Spring 4-13-2017

THE EFFECT OF SEQUENTIAL OF BILATERAL TRANSFER IN UNDERHAND SERVING FOR VOLLEYBALL

Savanna Ashbaugh
smashba@siu.edu

THE EFFETS OF SEQUENTIAL PATTERENS OF BILATERAL TRANSFER IN UNDERHAND SERVING FOR VOLLEYBALL

by

Savanna M. Ashbaugh

B.S. Illinois State University, 2015

A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
Master of Science in Education

Department of Kinesiology
in the Graduate School
Southern Illinois University Carbondale
May 2017

RESEARCH PAPER APPROVAL

THE EFFECT OF SEQUENTIAL PATTERNS OF BILATERAL TRANSFER IN UNDERHAND SERVING FOR VOLLEYBALL

By

Savanna M. Ashbaugh

A Research Paper Submitted in Partial
Fulfillment of the Requirements
for the Degree of
Master of Science in Education
in the field of Kinesiology

Approved by:
Julie Partridge

Graduate School
Southern Illinois University Carbondale
January 17, 2017

AN ABSTRACT OF THE RESEARCH PAPER OF

SAVANNA M. ASHBAUGH, for the Master of Science in Education in KINESIOLOGY, presented on JANUARY 17, 2016, at Southern Illinois University Carbondale.

TITLE: THE EFFECT OF SEQUENTIAL OF BILATERAL TRANSFER IN UNDERHAND SERVING FOR VOLLEYBALL

MAJOR PROFESSOR: Julie Partridge

The purpose of the study was to test the sequential pattern effects in participants with no experience with the underhand volleyball serve in a bilateral transfer model. Sixty, college aged participants that were right hand dominant and had no structured volleyball experience, volunteered for this study. The participants were counterbalanced to control for the order effects of dominant to non-dominant (n=30) and non-dominant to dominant (n=30). Each group was given ten trials before switching serving hands for another ten trials. Data from right to left included, M = 12.2, and SD = 4.77 while the data from left to right included, M = 11.90, and SD = 5.86. The paired differences were M = .30, SD = 7.7, t (29) = .21, p = .83, d = .0561. The results were not found to be statistically significant when examining the data collected from the dominant to non-dominant limbs and vice versa. In conclusion, there was no effect when an individual served from the dominant to non-dominant limb and vice versa.

TABLE OF CONTENTS

CHAPTER PAGE

ABSTRACT i

LIST OF TABLES iii

CHAPTERS

CHAPTER I – Introduction 1

CHAPTER II – Method 10

CHAPTER III – Results 13

CHAPTER IV – Discussion 14

REFERENCES 17

VITA 20

LIST OF TABLES

TABLE PAGE

Table 1 13

CHAPTER I

INTRODUCTION

Bilateral transfer refers to the improvement or forfeiture of task performance with a limb that is not typically involved or participating in the task (Liu & Wrisberg, 2005). Individuals tend to favor one limb (i.e., dominant limb) over the other limb (i.e., non-dominant limb) when performing movements during every day activities and participating in athletic competition. Research has shown that activities that involve "muscular performance, power, and endurance" have a positive bilateral transfer from one limb to the other (Liu & Wrisberg, 2005, p. 20). In sport research, bilateral transfer has been examined in athletes that use dominant and non-dominant limbs during competitive play. When athletes are forced to face competition, they must have the skill to transfer the motor ability of performing a task from dominant to the non-dominant limbs at different times during the game or practice (Liu & Wrisberg, 2005) in order to be successful. Research studies on dribbling in basketball (Stöckel, Weigelt, & Krug, 2011) and throwing balls at a target (Liu & Wrisberg, 2005) have shown that the practice of a specific task with one limb will result in a contralateral effect that allows the opposite limb to show improvements in motor performance.

Bilateral Transfer Literature Review

Bilateral Transfer Models

There are three models that are commonly used to explain bilateral transfer in motor learning: the access model, the cross-activation model, and the dynamic-dominance model. The access model (Anguera, Russell, Noll, & Seidler, 2007; Pan & Germmert, 2013) suggests there is a single regulator for each of an individual's limbs and has an "unilateral activation" (Anguera et

al., 2007, p. 138). This single regulator is known as an "engram" (Pan & Gemmert, 2013) that is located in the dominant hemisphere of the brain regardless of the dominant limb. For example, a right-handed individual would possess the "engram" in the left hemisphere of the brain, whereas a left-handed individual would possess the "engram" in the right hemisphere. When an individual practices a task with the dominant limb, the task is performed with ease and accuracy due to the direct access to the "engram" in the dominant hemisphere. However, the non-dominant limb has indirect access to the same "engram". With this indirect access, a non-dominant limb can still be successful at completing the same task as the dominant limb (Pan & Gemmert, 2013). Since the dominant limb has access to the essential pattern of movement that a task requires, the non-dominant hemisphere can access that same pattern of the task and complete the movement (Anguera et al., 2007).

The cross-activation model of bilateral transfer is a "bilateral activation" that differs from the "unilateral activation at transfer" (Anguera et al., 2007, p. 138). A "dual engram" (Pan & Gemmert, 2013) is created and stored in both the dominant hemisphere and in the non-dominant hemisphere (Stöckel & Weigelt, 2012). In this model, the non-dominant limb retrieves information from its part of the "dual engram" to produce the movements of the desired task. However, the dominant limb is always responsible for the creation of all "engrams" and not vice versa. In other words, the movements that the non-dominant limb make are not transferred to the dominant limb (Stöckel & Weigelt, 2012). Since the dominant limb/hemisphere is favored to the non-dominant limb/hemisphere the "cross activation" cannot take place because the non-dominant limb/hemisphere is more willing to adapt to the dominant's limb/hemisphere (Pan & Gemmert, 2013; Stöckel, & Weigelt, 2012).

Contrary to these two models, the dynamic-dominance model examines the disproportionateness of bilateral transfer in the hemispheres and limbs (Pan & Gammert, 2013). Research also refers to this model as the dynamic-dominance hypothesis and suggests that the dominant limb is associated with even and straightforward transitions with the non-dominant limb maintaining precision that allows for a desired outcome (Przybyla, Good, & Sainburg, 2012). More specifically, the hypothesis states that for right hand dominant individuals, the left hemisphere of the brain is responsible for the movement patterns and the right hemisphere of the brain is responsible for the execution. Research studies confirm that for an individual to be successful, both hemispheres have to work together and give their specific specializations (Stöckel et al., 2011). In a study by Haaland and Hoff (2003) soccer players (n = 39, average age 17.5 years) were tested using three different skill specific soccer movements and two standard "foot-tapping" tests. The players that were assigned to the training group only used their non-dominant leg to participate in skills. However, participants assigned to the control participated with their dominant leg. Players completed a pre-and post-test to track progress over the eight-week study. Researchers found that the training group improved significantly in the post-test when compared to the pre-test and when compared to the control group (Haaland & Hoff, 2003). The same findings have been demonstrated by other researchers where movements are better executed when the hemispheres of the brain work together. Further investigation of the hypothesis by Przybyla et al. (2012) showed that dominant limbs are well coordinated and capable of completing specific tasks. In that study, participants used different reaching motions with both the non-dominant and dominant limbs when given a "go" tone to place a cursor over desired targets on a virtual imaging screen. When testing left-hand dominant participants (n =

20), the right (i.e., non-dominant) hand was better coordinated than the non-dominant arm of the right hand dominant participants in a test of accuracy (Przybyla et al., 2012).

Bilateral Transfer and Injury

Research has demonstrated that physical therapists, doctors, and nurses can help individuals enable and maintain functions of an injured limb through bilateral transfer. By focusing on the non-injured limb, the injured limb can regain motor skills previously lost due to an injury (Yao, Cordova, Huang, Wang, & Lu, 2014). The human nervous system is well-equipped with the capability to recover and maintain function. In a study by Mier (2006), children as young as four years old displayed fluent movements and evolving changes in the non-dominant hand with drawing tasks. The changes observed in Mier's (2006) study indicate that rehabilitation can take place to help individuals recover from an injury through bilateral transfer or through teaching the non-dominant hand to produce smooth movements that allow an individual to remain capable of maintaining function (Mier, 2006).

In an anterior cruciate ligament (ACL) tear an individual can lose the ability to bear weight which may lead to a reduction in function. However, bilateral transfer has been examined as a rehabilitation tool to help an individual regain function in the injured knee (Ageberg, Zätterström, Moritz, & Friden, 2001). In a study by Ageberg, Pettersson, & Friden (2007), the bilateral transfer model was applied to patients (M_{age} = 26), with critical anterior cruciate injuries that occurred in recreational activities at 1, 3, and 5 years after the initial injury. The uninjured knee performed normal movements while the injured knee performed movements without weight bearing consequences on a sloped board to produce coactivation of muscles. Research found that movements of the injured knee started to occur naturally and that bilateral transfer had been successful (Ageberg et al., 2007).

Stroke is one of the leading causes of disability in adults (Ausenda, Togni, Biffi, Morlacchi, Corrias, et al., 2014). A stroke can cause an individual to suffer many neurological defects including loss of function in the hands. Once an individual loses functions of the hands, everyday tasks become a challenge (Ausenda, Togni, Biffi, Morlacchi, Corrias, et al., 2014). The hand that is affected by the stroke is called a "paretic hand" (Lin, Chou, Luo, Tsai, Lieu, Chiang, & Sung, 2015), and it has been shown that this paretic hand can regain function through the practice of bilateral transfer. Research also has demonstrated that bilateral transfer allows the injured hand to relax while the uninjured hand does the work (Ausenda et al., 2014). With this finding, rehabilitation sessions can be more productive and last longer than forcing the injured hand to participate when it is in recovery (Ausenda et al., 2014).

Physical practitioners can focus on applying imagery to their method of rehabilitation in the early stages (Land, Liu, Cordova, Fang, Huang, & Yao, 2016). The "effectiveness of imagery in facilitating motor skill learning, increasing muscle strength, enhancing the development of cognitive skill representations, and most importantly its potential to be an effective therapeutic technique for the rehabilitation of patients with motor impairments, such as stroke survivors" (Land et al., 2016, p. 2). Then as the rehabilitation enters the later stages of treatment, the focus should become on the physical practice. This method of implementing imagery and then physical practice is to assist individuals both mentally and physically for movement in the affected limb (Land et al., 2016). Bilateral transfer can be utilized in a variety of formats and situations, with the introduction of using imagery in bilateral transfer, future research can examine the implications of progress that individuals can achieve.

Bilateral Transfer and Sequential Patterns

The topic of bilateral transfer has been examined in many research studies and understanding the direction in which bilateral transfer will be successful. Many research studies have examined the sequential patterns of testing the dominant limb to the transfer of the non-dominant limb and vice versa (Land et al., 2016). Through sequential patterns of bilateral transfer researchers can examine the influence of how well the task transfers to the opposite limb. Research has recognized that when an individual is taught to do a task with their non-dominant hand the same task can be performed with the same speed and effectiveness as the dominant hand (Grafton, Hazeltine, & Ivry, 2002). Senff & Weigelt (2011) researched the sequential effect in a coin sliding study where students were placed into four different groups. The groups were asked to practice sliding coins onto a target, group one: dominant hand only (80 trials), group two: non-dominant hand only (80 trials), group 3: dominant hand (40 trials) switch to non-dominant hand (40 trials), and group four: non-dominant hand (40 trials) switch to dominant hand (40 trials). In the first testing period the participants were asked to go through initial testing for a pre-test score then immediately completed the task again as a post-test score. The second testing period had a pre-test and a post-test following a ten-minute break. Finally, after seven days from the second testing period the participants completed the same coin sliding task for the long-term retention test. Throughout the study, a pattern emerged, students that practiced with their non-dominant hand before practicing with dominant hand exhibited better performance on the coin sliding test. Specifically, the retention of task performance in the unfamiliar task of sliding coins exhibits that learning new motor skills can be obtained through practicing with the non-dominant limb as well as the dominant limb (Senff & Weigelt, 2011).

Land et al. (2016) tested the sequential pattern of non-dominant to dominant limbs and vice versa, using a sequential tapping study. The study also included the use of imagery, a recent addition to research in bilateral transfer, as a tool to allow individuals to picture themselves tapping the keys before performing the task. Participants were assigned different groups in order to practice key tapping sequences. In the first experiment, groups were tested on the sequential tapping task using their non-dominant hand and performed the bilateral transfer to the dominant hand, while in the second experiment, individuals were trained with their dominant hand and made the subsequent bilateral transfer to the non-dominant hand. Each experiment included group 1: physical practice, group 2: imagery, and group 3: no practice. Physical practice was more successful in the trained limb and have more benefits when using bilateral transfer from the non-dominant hand to the dominant hand (Land et al., 2016). It is important to note that the untrained hand (i.e., non-dominant hand) performed better on the test when only stimulated with imagery of the task (Land et al., 2016). Future research will have the opportunity to further test the implications of imagery in the bilateral transfer setting. However, in the importance of bilateral transfer through physical practice, research from many different bilateral studies have demonstrated that practice with the non-dominant limb has a positive impact on the movements of the dominant limb.

Bilateral Transfer and Sport Specific Skills

Bilateral transfer can be used in sport specific situations. In sports, players are presumably more likely to use their dominant hand when executing movements. However, players have to be able to use their dominant and non-dominant limbs to be able to gain success when playing against their opponents. Bilateral transfer allows players to be successful by transferring the specific skills from the dominant hand to the non-dominant hand (Liu &

Wrisberg, 2005). Researchers have studied many different areas of sport and have found patterns of successful transfers that correlate with the same patterns that are practiced with sequential patterns (Land et al., 2016; Stöckel, Weigelt, & Krug, 2011).

Adolescents have been researched as being successful when throwing a ball with both the dominant and non-dominant limb. The bilateral transfer of the task of throwing was successful immediately following practice and after a twenty-four-hour recall period (Liu & Wrisberg, 2005). In a badminton serve, research with college students indicated the same successful bilateral transfer. In a study by Boroujenia and Shahbazi (2011), participants were 36 female badminton players that were divided into two groups. Participants were tested on their ability to serve the birdie over the net accurately with short, low placement. There was no statistical significance observed between the two groups (i.e., dominant to non-dominant and vice versa). The only supporting evidence from the research study demonstrated that bilateral transfer existed when a participant served with the dominant limb then switched limbs to serve with the non-dominant limb and vice versa (Boroujenia & Shahbazi, 2011).

In basketball dribbling, a sport specific skill to play the game of basketball, researchers discovered that adolescents benefitted from non-dominant hand practice. Adolescents (n = 52, M_{age} = 11 years), who were right hand dominant dribbled a basketball through an obstacle course. Participants were place into two groups, group 1: dominant hand dribbling to non-dominant hand dribbling and group 2: non-dominant to dominant hand dribbling. The obstacle course was practiced in eight sessions over a four-week time span. Results showed statistical significance between the two groups on dribbling performance. The adolescents that had participated in group two (non-dominant to dominant) demonstrated improvement in their dominant hand dribbling after practicing the non-dominant dribbling patterns (Stöckel, Weigelt,

& Krug, 2011). These findings associate with the same findings that examined in participants that were asked to practice tasks in a sequential order.

Purpose and Hypothesis

Many bilateral research studies have examined participants that have experience in the skill that is being tested, however, to the researcher's knowledge, there have been no bilateral transfer studies done on participants that have no experience in a skill-specific movement in the skills used to play volleyball. One of the earliest skills that youth players learn in the game of volleyball is the underhand serve. So, the purpose of the study was to test the sequential pattern effects in participants with no experience with the underhand volleyball serve within a bilateral transfer model. The hypothesis for this study will be that sequential effects from non-dominant hand to dominant hand practice will show greater success (i.e., getting the ball over the net and landing in-bounds) than the sequential effects of dominant hand to non-dominant hand practice.

CHAPTER II

METHOD

Participants

Sixty undergraduate students from Southern Illinois University Carbondale, were recruited to participate in the study. These 60 participants were right hand dominant. A self-report measure, the Edinburgh Handedness Inventory (Oldfield, 1971), was used in confirmation of the dominant hand. Along with testing the handedness of the participants, there was a series of questions on volleyball playing experience. Each participant answered that they had never played structured volleyball with a coach (i.e., playing on a school team, recreational team, or club team). Participants were allowed to participate if they had played volleyball in physical education. Testing took take place in the Southern Illinois University's Davies Gymnasium. All participants signed an informed consent.

Task and Apparatus

Pilot testing was done to determine the high school height net (2.24 meters) was suitable for the participants. A standard volleyball net with marking antennas was used to complete the study. The standard volleyball court, 18 meters long by 9 meters wide, was the target in which participants were aiming and the boundary lines were considered in-bounds. Blue tape was used to mark an "X" on the floor at 4.5 meters behind the baseline of one side of the volleyball court to signal where participants were to stand while performing trials. On the opposite side of the net where participants served, the court was swept and cleared of any equipment that would prevent the ball from landing within the court area. Participants used ten, female collegiate regulation size volleyballs to complete the serving trials.

Procedures

Participants were randomly placed into two groups of 30. The order of practice trials was counterbalanced to control for possible order effects. One group was taught how to serve the volleyball underhand with their dominant hand (n = 30) and the other group (n = 30) was taught how to serve with their non-dominant hand. Each group was given 10 trials before switching serving hands for another ten trials. One point was awarded for every serve that went over the net and landed in-bounds; while any serve that touched the marking antennas or landed out of bounds resulted in a zero.

The scoring system was explained to the participants, followed by instructions on how to perform an underhand volleyball serve: "Stand on the blue 'X'; The hand holding the ball needs to be cupped so the ball does not fall off. The side of the body holding the ball will have the same side leg placed forward with the opposite foot slightly behind the front foot. The serving hand will be made into a fist with the palm facing forward, this is the hand position that will contact the ball. The serving arm will swing slightly backwards; accelerate through while flexing the elbow. Through the arm swinging motion the weight of the body will shift from the back leg to the front leg." Participants were encouraged to contact the ball on the lower portion to ensure that the ball had enough height to go over the net. Before the trials began, participants were given a demonstration of the underhand serving technique and were given two familiarization trials before the initial trial condition. After the two familiarization trials, participants were reminded one last time to stand on the blue "X", serve the ball over the net, and keep the ball in-bounds. Once the initial condition was completed the servers received the following instructions; "Remain standing on the blue "X". Place the opposite foot forward

(different than the first condition)." Participants were read the instructions for performing the task one last time and reminded that the goal of the serve was to get the ball over the net and in-bounds. Participants were then asked to serve the remaining 10 balls with the opposite hand.

The dependent variable for this study was the number of successful serves in-bounds during the two different trial conditions.

CHAPTER III

RESULTS

Sixty right hand dominant participants were recruited to participate in this study. The hypothesis for this study was that sequential effects from the non-dominant hand to dominant hand would result in greater success (i.e., getting the ball over the net and in-bounds) than the sequential effects of a dominant hand to non-dominant hand sequence. Findings from the data did not support the hypothesis. Data from dominant to non-dominant included, $M = 12.2$, and $SD = 4.77$ while the data from non-dominant to dominant included, $M = 11.90$, and $SD = 5.86$. The paired samples T-test revealed that the order of practice did not have a significant effect on serving accuracy ($M = .30$, $SD = 7.7$, $t\ (29) = .21$, $p = .83$, $d = .0561$). A .05 alpha level was used for all statistical tests. Table 1 demonstrates the paired sample test of dominant to non-dominant hands and non-dominant to dominant hands.

Table 1. *Test (Paired Sample)*

Paired Differences	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Right to Left & Left to Right	.30	7.729	1.411	-2.586	3.186	.213	29	.833

Chapter VI

DISCUSSION

The results of this study suggest that bilateral transfer of a volleyball serve occurs equally effectively from the sequence of dominant to non-dominant hand compared to non-dominant to dominant hand. Thus, in the context of this study, the hypothesis was not supported. Specifically, the results of this study demonstrated that the order of practicing volleyball serves based on hand dominance did not influence serving accuracy. However, previous research findings (Land et al., 2016; Stöckel, Weigelt, & Krug, 2011) demonstrated that bilateral transfer is important when looking to improve the dominant hand's motor ability through practice with the non-dominant hand. In previous research, participants have been exhibited as being successful in a sequential tapping pattern (Land et al., 2016) and with the skill specific task of basketball dribbling (Stöckel, Weigelt, & Krug, 2011) when using the bilateral transfer model. In Land et al. (2016) and Stöckel et al. (2011) participants were given a longer duration to practice their tasks than in the current study. As a result, the shorter practice duration used in the present study may not have been long enough to facilitate the successful acquisition of bilateral transfer.

Although the majority of bilateral transfer research has found that non-dominant to dominant hand transfer is most effective, there is some evidence to suggest that the context of the skill performance may impact this outcome. In a study by Boroujenia and Shahbazi (2011) participants were tested on badminton serving using a dominant to non-dominant progression and a dominant to non-dominant hand progression. Results from the study were not found to be statistically significant for either the dominant to non-dominant hand or the non-dominant to

dominant hand (Boroujenia & Shahbazi, 2011). The scoring system used in the Boroujenia and Shahbazi's (2011) study was similar to the scoring system used in the current experiment. The scoring system used was based on a system of "in-bounds" and "out-of-bounds" and gave no further indication of the accuracy of the badminton serve. Specifically, the present study utilized a comparable scoring system with the ball landing in the court marked as one point and a ball that was served out of bounds, into the net, or touching the marking antennas resulting in zero points. This scoring system was basic and had few guidelines much like the scoring system used in the Boroujenia and Shahbazi's (2011) study. Scoring systems such as these do not capture the nuances of motor performance. As a result, potential group differences may have been lost due to the lack of specificity in the utilized evaluation tool. This provides a plausible explanation by predicted differences were not observed in the present study or in earlier research using a similar scoring system (Boroujenia & Shahbazi, 2011).

Like all research, the current study is not without limitations. For example, a more sensitive scoring system would have allowed the researcher to evaluate potential performance differences between the experimental conditions more accurately. The use of a target where areas of the court contained certain amount of points would have allowed for the scores to be more precise in terms of measuring variance in performance outcomes. If the participant were to serve the ball out of bounds, into the net, or strike one of the marking antennas then negative points could be assigned reducing the overall score. This modification to the scoring system would more accuralty capture the variability in serving performance and better reflect participant performance outcomes. For example, if participants were to struggle at serving the ball over the net then a negative score would be present demonstrating that the individual was not cable of placing the ball over the net onto the court.

To improve on the methods used in this experiment future research can use two control groups where participants only serve with their dominant hand or only serve with their non-dominant hand. Using two control groups will allow the researchers to compare the data obtained from the bilateral transfer to the results in the control groups. Participants, in the current study, were required to have no formal training in the sport of volleyball to participate in the study. In future studies, examining how experienced an individual has in volleyball may affect the overall performance of accuracy in a bilateral transfer study. Individuals that have volleyball experience may be more accurate in their serving ability than their non-experienced counterpart. Using more skilled participants in conjunction with a more sensitive scoring system may yield different results than those reported here.

In conclusion, the current study did not yield statistically significant results when examining theorized bilateral transfer affects. It is worth noting that the findings from this study are consistent with those reported by Boroujenia and Shahbazi's (2011). This study makes a unique contribution to the existing body of bilateral transfer literature by suggesting that the order of initial limb practice (e.g., dominant or non-dominate) may not have a meaningful effect on how successful a beginner learns underhand serving in volleyball.

REFERENCES

Ageberg, E., Pettersson, A., & Fridén, T. (2007). 15-year follow-up of neuromuscular function in patients with unilateral nonreconstructed anterior cruciate ligament injury initially treated with rehabilitation and activity modification. *The American Journal of Sports Medicine, 35* (12), 2109-2117.

Ageberg, E., Zätterström, R., Mortiz, U., & Fridén, T. (2001). Influence of supervised and nonsupervised training on postural control after an acute cruciate ligament rupture: A three-year longitudinal prospective study. *Journal of Orthopaedic & Sports Physical Therapy, 31,* (11), 632-644.

Anguera, J. A., Russell, C. A., Noll, D. C., & Seidler, R. D. (2007). Neural correlates associated with intermanual transfer of sensorimotor. *Brain Research, 1185,* 136-151.

Ausenda, C. D., Togni, G., Biffi, M., Morlacchi, S., Corrias, M., & Cristoforetti, G. (2014). A new idea for stroke rehabilitation: Bilateral transfer analysis from healthy hand to the paretic one with a randomized and controlled trial. *International Journal of Physical Medicine & Rehabilitation, S3:008,* 1-8.

Boroujeni, S. T., & Shahbazi, M. (2011). The study of bilateral transfer of badminton short service skill of dominant to non-dominant hand and vice versa. *Procedia Social and Behavioral Sciences, 15,* 3127-3130.

Grafton, S. T., Hazeltine, E., & Ivry, R. B. (2002). Motor sequence learning with the nondominant left hand. *Experimental Brain Research, 146,* 369-378.

Haaland, E., & Hoff, J. (2003). Non-dominant leg training improves the bilateral motor performance of soccer players. *Scandinavian Journal of Medicine & Science in Sports, 13,* 179-184.

Land, W. M., Liu, B., Cordova, A., Fang, M., Huang, Y., & Yao, W. X. (2016). Effects of physical practice and imagery practice on bilateral transfer in learning a sequential tapping task. *PLoS ONE, 11* (4), 1-14.

Lin, C. H., Chou, L. W., Lou, H. J., Tsai, P. Y., Liew, F. K., Chiang, S. L., & Sung, W. H. (2015). Effects of computer-aided interlimb force coupling training on paretic hand and arm motor control following chronic stroke: A randomized controlled trial. *PLoS ONE, 10* (7), 1-15.

Liu, L., & Wrisberg, C. A. (2005). Immediate and delayed bilateral transfer of throwing accuracy in male and female children. *Research Quarterly for Exercise and Sport, 76,* 20-27.

Mier, H. V. (2006). Developmental differences in drawing performance of the dominant and non-dominant hand in right-handed boys and girls. *Human Movement Science, 25,* 657-677.

Oldfield, R. C., (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia, 9,* 97-113.

Pan, Z., & Gemmert, A. W. A. V. (2013). The direction of bilateral transfer depends on the performance parameter. *Human Movement Science, 32, 1070-1081.*

Przybyla, A., Good, D. C., & Sainburg, R. L. (2012). Dynamic dominance varies with handedness: Reduced interlimb asymmetries in left-handers. *Experimental Brain Research, 216,* 419-431.

Senff, O., & Weigelt, M. (2011). Sequential effects after practice with the dominant and non-dominant hand on the acquisition of a sliding task in schoolchildren. *Laterality, 16* (2), 227-239.

Stöckel, T., & Weigelt, M. (2012). Brain lateralisation and motor learning: Selective effects of dominant and non-dominant hand practice on the early acquisition of throwing skills. *Laterality, 17* (1), 18-37.

Stöckel, T., Weigelt, M. & Krug, J. (2011). Acquisition of a complex basketball-dribbling task in school children as a function of bilateral practice order. *Research Quarterly for Exercise and Sport, 82* (2), 188-197.

Stöckel, T., Weigelt, M., & Krug, J., (2011). Acquisition of a complex basketball-dribbling task in school children as a function of bilateral practice order. *Research Quarterly for Exercise and Sport, 82,* 188-197.

Yao, W. X., Cordova, A., Huang, Y., Wang, Y. & Lu, X. (2014). Bilateral transfer for learning to control timing but not for learning to control fine force. *Perceptual & Motor Skills: Learning & Memory, 118* (2), 40-410.

VITA

Graduate School
Southern Illinois University

Savanna M. Ashbaugh

CUCstudent@hotmail.com

Illinois State University
Bachelor of Science, August, 2015

Research Paper Title:
The effect of sequential patterns of bilateral transfer in underhand serving for volleyball

Major Professor: Julie Partridge