at time four three weeks post intervention (M4), there was no statistical change ($p>.05$) in the balance assessment from time three to time four [$F(1,18)=1.61$, $p=.22$]. Thus, similar to the anterior reach, displays no significant negative change to participant's balance three weeks post intervention, revealing sustained changes to balance once the participants stopped riding, but not significant changes were found from M1-M3. While these results may have limited meaningfulness since the programmatic posterior change was insignificant (M1-M3) over the 10-week program, it does reinforce the thought that effects, even if minimal, do not significantly diminish after three weeks without therapeutic horseback riding.

Left Reach

The tests of within subjects contrast indicated a statistical change in balance [$F(1,18)=12.28$, $p=.00$] when comparing the difference from the left baseline balance measurement at time one (M1) to the end of the intervention at time three (M3) indicating a change in a therapeutic direction for the course of the comprehensive program. Furthermore,

when looking at the change from time three at the end of the ten week intervention (M3) to the change in balance means at time four (M4) three weeks after the completion of the intervention for the left reach, there was no statistical reduction ($p>0.05$) in the balance assessment from measurement three (i.e., taken post intervention) to measurement four (i.e., taken three weeks after the intervention was complete), [$F(1,18)=1.43, p=0.25$]. This indicated that the changes made in balance over the course of the program did not decline three weeks after the conclusion of the intervention.

Right Reach

The tests of within subjects contrast provided some evidence of a therapeutic effect in balance as it reached statistical significance ($p=.00$) from the right baseline balance measurement (pre-intervention) at time one (M1) to the end of the comprehensive program intervention at time three (M3) indicating the right reach displayed a positive therapeutic change. Furthermore, when looking at the change from time the comprehensive program at measurement three (M3) to the change in balance means at time four (M4) once the participants were no longer participating in therapeutic horseback riding, there was no statistical reduction [$F(1,17)=0.67, p=0.43$] in the balance assessment for the right reach indicating the therapeutic change was sustained after three weeks post intervention.

Discussion

Daily Session Effects of THR on Balance (RQ1)

To determine the *session* effects of therapeutic horseback riding on balance, this study compared the MDRT (Newton, 2001) reaches (anterior, posterior, left and right) from baseline to post-session of the first ride of the ten-week intervention. This study found no significant changes to balance after just one session of therapeutic horseback riding in any of the reaches of

the MDRT (Newton, 2001), except for the non-therapeutic balance change in the posterior reach. Balance takes time to practice and individuals need time to grow in skill and strength (Hof & Duysens, 2013). The most interesting results found over the short-term duration of the intervention were the marginally significant positive mean changes in the lateral reach versus the negative mean changes in the anterior/posterior reaches. From this study, it can be suggested that during the short term duration of a therapeutic horseback ride, the lateral movements caused by riding a horse (Bertoti, 1988) may have caused the body to stretch through the movement of the antagonist and agonist muscle (LeRoy, 1960) creating a positive therapeutic gain in lateral reach ability. However, the negative balance change viewed in the anterior/posterior direction of balance may be attributed to the tired body after physical exertion (Bongers & Takken, 2012) and the repercussions that riding a horse placed on postural sway (Biery & Kauffman, 1989). This implies that individuals who are in need of lateral balance work may benefit immediately following a ride on a horse, but those with anterior/posterior balance needs may not see such immediate effects due to the fatigue experienced after a short-term session.

Comprehensive Balance Changes Post 10-Week Intervention (RQ2)

This study suggested potential long term, comprehensive effects of therapeutic horseback riding by comparing the baseline pre-ride measurement to the balance measurement taken once the ten-week intervention was completed. Each reach of the MDRT (Newton, 2001) was used to analyze results. This study found significant positive changes in participant's balance for the anterior ($t(32)=-2.51, p=.02$), left ($t(32)=-3.60, p=.00$), and right ($t(31)=-3.27, p=.00$), reach after the ten-week intervention. These positive therapeutic changes may be attributed to the many required physical tasks in horseback riding that promote balance development. First, horseback riding requires the use of all muscles and improves muscle strength as it prompts muscle

contraction and relaxation, which directly improves physical balance and muscular endurance (Drnach et al., 2010). Moreover, horseback riding increases flexibility as the continuous movement of the horse encourages and actively engages movement in the anterior, posterior, left and right directions (Bertoti, 1988). This movement of the horse is rotating (Bertoti, 1988), therefore simulating a stretch and reflex effect, which engages the lateral movement of the body. Lateral movements tremendously influence balance because any sway in the lateral direction can create a risk for fall (Newton, 2001), as lateral asymmetry affects gross motor performance and causes muscle weakness. The rhythmic forward and downward movement of the horse encourages the hip and pelvis to move anteriorly and posteriorly, simulating human walking (Biery & Kauffman, 1989). This enables the anterior and posterior balance reaches to improve due to the anterior/posterior shifts of the body atop a horse. These shifts are a form of physical exercise that improves strength and coordination (Drnach et al., 2010). Horseback riding has been found to encourage a more symmetrical alignment of participants' spines, therefore allowing for better gross motor function (Lee et al., 2011), and enhanced dynamic balance over the course of an intervention. This study found that therapeutic horseback riding is associated with change in balance after long-term intervention.

Programmatic Carry-Over Effects Post Intervention (RQ3)

To address the potential carry-over effect that therapeutic horseback riding has on balance, the balance measurements from the MDRT (Newton, 2001) were compared from the comprehensive program effects measurements after the 10-week intervention to measurements taken three weeks once the intervention was complete. This study explored whether the balance changes that occurred during the course of the intervention were altered in any way once the intervention was over and three weeks had lapsed with no riding. It was found that there were no

significant decreases in balance three weeks post completion of the intervention, indicating that the changes in balance were sustained. These effects may best be explained through balance motor learning. Motor learning is how the brain adapts to control the body and is critical to balance skill acquisition (Wolpert, Ghahramani, & Flanagan, 2001).

Learning occurs only when the movement is executed—the feedback gained from the execution of this movement from the environment creates the opportunity for motor learning to be refined (Willingham, 1998). In a motor learning situation, one uses references from past movements and the strength of this reference grows from the experience of feedback. Feedback comes from proprioception and visual references which ultimately lead a performer to make responses different from previous failed trials (Adams, 1971). Different responses are made up of adjustments in response to learning new motor skills. The correct adjustment enables the performer to continue to make the correct response each time a motor activity is performed, therefore strengthening the skill, and thus creating a new learned behavior (Adams, 1971). It is because of this that learning is continuous, as skills can always be refined (Newell, 1991).

Skills can be effortlessly performed through practice, and retained once learned (Salvion-Lemieux & Penhune, 2005). Once a motor skill is learned it can be retained and used over and over again (Karni & Sagi, 1993). Practice leads to the acquisition and retention of a motor skill (Salvion-Lemieux & Penhune, 2005), and it has been found that spacing practice over time in several different sessions leads to greater skill retention, rather than a large amount of practice one time (Baddely & Longman, 1978; Salvion-Lemieux & Penhune, 2005).

In this study, the participants practiced horseback riding, which requires the skill of balance (Bongers & Takken, 2012) over a 10-week period, once a week. This is the practice of balance over several different sessions (Baddely & Longman, 1978), which may have led the

participants to retaining their newly acquired balance skills (Salvion-Lemieux & Pehune, 2005). As this intervention was designed to be a program to enable balance practice for the participants, and balance is a skill that can be learned through motor learning (Carron & Bracegirdle, 1974), it can be suggested that through motor learning, balance skills were retained and not lost once the intervention was complete. This has positive implications for therapeutic horseback riding because once the intervention is complete the positive changes to balance gained are not lost in the short-term. Therefore, it can be suggested that balance is a physical *and* learned motor skill that can be improved and sustained over the short-term.

Conclusion

The results of this study suggest a valuable therapeutic outcome for the individuals that participate in this intervention. The balance mean changes indicated that there was some change to balance following the short-term intervention, but it was not significant and only provided light stretching and exercise for the participants. However, positive improvements in balance were evident over the 10-week program for the long-term period of this study, and these improvements were sustained in the short-term, once the intervention was complete. It is important for interventions to be effective and efficient, and this study suggests that therapeutic horseback riding may have contributed to the individuals' potential for balance.

Limitations

This study faced a few limitations. The sample size for this study was small, making it hard to be certain of the trend in balance changes. The small sample also did not allow this study to account for medication and number of hours of additional therapy. Due to the lack of a covered arena at the facility, some of the participants missed sessions during the ten weeks due to the weather. This created an inconsistent intervention period for some of the individuals. The

small sample size also demanded that the study use a sample of individuals with a multitude of diagnoses, making it unclear whether there is a certain diagnosis or disability that therapeutic horseback riding influences more than another. This also created some variability between subjects; as they did not all have the same balance issues. Variability also could have been influenced as there were eight different instructors teaching the lessons and twelve different horses used creating possible changes in balance that occurred between subjects. Additionally, ten weeks may not be a long enough time to see accurate results of balance changes due to riding.

In addition, the MDRT (Newton, 2001) can also be considered a limitation to this study. While this measurement tool is valid and reliable, it may not be the correct tool for this population. The MDRT (Newton, 2001) asks the participants to “reach as far as they can”. This is subject to interpretation between each of the participants, and therefore carries a different meaning between participants. Due to the varying cognitive limitations between subjects, it is uncertain if all participants reached as far as possible or if they were completely able to understand the instructions. “As far as you can” may not be concrete enough for the population of this study. Furthermore, this study used a sample that was limited to a certain demographic region and one therapeutic riding center. The results of this study indicated the positive effects that therapeutic horseback riding had on this small portion of the population, but in order to generalize the results to a broader population it would be useful to increase the sample size and include other centers in the data collection process (Cuypers et al., 2011). Repeated observations of effects, with a control group would establish that the intervention influences balance.

Future Research

To increase the body of knowledge in therapeutic horseback riding, future studies should measure participants who have never participated in therapeutic horseback riding previously to show a purer measure of balance change. It would also be valuable to the literature to increase the number of sessions to determine if the balance changes are different during a more intense form of the intervention (Bass, Duchowny, & Llabre, 2009), as well as allowing for enough time to determine if there is ever a point where the changes in balance plateau instead of continually increasing. Further research is needed to determine the effects of therapeutic horseback riding between diagnoses. It is possible that therapeutic horseback riding has different effects on the balance in individuals with varying diagnoses (Bertoti, 1988), and it would benefit the literature to examine these differences between populations. This would allow for a more effective use of this intervention, and would contribute to the knowledge of how to apply this intervention to address balance goals.

Additionally, it would facilitate balance research accuracy if there was a simpler, more efficient way to test the balance of participants. To limit the variability between interventions, participants should have the same instructor and horse for each intervention to provide more control of an important potential confounding variable. It may also be beneficial for future research to include a multicenter trial (Cuypers et al., 2011) to further extend results and more importantly allow the analysis of results as a whole instead of a small sample of the population who participates in therapeutic horseback riding. Further research is needed to determine the effects that riding has on participants' range of motion, weight shifting, and strength (Bertoti, 1988), and behavior (Bass et al., 2009).

As a whole, the field of therapeutic horseback riding would benefit from more research to create an organized and efficient method to collecting empirical data, as well as assessment tools that can evaluate the effectiveness and benefits of therapeutic horseback riding, and intervention protocols. To further this field, it would also be valuable to have a collaboration of therapeutic horseback riding research that can be easily accessed by health professionals in order to encourage this community to prescribe therapeutic horseback riding as adjunct treatment for individuals with disabilities, and possibly lead to reimbursement from insurance companies (Drnach et al., 2010).

SECTION I REFERENCES

- Adams, J.A. (1971). A closed loop theory of motor learning. *Journal of Motor Behavior*, 3(2), 111-150.
- Baddely, A.D., & Longman, D.J.A. (1978). The influence of length and frequency of training session on the rate of learning to type. *Ergonomics*, 21, 627-635.
- Bass, M.M., Duchowny, C.A., & Labre, M.M. (2009). The effect of therapeutic horseback riding on social functioning in children with autism. *Journal of Autism & Developmental Disorders*, 39(9), 1261-1267. doi: 10.1007/s10803-009-0734-3
- Belsom, C., & School Mathematics Project. (1997). *Statistics*. Cambridge, U.K: Cambridge University Press.
- Bertoti, D.B. (1988). Effect of therapeutic horseback riding on posture in children with cerebral palsy. *Physical Therapy*, 68(10), 1505-1512.
- Biery, M.J., & Kauffman, N. (1989). The effects of therapeutic horseback riding on balance. *Adapted Physical Activity Quarterly*, 6(3), 221-229.
- Bongers, B.C., & Takken, T. (2012). Physiological demands of therapeutic horseback riding in children with moderate to severe motor impairments: An exploratory study. *Pediatric Physical Therapy*, 24(3), 252-257.
- Brauer, S.G., Burns, Y., & Galley, P. (1999). Lateral reach: A clinical measure of medio-lateral postural stability. *Physiotherapy Research International*, 4, 81-88.
- Carr, J.H., & Shepherd, R. (1998). *Neurological rehabilitation: Optimizing motor performance*. Oxford: Butterworth Heinemann.
- Carron, A.V., & Bracegirdle, M. (1974). A motor learning task involving two-arm balance-coordination. *Perceptual and Motor Skills*, 38, 183-187.

- Cuypers, K., De Ridder, & Strandheim, A. (2011). The effect of therapeutic horseback riding on 5 children with attention deficit hyperactivity disorder: A pilot study. *Journal of Alternative & Complementary Medicine, 17(10)*, 901-908. doi: 10.1089/acm.2010.0547
- Drnach, M., O'Brien, P., & Kreger, A. (2010). The effects of a 5-week therapeutic horseback riding program on gross motor function in a child with cerebral palsy: A case study. *Journal of Alternative & Complementary Medicine, 16(9)*, 1003-1006. doi: 10.1089/acm.2010.0043.
- Duncan, P., Weiner, D., Chandler, J., & Studenski, S. (1990). Functional reach: A new clinical measure of balance. *Journal of Gerontology, 45*, M192-M197.
- EAAT Definitions. Path International. Retrieved November 12, 2012 from <http://www.pathintl.org/resources-education/resources/eaat/193-eaat-definitions>.
- Edgren, J., Salpakoski, A., Rantanen, T., Heinonen, A., Kallinen, M., VonBonsdorff, M.B., Portegijis, E., Sihoven, S., & Sipila, S. (2013). Balance confidence and functional balance are associated with physical disability after hip fracture. *Gait & Posture, 37(2)*, 201-205.
- Fox, V.M., Lawlor, V.A., & Luttges, M.W. (1984). Pilot study of novel test instrumentation to evaluate therapeutic horseback riding. *Adapted Physical Activity Quarterly, 1(1)*, 30-36.
- Gabriels, R.L., Agnew, J.A., Holt, K.D., Shoffner, A., Zhaoxing, P., Ruzzano, S., Clayton, G.H., & Mesibov, G. (2012). Pilot study measuring the effects of therapeutic horseback riding on school-age children and adolescents with autism spectrum disorders. *Research in Autism Spectrum Disorders, 6(2)*, 578-588.
- Gibala, M., Macdougall, J., & Sale, D. (1994). The effects of tapering on strength in trained athletes. *Internal Journal of Sports Medicine, 15*, 492-497.

- Gordon, A.T., Ambegaonkar, J.P., & Caswell, S.V. (2013). Relationships between core strength, hip external rotator, muscle strength, and star excursion balance test performance in female lacrosse players. *International Journal of Sports Physical Therapy*, 8(2), 97-104.
- Hale, S.A. (2004). *Postural control in children and young adults* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses. (305149088).
- Hof, A.L., & Duysens, J. (2013). Responses of human hip abductor muscles to lateral balance perturbations during walking. *Experimental Brain Research*, 230(3), 301-310.
- Horak, F., Henry, S., & Shumway-Cook, A. (1997). Postural perturbations: New insights for treatments. *Physical Therapy Journal*, 77, 517-533.
- Huxham, F.E., Goldie, P.A., & Aftab, E.P. (2001). Theoretical considerations in balance assessment. *Australian Journal of Physiotherapy*, 47, 89-100.
- Karni, A., & Sagi, D. (1993). The time course of learning a visual skill. *Nature*, 365, 250-252.
- Learn about EAAT. Path International. Retrieved November 12, 2012, from <http://www.pathintl.org/resources-education/resources/eaat>.
- Lee, D.R., Lee, N.G., Cha, H.J., O, Y.S., You, S., Oh, J.H., & Bang, H.S. (2011). The effect of robo-horseback riding therapy on spinal alignment and associated muscle size in MRI for a child with neuromuscular scoliosis: An experimenter-blind study. *NeuroRehabilitation*, 29(1), 23-27.
- LeRoy, L.C. (1960). *Postural fitness: Significances and variances*. Philadelphia: Lea & Febiger.
- Mansfield, A., Peters, A., Liu, B., & Maki, B. (2007). A perturbation-based balance training program for older adults: study protocol for a randomized controlled trial. *BMC Geriatrics*, 7(12). doi: 10.1186/1471-2318-7-12.

- Mares, J.M. (2003). *Reach capabilities in older Mexican-American adults*. (Master's thesis). Retrieved from ProQuest Dissertations and Theses. (No. 305264661)
- Massion, J., & Woollacott, M.H. (1996). Posture and equilibrium. In Bronstein A, Brandt T and Woollacott M (Eds), *Clinical Disorders of Balance Posture and Gait* (pp. 1-18). London: Arnold.
- Nashner, L.M. (1980). Balance adjustments of humans perturbed while walking. *Journal of Neurophysiology*, 44, 650-664.
- Newell, K.M. (1991). Motor skill acquisition. *Annual Review of Psychology*, 42, 213-37.
- Newell, K.M., & Rovengo, I. (1990). Motor learning: Theory and practice. *Quest*, 42, 184-192.
- Newton, R.A. (2001). Validity of the multi-directional reach test: A practical measure of limits of stability in older adults. *Journal of Gerontology: Medical Sciences*, 56A(4), 248-252.
- Path International. Path International. Retrieved November 12, 2012, from <http://www.pathintl.org>.
- Patla, A.E. (1997). Understanding the roles of vision in the control of human locomotion. *Gait and Posture*, 5, 54-69.
- Petrofsky, J.S. (2006). A device for the evaluation of sitting and reach balance in people in wheelchairs and standing. *Journal of Medical Engineering & Technology*, 30(6), 358-367. doi: 10.1080/03091900500139634.
- Poulsen, A., Ziviani, J., Cuskelly, M., & Smith, R. (2007). Boys with developmental coordination disorder: loneliness and team sports participation. *American Journal Occupational Therapy*, 61, 451-462.

- Rimmer, J.H., Riley, B., Wahg, E., Rauworth, A., & Jurkowski, J. (2004). Physical activity participation among persons with disabilities: Barriers and facilitators. *American Journal of Preventive Medicine, 26*(5), 419-425.
- Salvion-Lemieux, T., & Penhune, V.B. (2005). The effects of practice and delay on motor skill learning and retention. *Experimental Brain Research, 161*(4), 423-431.
- Shih, C.H., Chen, L.C., & Shih, C.T. (2012). Assisting people with disabilities to actively improve their collaborative physical activities with Nintendo Wii Balance Boards by controlling environmental stimulation. *Research in Developmental Disabilities, 33*(1), 39-44.
- Shkuratova, N., Morris, M., & Huxham, F. (2004). Effects of age on balance control during walking. *Archives of Physical Medicine and Physical Rehabilitation, 85*(4), 582-588.
- Silkwood-Sherer, D.J., Killian, C.B., Long, T.M., & Martin, K.S. (2012). Hippotherapy-an intervention to habilitate balance deficits in children with movement disorders: A clinical trial. *Physical Therapy, 92*(5), 707-717.
- US Department of Health and Human Services, Office of Disability. (2013). *About Us 2013*. Retrieved from http://www.hhs.gov/od/about/fact_sheets/whatisdisability.html.
- Wang W., & Chang J. (1997). Effects of jumping skill training on walking balance for children with mental retardation and Down's Syndrome. *Kaohsiung Journal of Medical Science, 13*, 487-494.
- Whalen, C.N., & Case-Smith, J. (2012). Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: A systematic review. *Physical & Occupational Therapy in Pediatrics, 32*(3), 229-242.
doi:10.3109/01942638.2011.619251.

- Willingham, D.B. (1998). A neuropsychological theory of motor skill learning. *Psychological Review*, 105(3), 558-584.
- Winter, D.A. (1995). Human balance and posture control during standing and walking. *Gait & Posture*, 3, 193-214.
- Wolpert, D.M., Ghahramani, Z., & Flanagan, J.R. (2001). Perspectives and problems in motor learning. *TRENDS in Cognitive Sciences*, 5(1).
- Zadnikar, M., & Kastrin, A. (2011). Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: A meta-analysis. *Developmental Medicine & Child Neurology*, 53(8), 684-691. doi: 10.1111/j.1469-8749.2011.03951.x

SECTION II: EXTENDED REVIEW OF THE LITERATURE

Animal Assisted Therapy

Animals and humans share a special relationship. Documentation of this relationship occurs as early as the cave paintings portraying wolves and humans together around campfires. It is also evident by the fact that Ancient Egyptians included their cats in their entombments (Gammonley, & Yates, 1991), and the domestication of animals started more than twelve thousand years ago (Loving & All, 1999). Animals are a part of the natural environment and relate to both the physiological and psychological health of individuals (Gammonley & Yates, 1991). Today, 62% of American households contain a pet (ASPCA, n.d.); 7.9 million of these pets are horses (APPA, n.d.). Animals, including horses, enact multiple roles for human beings. They not only serve as pets, but they can also be considered working companions used for therapeutic purposes (Gammonley & Yates, 1991).

The ideology of pet therapy was developed by the psychologist, Boris Levinson in the 1960s who realized that animal contact promoted health and healing (Leslie, 2011). Using animals for therapeutic purposes is now known as animal assisted therapy. Animal-Assisted Therapy (AAA) is defined as:

a goal-directed intervention in which an animal that meets specific criteria is an integral part of the treatment process. AAT is directed and/or delivered by a health/human service professional with specialized expertise, and within the scope of practice of his/her profession. Key features include: specified goals and objectives for each individual; and measured progress (Fine, 2010, p. 34).

This type of therapy can be used by providing Animal-Assisted Activities. An Animal-Assisted Activity is an activity that

provides opportunities for motivational, educational, recreational, and/or therapeutic benefits to enhance quality of life. AAAs are delivered in a variety of environments by specially trained professionals, paraprofessionals, and/or volunteers, in association with animals that meet specific criteria (Fine, 2010, p. 34).

Horse Therapy

It is believed that animal assisted therapy has been used as a therapeutic intervention for as long as humans have been on this earth. One of the common animals used as a therapeutic tool is the horse. In 300 B.C., “Xenophon stated that “The outside of a horse is the best thing for the inside of a man” (Kurschner, 1988)” (Engel, Galloway, & Bull, 1989, p. 2). The ancient Greeks used horses as a form of treatment for patients that they considered incurable, as they felt that horses could improve the spirits of these patients (Depauw, 1986). Moreover, in 17th century literature there are references to horseback riding utilized for gout, neurological disorders, and low morale (Loving & All, 1999). In 1600, a doctor names Sir Thomas Sydenham, said “The best way I know to improve morale and to strengthen muscles is to ride horseback several times a day” (Engel et al., 1989, p. 2). Florence Nightingale noted in 1860 that pets are perfect companion animals for the sick, as these individuals find pleasure in the animal (Loving & All, 1999). Chassigne completed a landmark study on the significance of horseback riding in Paris in 1875. In his study, he concluded that riding could benefit “hemiplegia, paraplegia, and other neurological disorders. He hypothesized that posture, balance, joint movement, and muscle control were improved by the active movement; as well as the passive movement provided by the horse” (Chassigne in DePauw, 1986, p. 217).

Animal assisted therapy using horses, also commonly known as therapeutic horseback riding, includes any equine activity performed by accredited centers around the world, and allows a person with a disability to participate in an activity the same way an able bodied person would (Engel et al., 1989). The centers are accredited by the Professional Association of Therapeutic Horsemanship International (PATH Intl.), formally known as the North American Riding for the Handicap Association (NARHA). This association specializes in accrediting

centers and certifying riding instructors around the world in order to promote and advocate for therapeutic horseback riding. PATH acts as the voice of the equine assisted therapy industry, and ensures that the centers provide standards for “safe and ethical equine interaction, through education communication, standards and research” (Learn, n.d.). Within the organization, there are more than 3,500 instructors and 800 centers serving 48,000 children and adults around the world, with a mission to “ensure excellence and changing lives through equine assisted activities and therapies” (Path, n.d.). This organization breaks therapeutic horseback riding down into several major categories. These categories are as follows:

Equine-Assisted Activities (EAA): “Equine-assisted activities are any specific center activity, e.g. therapeutic riding, mounted or ground activities, grooming and stable management, shows, parades, demonstrations, etc., in which the center’s clients, participants, volunteers, instructors and equines are involved” (EAAT, n.d.).

Equine-Assisted Therapy (EAT): “Equine-assisted therapy is treatment that incorporates equine activities and/or the equine environment. Rehabilitative goals are related to the patient’s needs and the medical professional’s standards of practice” (EAAT, n.d.).

Equine-Facilitated Learning (EFL): “Equine Facilitated Learning (EFL) is an educational approach to equine-assisted activities. EFL content is developed and organized by credentialed practitioners with the primary intent to facilitate personal growth and development of life skills through equine interactions” (EAAT, n.d.).

Equine-Facilitated Psychotherapy (EFP): “EFP is defined as an interactive process in which a licensed mental health professional working with or as an appropriately credentialed equine professional, partners with suitable equine(s) to address psychotherapy goals set forth by the mental health professional and the client” (EAAT, n.d.).

These horse-related aspects of therapy are all useful in addressing physical, cognitive, or emotional needs in the individuals that participate. These interventions do not limit themselves to any population, and provide physical and emotional rewards that can lead to increased flexibility, balance, muscle strength, confidence, and self-esteem (Learn, n.d.). The interventions that certified instructors incorporate to implement goals and reach these rewards are also divided into sections by the Professional Association of Therapeutic Horsemanship International, and are therapeutic riding, hippotherapy, interactive vaulting, and therapeutic driving.

PATH defines therapeutic riding as an equine-assisted activity used “for the purpose of contributing positively to cognitive, physical, emotional and social well-being of people with disabilities. Therapeutic riding provides benefits in the areas of therapy, education, sport and recreation, and leisure” (EAAT, n.d.). Riding therapy can also be described as active physiotherapy where the rider performs exercises on the horses back (DePauw, 1986). These exercises are used to reach physical, emotional, social, cognitive, behavioral and educational goals. Riding therapy exercises are designed to involve leisure and therapeutic activities, learned riding skills, and facilitate an emphasis on the horse-rider relationship (Lessick, Shinaver, Post, Rivera, & Lemon, 2004). The rider is encourage to ride in the most “normal” riding situation as possible, encouraging the participant to ride with as little adaptive equipment as possible. Safety equipment is encouraged including boots, helmets, and a belt with loops around the rider’s waist that can be used as stabilization controls for the volunteers walking alongside the rider (Trapani & Parise, 1995).

Riding therapy is a form of individualized treatment as each rider has specific goals they are working towards. These goals are reached practicing a team construct. The team consists of the rider, horse, volunteers, and instructor of the session. The riding therapy instructor is equipped with an equine background, full knowledge of the disabilities facing the rider, and tools to enact therapy upon a horse in order to reach the set goals (Lessick et al., 2004). From this style of riding confidence, coordination, balance, attention span, upper body strength, and posture can improve (Trapani & Parise, 1995).

Hippotherapy, another equine-related intervention, is defined by the Professional Association of Therapeutic Horsemanship and the American Hippotherapy Association as:

a physical, occupational or speech therapy treatment strategy that utilizes equine movement. The word hippotherapy derives from the Greek word hippos, meaning horse. The term hippotherapy refers to the use of the movement of the horse as a treatment strategy by physical therapists, occupational therapists and speech/language pathologists to address impairments, functional limitations and disabilities in patients with neuromotor and sensory dysfunction. This treatment strategy is used as part of an integrated treatment program to achieve functional goals (Hippotherapy, n.d.).

Hippotherapy refers to therapeutic riding where the rider is placed on the horse in specific positions, and is made to adjust to the swinging motion of the horse's gait (DePauw, 1986). This type of riding promotes functional goals that include sitting, dressing, and following directions. Unlike riding therapy the rider is not learning to ride the horse. The horse is viewed as a therapeutic tool rather than a team member during hippotherapy (Bender & McKenzie, 2008).

Interactive Vaulting is another style of a horseback riding intervention introduced by the Professional Association of Therapeutic Horsemanship, and is defined as:

an activity in which the students perform movements on and around the horse. These movements can be very simple such as sitting without holding onto the surcingle or a more elaborate compulsory move such as kneeling or standing on the horse. It all depends on the individual needs of the vaulter (EAAT, n.d.).

Most often this is considered gymnastics on a horse, as the rider performs freestyle movements on the horse's back, while the horse is on a lunge line. The horse is equipped with a leather belt with two handles attached. The rider can hold on to the handles while performing the vaulting moves. This type of riding "promotes strength, flexibility, balance and coordination through the physical moves; as well as confidence, trust, patience and critical thinking" (Interactive vaulting certification, n.d.).

Therapeutic Driving is an alternative method of delivering horse therapy to individuals. This enables certified instructors to reach people who are unable to sit on top of a horse due to

fear of heights, illnesses, or other limitations. The Professional Association of Therapeutic Horsemanship describes this as a type of equine assisted activity that “offers students with physical, mental, sensory or emotional disabilities the rewards of interaction and control of a horse or pony while driving from a carriage seat or in their own wheelchair in a carriage modified to accommodate their wheelchair” (EAAT, n.d.). Utilizing this form of intervention allows for the student to experience motor sensory and range of motion skills, as well as learning about horses, horse safety, and driving skills. Participants are often encouraged to enter into carriage competitions, where they can compete against other competitors without disabilities.

Each of these styles of therapeutic riding has been studied to explore the effects of using therapeutic horseback riding as an intervention. Bass, Duchowny, and Labre (2009) encouraged looking at the horse as a multi-sensory environment, which enables the horse to transform into a multi-purpose therapy tool. The success of this intervention is due to the horse and the unique aspects of riding a horse; as the settings that horses are in, as well as the new experiences, such as the smells, create an environment that encourages positive therapeutic elements (Bizub, Joy, & Davidson, 2003).

During a ride on a horse’s back, the warmth of the horse’s body aids in soothing, stretching, and loosening muscles. Horseback riding is considered exercise, and only swimming uses more muscles in your body (Lyons, 2012). With every step and move the horse takes, the rider must counteract with a move in order to stay upright and equally balanced. The gait of a horse is similar to the gait of a human; the person sitting on the horse will experience a forward and downward movement respectively as the horse works its hips in order to walk (Biery & Kauffman, 1989). This creates the ability for the horse walk to simulate human walking (Lyons, 2012). Therapeutic riding is an effective intervention, as it facilitates cognitive,

social, physical, educational, and behavioral goals leading to functional improvements for the participants (Drnach, O'Brien, & Kreger, 2010).

Children and Adults with Disabling Conditions

Participants of therapeutic horseback riding have a wide range of disabling conditions (Bertoti, 1988). Approximately 54 million people in the United States are living with a disabling condition. This equates to one in every five people (US Department of Health and Human Services, 2013). Disabling conditions cause major limitations for both children and adults, as access (Rimmer, Riley, Wahg, Rauworth, & Jurkowski, 2004) and participation (Poulsen, 2007) in recreation is low for these individuals. Physical inactivity is a common problem of those individuals with disabling conditions, as it causes a decrease in maintaining independence (Shih, Chen, & Shih, 2012). Children and adults with disabling conditions most often have balance deficits (Silkwood-Sherer, 2012) that can cause individuals to lose independence (Edgren et al., 2013).

Balance is a part of all activity whether it is static or dynamic. Static balance keeps the body in position while it is resting, and dynamic balance keeps the body in balance while movements are occurring (Hale, 2004). Static and dynamic balance are dependent on nervous system control. The nervous system contributes inputs gained from the visual, vestibular, and somatosensory systems, working together to control the bodies ability to balance (Hale, 2004). Balance Theory describes this occurrence (Huxham et al., 2001). The determinants of balance work together and promote an individual's balance. The way that individuals learn to balance directly affects their capability to balance (Hale, 2004). With practice, balance is a skill that can be improved upon. Repetitive balance practice of the same activity that only calls for similar determinants of balance to be activated allows for greater learning of balance in that one activity

(Huxham et al., 2001). However, when a skill is practiced that requires balance determinants to vary or change, this develops motor problem solving abilities in clients. Balance is a part of all movement, and the environment and task challenges the informational processing and biomechanical aspects of balance; thus, motor problem solving ability is necessary. The benefit of varied balance practice is that balance and the motor problem solving skills learned can transfer to all activities of daily life (Huxham et al., 2001).

Given this information, it seems important to find interventions that are effective in enhancing functional balance because it is an integral part of a person's ability to interact with the environment (Silkwood-Sherer, 2012). Children and adults with disabling conditions most often have balance deficits (Silkwood-Sherer, 2012), and impaired balance leads to physical disability and greater problems with activities of daily living (Edgren et al., 2013). Without sitting balance, individuals in wheelchairs can lose their ability to participate in functional activities of daily living (Petrofsky, 2006). Losing balance skills is devastating as it can cause individuals to lose independence (Edgren et al., 2013). Similarly, deficits in balance affect all task performance and mobility (Hale, 2004), as it is essential to the neuromuscular development of individuals. Higher levels of activity create challenges to balance that enable balance training. Balance can be modified through an effective balance training program (Hale, 2004), and this training has been shown to improve balance (Wang & Chang, 1997).

Theoretical Framework

The field of therapeutic horseback riding and animal assisted therapy lacks a theoretical framework that can effectively explain why relationships between humans and animals are therapeutic. Theories have been borrowed from other fields and applied to animal assisted therapy. The literature suggests a variety of theories. The idea that animals are an intrinsic

attribute which reduce anxiety (e.g., Learning Theory), animals are social mediators in the bond between human and animal (e.g., Transitional Effect), and social cognitive theory have all been suggested (Fine, 2010). Each theory offers a unique way of conceptualizing animals as a therapeutic element, but emphasizes different elements of the animal.

Learning Theory

Brickel (1985) suggested learning theory may help explain the therapeutic influence of animals through two concepts “(1) We perceive animals as our emotional wards...Generally speaking the emotional association between people and animals is a positive one...(2) We learn to perceive animals in this manner...In western culture we learn that certain classes of animals (e.g. dogs and cats) exist primarily to be loved” (Brickel, 1985, p. 33). Therefore, he suggests that animals buffer anxiety stimulating events, implying that animals have the capacity to reduce anxiety (Fine, 2010). Animals are also seen as social facilitators that can enable the patient therapist relationship to develop stronger bonds, as individuals tend to reveal more information about themselves in the presence of an animal (Fine, 2010).

Transitional Effect

The bond between animal and human has also been a topic that implies the therapeutic gain that happens during animal assisted therapy, and this gives way to the transitional effect. This effect was proposed by the psychoanalyst Winnicott (Holmes, 2001), who determined that objects can be considered transitional (Holmes, 2001). A transitional object facilitates forming an independent view of one’s self (Holmes, 2001). Winnicott established that this object raises an awareness of the external world that is related to one’s internal world; therefore developing a relationship between the two (Nutkevitch, 1986). The inner world directly affects ones perception of the outside world. This perception of the outside world can defend against

depressive anxiety as one can use this object to work through the consequences of instinctual experiences, and better understand one self, therefore relaxing in the presence of the object (Nutkevitch, 1986). The animal can enact as this transitional object during therapy, aiding in therapeutic goals being reached as the participant gains an understanding of their relationship with themselves and the animal.

Social Cognitive Theory

Social cognitive theory has also been used as an approach to understanding the benefits of animal assisted therapy, as the goal of therapy is to bring positive changes to a person (Fine, 2010). Albert Bandura's social cognitive theory (2004) is often applied to animal assisted therapy. Social cognitive theory can promote health and the management of healthy habits. Within social cognitive theory (as relating to health), there are a set of determinants which include: knowledge of the health risk and benefits of health practices, outcome expectations about the costs and benefits of health habits, health goals followed by strategies to reach these goals, and lastly, the facilitators and social/structural impediments to the changes to health that are sought (Bandura, 2004).

“Knowledge of health risks and benefits creates the precondition for change” (Bandura, 2004, p. 144); if individuals do not have any knowledge of their lifestyle and the implications it has on their health, then there would be no belief that change or improvement was needed. Encompassing the knowledge of your health is the “foundation of human motivation and action” (Bandura, 2004, p. 144). This knowledge leads individuals to the desire to change one's health. This change in health behavior will bring outcomes which are expected by the individual. These outcomes can include physical, social, and positive and negative self-evaluative reactions to one's health (Bandura, 2004). From the expected outcomes individuals set personal goals that

“provide further self-incentives and guides for health habits. Long-term goals set the course of personal change...Short-term attainable goals help people to succeed by enlisting effort and guiding action in the here and now” (Bandura, 2004, p. 144). These goals are accompanied by impediments which are obstacles that get in the way of reaching goals. The way an individual faces these impediments stems from self-efficacy (Bandura, 2004).

Self-efficacy is an attribute that shapes how people motivate themselves. It refers to “personal capability, which is concerned with judgments of how well one can execute courses or action required to deal with a prospective situation” (Joy, 2003, p. 11). Efficacy beliefs directly affect an individual’s goals. High self-efficacy (believing you can overcome an impediment) allows a person to set higher goals and display stronger commitments to these goals. Low self-efficacy (believing you cannot overcome impediments) allows people to “expect their efforts to bring poor outcomes” (Bandura, 2004, p. 145). “If there are no impediments to surmount, the behavior (goal attainment) can be easy to perform and everyone is efficacious” (Bandura, 2004, p. 145). Given that there are impediments in life, self-efficacy controls the attainability of goals. Social cognitive theory is at work during animal assisted therapy as cognitive and physical goals are set.

Each of these theoretical frameworks has been used in order to discuss the benefits of therapeutic horseback riding, an animal assisted activity that uses recreation as an intervention. Recreational therapy uses “recreation to achieve positive or enhanced outcomes for people with disabilities or special needs” (Joy, 2003, p. 24). This literature review focuses on the benefits that therapeutic horseback riding has on behavior and balance. Behavior and balance each offer a need for specific theoretical frameworks to interpret the benefits. To further understand how

therapeutic horseback riding affects balance, balance theory (Huxham, Golide, & Aftab, 2001) will be used.

Functional Determinants of Balance

Balance is integral to the activities that one performs, as balance can never be separated from the action that is being performed. Horseback riding requires “different and complex changes in muscle tone and activity within the balance control system” (Huxham et al., 2001, p. 89). This control system is comprised of postural control and equilibrium control which react to consequences of task constraints and environmental context (Huxham et al., 2001). Postural control is defined as “an involuntary neurological loop consisting of motor, sensory, and integrative processes used to maintain the body’s position relative to gravity and of its segments relative to each other for stability...Balance is a hallmark of postural control” (Postural control, 2009, p. 1). Equilibrium is when the body displaces itself due to an outside force, and counteracts with “forces that tend to oppose the displacement and return the body to equilibrium” (equilibrium, 2009, p. 1). Postural control and equilibrium are both comprised of biomechanical aspects and information processing that are determined by the environment and the task (Massion & Woollacott, 1996).

Biomechanical Mechanisms of Postural Control

Task constraints and environmental contexts challenge an individual’s postural control and equilibrium by affecting their biomechanical and information processing aspects. Biomechanical features of an activity may be altered by the task at hand and the environment the task is surrounded by; likewise information processed will be altered to achieve balance during the activity according to the task constraints and the environment. In postural control, the biomechanical aspects influence even a body that is not in motion (Huxham et al., 2001). Due to

the Earth's gravitational pull, the body must work to remain upright. When a body is in motion, there must always be an extensor activity occurring to prevent collapse. Postural control works to counterbalance any movement that alters the projection of the body (Winter, 1995).

Biomechanical Mechanisms of Equilibrium

Equilibrium biomechanical aspects maintain stability of the body regardless of the opposing forces. Forces are the linear and angular accelerations, which occur when body parts perform a movement (Huxham et al., 2001). When walking one side of the hip is forward (linear acceleration), so the balance system produces equal opposite hip motions (the other hip backwards) to remain in balance, otherwise known as intersegmental stabilization (Huxham et al., 2001). Intersegmental stabilization is equilibrium and the amount of equilibrium necessary depends on the speed of the acceleration and the mass of the body part (Huxham et al., 2001).

Task Constraints on Biomechanical Mechanisms

Tasks can influence the biomechanical aspects of postural control and equilibrium, therefore challenging balance. The tasks performed require a combination of gravity and acceleration which directly affect the biomechanical aspects of balance (postural control and equilibrium). The tasks of walking and standing are different and have separate biomechanical needs (Huxham et al., 2001). The acceleration (equilibrium) and counterbalance (postural control) mechanisms must act and react to continue walking (Winter, 1995), and act and react in a different way to stand. If you are walking fast, these mechanisms are working differently than they are when you are walking slowly. The task sets the determinant for the combination of biomechanical mechanisms (Patla, 1997).

Environmental Contexts of Biomechanical Mechanisms

Environmental contexts influence the biomechanical mechanisms of balance as well (Huxham et al., 2001). Walking over a paved road requires different activations of acceleration and counterbalance than are required of walking on a rocky road. Likewise, environmental avoidance strategies affect balance (Huxham et al., 2001). Avoidance strategies consist of increasing one's stride to step over a puddle on that rocky road. Environmental contextual balance is achieved by proactive and reactive mechanisms. Proactive mechanisms "reduce or counteract stresses acting on the body...reactive mechanisms respond to the failure of the proactive component" (Huxham et al., 2001, p. 47).

Proactive balance is determined by the visual system as information about the environment is gained through the eyes (Patla, 1997). We see obstacles and other impediments and evaluate the environment and make adjustments. Part of our proactive balance comes from predictive balance control which maintains equilibrium. This is a learned awareness of one's body and how one's body will react to muscle movements (Nashner, 1980). This is accomplished by anticipatory postural movements. When walking, one places their weight securely on the forward leg before swinging the behind leg forward. The placement of weight on the forward leg is a predictive reaction. There is also a mechanism that facilitates balance if all other mechanisms fail, which is reactive balance control consisting of postural reflexes. When you trip, but catch yourself, the ability to catch yourself is your reactive control (Huxham et al., 2001). The environment in which you are performing the tasks creates the complexity of the biomechanical actions (Huxham et al., 2001). Biomechanical aspects of postural control, equilibrium, proactive balance, predictive balance, and reactive balance, are all affected by the environmental context of the task that is being performed, as well as the task that is actively happening (Huxham et al.,

2001). In order for the biomechanical mechanisms to work appropriately, strong information processing is needed. Information processing is influenced by the task constraints and the environmental context of the task.

Information Processing

Appropriate sensory input that we receive, mostly from visual input, streams into the central nervous system. At this point, the information received is judged and relevance is determined. The accuracy of this judgment depends on the capacity of the processing region, and the level of attention the information is given (Huxham et al., 2001). Balance is not automatic and it takes proper information processing to occur. The information processed depends on the environment and the task (Huxham et al., 2001). Walking through the environment of a dark hallway requires different information processing than through the environment of a well-lit hallway. If you then fill that hall way with people, even more processing is required. The task of walking in the environment of the dark hallway filled with people challenges information processing. One must properly process the people they need to dodge, and that they can barely see, in the dark environment, to successfully make the balance adjustments to effectively complete the task. This requires the relationship between the task and the environment to be properly processed (Huxham et al., 2001). Research suggests that balance can be practiced and improved upon (Wang & Chang, 1997).

Therapeutic Horseback Riding and Balance

Therapeutic horseback riding is a balance training intervention that provides an opportunity for balance skills to be practiced as the rider of the horse falls into place with the horse's rhythm and experiences a range of benefits due to this practice (Biery & Kauffman,

1989). Therapeutic horseback riding is considered to address musculoskeletal, motor, and sensory processing rate while focusing on both static and dynamic tasks, which leads to improved balance (Silkwood-Sherer, 2012). Wingate (1982) studied seven children and qualitatively found that the parents of the children reported improved posture, less falling, better sitting, more head control, and improved gait at home after the sessions. The parents also reported that the children enjoyed the program and were not aware that they were receiving therapy. Improvements in balance and posture in children with cerebral palsy were found as a direct result.

Wingate (1982) encouraged researchers to develop quantitative studies to better assess the benefits. Similarly, Fox, Lawlor, and Luttgies (1984) concluded that balance improved by 18.6% from pre to post riding session testing. The strength tests showed an 8.1% increase in arm strength, and a 13.8% increase in leg strength. The results showed that after the riding sessions there was an 18.0% improvement in the ability to sit straighter. Bertoti (1988) conducted another study that found that therapeutic horseback riding was invaluable to posture control in children with cerebral palsy, as the result of the Friedman test showed a pre to post test improved score of 12.86 at ($p = .05$). Additionally, Bertoti (1988) concluded that the kids exhibited more self-confidence with their bodies and movement after these sessions. Biery and Kauffman (1989) found that during riding sessions balance and coordination skills improved, ($t = 4.17, p = 0.00$), for eight children with mental retardation after a year of therapeutic horseback riding because the intervention facilitates the rider's muscles in activation and relaxation. In turn, balance was improved.

The results of a study by Drnach et al. (2011) also showed an increase in strength, balance, coordination, and mobility after therapeutic horseback riding as scores on the Gross

Motor Function Measure improved in these areas (the scores jumped from a two to a three) after the five week intervention period. The authors reasoned that these scores improved due to the child's ability to improve upon complex patterns of movement while riding a horse. Zandikar and Kastrin (2011) found that therapeutic horseback riding fosters positive postural control and greater balance in children with cerebral palsy. A meta-analysis revealed through the DerSimonian-Laird estimate of (OR=25.41), ($p < 0.00$) (Zandikar & Kastrin, 2011) the statistically significant effectiveness of therapeutic horseback riding. Zandikar and Kastrin (2011) noted that as the horse's gait shifts its center of balance in a three dimensional pattern when walking; the rider must adjust to these movements. This adjustment involves muscle and joint movements that increase range of motion and improve balance and posture. Drnach et al. (2011) found that the relationship between improved postural control and ability to walk was the primary reason that therapeutic horseback riding was effective. Lee et al. (2011) tested an individual with neuromuscular sclerosis using the robo-therapeutic horseback riding technique. In this single subject study it was found that the child's gross motor function improved and muscle strength increased. Spinal alignment was increased by seventeen percent. The electromyography (EMG) test showed that muscle activity amplitudes increased by 33.0% to 66.0%. Whalen and Case-Smith (2012) found that the rhythmical pattern of the horse's gait, the warmth, and three-dimensional shape of the horse contributes to improvements in range of motion, tone, balance and posture.

Summary

There is diverse literature claiming the benefits of therapeutic riding (DePauw, 1986). The literature indicates that animals and humans share a special bond with each other, dating back to the beginning of civilization (Loving & All, 1999). Animals are a part of our natural

environment and can be utilized therapeutically as tools (Gammonley & Yates, 1991) because of this animal assisted therapy was developed in the 1960s (Leslie, 2011). Therapeutic horseback riding is an example of this and it can provide cognitive, physical and emotional gains for its participants (EAAT, n.d.). These gains are achieved through balance changes, and can be explained by balance theory. Balance increases as a result of this therapeutic intervention (Fox et al., 1984) and behavior improvements (Berget et al., 2008). Though the literature shows evidence of this, the effect of therapeutic riding on participants' balance and behavior needs to be better researched to sustain the benefits of this animal assisted intervention. Therefore, this added to the literature to determine the effects of therapeutic horseback riding on balance.

SECTION III: EXTENDED DISCUSSION

Daily Session Effects of Therapeutic Horseback Riding on Balance (RQ1)

To determine the session effects of therapeutic horseback riding on balance, the MDRT (Newton, 2001) was used to measure the changes in length of reach (anterior, posterior, left and right). A baseline measure was taken before the rider started the structured therapeutic horseback riding intervention and a second measure was collected immediately after the rider dismounted from their first thirty minute intervention. This short-term balance assessment aimed to determine how the participants' balance changes after a therapeutic horseback riding session to show the immediate session effects.

Anterior and Posterior Balance Changes (Session)

In this study, there was no statistically significant change in the anterior reach group means from measurement at baseline to measurement at time two. It is interesting to note that the baseline mean ($M=9.03$) was higher than the mean once the rider had dismounted from their first ride ($M=7.85$) for their anterior balance measurements. This indicates a decrease (mean change= -1.18 inches) in balance score for the anterior reach from baseline to after the rider finished the lesson. This means that participants could not reach as far after riding the horse, indicating less balance in the forward reach position.

Similarly, the results of the posterior reach test indicated that posterior baseline reach at time one (M1) ($M=6.35$) was higher than the reach at time two (M2) ($M=5.26$), indicating a significant change in the group means at ($p=.05$). This negative change (mean change= -1.09 inches) in means suggests a lowering of balance scores for the posterior reach once the rider completed the initial intervention. It stands to reason that a tired body does not balance as well

(Avlund, Vass, & Hendriksen, 2003), accounting for the downward trend in the posterior group means.

Anterior reach is the length of your forward reach, allowing for bending of the hip as long as the feet stay in the same position (Newton, 2001). Postural control can be understood by considering anterior-posterior body sway while moving the center of mass and maintaining balance. Simply put, posture is challenged by anterior and posterior (as well as rotational, left-right) movements of the torso at the same time our body maintains its balance by controlling where our center of mass is placed by purposeful movements or adjustments (Peterka, 2002). The body makes adjustments to keep its postural and balance systems in place as stimulus and the environment around us constantly challenges these systems (Peterka, 2002). Horseback riding creates an anterior body sway due to the movement of the horse, challenging the participant to change their position as the rider experiences an alternating forward and downward movement as the horse drops its hips to continue movement in the forward direction (Biery & Kauffman, 1989). This indicates that the rider is actively moving and resisting anterior movement.

The posterior reach shows the participants' ability to lean back from the hips as far as possible without moving the placement of the feet. This reach is generally the shortest of all reaches (Newton, 2001). Horseback riding causes the body to keep symmetry of the trunk, and decrease lateral trunk flexion while elongating the trunk into a more erect posture. To elongate posture, the pelvis must decrease its' anterior pelvic tilt and maintain alignment of the pelvis. The elongating of the trunk and alignment of the pelvic creates a stronger lumbar support, thus encouraging strengthening of the trunk. Hip flexion is also challenged as the movement of the horses encourages movement of the hip (Bertoti, 1988). A posterior reach requires a shifting of

the center of gravity and muscle control (Silkwood-Sherer, 2012), which are tired after physical exertion (Bongers & Takken, 2012).

Movements and counter movements are required to maintain posture when the body is in continuous motion, as it is when a person sits atop a horse. Posture affects the body's equilibrium. When balance is disturbed, the body makes anterior and posterior adjustments to adjust and maintain balance. This is known as center of mass displacement. Postural sway anteriorly or posteriorly is the adjustment (Clifford & Holder-Powell, 2010). Commonly during activities of daily living, the center of pressure is purposely placed to maintain the center of mass. Maintaining balance in the frontal and posterior planes of the body consists of predicting the future placement of the body's center of mass and making subsequent adjustments (Pennycott, Wyss, Vallery & Riener, 2011). This adjustment, as well as the act of riding a horse, requires participants to expend energy; therefore, feeling total body fatigue once off the horse is not uncommon (Bongers & Takken, 2012).

It is commonly known that once the body feels fatigue, the body's performance is compromised (Gribble, 2012). When the lower extremities have worked hard atop a horse, and are in turn experiencing tiredness (Bongers & Takken, 2012), this will adversely affect dynamic postural control and therefore reaching ability (Gribble, 2012). In order to get a full anterior reach, ideally the knee would flex as much as possible with as little hip flexion. For the knee to flex fully, it requires full activation of the quadriceps and hamstrings (Gribble, 2012). The quadriceps and hamstrings once exposed to a fatiguing task (e.g., riding a horse in this study) often lose the ability to assist in maintaining the anterior reach. Similarly, the posterior reach requires knee and hip flexion, as well as requiring ankle flexion. Ankle and knee fatigue do have a negative impact on the ability to reach posteriorly, as strength of the lower body is necessary to

complete this task. Once the body is tired, it becomes stiffer in the knee, allowing for less room to reach. Decreased knee flexion due to fatigue is the primary antagonist when considering reach ability in the posterior or anterior directions (Gribble, 2003).

It should also be noted that with body fatigue there is an increase in the amount of body sway in the anterior and posterior directions, resulting in a direct hindrance to balance. Balance is affected by exercise because it creates fatigue (Corbeil, Blouin, Begin, Nougier, & Teasdale, 2003). This increase in fatigue creates an inability to control posture changes in the anterior and posterior direction. When an individual feels fatigue, the person resorts to a stiffening strategy to prevent deviations to balance. Subsequently, when an individual stiffens their body, he or she engages in increasing the activation of the antagonist muscles, which maintains stability but does not allow for flexibility allowing for reaching ability in the anterior and posterior directions (Corbeil et al., 2003). Stiffening the body, due to fatigue, places a higher demand on an individual's postural control system and creates a need for more movement and adjustment to posture to allow for balance to remain intact (Corbeil et al., 2003). In turn, balance reach ability is harder to maintain because postural control requires more effort when reaching anteriorly and posteriorly (Gribble, 2003). This study found that due to fatigue, the anterior and posterior reaches showed no significant change due to one thirty minute riding session; in fact, the mean change decreased after the ride. This reveals a negative change in balance in the anterior and posterior direction of the scores on the MDRT (Newton, 2001), indicating that the short term session effects of therapeutic horseback riding has a non-therapeutic value in the anterior and posterior directions.

Lateral Balance Changes (Within Session)

This study determined the session effects of therapeutic horseback riding on lateral balance by using the MDRT (Newton, 2001) to measure the changes in lateral length of reach from baseline (M1) to lateral reach length after the first intervention was complete. Statistical evidence suggests that there was no difference in participants' balance from the baseline balance assessment (M1) taken before the rider started therapeutic horseback riding and the follow up measure (M2) taken after the participants' first therapeutic riding session of the ten-week intervention. This short-term balance assessment was directed to determine how a single session of therapeutic horseback riding changed the participants' lateral balance once the rider dismounted.

This study found that both of the lateral baseline measurement means for the left reach ($M=7.24$), and the right reach ($M=7.35$) were lower than the mean of the reaches at time two for both the left ($M=8.15$), and right ($M=8.56$) reaches at measurement at time two. Both lateral reaches showed a positive mean change from baseline, indicating a positive therapeutic value for the participants. While these mean changes were not significant, it is interesting to see the group mean raise from baseline, whereas for the other reaches (anterior & posterior), the means declined after the initial ride in the therapeutic horseback riding intervention in this study. The results conclude that there are therapeutic session effects on balance laterally, but not anteriorly and posteriorly. It seems that the demands that a horse places on the rider's body had a profound effect on the lateral shifting (Biery & Kauffman, 1989) of the functional stability region (Holbein-Jenny, McDermott, Shaw & Demchak, 2005). In a study done by Biery and Kauffman (1989), the most dramatic increases found in balance were the lateral movements after a twenty-minute riding session. This article attributed these balance changes to the specific postures used

frequently on a horse. These postures stressed lateral positioning and re-positioning while the horses movement encouraged continued movement and stretching. This type of stimulation to a person's body with the base of the horse used for support, requiring hip, ankle and knee flexion provided continued challenge to dynamic balance, and offers balance practice from a lateral viewpoint. The horse's base allows for the individual to attempt balance movements that they otherwise would not be able to perform while standing or sitting, especially regarding lateral movements (Biery & Kauffman, 1989). These movements could stretch and loosen a person's agonist and antagonists muscle groups (LeRoy, 1960), giving them the ability to reach further to the left and right after being on top of a horse.

While this study did show increases in short term mean balance score from baseline (M1) to after the initial ride (M2), these changes were not significant ($p > .05$). This can possibly be attributed to the trend that balance and strength generally takes two to four weeks to show improvement (Kang et al., 2012). It is also suggested that horseback riding intervention should last at least six weeks to show improved muscle strength and endurance as changes are not often seen prior to this time frame (Kang, Jung, Moon, Choi, Kim, & Kwon, 2012). This study assessed balance immediately following the first ride during the first week of a ten week intervention. Therefore, it is likely that a short-term session of therapeutic horseback riding does not result in *immediate* effects, and therefore, therapeutic riding should be provided as a long-term intervention program. Additionally, riding is a form of physical exercise that increases the metabolic demand on the body as the horse moves, requiring an intense exertion from the body with cardiopulmonary implications even if for a short duration (Bongers & Takken, 2012). This could explain why the balance measurement changes were not significant, as the body tires and requires a recovery period. Lateral balance is an energetic cost to the body as it actively works to

control its balance systems. As a person rides a horse and engages in lateral trunk movement, energy is being expended; therefore, this energetic cost can tire individuals and thus reduce lateral balance (Arellano & Kram, 2011), creating only a small and non-significant change in the short-term results of this study.

Lateral balance is more involved when a person is practicing dynamic balance (i.e., balance while moving) because the movement of one's center of mass constantly shifts one's base of support. This shift necessitates there to be weight support when the body moves in the lateral planes, and the instability in these planes must be controlled by feedback. Input from the body's visual, vestibular, and proprioceptive systems give a person the ability to actively control lateral stabilization while the limbs and spinal cord provide a more passive stabilization property. It is easier for a person to stabilize themselves to reach laterally if their foot stance is wider (Bauby & Kuo, 2000), but this study required the participants to stand with their feet shoulder width apart. This effectively requires participants to engage in active control of their lateral balance, and may have created a more difficult lateral reach that ultimately affected balance scores.

Additionally, it should be noted that humans do not have an easy control of lateral balance because of their high center of mass and narrow base of support (Hof & Duysens, 2013). Lateral balance deficits are more responsible for loss in functional balance and can often predict fall risk (Newton, 2001). When a person is confronted with a lateral perturbation (i.e., challenge to balance), their natural response is to step in the opposite direction of the perturbation in order to correct the challenge (Hof & Duysens, 2013). This occurs in natural walking as the human gait involves an ongoing alternation of left and right steps creating a lateral oscillation of the center of mass (Hof & Duysens, 2013). Maintaining lateral balance requires individuals to engage their

center of pressure, which is the midpoint of pressure distribution in an individual's foot as they project their center of mass on the floor. Good control of lateral balance means that after a perturbation has occurred, the center of pressure (in the foot or bottom if sitting) is in a relative position that can hold the center of mass projection. Simply stated, the human foot must be able to support the body's center of mass—and this is determined by the ability of the foot to hold the center of mass stable where the center of pressure is placed in the foot (or bottom if sitting). The left/right (depending on which side the perturbation has occurred) abductor and gluteus medius must support the center of pressure on the foot as the entire body is involved in executing balance. While the body is maintaining balance, added ankle dorsiflexion and abduction of the hip is beneficial to keeping lateral balance while reaching. This allows for the restoration of balance. The restoration and maintaining of balance is a skill in which the body has room to improve over a period of time as opposed to a short time frame (Hof & Duysens, 2013). The daily session effects of this study were analyzed over a short time frame, may have attributed to the non-significant results.

Conclusion of Daily Session Effects of THR on Balance

This study found no significant changes to balance for the short term session of therapeutic horseback riding in any of the reaches of the MDRT (Newton, 2001). This is understandable since balance is a skill that will take time to practice and time to grow in skill and strength (Hof & Duysens, 2013). The most interesting results found over the short term duration of the intervention were the positive mean changes in the lateral reach vs. the negative mean changes in the anterior/posterior reaches. From this study it can be determined that during the short term duration of a therapeutic horseback ride, the lateral movements caused by riding a horse (Bertoti, 1988) cause the body to stretch through the movement of the antagonist and

agonist muscle (LeRoy, 1960) creating a positive therapeutic gain in lateral reach ability. However, the negative balance change viewed in the anterior/posterior direction of balance can be attributed to the tired body after physical exertion (Bongers & Takken, 2012) and the repercussions that riding a horse place on postural sway (Biery & Kauffman, 1989). This implies that individuals who are in need of lateral balance work may benefit immediately following a ride on a horse, but their anterior/posterior balance may require further intervention as a result of being fatigued following a short term intervention.

Comprehensive Balance Changes Post 10-Week Intervention (RQ2)

Assessing the change in participants' balance once the intervention was completed is useful to determine the changes that are made in balance due to the long-term effects of the intervention. This study revealed comprehensive effects of therapeutic horseback riding by comparing the baseline measurement (M1) to the balance measurement taken once the ten week intervention was complete (M3). This study attempted to determine whether therapeutic riding has long term effects on balance, and compare them to the noted short-term session effects. Each reach assessed by the MDRT (Newton, 2001) when analyzing the results.

Anterior and Posterior Balance Changes (Comprehensive Effects)

The anterior reach revealed a statistically reliable difference between group means at baseline (M1) and group means after the ten week intervention was completed (M3). The anterior reach balance assessment showed that group means were significantly higher post intervention at the ten week mark ($M=12.09$), than they were at the baseline measure ($M=9.00$) for the anterior reach, displaying a positive change (mean change= $+3.09$ inches) in participants' anterior reach for the duration of the intervention.

The posterior reach balance measurement was the only balance measurement to reveal no significant change from group means from baseline to post-intervention. The baseline group mean ($M=6.39$) was still lower than the group mean at post-intervention ($M=6.79$), indicating a positive change score of (mean change= $+0.40$ inches), but this change was small and not significant. It is still relevant in that it does show a small increase in means, revealing a small positive change throughout the ten week intervention. It is important to note that the posterior reach depends on knee and hip motion, more so than the other reaches, creating a more challenging reach and balance effect (Hoch et al., 2012). Additionally, the posterior reach requires more core support than the other reaches, as these muscles are required to keep the pelvis and lumbar regions balanced while reaching posteriorly (Sellentin & Jones, 2012); thus, creating additional difficulty in the posterior reach of the MDRT (Newton, 2001).

Horseback riding requires the use of participants ankles while riding (Bertoti, 1988), and it has been found that anterior reach length requires reliability on the ankle to handle dorsiflexion and to provide responses to the body so that it will maintain balance (Hoch et. al, 2012). When riding a participant is practicing dorsiflexion of the ankle, therefore this practice over a ten-week period would contribute to positive balance gain in the anterior reach. Additionally, trunk stability is challenged and impacted when riding a horse. In this study, participants were required to stretch and hold their hands above their heads for at least ten seconds. This is a balance perturbation (anything that challenges the body's center of balance). The stretch above their heads challenges their anterior and posterior trunk stability and makes the lumbar and thoracic regions of the trunk become engaged (Bertoti, 1988). This engagement practices the strengthening of the trunk which encourages the build-up of muscle support, and the increases one's ability to reach forward (Hoch et al., 2012). If the lumbar and

thoracic regions have practiced performing, then a reach forward becomes easier (Hoch et al., 2012) and potentially attributes to the positive therapeutic gain seen in this study. This program lasted for ten weeks, allowing for time and practice to encourage better balance.

The ability to control posture is immediately affected by the demands of the task the body is faced with accomplishing. This control of posture is complex, as it requires altering the degree of postural sway or the degree of body symmetry depending on the task at hand. Balance training can improve the way the body handles the demands of the task of balancing (Haddad, Rietdyk, Claxton, & Huber, 2013). Postural control is a basic ability and provides coordination in all activities as it allows for the orientation of the body in space (Westcott & Burtner, 2004). The human musculoskeletal system allows the body to counteract perturbations to balance through adapting our postural muscle activity to reinforce our base of stability. Practice of motor skills has been shown to provide positive changes to postural control (Shumway-Cook & Woollacott, 1985) and complement independent balance ability (Westcott & Burtner, 2004).

As mentioned previously, muscular strength is a function of balance, and there is strong evidence in the literature that physical exercise training greatly improves muscle capabilities (Kloubec, Rozga, & Block, 2012). Interventions that involve gait, balance, coordination and functional exercises seem to have the greatest functional improvement on balance (Kloubec et al., 2012), and horseback riding involves all of this (Bertoti, 1988). The length of a physical training program plays an important role in the functional improvements seen in balance, as programs lasting only six weeks have not shown significant results as programs lasting more than six weeks (Kloubec et al., 2012). This has major implications as it suggests that the duration of a program is essential to show balance improvements. This study found similar results, as the short-term session effects of therapeutic horseback riding showed no significant changes, but

after the intervention was carried out for ten weeks, significant improvements to balance were noted. However, the exact duration of a program and how it relates to outcomes still needs research.

Lateral Balance Changes (Comprehensive Effects)

This study examined the changes in the long term lateral reach balance of the participants' by comparing the means of the baseline lateral (left and right) balance reach to the lateral balance reach post the ten week intervention. The left reach balance assessment revealed a significant change in group means from baseline ($M=7.27$) and post-intervention ($M=9.79$). This indicated a positive therapeutic change in balance means (mean change= $+2.52$ inches). The right reach long-term balance assessment from baseline to post-intervention also indicated a significant change in group means. The mean at baseline ($M=7.38$) was significantly lower than the mean post-intervention ($M=10.22$), resulting in a positive change (mean change= $+2.84$ inches) in the right reach over the course of the intervention.

The value of therapeutic horseback riding on participants' lateral balance over the course of a ten-week intervention has been previously noted. Bertoti (1988) reported beneficial postural changes in the participants, and Biery and Kauffman (1989) also found positive lateral balance changes in participants over a long-term period. These changes have been attributed to the movement of the horse, as the gait of a horse constantly shifts the rider's center of gravity rhythmically mimicking the pattern of a human walk (Homnick, Henning, Swain, & Homnick, 2013). The horses' gait moves the rider's body in way that requires underutilized muscles to work in response to the shift of the center of gravity. This creates improved muscle response to stimulation, which in turn can increase strength, posture, and the ability for dynamic balance (Homnick et al., 2013).

Dynamic balance is a complex task, but is required for maintaining the body during propulsion. Propulsion occurs when a person is moving, and can also occur while a person is sitting, reaching, performing activities of daily living and in many other facets of life. Propulsion highly destabilizes the body, requiring the body to react and engage the balance systems (Falkerslev, Baagoa, Alkjaer, Remvig, Halkjaer-Kristensen, Larsen, Juul-Kristensen, & Simonsen, 2013). Riding a horse requires the participant to propulse laterally due to the movement of the horse (Bongers & Takken, 2012). Lateral trunk stabilization is required during propulsion and can be responsible for the loss of balance. A loss of balance can occur when the lateral trunk equilibrium is challenged, causing one side of the body to fall too far to the left or right (Falkerslev et al., 2013). Decreased lateral stability of the trunk can be caused by decreased head stability, and decreased lumbar and thoracic control, which are important facets of walking (Falkerslev et al., 2013) as well as riding a horse (Biery & Kauffman, 1989). Therapeutic horseback riding involves lateral postural challenges as long as the horse is in motion (Hakanson, Moller, Lindstrom, & Mattsson, 2009), creating balance practice as the riders torso and pelvis are voluntarily and involuntarily challenged and movement is created. Lateral control of the torso is directly linked to balance ability (Hakanson et al., 2009).

Balance improvements come from a number of different types of training which involve much practice and strength improvements. Strength improvements take time as the body needs time to recover and grow stronger from exercise (Sherk, Bembem, Brickman & Bembem, 2012). This is why therapeutic horseback riding may take up to ten weeks to show any changes in lateral balance. Arellano and Kram (2011) found that the energy expended to maintain lateral stabilization can have a huge cost on the body, but once lateral stabilization is practiced and the stabilization muscles are stronger, lateral stabilization expends less energy creating a better

ability to balance. Similarly, it has been found that gradual lateral balance control training teaches the participant to perform better when balancing versus sudden lateral balance training (Sawers, Kelly, Kartin & Hahn, 2013). This gradual performance of lateral balance over time promotes the development of a balance strategy within the body. When the body is given time to create muscle memory and to practice communicating within its balance systems, balance is greatly influenced and improved upon (Sawers et al., 2013).

Regular balance exercise has been shown to increase balance performance as it creates a quicker reaction time to balance perturbations and can train the body's balance system to respond more effectively to balance challenges. Lateral balance practice enables a person to improve their functional mobility and enhance functional independence. Similarly, this happens when training postural sway; the center of mass and center of pressure placement can improve invoking a greater feeling of confidence once balance has been challenged (Singh, Rajaratnam, Palaniswamy, Vimal & Bong, 2012). Greater feelings in balance confidence have been shown to create successful responses to balance perturbations; and therefore success in restoring balance (Singh et al., 2012).

Lateral balance confidence and ability is greatly affected by the participants muscle mass and strength. Loss of strength greatly influences a body's ability to balance and the ability to perform activities of daily living. Strength training incorporating upper and lower body contributes to greater balance levels (Sherk et al., 2012), as unilateral balance between opposing muscle groups must be obtained to continue keeping the body in balance. The agonist muscle group initiates a movement, and the opponent muscle group (antagonist) controls that movement. To gain proper alignment (lateral) of the body segments the

antagonist muscle group controls the speed, the range, and the force of the agonist. The agonist is in action as this is happening. To coordinate fine adjustments the strength of the antagonists is imperative. To create greater ability in lateral movement, the antagonists must be strong to balance the opponent muscle groups. Strong antagonist muscles create for a more reflexive habitual balance adjustment as the muscles are stronger and tire less easy. For an individual who is in a state of imbalance due to faulty posture or weak abdominal and back muscles, the stabilizing (agonists) muscles and ligaments which control the balance performance are stretched, and the antagonists are shortened and tightened. As imbalance increases, excess work is required of the body and creates incoordination. To address this balance training is necessary. This training is not to make muscles work, but rather to strengthen muscles to build up a base of neutral stability and control (LeRoy, 1960). Horseback riding in this study provided the balance training necessary with an adequate time frame of ten weeks to foster positive therapeutic changes in balance.

Conclusion of Comprehensive Program Effects of THR on Balance

Horseback riding requires the use of all muscles and improves muscle strength as it prompts muscle contraction and relaxation, which directly improves physical balance and muscular endurance. Moreover horseback riding increases flexibility as the continuous movement of the horse encourages and actively engages movement in the anterior, posterior, left and right directions. This movement of the horse is rotating (Bertoti, 1988), therefore simulating a stretch and reflex effect, which engages the lateral movement of the body. As noted previously, lateral movements tremendously influence balance as any sway in the lateral directions is a predictor of fall risk (Newton, 2001) as lateral asymmetry affects gross motor performance and causes muscle weakness. The rhythmic forward and downward movement of the horse also

encourages the hip and pelvis to move anteriorly and posteriorly, simulating human walking (Biery & Kauffman, 1989). This enables the anterior and posterior balance reaches to improve due to the anterior/posterior shifts of the body atop a horse. These shifts are a form of physical exercise that improves strength and coordination (Drnach et al., 2010). Horseback riding has been found to encourage a more symmetrical alignment of participants' spines, therefore allowing for better gross motor function (Lee et al., 2011) and enhanced dynamic balance over the course of an intervention.

Programmatic Carry-Over Effects Post Intervention (RQ3)

To address the carry-over effect that therapeutic horseback riding had on balance, the balance measurements from the MDRT (Newton, 2001) were compared from the program effects measurements after the 10-week intervention to measurements taken three weeks once the intervention was complete. This study explored if the balance changes that occurred during the course of the intervention were altered in any way once the intervention was over and three weeks had lapsed of no riding.

Anterior & Posterior Balance Changes (Carry-Over)

For the anterior reach, the repeated measures ANOVA test did not show a statistical change from baseline (M1) to the end of the intervention (M3) but there was no significant drop in balance three weeks later (M4). The means of the balance scores increased from baseline (M1) ($M=8.70$) to post intervention (M3) ($M=12.60$). This displays a general trend increasing balance, as the change (mean change= $+3.90$ inches) indicated a statistically significant positive therapeutic change for the length of the intervention. The mean for the anterior balance scores three weeks after the intervention was completed (M4) only slightly decreased, ($M=11.65$) from the post intervention score, displaying a mean change of (mean change= -0.95 inches). This

revealed no significant decrease in anterior reach once the intervention was complete, and demonstrating a carry-over effect in anterior reach.

The tests of within subjects contrast revealed no statistical change from the posterior baseline balance measurement at time one (M1) to the end of the intervention at time three (M3). While there was no statistical change in the repeated measures tests, there was an observable positive change in balance (mean change= $+0.90$ inches) in posterior balance between M1 ($M=6.26$) and M4 ($M=7.37$). No negative change in balance once the intervention was stopped for three weeks. This indicated that once the intervention was concluded, the balance gains throughout the intervention were sustained.

Both the anterior and posterior balance changes were sustained once the participants in this study stopped riding horses. This may be attributed to the fact that in addition to range of motion, flexibility and strength training also occur during therapeutic riding and this is a form of proprioception training (The benefits of balance training, 2007). Proprioception is the sensation that an individual feels that connects them to their position in space. This is more commonly described as what allows us to walk in the dark. Any balance training can be considered a proprioceptive exercise. There are receptors known as proprioceptors that are in the joints, muscles, tendons, ligaments, and skin of the body (Hong, Kim, & Ryssegem 2011). It is the responsibility of the receptors to receive certain stimuli that help the body indicate the position, movement, and orientation in space, and send this information to the brain. The brain is then able to direct its' movements and counter movements to maintain balance. In short, the brain holds the map of the body's position in space, while the proprioceptors direct the brain where to lay the roads due to the stimuli received. The ability of the brain to listen and respond accurately to the

information that the proprioceptors send to the brain is a skill. This skill, just like balance, can be practiced, as it is a trainable skill.

The neural connections are a part of the central nervous system (Hong et al., 2011), and can be considered the paths that connect the proprioceptors to your brain and can be lost or be less clear if they are not used on a regular basis (The benefits of balance training, 2007). These paths, if used, can also become clearer resulting in better balance as the pathways produce more awareness of the body's limb, trunk, position of head and movement (Hong et al., 2011). There have been many findings that proprioceptive training can induce better balance, especially if this training is passive. Passive proprioception movements regard inputs that are externally imposed (no completed by individual), which challenge the body's ability to reposition to a balanced state because it is not in control. Horseback riding is an activity that externally places an imposition on the body, making it a form of passive proprioceptive training (Bongers & Takken, 2012). Wong, Kistemaker, Chin and Gribble (2012) studied the effect that passive proprioceptive training had on motor learning and found that the subjects that experienced this form of passive training had better results in motor performance than those who did not receive the training. It concluded that passive proprioceptive training reduced the amount of error in natural movements.

The proprioception of one's body (sensory information regarding one's position in space) is an act that can be perceived consciously through muscle sense and posture as well as unconsciously through proprioceptors. This allows the body to improve its reflexive and cognitive motor response in order to carry out the task of balance, more specifically accurately achieving a movement goal. This increases coordination and consistency of balance.

Improvements in balance can be attributed to a diminished proprioceptive functioning of the body (Argatov, 2013). Postural control involves maintaining body orientation and posture despite gravity and other external perturbing forces. To maintain body orientation involves awareness of the body's position in space (proprioception) and reacting to perturbations and correcting body position to maintain balance. This is a complex system that requires the integration of sensory information with cognitive and reflexive motor response (counter movements to maintain balance). Training allows for a greater ability to infer sensory information and provides a more accurate response by the body to maintain verticality. Body tilt (anteriorly and posteriorly) is observed by the body through muscular proprioceptors, and requires accurate information to correct. Training allows for an individual to have more accurate response to this tilt, and therefore maintain balance (Argatov, 2013). Balance training allows for individuals to not only work on maintaining balance through passive proprioceptive training, but additionally practice postural control through spinal alignment (maintaining a neutral posture—neither anterior or posterior tilt) and in turn muscular strength is improved. Muscular strength allows for posture to remain intact, thus influencing balance ability (Imagama, Wakao, Seki, Hirano, Muramoto, Sakai, Matsuyama, Hamajima, Ishiguro, & Hasegawa, 2013).

Muscular strength gained through proprioceptive functioning and postural control practice can improve balance ability. It has been noted that weak or fatigued muscles affect postural control by increasing the amount of postural tilt, therefore impeding balance (Imagama et al., 2013). Postural strength allows for greater reaching ability (Arain, 2008), and can be gained through therapeutic horseback riding as this is a form of strength training (Bongers & Takken, 2012). To maintain optimal performance whilst strength training, it is essential to observe a period of abstinence from training to recover and maintain balance (Hortobagyi,

Houmard, Stevenson, Fraser, Johns & Israel, 1993). Hortobagya et al. (1993) discovered that after fourteen days of rest there were no changes in muscular strength following a period of strength training. Similarly, Anderson and Cattanach (1993) found that after strength training, athletes showed no change in strength following seven days of no training. Most performance-based athletes participate in tapering—when training is drastically reduced prior to event—to increase their performance on event day. Numerous studies have exhibited the benefits of tapering on strength performance (Costill, 1986; Gibala, MacDougall, & Sale, 1994). The primary aim of tapering is to minimize fatigue. Fatigue is accumulated throughout the training period (i.e., the ten-week horseback riding intervention), and will drastically affect a person's strength. Tapering allows the body to compensate and rest allowing for maximal performance after the rest period. Rest also allows for quality training because rest avoids detraining. Detraining is breaking down the body due to overuse and too much training and ultimately promotes optimal performance (Gibala et al., 1994).

In this study, following three weeks of rest, the subjects showed no change in balance ability when performing the anterior and posterior reaches as measured by the MDRT (Newton, 2001). This may have been because of the ability of therapeutic horseback riding to act as a proprioceptive balance training exercise (Bongers & Takken, 2012), which enhances the body's capability to exhibit postural control in the anterior and posterior direction, therefore developing postural strength. This strength was built up over the ten-week intervention period, as it only takes eight weeks before strength training displays results (Weiss, Coney, & Clark, 2006), and was sustained through the rest period. The rest period was able to sustain performance of the subjects due to the advantages of tapering training. Rest allows for the body to rest and recover, but does not cause a reduction of gains made in training (Gibala et al., 1994). This has positive

implications for therapeutic horseback riding as it shows that the effects this intervention has on postural strength (anteriorly and posteriorly) are not lost once the intervention is complete. Not only are the gains not lost, a brief two-week period of rest is beneficial to the build up of the strength gained and may ultimately lead to better balance in participants (Bertoti, 1988).

Lateral Balance Changes (Carry-Over)

To address the carry-over effect that therapeutic horseback riding has on lateral balance, the long-term change in lateral balance was compared to the change in the lateral balance of the participants once the intervention was completed. This was addressed by measuring the participants balance three weeks post completion of the therapeutic horseback riding semester. The sample size for the last measurement was smaller, as not all subjects participated in the final measurement.

The tests of within subjects contrast revealed that from the left reach baseline balance measurement at time one (M1) to the end of the intervention at time three (M3), there was a statistical change in balance ($p=.00$). This means that from baseline to end of intervention, the left reach displayed a positive influence of therapeutic horseback riding on balance. Furthermore, when looking at the comprehensive balance change (M3) to the change in balance means three weeks post intervention (M4) for the left reach, there was no statistical decrease in the balance assessment from M3 to M4. This lack of change indicated that there was no significant loss in balance gains from the intervention after the intervention was completed.

Similarly, the tests of within subjects contrast revealed that from the right reach baseline balance measurement at time one (M1) to the end of the intervention at time three (M3) there was a statistical change in balance ($p=.00$), showing that from baseline to end of intervention the right reach displayed a positive change. Furthermore, when looking at the change from

comprehensive intervention (M3) to the change in balance means at time four three weeks post intervention (M4) for the right reach, there was no statistical change in the balance assessment from time three to time four. This implied that there were no negative decreases in balance once the intervention was complete, meaning that the balance gains from therapeutic horseback riding were sustained three weeks post-intervention.

Lateral balance ability, as measured by the left and right reaches of the MDRT (Newton, 2001), increased throughout the intervention and was sustained once the intervention was completed. The ability of the body to maintain lateral balance involves the ability to modify the activation levels of the agonist and antagonist muscles as the body shifts laterally and maintains balance. The activation of the agonist and antagonist muscles is known as muscular coactivation. Coactivation is a strong force in the action of stability and coordination in the production of movements (Tsatalas, Spyropoulos, Sileloglou, Sideris & Giakas, 2009). Strength training (in the form of therapeutic horseback riding) maintains the stability of coactivation (Tsatalas et al., 2009).

The agonist muscle in short provides the force of a movement, while the antagonist muscles provide the force necessary to put a stop to the movement (Slobodan, 2000). These muscles work together to provide coordinated movements and balance. Strength training increases the ability of the agonist muscles to provide the force and the antagonist ability to decelerate the force of the agonist movement. Simply stated, the agonist creates energy while the antagonist stops the energy. These two actions work together to perform tasks, especially the task of balance. The synergistic relationship between the agonist and antagonist muscles changes with training and fatigue (Slobodan, 2000). It has been shown that strength training leads to increases in performance due to neural improvements (i.e., proprioceptive pathway improvements, and

increased musculature strength). During this training, voluntary activation of the agonist muscles is increased, and the coactivation of the antagonist is better coordinated allowing for greater balance ability (Hakkinen, Kallinen, Izquierdo, Jokelainen, Lassila, Malkia, Kraemer, Newton, & Alen, 1998).

The combination of agonist and antagonist activation also allows for compensatory reactions and anticipatory postural adjustments to occur. The magnitude and the direction from which a balance perturbation (any challenge to balance) occurs determines the type of compensatory reaction and anticipatory postural adjustment needed (Hakkinen et al., 1998). Lateral muscles, part of our core, have an enormous role in the control of posture. For example, the external obliques are central in maintaining posture to sustain balance when asymmetrical perturbations (left and right reaches) occur (Slobodan, 2000). When anticipatory postural changes occur, the lateral agonist and antagonist muscles are activated to react to the direction specific balance perturbation. When a perturbation comes from a lateral direction, such as the left and right reach in the MDRT (Newton, 2001), the lateral muscles engage to provide lateral stability to the pelvis and provide compensatory reaction to keep in balance. Many activities of daily living involve perturbations in the lateral plane; therefore, practice in learning how to combine anticipatory activation of core muscles (obliques) with compensatory reaction is crucial in maintaining lateral balance (Santos & Aruin, 2007).

Core strength is essential for lateral balance as it creates stability. Core stability is the foundation of the mobility and control of force of the human body (Gordon, Ambegaonkar, & Caswell, 2013). Strength of the core allows for an increase in stability in all tasks. Decreased balance and proprioception is known to be a result of a weak core, and often a cause of many injuries (Gordon et al., 2013). To increase lateral balance, strengthening of the core is a necessity

(Gordon et al., 2013). Therapeutic horseback riding is an activity that can often increase core strength (Bertoti, 1988). In this study, participants participated in therapeutic horseback riding for a ten-week intervention which acted as a core strengthening training program (Drnach et al., 2010). It has been found that rest is influential in the strengthening of muscles (Gibala, MacDougal, & Sale, 1994). Once the participants stopped riding for three weeks, their core strength from therapeutic horseback riding did not decrease, therefore the balance effects in the lateral direction remained constant.

Conclusion of Program Carry-Over Effects of THR on Balance

The programmatic carry-over effects in this study on therapeutic horseback riding and its effect on participant balance indicated that once the intervention was complete, the changes made in balance may have been sustained due the effect of rest on muscular strength (Weiss, Coney, & Clark, 2006). Because therapeutic horseback riding can be considered a strength-training program (Cuypers et al., 2011), muscles that control the anterior and posterior tilt as well as the lateral core muscles during sessions may have promoted the increase in strength throughout the intervention and after the program ended. The two-week recovery period after the ten week session may have been beneficial to the individual as it may have actually promoted further retention of therapeutic gains (Gibala et al., 1994). This has positive implications for therapeutic horseback riding because once the intervention is complete; the positive changes to balance gained are not lost. Balance is a skill that can be improved and sustained over time.

Another way of comprehending the acquisition of balance in this study once the intervention is complete is through motor learning. Practice of a skill is the most effective factor in the permanent improvement of the skill (Adams, 1964). The attainment of a skill requires time spent practicing (Ericsson, 1996). Learning relates to the task depending on the information and

challenge that is present to the performer. Information allows learning to occur, depending on how difficult the task is for the performer to complete. In short, learning does not occur without information. Learning can be stifled by too much or too little information and an optimal amount of information must match a functional skill in order to be practiced. The information received by the performer depends on the task difficulty (Guadagnoli & Lee, 2004).

Task difficulty is broken into two parts 1) nominal difficulty and 2) functional difficulty. Nominal difficulty refers to the constant difficulty of the task due to the requirements of completing the task (Guadagnoli & Lee, 2004). This refers to what completing the task entails, and does not refer to the level of the performer. This is the basic need of the task. Functional difficulty is the challenge of the task to the individual performing based on the amount of practice and skill the performer has in completing a task. For example, for a professional basketball player a dunk has little functional difficulty—but for a 10 year old this task has great functional difficulty. The act of jumping and coordination required to put the ball in the net are the nominal difficulties of a dunk (Guadagnoli & Lee, 2004). These difficulties together dictate the amount of practice, and effort a performer will have to put forth to learn the task at hand (Guadagnoli & Lee, 2004).

To learn a task, not only does it depend on the amount of difficulty the task presents, it also depends on the information present to the performer. After each task attempt by the performer, the information gathered from feedback gained from the proprioceptive and visual systems during and after the task attempt are remembered (Guadagnoli & Lee, 2004).

Remembering this feedback and using this new knowledge when performing the task the next time create basis of learning the task. Remembering learned information from task attempts contributes to the permanent improvement in the skill from practice. Practice provides

opportunities for information to be learned as the opportunity for feedback is present (Guadagnoli & Lee, 2004). The amount of feedback greatly depends on the difficulty of the task. Task functional difficulty should increase as the learners' ability to use the information changes—as the learner grasps a part of a skill, another should be added—this allows the optimal challenge level of the performer to remain constant, fostering learning (Guadagnoli & Lee, 2004).

Optimal performance can be considered the accuracy of the movement which is performed and practiced (Willingham, 1998). Performance is tied into motor control, and motor control is directly related to motor learning. Motor control is a process in which the body can fine tune through practice, and motor learning is the acquisition of more correct responses in action, or improved performance (Newell, 1991). Learning occurs only when the movement is executed—the feedback gained from the execution of this movement from the environment creates the opportunity for motor control to be refined (Willingham, 1998). Simple movements act as a predecessor for more complex movements (Newell & Rovengo, 1990). In a motor learning situation one uses references from past movements; the strength of this reference grows from the experience of feedback. Feedback comes from proprioception and visual references which lead a performer to make responses different from previous failed trials (Adams, 1971). Different responses are made up of adjustments—these adjustments are the response to learning. The correct adjustment enables the performer to continue to make the correct response each time a motor activity is performed, therefore strengthening the skill, and creating a learned behavior (Adams, 1971). It is because of this that learning is continuous, as skills can always be refined (Newell, 1991).

Skills can be effortlessly performed through practice, and retained once learned. This is known as motor skill learning (Salvion-Lemieux & Penhune, 2005). Once a skill is learned it can be retained and used over and over again (Karni & Sagi, 1993). Long-term skill learning with practice requires less practice as time moves forward and the skill is more learned because the skill is retained. Practice leads to the acquisition and retention of a motor skill (Salvion-Lemieux & Penhune, 2005), and it has been found that spacing practice over time in several different sessions leads to greater skill retention, rather than a large amount of practice one time (Baddely & Longman, 1978; Salvion-Lemieux & Penhune, 2005).

In this study the participants practiced horseback riding, which requires the skill of balance (Bongers & Takken, 2012), over a 10-week period, once a week. This is the practice of balance over several different sessions (Baddely & Longman, 1978), which may have led the participants to retaining their newly acquired balance skills (Salvion-Lemieux & Pehune, 2005). As this intervention was designed to be a program to enable balance practice for the participants, and balance is a skill that can be learned through motor learning (Carron & Bracegirdle, 1974), it can be suggested that through motor learning, balance skills were retained and not lost once the intervention was complete.

Conclusion

The results of this study show a valuable therapeutic outcome for the individuals that participated in this intervention. Balance positively improved over the comprehensive program for the long-term period of this study, and these improvements were sustained once the intervention was complete. It is important for interventions to be effective and efficient, and this study found that therapeutic horseback riding was able to maximize the individual's potential for balance.

Limitations

There were several limitations to this study; most notably there was no information on how long the participants had been participating in therapeutic horseback riding prior to the study. Some of the participants had attended this intervention in the previous years, and some of the participants were new to riding. This information would have been helpful to include as it would have given a clearer indicator of when balance changes occurred and could have explained some of the smaller changes in balance. Additionally, the sample size of this study was small making it hard to be certain of the trend in balance changes. The small sample size also made it hard to determine confounding variables such as medication and number of hours of additional therapy as the range in confounding variables made it impossible to categorize. Also, due to lack of a covered arena at the facility, some of the participants missed sessions during the ten weeks due to the weather. This created an inconsistent intervention period for some of the individuals. The small sample size also demanded that the study use a sample of individuals with a multitude of diagnoses, making it unclear whether there was a certain diagnosis or disability that therapeutic horseback riding influenced more than another. This may have also created some variability between subjects; as they did not all have the same balance issues.

There was also some variability in the interventions between the participants. In this study, the therapeutic horseback riding intervention was planned and included a certain protocol; however, there were eight different instructors who taught the intervention to the participants. The instructors were all PATH certified and trained in the protocol of this study, but there could have been some differences in their teaching styles of the instructors, creating some variability in protocol (Cuypers et al., 2011). This could have affected the changes in balance that occurred between participants, as some instructors may have influenced changes through their specific

facilitation techniques. Another variability limitation in this study could also include the fact that there were up to twelve horses used between all the participants. Each of these horses is built differently, causing variations in movement, and creating a different effect on the body of the rider. This makes it hard to attribute what makes balance change.

While some significant changes were noted, the time frame of ten weeks can also be considered a limitation to this study. This may not be a long enough time to see accurate changes in balance. A longer time frame may have been able to provide more detailed and specific information as to how and when balance changed. The MDRT (Newton, 2001) can be considered a limitation to this study. While this measurement tool is valid and reliable, it may not be the correct tool for this population. The MDRT (Newton, 2001), asks the participants to “reach as far as they can”. This is subject to interpretation between each of the participants, and therefore carries a different meaning between participants. Due to the varying cognitive abilities of the participants, some individuals reached as far as they possible could due to understanding of the instructions. However, other participants may not have reached as far they were able due to a lack of understanding these instructions. “As far as you can” may not have been concrete enough for the population of this study.

Furthermore, this study used a sample that was limited to a certain area and one particular therapeutic riding center. The results of this study can be concluded to determine the effects that therapeutic horseback riding has on this small segment of the population, but in order to generalize the results to fit a broader population it would be useful to include a larger sample among other centers (Cuypers et al., 2011).

Future Research

To extend the efficacy of therapeutic horseback riding, future studies should measure participants who have never participated in therapeutic horseback riding previously to show a purer measure of balance change. It would also be valuable to increase the number of sessions to determine if the balance changes are different during a more intense form of the intervention (Bass, Duchowny, & Llabre, 2009), as well as allowing for enough time to determine if there is ever a point where the changes in balance plateau instead of continually increase. This study, due to time and lack of research funds, could not measure the balance of participants before and after each ride during the ten-week intervention. Future studies should consider measuring pre and post ride during each intervention of the time period, as well as studying this intervention for more than ten weeks. This would allow for a more detailed view of how and when balance change occurs during therapeutic horseback riding programs.

Further research is needed to determine the effects of therapeutic horseback riding on individuals with specific diagnoses. It is possible that therapeutic horseback riding has different effects on the balance in individuals with varying diagnoses (Bertoti, 1988), and it would benefit the literature to examine these differences between populations. This would allow for a more effective use of this intervention and would contribute to the knowledge of how to apply this intervention to address balance goals among various disabling conditions. Testing the balance of individuals with cognitive and physical disabilities creates some hardships for the researcher. Balance is not an easy skill to measure, especially when dealing with a population that has some cognitive limitations. It would benefit balance researchers to have a test that is easily adapted to this population. The MDRT (Newton, 2001) was hard to administer given that directing the participant to “reach as far as they can” (Newton, 2001) does not carry the same meaning for

every individual. Other balance measurement instruments, particularly those specifically designed for children with physical and cognitive impairments, may provide a simpler and more efficient way to test the balance of participants.

In an effort to limit the variability between interventions of the participants, should also have the same instructor for each intervention, and thus control for the facilitation style of the instructors. Similarly, each rider should ride the same horse to address some of the same concerns of variability between each participant. Some horses have wider backs, or take longer strides, etc, and the inconsistency between horses should be controlled so that the balance changes in the participants can be more readily explained. Using the same horse and same instructor may lead to a more systematic and non-varied lesson and provide a more valid control of confounding variables.

It may also be beneficial for future research to include a multicenter trial (Cuypers et al., 2011) to further extend the reach of the data collected so that the results can be analyzed more as a whole instead of a small sample of the population who participates in therapeutic horseback riding. Additionally, while this study only examined the effects that therapeutic horseback riding has on balance, there is further research needed to determine the effects that riding has on participants' range of motion, weight shifting, and strength (Bertoti, 1988). Additionally, it would be beneficial to understand the behavioral impact that this type of intervention can bring to individuals, as riding a horse has more than just physical implications (Bass, Duchowny & Llabre, 2009).

As a whole, the field of therapeutic horseback riding could benefit from more research that involves addressing several key factors. These factors include an organized and efficient method to collecting empirical data, as well as assessment tools that can evaluate the

effectiveness and benefits of therapeutic horseback riding. It is also imperative for the field as a whole to continue to develop protocols for interventions. These protocols must be developed to address specific goals for the rider (i.e., balance, strength, coordination, behavior, etc.) and not be generalized to simply riding a horse (DePauw, 1986). To further this field, it would also be valuable to have a collaboration of therapeutic horseback riding research so that it can be easily accessed by health professionals in order to encourage this community to prescribe therapeutic horseback riding as adjunct treatment for individuals with disabilities, and possibly lead to reimbursement from insurance companies (Drnach et al., 2010).

APPENDIX A:



EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building · Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · www.ecu.edu/irb

Notification of Initial Approval: Expedited

From: Social/Behavioral IRB
To: [Susan Keel Anderson](#)
CC: [David Loy](#)
Date: 7/15/2013
Re: [UMCIRB 13-000384](#)
Therapeutic Horseback Riding & Balance

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 7/14/2013 to 7/13/2014. The research study is eligible for review under expedited category #4. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Name	Description
1.Proposal.doc	Study Protocol or Grant Application
6.DemographicSurvey.DataCollection.xlsx	Surveys and Questionnaires
6.DemographicSurvey.DataCollection.xlsx	Data Collection Sheet
AdultInformedConsent.docx	Consent Forms
Assent.docx	Consent Forms
Cover.doc	Recruitment Documents/Scripts
ParentConsent.docx	Consent Forms

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

APPENDIX B:

April 8, 2013

To Whom It May Concern:

This letter is written in support of the clinical research proposal of Susan Keel Anderson to determine the effects of therapeutic horseback riding as a therapeutic intervention to improve balance. This study will be a cooperative venture between Ms. Anderson and [REDACTED], which will be the site of the actual equine activities and where the 30 students who will be subjects of the study are enrolled as students. The [REDACTED] staff members who will be principally involved in this project are all PATHIntl (Professional Association of Therapeutic Horsemanship) registered instructors employed by the program with several years teaching experience.

[REDACTED] Therapeutic Riding Program was founded in 1991 to provide equine assisted activities and therapy to children and adults with physical, cognitive, or psychological disabilities in eastern North Carolina. It has been a PATHIntl member center since 1992. For the last 10 years, [REDACTED] has been a full-time program operating a dedicated therapeutic riding facility here in Greenville. Services available to students include therapeutic horseback riding, hippotherapy, interactive vaulting, and equine facilitated mental health/learning modules. The program currently has a staff of 11 PATHIntl registered instructors. About 90 students are enrolled in weekly lessons, with a variety of diagnoses including cerebral palsy, spina bifida, autism, psychiatric and behavioral disorders, brain/spinal cord injury, multiple sclerosis, cancer, and stroke. Instructors plan lessons that facilitate independence within a framework tailored to each student's specific needs and strengths, while stressing safety for all participants. Horses used in the program are carefully selected, and have an ongoing conditioning and training schedule to ensure their suitability for this type of work.

[REDACTED] has committed to helping identify the students who will be study subjects in this project and having instructors incorporate the activities designed for the study into their lesson plans. All of the usual safety procedures for therapeutic riding lessons will apply to these participants while they are students at [REDACTED]. The staff of [REDACTED] is excited to participate in this study of the efficacy of therapeutic riding. Thank you for this opportunity.

Sincerely,
Linda Moran, PT
Executive director

[REDACTED] is a charitable organization which is exempt from taxation under Internal Revenue Code Section 501(c)(3).

APPENDIX C:
**Therapeutic Horseback Riding
& Balance**

*East Carolina University
Master's Thesis Research Study*

During the fall semester at [REDACTED] I will be doing a research study to determine the effect of therapeutic horseback riding on balance. This is a graduate study, and is part of my Master's requirements at ECU. In order to do this study I need volunteers to participate.

Participation will require that the volunteer:

- Sign up for lessons during the fall 2013 semester at [REDACTED].
- Participates in a balance assessment, known as the Multi-Directional Reach Test (MDRT), which will be administered by Susan Keel Anderson at [REDACTED].
 - The MDRT involves measuring the volunteers reach:
 - Forwards, Backwards, To the left, To the right
- The balance assessment will occur (3) times:
 - (1) The week of **September 15th, 2013**, balance will be measured before and after your first scheduled lesson of the semester at [REDACTED].
 - Participation requires the volunteer on that day to:
 - Arrive 15 minutes before your first lesson begins.
 - Stay 15 minutes after your first lesson ends.
 - (2) The week of **November 17th, 2013**, balance will be measured after your last scheduled lesson of the semester at [REDACTED].
 - Participation requires the volunteer on that day to:
 - Stay 15 minutes after your last lesson ends.
 - (3) Returns to the barn *three weeks* after fall semester ends for the last balance measurement.
 - December 14th, 2013, anytime from 11am-1pm
 - **OR** December 15th, 2013, anytime from 3pm-5pm

***Participation gives an opportunity for the volunteer to be entered into a drawing to win their very own helmet to wear during lessons at [REDACTED].**

If you have any further questions please feel free to contact:

Susan Keel Anderson
ECU Graduate Student
MS Recreational Therapy
(252) 955-8019
andersonsus12@students.ecu.edu

Linda Moran
[REDACTED]
Physical Therapy
(252) 752-0153
[REDACTED]

David P. Loy
ECU Professor
CTRS/LRT
(252) 328-2718
loyd@ecu.edu

APPENDIX D:

East Carolina University



Informed Consent to Participate in Research

Information to consider before taking part in research that has no more than minimal risk.

Adult Participant Consent Form

Title of Research Study: Therapeutic Horseback Riding & Balance

IRB Study#: UMCIRB 13-000384

Principal Investigator: Susan Keel Anderson
(252) 955-8019
Andersonsus12@students.ecu.edu

Institution Department: ECU RCLS/Recreational Therapy
(252) 328-4640
RCLS@ecu.edu

Researchers at East Carolina University (ECU) study problems in society, health problems, environmental problems, behavior problems and the human condition. Our goal is to try to find ways to improve the lives of you and others. To do this, we need the help of volunteers who are willing to take part in research.

Why is this research being done?

The purpose of this research is to examine the effect that therapeutic horseback riding has on balance. The decision to take part in this research is yours to make. By doing this research, we hope to learn how therapeutic horseback riding benefits its participants.

Why am I being invited to take part in this research?

You are being invited to take part in this research because you are an individual who participates in the therapeutic riding program at [REDACTED]. If you volunteer to take part in this research, you will be one of about 40 people to do so

Are there reasons I should not take part in this research?

I understand that I should not participate in this study if I cannot meet the time requirements. This study will require you to arrive 15 minutes early before your first riding lesson of the Fall 2013 semester, 15 minutes late after your first lesson, and 15 minutes late after the last session of your riding lessons during the Fall 2013 semester at [REDACTED]. It would also require you to return to [REDACTED] three weeks after your last lesson for a holiday party and the last measurement.

What other choices do I have if I do not take part in this research?

You can choose not to participate in the research study but continue your therapeutic horseback riding as planned.

Where is the research going to take place and how long will it last?

The research procedures will be conducted at [REDACTED]. The study will be conducted in the barn aisle during the Fall Semester at [REDACTED]. The total amount of time you will be asked to volunteer for this study is 15 minutes before and after your first ride at [REDACTED], 15 minutes after your last ride during the fall 2013 semester [REDACTED], and three weeks after the semester has ended [REDACTED].

What will I be asked to do?

You are being asked to do the following: Before you get on your horse:

- 1) You will be asked to stand/sit without moving your feet to:
 - A. Reach forward as far as you can.
 - B. Reach backward as far as you can.
 - C. Reach left as far as you can.
 - D. Reach right as far as you can.
- 2) I will measure how far you reach each time.

After your ride your horse:

- 1) You will be asked to stand/sit without moving your feet to:
 - A. Reach forward as far as you can.
 - B. Reach backward as far as you can.
 - C. Reach left as far as you can.
 - D. Reach right as far as you can.
- 2) I will measure how far you reach each time.

What possible harms or discomforts might I experience if I take part in the research?

It has been determined that the risks associated with this research are no more than what you would experience in everyday life. As you are reaching to partake in the balance test, there is a small risk of falling. Rubber mats will be underneath you at all times, and I will be there to prevent falling at all times.

What are the possible benefits I may experience from taking part in this research?

We do not know if you will get any benefits by taking part in this study. This research might help us learn more about how therapeutic horseback riding affects balance. There may be no personal benefit from your participation but the information gained by doing this research may help others in the future.

Will I be paid for taking part in this research?

We will not be able to pay you for the time you volunteer while being in this study. However, your name will be entered into a drawing to win a free riding helmet of your own if you participate in this study.

What will it cost me to take part in this research?

It will not cost you any money to be part of the research.

Who will know that I took part in this research and learn personal information about me?

To do this research, ECU and the people and organizations listed below may know that you took part in this research and may see information about you that is normally kept private. With your permission, these people may use your private information to do this research:

- Any agency of the federal, state, or local government that regulates human research. This includes the Department of Health and Human Services (DHHS), the North Carolina Department of Health, and the Office for Human Research Protections.
- The University & Medical Center Institutional Review Board (UMCIRB) and its staff, who have responsibility for overseeing your welfare during this research, and other ECU staff who oversee this research.

How will you keep the information you collect about me secure? How long will you keep it?

Data and identifying information will be kept for the length of this study (August – December 2013), and will be destroyed after.

APPENDIX E:

East Carolina University



Informed Consent to Participate in Research

Information to consider before taking part in research that has no more than minimal risk.

Parent Consent Child Participate

Title of Research Study: Therapeutic Horseback Riding & Balance
IRB Study#: UMCIRB 13-000384
Principal Investigator: Susan Keel Anderson
(252) 955-8019
Andersonsus12@students.ecu.edu

Institution Department: ECU RCLS/Recreational Therapy
(252) 328-4640
RCLS@ecu.edu

Researchers at East Carolina University (ECU) study problems in society, health problems, environmental problems, behavior problems and the human condition. Our goal is to try to find ways to improve the lives of you and others. To do this, we need the help of volunteers who are willing to take part in research.

Why is this research being done?

The purpose of this research is to examine the effect that therapeutic horseback riding has on balance. The decision to allow your child to take part in this research is yours to make. By doing this research, we hope to learn how therapeutic horseback riding benefits its participants.

Why is my child being invited to take part in this research?

Your child is being invited to take part in this research because he/she participates in the therapeutic riding program at [REDACTED]. If you allow your child to take part in this research, he/she will be one of about 40 people to do so.

Are there reasons I should not allow my child to take part in this research?

I understand that my child should not participate in this study if they cannot meet the time requirements. This study will require your child to arrive 15 minutes early before your first lesson [REDACTED], and stay 15 minutes after their first lesson [REDACTED]. It will also require that your child stays 15 minutes after their last lesson of the semester at [REDACTED]. Additionally your child will be asked to come back three weeks after the semester ends for a holiday party and a balance assessment. These time requirements provide the opportunity for your child to participate in the Multi-Directional Reach Test, which will measure balance.

What other choices does my child have if they do not take part in this research? Your child can choose not to participate, and this will have no negative effect on their participation at [REDACTED]

Where is the research going to take place and how long will it last?

The research procedures will be conducted [REDACTED]. The study will be conducted in the barn aisle during the Fall Semester at [REDACTED]. The total amount of time your child will be asked to volunteer for this study is 15 minutes before and after their first ride at [REDACTED], 15 minutes after their last ride during the fall 2013 semester at [REDACTED], and three weeks after the semester has ended at [REDACTED].

What will my child be asked to do?

Your child will be asked to do the following:

Before your child gets on their horse:

2. They will be asked to stand/sit without moving their feet to:

- A. Reach forward as far as you can.
- B. Reach backward as far as you can.
- C. Reach left as far as you can.
- D. Reach right as far as you can.

3) I will measure how far they reach each time.

After your child rides their horse: (ONLY after the first lesson of the semester)

2) They will be asked to stand/sit without moving their feet to:

- A. Reach forward as far as you can.
- B. Reach backward as far as you can.
- C. Reach left as far as you can.
- D. Reach right as far as you can.

3) I will measure how far they reach each time.

What possible harms or discomforts might my child experience if I allow him/her to take part in the research?

It has been determined that the risks associated with this research are no more than what your child would experience in everyday life. As you are reaching to partake in the balance test, there is a small risk of falling. Rubber mats will be underneath your child at all times, and I will be there to supervise and prevent falling at all times.

What are the possible benefits my child may experience from taking part in this research?

We do not know if your child will get any benefits by taking part in this study. This research might help us learn more about how therapeutic horseback riding affects balance. There may be no personal benefit from your child's participation but the information gained by doing this research may help others in the future.

Will I be paid for taking part in this research?

We will not be able to pay you for the time your child volunteers while being in this study, but your child will be entered into a drawing to win a horseback riding helmet of their own for participating in this study.

What will it cost me for my child to take part in this research?

It will not cost you any money to be part of the research.

Who will know that my child took part in this research and learn personal information about my child?

To do this research, ECU and the people and organizations listed below may know that your child took part in this research and may see information about your child that is normally kept private.

With your permission, these people may use your child's private information to do this research:

- Any agency of the federal, state, or local government that regulates human research. This includes the Department of Health and Human Services (DHHS), the North Carolina Department of Health, and the Office for Human Research Protections.
- The University & Medical Center Institutional Review Board (UMCIRB) and its staff, who have responsibility for overseeing your welfare during this research, and other ECU staff who oversee this research.

How will you keep the information you collect about my child secure? How long will you keep it?

Data and identifying information will be kept for the length of this study (August – December 2013), and will be destroyed after.

What if I decide I do not want my child to continue in this research?

If you decide you no longer want your child to be in this research after it has already started, you may withdraw your consent at any time. Your child will not be penalized or criticized for stopping. Your child will not lose any benefits that he/she should normally receive.

Who should I contact if I have questions?

The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the Principal Investigator at (252) 955-8019 anytime.

If you have questions about your child's rights as someone taking part in research, you may call the Office for Human Research Integrity (OHRI) at phone number 252-744-2914 (days, 8:00 am-5:00 pm). If you would like to report a complaint or concern about this research study, you may call the Director of the OHRI, at 252-744-1971

I have decided I will allow my child to take part in this research. What should I do now?

The person obtaining informed consent will ask you to read the following and if you agree, you should sign this form:

- I have read (or had read to me) all of the above information.
- I have had an opportunity to ask questions about things in this research I did not understand and have received satisfactory answers.
- I know that my child can stop taking part in this study at any time.
- By signing this informed consent form, I am not giving up any of my child's rights.
- I have been given a copy of this consent document, and it is mine to keep.

Participant's Parent's Name (PRINT)	Signature	Date
--	------------------	-------------

Person Obtaining Informed Consent: I have conducted the initial informed consent process. I have orally reviewed the contents of the consent document with the person who has signed above, and answered all of the person's questions about the research.

Person Obtaining Consent (PRINT)	Signature	2 Date
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APPENDIX F:

East Carolina University



Assent Form

*Things You Should Know Before You Agree To Take Part In
This Research*

Title of Research Study: Therapeutic Horseback Riding & Balance
IRB Study#: UMCIRB 13-000384

Principal Investigator: Susan Keel Anderson
(252) 955-8019
Andersonsus12@students.ecu.edu

Institution Department: ECU RCLS/Recreational Therapy
(252) 328-4640
RCLS@ecu.edu

People at ECU study ways to make people's lives better. These studies are called research. This research is trying to find out if riding a horse makes you be able to balance better.

Your parent(s) needs to give permission for you to be in this research. You do not have to be in this research if you don't want to, even if your parent(s) has already given permission.

You may stop being in the study at any time. If you decide to stop, no one will be angry or upset with you.

Why are you doing this research study?

The reason for doing this research is to see if when you ride your horse your balance increases. Balance is your ability to keep yourself upright. Imagine that there was a line drawn down the middle of you that line is your balance. I want to know if after you ride your horse you can keep that line straighter.

Why am I being asked to be in this research study?

We are asking you to take part in this research because you like to ride horses at [REDACTED] and that makes you perfect for this study!

How many people will take part in this study?

If you decide to be in this research, you will be one of about 40 people taking part in it.

What will happen during this study?

Before you get on your horse:

- 1) You will be asked to stand/sit without moving your feet to:
 - A. Reach forward as far as you can.
 - B. Reach backward as far as you can.
 - C. Reach left as far as you can.
 - D. Reach right as far as you can.
- 2) I will measure how far you reach each time.

After your ride your horse:

- 1) You will be asked to stand/sit without moving your feet to:
 - A. Reach forward as far as you can.
 - B. Reach backward as far as you can.
 - C. Reach left as far as you can.
 - D. Reach right as far as you can.
- 2) I will measure how far you reach each time.

I would like to write down your measurements and see how they differ over the next rides you have here at [REDACTED].

This study will take place at [REDACTED] and will last for ten weeks.

Who will be told the things we learn about you in this study?

After I record your measurements I am going to write about the measurements that I found. The only person who will know which measurements are yours is me. Once I write about the measurements I can give you the study and show you how your measurements were used.

What are the good things that might happen?

Sometimes good things happen to people who take part in research. These are called “benefits.” The benefits to you of being in this study may be seeing a change in your ability to balance. You will be able to watch as you learn from therapeutic horseback riding.

What are the bad things that might happen?

There is a small chance that you could fall during your balance test. Your test will be performed on top of rubber mats to make sure the ground is soft. I will also be there to catch you if you begin to fall.

Will you get any money or gifts for being in this research study?

You will not receive any money or gifts for being in this research study, only a huge thanks from me and a chance to be entered into a drawing for your very own helmet.

Who should you ask if you have any questions?

If you have questions about the research, you should ask the people listed on the first page of this form. If you have other questions about your rights while you are in this research study you may call the Institutional Review Board at 252-744-2914.

If you decide to take part in this research, you should sign your name below. It means that you agree to take part in this research study.

Sign your name here if you want to be in the study

Date

Print your name here if you want to be in the study

Signature of Person Obtaining Assent

Date

APPENDIX G: CORRELATION TABLE

CORRELATION TABLE (Years Riding to Change in Balance Score)		
PS	Pearson Correlation	-.311
	Sig. (2-tailed)	.078
	N	33
LS	Pearson Correlation	.224
	Sig. (2-tailed)	.211
	N	33
RS	Pearson Correlation	.203
	Sig. (2-tailed)	.258
	N	33
AL	Pearson Correlation	-.002
	Sig. (2-tailed)	.992
	N	33
PL	Pearson Correlation	-.235
	Sig. (2-tailed)	.196
	N	32
LL	Pearson Correlation	.239
	Sig. (2-tailed)	.187
	N	32
RL	Pearson Correlation	.022
	Sig. (2-tailed)	.903
	N	32
AP	Pearson Correlation	-.113
	Sig. (2-tailed)	.537
	N	32
PP	Pearson Correlation	.067
	Sig. (2-tailed)	.779
	N	20
LP	Pearson Correlation	-.226
	Sig. (2-tailed)	.352
	N	19
RP	Pearson Correlation	.372
	Sig. (2-tailed)	.116
	N	19
	Pearson Correlation	.045
	Sig. (2-tailed)	.855
	N	19

APPENDIX H: FULL REFERENCES

- Adams, J.A. (1964). Motor skills. *Annual Review of Psychology*, 15, 181-202.
- Adams, J.A. (1971). A closed loop theory of motor learning. *Journal of Motor Behavior*, 3(2), 111-150.
- APPA American Pet Products Association. Industry Statistics and Trends. Retrieved November 4, 2012, from http://www.americanpetproducts.org/press_industrytrends.asp,
- Anderson, T. & Cattanach, D. (1993). Effects of three different rest periods on expression of developed strength. *Journal of Strength Conditioning Research*, 7, 185.
- Arellano, C.J., & Kram, R. (2011). The energetic cost of maintaining lateral balance during human running. *Journal of Applied Physiology*, 112, 427-434.
doi:10.1152/jappphysiol.00554.2011
- Argatov, I. (2013). A subject-specific postural instability parameter. *Gait & Posture*, 37(1), 141-143.
- Aruin, A.S. (2008). Anticipatory postural control following fatigue of postural and focal muscles. *Clinical Neurophysiology*, 119(10), 2304-2313.
- ASPCA We Are Their Voice. Pet Statistics. Retrieved November 4, 2012, from <http://www.aspca.org/about-us/faq/pet-statistics.aspx>.
- Avlund, K., Vass, M., & Hendriksen, C. (2003). Onset of mobility disability among community-dwelling old men and women. The role of tiredness in daily activities. *Age and Ageing*, 32, 579-584.
- Baddely, A.D., & Longman, D.J.A. (1978). The influence of length and frequency of training session on the rate of learning to type. *Ergonomics*, 21, 627-635.

- Bandura, A. (2004). Health promotion by social cognitive means. *Health Education & Behavior*, 31, 143-164. doi: 10.1177/1090198104263660
- Bass, M.M., Duchowny, C.A., & Labre, M.M. (2009). The effect of therapeutic horseback riding on social functioning in children with autism. *Journal of Autism & Developmental Disorders*, 39(9), 1261-1267. doi: 10.1007/s10803-009-0734-3
- Bauby, C.E., & Kuo, A.D. (2000). Active control of lateral balance in human walking. *Journal of Biomechanics*, 33, 1433-1440.
- Bender M., & McKenzie, S. (2008). Hippotherapy. *Palaestra*, 24(1), 43-44.
- Berget, B., Ekeberg, O., & Braastad, B. (2008). Animal-assisted therapy with farm animals for persons with psychiatric disorders: Effects on self-efficacy, coping ability, and quality of life, a randomized controlled trial. *Clinical Practice and Epidemiology in Mental Health*, 4(9). doi:10.1186/1745-0179-4-9
- Bertoti, D.B. (1988). Effect of therapeutic horseback riding on posture in children with cerebral palsy. *Physical Therapy*, 68(10), 1505-1512.
- Bizub, A.L., Joy, A., & Davidson, L. (2003). It's like being in another world: Demonstrating the benefits of therapeutic horseback riding for individuals with psychiatric disability. *Psychiatric Rehabilitation Journal*, 26(4), 377.
- Biery, M.J., & Kauffman, N. (1989). The effects of therapeutic horseback riding on balance. *Adapted Physical Activity Quarterly*, 6(3), 221-229.
- Brauer, S.G., Burns, Y., & Galley, P. (1999). Lateral reach: A clinical measure of medio-lateral postural stability. *Physiotherapy Research International*, 4, 81-88.

- Brickel, C.M. (1985). Initiation and maintenance of the human-animal bond. *Marriage and Family Review*, 8(3-4), 31-48. doi: 10.1300/J002v08n03_04.
- Bongers, B., C., & Takken, T. (2012). Physiological demands of therapeutic horseback riding in children with moderate to severe motor impairments: An exploratory study. *Pediatric Physical Therapy*, 24(3), 252-257.
- Carr, J.H., & Shepherd, R. (1998). *Neurological rehabilitation: Optimizing motor performance*. Oxford: Butterworth Heinemann, pp.154-181.
- Carron, A.V., & Bracegirdle, M. (1974). A motor learning task involving two-arm balance-coordination. *Perceptual and Motor Skills*, 38, 183-187.
- Clifford, A.M., & Holder-Powell, H. (2010). Postural control in healthy individuals. *Clinical Biomechanics*, 25, 546-551.
- Corbeil, P., Blouin, J.S., Begin, F., Nougier, V. & Teasdale, N. (2003). Perturbation of the postural control system induced by muscular fatigue. *Gait & Posture*, 18(2), 92-100.
- Costill, D., King, D., Thomas, R. & Hargreaves, M. (1985). Effects of reduced training on muscular power in swimmers. *Physician and Sports Medicine*, 13, 94-101.
- Cuyper, K., De Ridder, & Strandheim, A. (2011). The effect of therapeutic horseback riding on 5 children with attention deficit hyperactivity disorder: A pilot study. *Journal of Alternative & Complementary Medicine*, 17(10), 901-908. doi: 10.1089/acm.2010.0547
- DePauw, K.P. (1986). Horseback riding for individuals with disabilities: Programs, philosophy, and research. *Adapted Physical Activity Quarterly*, 3(3), 217-226.
- Doughty, R.W. (1996). The biophilia hypothesis. *Association of American Geographers*, 86(4), 782-784.
- Drnach, M., O'Brien, P., & Kreger, A. (2010). The effects of a 5-week therapeutic horseback

- riding program on gross motor function in a child with cerebral palsy: A case study. *Journal of Alternative & Complementary Medicine*, 16(9), 1003-1006.
- doi: 10.1089/acm.2010.0043
- Duncan, P., Weiner, D., Chandler, J., & Studenski, S. (1990). Functional reach: A new clinical measure of balance. *Journal of Gerontology, Medical Science*, 45, M192-M197.
- EAAT Definitions. Path International. Retrieved November 12, 2012, from <http://www.pathintl.org/resources-education/resources/eaat/193-eaat-definitions>.
- Edgren, J., Salpakoski, A., Rantanen, T., Heinonen, A., Kallinen, M., VonBonsdorff, M.B., Portegijis, E., Sihoven, S., & Sipila, S. (2013). Balance confidence and functional balance are associated with physical disability after hip fracture. *Gait & Posture*, 37(2), 201-205.
- Engel, B., Galloway, M., & Bull, M. (1989). *The horse, the handicapped, and the riding team in a therapeutic riding program: A training manual for volunteers*. Durango, CO: Barabara Engel Therapy Services Publisher.
- Equilibrium. (2009). In *Britannica Concise Encyclopedia*. Retrieved from <http://www.credoreference.com/entry/ebconcise/equilibrium>.
- Ericsson, K.A. (Ed.), (1996). *The road to excellence: The acquisition of expert performance in the arts and sciences, sports and games*. Mahwah, NJ: Erlbaum.
- Falkerslev, S., Baagoa, C., Alkjaer, T., Remvig, L., Halkjaer-Kristensen, J., Larsen, P.K., Juul-Kristensen, B., & Simonsen, E.B. (2013). Dynamic balance during gait in children and adults with Generalized Joint Hypermobility. *Journal of Clinical Biomechanics*, 28, 318-324.

- Farias-Tomaszewski, S., Jenkins, S.R., & Keller, J. (2001). An evaluation of therapeutic horseback riding programs for adults with physical impairments. *Therapeutic Recreation Journal*, 35(3), 250-57.
- Fine, A.H. (Ed.) (2010). *Handbook on animal-assisted therapy: Theoretical foundations and guidelines for practice*, 3rd edition. Palo Alto, California: Academic Press.
- Fox, V. M., Lawlor, V.A., & Luttges, M.W. (1984). Pilot study of novel test instrumentation to evaluate therapeutic horseback riding. *Adapted Physical Activity Quarterly*, 1(1), 30-36.
- Gabriels, R.L., Agnew, J.A., Holt, K.D., Shoffner, A., Zhaoxing, P., Ruzzano, S., Clayton, G.H., & Mesibov, G. (2012). Pilot study measuring the effects of therapeutic horseback riding on school-age children and adolescents with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 6(2), 578-588.
- Gammonley, J., & Yates, J. (1991). Pet projects: Animal assisted therapy in nursing homes. *Journal of Gerontological Nursing*, 17(1), 12-15.
- Gibala, M., Macdougall, J. & Sale, D. (1994). The effects of tapering on strength in trained athletes. *Internal Journal of Sports Medicine*, 15, 492-497.
- Gordon, A.T., Ambegaonkar, J.P. & Caswell, S.V. (2013). Relationships between core strength, hip external rotator, muscle strength, and star excursion balance test performance in female lacrosse players. *International Journal of Sports Physical Therapy*, 8(2), 97-104.
- Gribble, P.A. (2003). *The effects of fatigue, gender and chronic ankle instability on dynamic postural control*. (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses (3106246).

- Gribble, P.A. (2003). *The effects of fatigue, gender and chronic ankle instability on dynamic postural control*. (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses (3106246).
- Guadagnoli, M.A., & Lee, T.D. (2004). Challenge point: A framework for conceptualizing the effects of various practice conditions in motor learning. *Journal of Motor Behavior*, *36*(2), 212-224.
- Haddad, J.M., Rietdyk, S., Claxton, L.J., & Huber, J.E. (2013). Task-dependent postural control throughout the lifespan. *Exercise and Sport Science Reviews*, *41*(2), 123-132.
doi: 10.1097/JES.0b013e3182877cc8
- Hakkinen, K., Kallinen, M., Izquierdo, M., Jokelainen, K., Lassila, H., Malkia, E., Kraemer, W.J., Newton, R.U., & Alen, M. (1998). Changes in agonist-antagonist EMG, muscle CSA, and force during strength training in middle-aged and older people. *Journal of Applied Physiology*, *84*(4), 1341-1349.
- Hale, S. A. (2004). *Postural control in children and young adults*. (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses. (305149088).
- Hippotherapy as a treatment strategy. American Hippotherapy Association. Retrieved November 10, 2012, from <http://www.americanhippotherapyassociation.org/hippotherapy/hippotherapy-as-a-treatment-strategy/>.
- Hoch, M.C, Staton, G.S., Medina, J.M., Mattacola, C.G., & McKeon, P.O. (2012). Dorsiflexion and dynamic postural control deficits are present in those with chronic ankle instability. *Journal of Science and Medicine in Sport*, *15*(6), 574-579.

- Hoch, M.C, Staton, G.S., Medina, J.M., Mattacola, C.G., & McKeon, P.O. (2012). Dorsiflexion and dynamic postural control deficits are present in those with chronic ankle instability. *Journal of Science and Medicine in Sport, 15(6)*, 574-579.
- Holbein-Jenny, M.A., McDermott, K., Shaw, C., & Demchak, J. (2007). Validity of functional stability limits as a measure of balance in adults aged 23-73 years. *Ergonomics, 50(5)*, 631-646. doi: 10.1080/00140130601154814
- Holmes, J. (2011). Transitional object-100 words. *The British Journal of Psychiatry, 198*, 423. doi: 10.1192/bjp.bp.110.087676
- Hong, J., Kim, D. & Ryssegem, G.V. (2011). Overcoming the myth of proprioceptive training. *Clinical Kinesiology: Journal of the American Kinesiotherapy Association, 65(1)*, 18.
- Hortobagyi, T., Houmard, J., Stevenson, J., Fraser, D., Johns, R., & Israel, R. (1993). The effects of detraining on power athletes. *Medicine and Science in Sports and Exercise, 25*, 929–935.
- Huxham, F.E., Goldie, P.A., & Aftab, E.P. (2001). Theoretical considerations in balance assessment. *Australian Journal of Physiotherapy, 47*, 89-100.
- Imagama, S., Ito, Z., Wakao, N., Seki, T., Hirano, K., Muramoto, A., Sakai, Y., Matsuyama, Y., Hamajima, N., Ishiguro & Hasegawa, Y. (2013). Influence of spinal sagittal alignment, body balance, muscle strength, and physical ability on falling of middle-aged and elderly males. *European Spine Journal, 22(6)*, 1346-1353.
- Interactive Vaulting Certification. Path International. Retrieved November 12, 2012, from <http://www.pathintl.org/resources-education/certifications/vaulting>.

- Joy, C.L. (2003). *The effect of recreational therapy on self-efficacy and leisure awareness for adolescents with disabilities*. (Master's Thesis) Retrieved from <http://search.proquest.com.jproxy.lib.ecu.edu/docview/288033280/previewPDF?accountid=10639>.
- Kahn, P.H. (1999). *The human relationship with nature: Development and culture*. Cambridge, Massachusetts: MIT Press.
- Karni, A., & Sagi, D. (1993). The time course of learning a visual skill. *Nature*, 365, 250-252.
- Kellert, S., & Wilson, E.O. (ed.) (1993). *The Biophilia Hypothesis*. Island Press: Washington DC.
- Kloubec, J.A., Rozga, M. & Block, M. (2012). Balance improvements in independent-living elderly adults following a 12-week structured exercise program. *Activities, Adaption & Aging*, 36(2), 167-178. doi: 10.1080/01924788.2012.673158
- Learn about EAAT. Path International. Retrieved November 12, 2012, from <http://www.pathintl.org/resources-education/resources/eaat>.
- Lee, D.R., Lee, N.G., Cha, H.J., O, Y.S., You, S., Oh, J.H., & Bang, H.S. (2011). The effect of robo-horseback riding therapy on spinal alignment and associated muscle size in MRI for a child with neuromuscular scoliosis: An experimenter-blind study. *NeuroRehabilitation*, 29(1), 23-27.
- LeRoy, L.C. (1960). *Postural fitness: Significances and variances*. Philadelphia: Lea & Febiger.
- Leslie, S. (2011). *Animal-assisted therapy*. Middletown: American Library Association dba CHOICE.

- Lessick, M., Shinaver, R., Post, K., Rivera, J., & Lemon, B. (2004). Therapeutic horseback riding: Exploring this alternative therapy for women with disabilities. *AWHONN Lifelines*, 8(1), 46.
- Loving, A.C., & All, A.C. (1999). Animals, horseback riding, implications for rehabilitation therapy. *Journal of Rehabilitation*, 65(3), 49-57.
- Lyons, M. (2012). The benefits of therapeutic horseback riding. *LILIPOH*, 17(66), 70-71.
- Mares, J.M. (2003). *Reach capabilities in older Mexican-american adults*. (Master's thesis). Retrieved from ProQuest Dissertations and Theses (305264661).
- Massion, J., & Woollacott, M.H. (1996). Posture and equilibrium. In Bronstein A, Brandt T and Woollacott M (Eds), *Clinical Disorders of Balance Posture and Gait* (pp. 1-18). London: Arnold.
- Matsuura, A., Takita, N., Shingu, Y., Kondo, S., Matsui A., Hiraga, A., Asai Y., Hata, H., & Okubo, M. (2003). Rhythm analysis for movements of horse and rider on a treadmill by sequential still VTR pictures. *Journal of Equine Science*, 14(4), 125-131. doi: 10.1294/jes.14.125.
- Nashner, L.M. (1980). Balance adjustments of humans perturbed while walking. *Journal of Neurophysiology*, 44, 650-664.
- Newell, K.M. (1991). Motor skill acquisition. *Annual Review of Psychology*, 42, 213-37.
- Newell, K.M., & Rovengo, I. (1990). Motor learning: Theory and practice. *Quest*, 42, 184-192.
- Newton, R.A. (2001). Validity of the multi-directional reach test: A practical measure of limits of stability in older adults. *Journal of Gerontology: Medical Sciences*, 56A(4), M248-252.

- Nutkevitch, I.V. (1986). *The transitional object and transitional phenomena: Winnicott revisited*. (Doctoral dissertation). Proquest Dissertations and Theses. (303405747).
- Path International. Path International. Retrieved November 12, 2012, from <http://www.pathintl.org>.
- Patla, A.E. (1997). Understanding the roles of vision in the control of human locomotion. *Gait and Posture* 5, 54-69.
- Pennycott, A., Wyss, D., Vallery, H., & Riener, R. (2011). Effects of added inertia and body weight support on lateral balance control during walking. Paper presented at the *Rehabilitation Robotics (ICORR), 2011 IEEE International Conference on*, 1-5. doi:10.1109/ICORR.2011.5975415
- Peterka, R.J. (2002). Sensorimotor integration in human postural control. *American Journal of Physiology*, 88(3), 1097-1118.
- Petrofsky, J.S. (2006). A device for the evaluation of sitting and reach balance in people in wheelchairs and standing. *Journal of Medical Engineering & Technology*, 30(6), 358-367. doi: 10.1080/03091900500139634.
- Postural control. (2009). In *Taber's Cyclopedia Medical Dictionary*. Retrieved from http://www.credoreference.com/entry/tcmd/postural_control.
- Poulsen, A., Ziviani, J., Cuskelly, M., & Smith, R. (2007). Boys with developmental coordination disorder: Loneliness and team sports participation. *American Journal Occupational Therapy*, 61, 451-462.
- Rimmer, J.H., Riley, B., Wahg, E., Rauworth, A., & Jurkowski, J. (2004). Physical activity participation among persons with disabilities: Barriers and facilitators. *American Journal of Preventive Medicine*, 26(5), 419-425.

- Robertson, T., & Long, T. (Eds.). (2008). *Foundations of Therapeutic Recreation*. Champaign, IL: Human Kinetics.
- Salvion-Lemieux, T., & Penhune, V.B. (2005). The effects of practice and delay on motor skill learning and retention. *Experimental Brain Research*, *161*(4), 423-431.
- Santos, M.J., Aruin, A.S. (2007). Role of later muscles and body orientation in feed forward postural control. *Experimental Brain Research*, *184*(4), 547-559.
- Sawyers, A., Kelly, V.E., Kartin, D., & Hahn, M.E. (2013). Gradual balance training reduces the challenge to lateral balance control during practice and subsequent performance of a novel locomotor task. *Gait & Posture*, *38*, 907-911.
- Sellentini, R., & Jone, R. (2012). The effect of core and lower limb exercises on trunk strength and lower limb stability on Australian soldiers. *Journal of Military & Veteran's Health*, *20*(4), 21-35.
- Sherk, K.A., Bemben, D.A., Brickman, S.E., & Bemben M.G. (2012). Effects of resistance training duration on muscular strength retention 6-month post training in older men and women. *Journal of Geriatric Physical Therapy*, *35*(1), 20-27.
- Shih, C.H., Chen, L.C., & Shih, C.T. (2012). Assisting people with disabilities to actively improve their collaborative physical activities with Nintendo Wii Balance Boards by controlling environmental stimulation. *Research in Developmental Disabilities*, *33*(1), 39-44.
- Silkwood-Sherer, D.J., Killian, C.B., Long, T.M., & Martin, K.S. (2012). Hippotherapy-an intervention to habilitate balance deficits in children with movement disorders: A clinical trial. *Physical Therapy*, *92*(5), 707-717.

- Slobodan, J. (2000). Changes in movement symmetry associated with strengthening and fatigue of agonist and antagonist muscles. *Journal of Motor Behavior*, 32(1), 9-15.
- The benefits of balance training. (2007). *Harvard Health Publications*.
<http://search.proquest.com.jproxy.lib.ecu.edu/docview/1370740970?accountid=10639>.
- Trapani, B., & Parise, J. (1995) Physical benefits of riding. *Accent on Living*, 39, 74-74.
- Tsatalas, T., Spyropoulos, G., Sileloglou, P., Sideris, V. & Giakas, G. (2009). The role of co-activation of agonist and antagonist muscles in neural adaptations of strength training. *Inquiries in Sport and Physical Education*, 7(2), 232-243.
- US Department of Health and Human Services, Office of Disability. (2013). About Us 2013. Retrieved from http://www.hhs.gov/od/about/fact_sheets/whatisdisability.html.
- Wang W., & Chang J. (1997). Effects of jumping skill training on walking balance for children with mental retardation and Down's syndrome. *Kaohsiung Journal of Medical Science*, 13, 487-494.
- Westcott, S.L. & Burtner, P. (2004). Postural control in children: Implications for pediatric practice. *Physical & Occupational Therapy in Pediatrics*, 24(1-2), 5-55.
- Whalen, C.N., & Case-Smith, J. (2012). Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: A systematic review. *Physical & Occupational Therapy in Pediatrics*, 32(3), 229-242. doi: 10.3109/01942638.2011.619251.
- Willingham, D.B. (1998). A neuropsychological theory of motor skill learning. *Psychological Review*, 105(3), 558-584.
- Wilson, E.O. (1984). *Biophilia*. Cambridge, Mass: Harvard University Press.

- Wilson, E.O. (1992). *The Diversity of Life*. Cambridge, Mass: Harvard University Press.
- Wingate, L. (1982). Feasibility of horseback riding as a therapeutic and integrative program for handicapped children. *Journal of the American Physical Therapy Association, 62*(2), 184-186.
- Winter, D.A. (1995). Human balance and posture control during standing and walking. *Gait & Posture, 3*, 193-214.
- Wolpert, D.M., Ghahramani, Z., & Flanagan, J.R. (2001). Perspectives and problems in motor learning. *TRENDS in Cognitive Sciences, 5*(1).
- Wong, J.D., Kistemaker, D.A., Chin, A., & Gribble, P.L. (2012). Can proprioceptive training improve motor learning. *Journal of Neurophysiology, 108*, 3313-3321. doi: 10.1152/jn.00122.2012
- Zadnikar, M., & Kastrin, A. (2011). Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: A meta-analysis. *Developmental Medicine & Child Neurology, 53*(8), 684-691. doi: 10.1111/j.1469-8749.2011.03951.x.

