A DESCRIPTIVE AND COMPARATIVE STUDY OF THE TRADITIONAL AND SPIN GOALBALL THROW RELATED TO BALL VELOCITY

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

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COLLEGE OF HEALTH SCIENCES

BY

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DENTON, TEXAS

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To the Dean of the Graduate School:

I am submitting herewith a disseration written by Stephanie J. Bowerman entitled "A Descriptive and Comparative Study of the Traditional and Spin Goalball Throw Related to Ball Velocity." I have examined this disseration for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in Kinesiology.

Ronald Davis

Ronald Davis, Ph.D., Major Professor

We have read this disseration and recommend its acceptance:

Department Chair

Accepted:

Dean of the Graduate School

DEDICATION

To my parents, John and Verna Bowerman, thank you for all your continuous love, support, and encouragement all through my educational journey.

To my academic advisor, Dr. Ronald Davis, thank you for all your guidance, continuous dedication, and wonderful example you provided me throughout my doctoral program.

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ABSTRACT

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A DESCRIPTIVE AND COMPARATIVE STUDY OF THE TRADTITIONAL AND SPIN GOALBALL THROW RELATED TO BALL VELOCITY

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The purpose of this study was to describe and compare the game and throwing variables of the traditional versus spin throw in goalball to determine their correlations to ball velocity. Twenty-nine goalball athletes (17 men, 12 women) competing at a United States Association of Blind Athletes Regional Goalball Tournament were recruited to participate. The following data were collected and described for both the traditional and spin goalball throw: (a) descriptive analysis of game statistics and throwing tendencies during competitive play through visual observation, (b) identified phases of movement for the goalball throw and duration in each phase was determined through visual observation of a 2-D video analysis, (c) Pearson correlation identified any relationships between ball velocity of each type of throw and physical/motor components (flexibility, strength, power, and balance), and (d) 2 x 2 ANOVA determined if any differences were found between gender and type of throw. Results indicated a spin throw was observed more in men (42%) than women (1.5%) in tournament play. Men throw the goalball at faster velocity than women for both the traditional and spin throw. Three phases of movements for the goalball throw were recognized: (a) preparatory, (b) approach, including the wind-up and the delivery, and (c) follow through; no strong correlations were found

between ball velocity and the duration in each phase of movement in either types of throw. A significant interaction was found between gender and the two types of throws ($F(1,8)$ = 33.17). Post hoc test determined that gender explained the interaction. A significant relationship was evident between the fitness-ball throw (seated and standing) and the ball velocity of the traditional (r = .77 and .78 respectively) and spin throw (r = .84 and .82 respectively). Additionally a significant relationship was reported between ball velocity of the traditional and spin throw and vertical jump (r = .72 and .77 respectively). Conclusions of the current study suggest that coaches should integrate practices of the spin throw for men and women goalball athletes in training routines. Resistance training programs could be utilized to increase sports performance of the goalball throw. Future investigators should build on this foundational research and conduct clinical 3-D kinematic and kinetic analysis verifying phases of movement, elements of movements, and parameters that affect the velocity and accuracy of various types of goalball throws.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

CHAPTER I

INTRODUCTION

Goalball is a sport that is played on a volleyball sized court, in a three versus three formation by individuals who are visually impaired (VI) and/or blind. The objective of the game is to throw or roll the ball from a team area past the goal line of the opponent's team area and their attempted blocks (Davis, 2002). One offensive skill in goalball is throwing. There are different types of throws used in goalball. Two common throws are the traditional throw, which is an underhand throw that resembles the motion to bowling, and a spin throw that is an underhand roll with a rotating moving approach similar to the discus throw. The faster the ball is thrown, the harder it is to block, which increases offensive strategies.

Goalball was first invented in 1946 to provide opportunities in the rehabilitation of blind war veterans (http://www.ibsa.es/eng/). The sport was first demonstrated in the 1976 Summer Paralympics and has been a part of every Paralympic since. In the United States, goalball is governed by the United States Association of Blind Athletes (USABA) founded in 1976 (Davis, 2002). It is a fast paced, challenging, strategic game that has grown in popularity after the involvement in world competitions (http://www.ibsa.es/eng/). Although goalball is a Paralympic sport, research focusing on the sport of goalball is scarce. Limited studies have been conducted on sports performance using goalball athletes as participants. Most research on goalball athletes is

related to physical fitness such as strength, power, flexibility and body composition (Colak, Bamac, Aydin, Meric, & Ozbek, 2004; Karakaya & Ergun, 2009).

Seeking ways to improve athlete's performance in any sport is a goal of coaches. Game analysis is a way to determine the game statistics of each individual player and team. Coaches can determine strengths and weaknesses from game performance and build practices around these tendencies. Game analysis in goalball has not been previously documented in the literature; however researchers have used game analysis in wheelchair basketball (Malone, Gervais, & Streadward, 2002; Malone, Nielsen, & Steadward, 2000). These researchers used visual observation of game performances to determine trends relating to free throw shooting in wheelchair basketball. Vanlandewijck et al., (2004) made use of game analysis through videotape to describe performance of elite women's wheelchair basketball players. Results of these studies gave coaches direction for intervention, training, and improved performance. By reviewing these studies, the use of game analysis through visual observation or videography can be applied to coaching goalball.

Identification of key components of any skill is an important concept for coaches to develop in order to improve athlete technique and performance. Coaches' understanding and application of movement is the beginning of athlete development. Dividing the throwing skill in goalball into phases of movement (e.g., preparatory, windup, release, and follow through) can lead to improved coaching and improvement in performance such as increased ball velocity and/or throwing accuracy. One resource that

can help coaches discern phases and components of movement is the utilization of sports skills analysis.

Sport skill analysis models, used to identify phases of movement have been applied to sports for persons without disabilities, in particular throwing sports such as softball (Flyger, Button, & Rishiraj, 2006), shot put (Coh, Stuhec, & Supej, 2008), discus (Yu, Broker, & Silverster, 2002), and baseball (Sachlikidis & Salter, 2007). While these models are common to able-bodied sports, limited application has been applied to disability sport, particularly the sport of goalball.

In order for coaches to observe their athletes performance of a goalball throw and be able to successfully correct the skill to improve performance (i.e. ball velocity), it is recommended to first identify the different phases of the throw. Carr's (2004) model of sports skills analysis can be used to breakdown the goalball throw into different phases. The six steps in this sport skills analysis model are: (a) determine the objectives of the skill, (b) note any special characteristics of the skill, (c) study top-flight performance of the skill, (d) divide the skill into phases, (e) divide each phase into key elements, and (f) understand the mechanical reason of why each key element is performed a particular way. Once the phases of a throw are determined and key elements within each phase are identified, a coach can begin to identify and correct errors in the skill.

Increasing ball velocity in the goalball throw is a goal of any athlete and as a result, advancement in the traditional throw has occurred (i.e., spin throw). Similar to the shot put throw, development from two different types of shot put throws (i.e., glide shot, rotational shot) has given athletes better results (Paish, 2005). When reviewing the

goalball literature, there are no data supporting that the spin throw creates higher ball velocity compared to the traditional throw.

Athletic skills are influenced by player's time in practice, physical attributes and ability (Malone et al. 2002). Studies associated with physical fitness of goalball athletes compared to non-goalball players (Karakaya & Ergun, 2009) and sighted peers (Colak et al. 2004) have been reported. Flexibility, power, strength and balance are sports related variables that can enhance an athlete's performance. It has been reported that the physical fitness of goalball players are greater compared to the physical fitness of a more sedentary group (Karakaya & Ergun, 2009). It was documented that goalball is also an effective way to improve motor skills in children with VI (Colak et al.), however no studies could be identified that linked performance variables (e.g., sports related or motor/physical fitness) to increasing ball velocity in the goalball throw.

Problem Statement

Goalball is a recognized Paralympic sport for both men and women. It is a highly competitive sport; therefore both coaches and athletes seek ways to enhance game performance by looking at game statistics, improving individual skills and increasing an athlete's physical ability. When searching the literature related specifically to the sport of goalball or goalball athletes, only three references appeared. Areas of physical fitness have been documented (Colak et al., 2004; Karakaya & Ergun, 2009) and mental imagery in goalball athletes was examined by Eddy and Mellalieu (2003). Limited literature related to goalball creates a problem when trying to develop new studies. Support of previous models and concepts have to come from literature concerning other sports and be applied

to goalball. Therefore, research needs to be conducted specifically associated to goalball. Results of the current study will contribute to the scientific literature and will form a foundation for future investigators to build upon. Therefore, the purpose of this study was to describe and compare the game and throwing variables of the traditional versus spin throw in goalball to determine their correlations to ball velocity.

Research Questions

1. What are the game statistics (frequencies, means and percentages) of men's and women's goalball competitive play?
2. What are the phases of movement observed in a traditional and spin goalball throw?
3. What is the time spent in each phase of movement in the traditional and spin goalball throw and does it relate to ball velocity?
4. Are the physical/motor fitness components of men and women highly correlated with the velocity of the goalball throw for both traditional and spin throw?
5. What are the differences in ball velocity for the two types of throws (traditional and spin) and gender (men and women)?

Hypotheses

1. The hypothesis for the current study and research question four is: (a) Ho: There are no significant relationships between the motor fitness variables and the velocity of the two types of throws.
2. The hypotheses that address research question five are: (a) Ho: There are no significant differences in velocity between gender (male and female), (b) Ho: There are no

significant differences in velocity between the types of throw (traditional and spin), and (c) Ho: There is no significant interaction between gender and types of throw.

Definitions

Traditional Goalball Throw: A one handed throw like in bowling, using an underhand back swing followed by a forward swing and release, with a linear forward moving approach.

Spin Goalball Throw: A one handed throw with an underhand back swing and a rotating forward moving approach like a discus thrower.

Visual Classification: Individuals with VI and/or blind in competition, compete based on four classification levels. Each athlete is classified according to the International Blind Sports Federation (IBSA) visual classification scale as either a B1, B2, B3 or B4 athlete [(www.usaba.org) see Table 1)].

Table 1

Description of the Visual Classification System of Athletes with a Visual Impairment

Classification	Description
B1	No light perception in either eye up to light perception. Unable to recognize any shapes at any distance or direction.
B2	From the ability to recognize shapes up to visual acuity of 20/600. Has a visual field of less than 5 degrees with best eye.
B3	Visual acuity above 20/600 and up to visual acuity of 20/200. Has a visual field of less than 20 degree and more than 5 degrees with best eye.
B4	Visual acuity above 20/200 and up to visual acuity of 20/70. Has a visual field larger than 20 degrees in the best eye.

Note: www.usaba.org.

Assumptions and Limitations

A small sample size is a limitation to this study. Athletes were individuals who had a VI and/or were blind which limited the availability of athletes. Purposive sampling occurred and only athletes who were at the Regional Goalball Tournament were chosen. This could lead to a bias sample. Findings may not be generalized and may not be representative of all goalball athletes.

A small sample size will also reduce the statistical power of the study. Correlation coefficients are affected by sample size.

Significance of the Study

This study may determine new knowledge for the sport of goalball. Determining throwing tendencies can be useful coaching information. Applying a sports skills analysis model to the specific skill of throwing a goalball will have potential for coaching improvement, athlete development, and contributions to the literature. In addition, once coaches learn to identify these phases, they can begin to assess the elements within each phase. Improved information can enhance the level of coaching which in turn has potential for improved athlete performance, both individual and team.

CHAPTER II

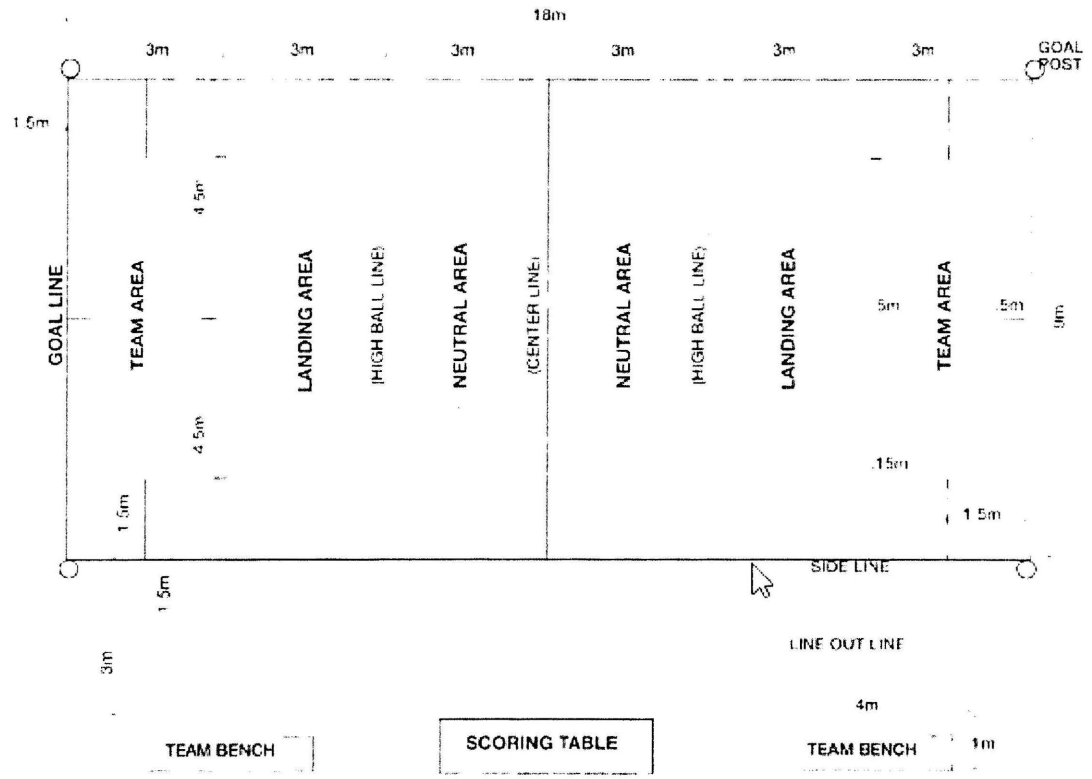
REVIEW OF THE LITERATURE

This chapter provides an overview of the current literature related to goalball athletes and sport performance. It also provides relevant literature to support models and ideas behind goalball that may be addressed in able-bodied sports. The chapter is outlined as follows: (a) introduction to goalball, (b) game analysis, (c) phases of movement, and (d) physical attributes of a player

Introduction to Goalball

Goalball is played by individuals with a visual impairment (VI) and/or who are blind. All athletes wear eye shades at all times to block out any vision that is present. Competition in general for individuals with a VI is usually divided into four classification groups based on their vision level however, for goalball, athletes with different classification can play on the same team, and fair and equitable play is achieved due to wearing the eye shades. Goalball is played on a volleyball sized court where the objective of the game is to throw or roll the ball that has bells embedded in it, from one team area across the opponent's team area and past their goal line (see Figure 1). The court is divided into three areas: (a) team area, (b) throwing or landing area, and (c) neutral area (Davis, 2002). When the ball is thrown, it must be rolling or at least come into contact with the floor before it crosses over the line of the neutral area or a throwing penalty is called. The skills of goalball are throwing, shot blocking, and ball control. A traditional

throw is an offensive skill where the player throws the ball underhand using a bowling motion. The faster the ball is thrown, the harder it is to block, which improves the chances to score a goal. Some athletes use a variation of the traditional throw identified as a spin throw.

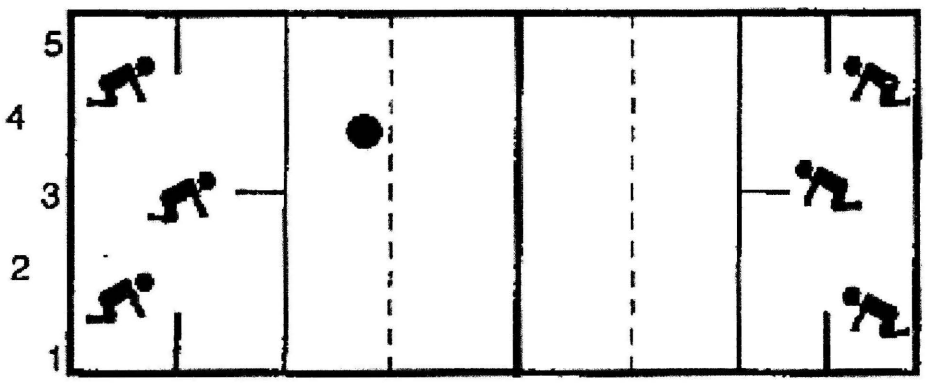


Note: www.usaba.org.

Figure 1. Playing areas and measurements of the goalball court.

During a game, there are three players on the court at a time for each team. The player in the middle of the court is the center, and the two players on either side of the center are wings. The players' position themselves on the court by using the three orientation lines that are on the floor (see Figure 2). These orientation lines can be felt

with the players' hands or feet and are standard for each goalball court. The lines are used for positioning and maintaining orientation on the court during the game. The players stand in the team area. The center position has the duty of covering the area of sideline to sideline. The two wings stand two to three feet behind the center, and have a smaller area to cover, approximately one body length or more from the sideline to their position (Davis, 2002). The center and wings are not lined up parallel on the floor. The defensive skill of blocking is performed from a horizontal position on the floor, therefore staggered positioning (see Figure 2) is used to avoid injury when blocking. There are five zones from which the players throw to and from in a game of goalball (see Figure 2). These zones have not been documented in the literature but are common to coaches and athletes familiar with the sport. Zone one covers the area from the right side line to the spot the right wing positions themselves. Zone two covers the area between the right wing players to the center position. Zone three represents the middle of the court at the center position. Zone four represents the area between the center (i.e., zone three) and the location that the left wing positions themselves, and zone five represents the area from the left wing to the left side line. During a game, athletes often have strategies of throwing into one of the specific zones during play. Either by choosing a specific zone (e.g., zone 2) or by using a combination of plays throwing in a sequence (e.g., zone, 5, 5, and 1).



Note: www.usaba.org.

Figure 2. Different playing zones on a goalball court.

Game Analysis

Goalball game analysis has not been previously documented in the literature. Game analysis of field performance among other disability sports is also very limited, but researchers have used game analysis in wheelchair basketball. Vanlandewijck et al. (2004) used game analysis through videotape to describe the performance of elite female wheelchair basketball players while also confirming athletes' performance to their functional classification. The researchers videotaped 12 championship wheelchair basketball games covering eight national teams participating in the 1998 World Championship for Wheelchair Basketball (Gold Cup) in Sydney, Australia. Data were received from a total of 95 elite female wheelchair basketball athletes, however only 59 athletes were used for data analysis because inclusion criteria was set that each participant had to play in a minimum of 10 consecutive minutes in each game. Games were videotaped using a Hi8 camcorder, and each team was videotaped for three 40

minute games. Players were classified into four classes according to the International Wheelchair Basketball Federation (IWBF) Player Classification System, and player position (center, forward or guard) were clearly identified. According to this classification system each of the four classes received a point from lowest function (1) to highest function (4). Player's contributions to the game were documented using the Comprehensive Basketball Grading System (CBGS) and specific performance points were given for different components of the game (e.g., offensive rebound, free throw completed, two-point baskets missed, etc) to determine the quality of game performance. To obtain informed consent of participants, the investigators received consent through the team's coaches/managers during the management meeting that was organized by the championship committee. There were five experts in the field of wheelchair basketball who analyzed the recordings after each game. A two-way analysis of variance (ANOVA) was completed with two factor groups (class and position) and a Duncan's post-hoc test was used to determine the specific effects. Findings indicated that the basketball performance observed for the female participants was class dependent. According to the results of the CBGS, players classified with a higher point performed better than the lower point players on game performance components (e.g., blocked shots, personal fouls, free throws completed, and two-points baskets missed).

In a similar study, Malone et al. (2000) collected data from 116 participants in a Gold Cup World Wheelchair Basketball Championship (July 1994) to determine a technique to describe the free throw outcome, and characteristics of free throw shots among elite male wheelchair basketball athletes during competition. In this study both

visual observation and recordings of free throw observations were documented on a schematic diagram. All free throw shots were visually observed at a predetermined basket. The ball flight pattern and outcome were also documented using visual observation and later coded for descriptive purposes. The following items were coded and observed: (a) clean swish, (b) backboard, (c) back rim, (d) front rim, (e) subsequent rim bounce, (f) success after a sequence of events or hoop, and (g) miss. There was also an overhead camera recording ball action for two games which were reviewed to check the accuracy of the observers, indicating 35 of the 37 (95%) diagrams were reliable. Free throws were then grouped into five categories, clean swish, long success, short success, long miss, and short miss. The following tournament statistics were computed including, final game points, percentage of team points by free throws, percentage of individual points by free throws, team free throw shooting percentage, and individuals free throw shooting percentage. The results of this study provided trends observed during the game related to the free throw and gave coaches ideas for training intervention. In this study, short shots (where the ball hit the front of the rim and then missed) made up most free throw errors, suggesting that since player positioning in a wheelchair is lower to the ground compared to able-bodied basketball, training techniques, or improved physical conditioning to improve strength of the upper body could be addressed.

Malone et al. (2002) also collected data through competitive play and videography. Data collection took place at the 6th Men's Gold Cup World Basketball Championship tournament focusing on basketball shooting mechanics of a free throw. The purpose of this study was to record free throw shooting using 3-D video data

collection and analysis. The free throw shooting space was calibrated before data collection began. Two 2-D cameras were used to obtain frontal and sagittal views and were placed to ensure the movement of the free throw was captured along with the movement path of the ball 15 frames after release. Both cameras were synchronized by manually triggering a light visible on both cameras. The following points were manually digitized (fingers, wrist, elbows, shoulder, hip, and the center of the basketball) all on the right side of the body for a right handed throw. Segments were created connecting specific points that were digitized (i.e., hand, forearm, arm and trunk). Using the digitized points on both videos, the 2-D video was converted in a 3-D image sequence. At the same time, free throw shooting outcomes were also manually recorded. Ball movement patterns to the basket were visually observed and recorded. The same investigator observed all free throws and tracked the ball pattern in a numerical sequence and over head camera views were recorded for two games confirming 95% of the diagrams were accurate. Free throw outcomes were sorted into five groups based on the type of shot (i.e., clean shot, long success, short success, long miss, and short miss). These are the same methods used by Malone et al. (2000) to analyze the ball movement pattern of the free throw and game performance statistics.

Results of the study (Malone et al., 2002) indicated that there were significant differences between classifications of wheelchair athletes in their free throw shooting mechanics. There was a difference in ball release and velocity when shooting between classes therefore athlete development requires an understanding and application of the movement mechanics of the skill. In wheelchair basketball, it was concluded that

identifying the key components of the free throw skill are essential when coaching proper timing and technique development. This concept can be applied to other disability sports, in particular goalball. The methods the above investigators utilized can be applied to tracking game statistics and tendencies observed for individual and team goalball data. Identification of components of goalball skills also need to be identified. The basic skill of throwing a goalball has not been viewed and reported in the literature, thus the phases of movement of this skill need to be determined.

Phases of Movement

This section of the chapter will discuss the general phases of movement recognized in able-bodied sports discussing similar throwing movements (e.g., under and overhand throwing, shot put, discus and bowling) and how they relate to the phases of movement found in the goalball throw.

Dividing a throwing skill into phases of movement (e.g., preparatory, windup, release, and follow through) is the first step coaches should take when analyzing their athletes' skill movements (Carr, 2004). In goalball, defining these phases could lead to skill improvements such as increased ball velocity and/or accuracy. Skills analysis model are common in able-bodied sports such as jumping, running, kicking and in particular throwing. Skills analysis model have been applied to sports such as softball, shot put, discus, and baseball. The softball pitch can be defined by three interlinked phases of the wind-up and stride, delivery, and follow-through (Flyger et al. 2006). The phases of the rotational shot put include the initial stance, entering the turn, flight phase, second single support phase, and second double support phase (Coh et al., 2008; Coh, Supej, Stuhec &

Smajlovi, 2007). The discus throw has six critical instants in the throw: maximum back swing, right foot takeoff, left foot takeoff, right foot touchdown, left foot touchdown, and release (Yu et al. 2002). The over arm throw in baseball can be divided into five common phases as the wind-up, stride, arm cocking, arm acceleration, arm deceleration and follow-through (Sachlikidis & Salter, 2007). Although these phases of the different throwing patterns have similarities, the details and elements of each phase are sport specific. Once these phases are identified, coaches and/or researchers can begin to address specific movements such as whether to use a flexed elbow or a straight-arm elbow in the windup for the baseball pitch. Although these phases of movement are common in able-bodied sports, limited application has been applied to disability sport, particularly the sport of goalball.

One skill that presents similar throwing developments to the goalball traditional and spin throw is the shot put. The shot put throw has evolved over the years beginning with the glide shot put to a rotational shot put technique. Outcomes of a shot put throw are to increase the distance of the throw and velocity. The glide technique of the shot put throw has various phases of movement such as preparatory, takeoff, flight, delivery, transition, and completion which all moves towards the front of the throwing circle in a relatively linear fashion (Young, 2007). The technique of the rotational shot put throw has similar phases, identified as: (a) initial stance, (b) entering the turn, (c) flight phase, (d) second single-support phases, and (e) second double support phase but moves towards the front of the throwing circle while rotating (Coh, Supej, Stuhec, & Smajlovi, 2007). Among a panel discussion between several knowledgeable coaches from Australia and

New Zealand, each elaborated on different aspects of the glide technique versus the rotational shot technique. One topic discussed was the advantage of using a rotational shot put throw. It was noted that the glide shot put throw can be hard on the body and has a more static starting position needing more energy, where as the rotational shot put throw can have an increase in release speed if performed technically correct. There is an increase capability to speed up the shot across the acceleration path using the rotational technique. The rotational shot put throw can travel up to 1.5 meters more in the approach compared to the glide shot put throw and the speed of the shot can be up to 1 m/sec faster (Lemke, Hellier, Supko, & Murphy, 2003). Other advantages stated using the rotational shot put throw compared to the glide shot put throw technique is that it develops more momentum, and allows greater force to be applied to the shot. The development of a glide shot put throw to a rotational shot put throw could hold true to the throw in goalball when observing the traditional versus spin throw. The objective of the throw in goalball is increased speed and accuracy. As previously stated, the faster the ball is thrown, the harder it is to block, which improves the chances to score a goal. Applying this concept from the able-bodied shot put release techniques to disability sport of goalball can be valuable.

In order for coaches to observe their athlete's performance of a goalball throw and be able to successfully correct the skill to improve performance (i.e. ball velocity), it is recommended to first identify the different phases of the throw. Carr (2004) model of sports skills analysis is one method that can be used to breakdown the goalball throw into different phases. Table 2 describes Carr's model with application to the goalball throw

identified and applied to the model by the author. To the author's knowledge, phases of movement for the goalball traditional throw have not been identified in the literature.

Table 2

Applications of Sports Skills Model to the Traditional Goalball Throw

Steps	Sport Skills Analysis Model	Application to the goalball throw
1	Determine the objectives of the skill	To roll the ball as fast as you can
2	Note any special characteristics of the skill	What type of throw is performed? Traditional vs. Spin Throw
3	Study top-flight performance of the skill	Study/review elite performance – consider National and International competition
4	Divide the skill into phases 1. Preparatory Movements (set up) 2. Windup (backswing) 3. Force-producing movements 4. Follow-through (recovery)	There are four phases of a skill: 1. Stance and hold ball 2. Stance to ball back position 3. Ball back position to forward release 4. Ball release to ending position
5	Divide each phase into key elements	Example: In the windup phase, key elements are the stance (approach to final step with opposite foot) and bringing throwing arm and ball to back position
6	Understand the mechanical reason each key element is performed as it is	Example: Knowing the purpose of rotating the hips ahead of the upper body and toward the direction of the throw: shifting body of mass, sequential acceleration of body segments, and stretching muscles and weight shift.

Note: Carr, 2004.

When following the model, after the first two steps are clearly identified, and top flight athletes have been observed, steps 4 and 5 of analyzing the skill can be completed.

When applying this to the goalball throw, the phases of movement for both the traditional and spin throw can be identified. Following models such as Carr's (2004), the phases and key elements of a traditional goalball throw needs to be defined. In a study completed by Bowerman and Davis (2010), the phases and key elements of the traditional goalball throw were identified. Table 3 describes how the authors applied the model to define each phase and their coinciding key elements.

Table 3

Steps 4 and 5 of Sports Skills Analysis Applied to the Traditional Goalball Throw

Skill Phases	Key Elements
Preparatory Movements	• Walking to throwing area • Stance • Holding the ball ready
Windup	• The approach and final step into throwing stance • Rotating torso to extend throwing arm to back position
Force Producing Movements	• Accelerating body segments from legs to throwing arm • Bringing throwing arm forward to point of ball release
Follow-through	• Shift in body weight • Throwing arm continues forward after ball release

Another movement that resembles the traditional goalball throw is rolling a bowling ball in the sport of bowling. When preparing to bowl, the bowler takes a stance,

moves into an approach and swing, releases the ball, and completes the delivery of the throw with a follow through. As Grinfelds and Hultstrand (1996) described concepts of bowling, a summary of the fundamentals of bowling are listed under six phases (e.g., stance, pushaway, approach, swing, delivery, and follow-through). Physical educators may teach the throw in bowling using: (a) grip, (b) stance, (c) approach, and (d) release (Schmottlach & McManama, 2002).

Some of the key elements in each of the specific phases in bowling are described by Grinfelds and Hultstrand (1996). In brief, the stance refers to standing with knees flexed, finding the hand and finger position of holding the ball, and shoulders and hips square to the target. The pushaway phase occurs when the ball is moved away from the body in the downward direction with a step forward using a straightened bowling arm. The swing phase is the pendulum back swing of the ball reaching the height of the backswing. The delivery phase is described as bending the knees to lower the body to the ground and the ball is released. In the follow-through phase the bowling arm continues to move forward and finishes in the 90° angle between the shoulder, arm and target.

When reviewing the phases of bowling by Grinfelds and Hultstrand (1996) and the skill phases identified by Carr (2004), it appears that there are some similarities between these two models. Using the study by Bowerman and Davis (2010), the traditional goalball throw skill phases were identified (i.e., preparatory movements, windup, force producing movements, and follow through) and can be compared to the bowling phases (i.e., stance, pushaway, approach, swing, delivery, and follow-through) identified by Grinfelds and Hultstrand (1996). In the goalball study, the preparatory

movements phase can relate to both the stance and push away phase in bowling. The wind up phase can be compared to the approach phase in bowling, and the force producing movements phase identified in the goalball study is similar to the swing and delivery phase in bowling.

Once phases of movement are defined, researchers can determine the importance of each phase as it plays a significant role in the performance of the throw. Young (2007) has discussed the time spent in phases of movement and its relation to the performance of the glide shot put throw. When reviewing the biomechanics of a glide shot put throw, phases were defined as preparatory phase, takeoff, flight phase and delivery phase, with transition and completion phase as part of the delivery phase. Young defines the phases from a specific beginning and ending point. For example, the preparatory phase begins when the throw is initiated until the moment of the takeoff phase. In the shot put throw, the preparatory phase is important because the athlete gains its beginning balance and rhythm which will affect the outcome of the throw. The takeoff phase in shot put begins the moment preparatory phase finishes when the athletes support foot breaks contact with the ground and a period of flight begins. Body positioning, foot positions and foot push off can be different for athletes in this phase. The flight phase is defined the instant the push off is completed, the push off leg travels near the ground and lands close to the center of the shot put circle. During the flight phase, duration has been reported and a range of .2 to .5 s has been documented (Young). The purpose of the completion phase is to maximize velocity that is implemented on the throw. This is influenced by the length of the completion phase and acceleration, the speed of the movement, and the body

positions and all affect the athlete's ability to generate the greatest amount of force. Stepanek as cited in Young, states that the speed of movement in the completion phase is inversely related with performance and the best athletes reduce their time spent in the completion phase. A variety of time spent in the duration phase has been reported, however the more elite shot put athletes are moving over a greater distance during the completion phase in a shorter period of time (Young).

The phases of movement specifically in goalball have not been reported in the scientific literature. By reviewing several different models and sports that resemble the goalball throw, the phases of movement for the goalball throw can be identified; in addition, the time spent in each phase can be determined.

Physical Attributes of a Player

The skills an athlete gained through the result of practice are influenced by the physical attributes and ability of a player (Malone et al. 2002). There are studies that have described adolescent goalball athletes and their physical fitness (Colak et al. 2004; Karakaya & Ergun, 2009). Karakaya and Ergun compared the male and female physical fitness levels 28 goalball athletes (age 10-16) to their age-matched sedentary visually impaired counterparts ($n = 27$). The *Brockport Physical Fitness Test* was selected as the assessment tool, and the 1-mile run/walk test, skinfold thickness of triceps and calf, curl-up, trunk lift, push-up, and shoulder stretch tests were evaluated. In addition, the vertical jump test was used to evaluate anaerobic power. Results indicated that the group who played goalball scored significantly better ($p < .05$) than the sedentary group in all items,

except the shoulder stretch where there were no significant differences between the groups.

Similarly, Colak et al., (2004) also compared physical fitness of male adolescents between goalball athletes and non-goalball players (14-15 years) with varying levels of VI. The following items were assessed to measure participant's physical fitness: (a) range of motion for the shoulder, elbow, and wrist, (b) flamingo one leg balance test, (c) unilateral isokinetic concentric peak torque strength of the shoulder, (d) vertical jump, (e) handgrip strength, and (f) sit and reach for hamstring flexibility. Results demonstrated that goalball athletes had significantly ($p < .05$) greater internal rotation isokinetic concentric peak torque strength, balance assessment, grip strength, vertical jump, and sit and reach scores than their non-goalball athletes. Conclusions these authors made were participation in goalball can enhance several areas of physical fitness skills for individuals with a VI.

According to the literature, physical fitness components have not been correlated to performance of the throw in goalball. Since physical fitness can affect performance, an association between fitness components and skill performance is warranted. Bowerman and Davis (2010) identified that leg strength was related to ball velocity in novice male goalball athletes. In addition walking variables (i.e., walking speed and step length) was correlated to ball velocity when grouped by classification that included males and females. Comparisons between physical fitness components and goalball performance should be conducted with higher skill level athletes.

CHAPTER III

METHODOLOGY

Prior to data collection, the investigator received approval from the University's Institutional Review Board (IRB) obtaining signed documentation (see Appendix A). The signed informed consent of each athlete was also collected (see Appendix B).

Participants

A total of 29 athletes including both men (17) and women (12) who competed in the United States Association of Blind Athletes (USABA) Regional Goalball Tournament held at the Student Recreation Center, Western Michigan University were recruited to participate in this study. Athletes were individuals with a visual impairment (VI) and classified as either a B1, B2, B3 or B4 athletes (Refer to Table 1).

Instruments and/or Apparatus

The following instruments were used as part of the data collection procedures: (a) a game data tracking sheet (see Appendix C), (b) a sit and reach box, and (c) a Sony digital video camera recorder - handy cam recording at a rate of 60 frames/second. The game data tracking sheet was modified from a tracking tool used by the USABA (J.Potts, personal communications, October 28, 2009).

Procedures

Game Analysis

Complete goalball games were electronically recorded (digital video camera) for game analysis to determine game statistics and throwing tendencies during play. The camera was set up in an elevated area behind the goal line of the goalball court on a volleyball standard for the women's games, and on a second floor walking track for the men's games. The entire court was in the field of view in order to see both offensive and defensive game play (see Figure 2). The type of throw (traditional, spin, or other) and the outcome of the throw (blocked, goal scored, out of bounds, or penalty) was recorded on the data tracking sheet (Refer to Appendix C). The following data were compiled for game analysis using all games observed to determine frequency and percentage for: (a) the number of throws in a game, (b) the number of goals scored in game, (c) the number of times the ball went out, and (d) the number of times a penalty was called after throwing. Data were compiled for both male and female games and by type of throw (traditional and spin). The outcome of penalty shots were tracked whether it was from a personal or team penalty. The researchers were interested in the outcome of the throw and not the reason or type of penalty called.

Phases of Movement

Phases of movement for both types of throw were defined through post game observation of the athlete's throw which was electronically recorded during a separate performance. During a separate throwing session, with their eye shades on, each athlete threw the goalball three times using a traditional throw. For those who also threw a spin

throw in their normal game repertoire, another three throws were completed using the spin throw. One digital video camera was located perpendicular to the throwing motion which had the entire throwing movement in the camera's field of view. Using this throwing session, the video obtained was used to establish both the phases of movement for the traditional and spin throw, and used to define the beginning and ending points of each phase in order to calculate the time (seconds) within each phase of movement. Of the three trials, the throw with the fastest ball velocity was the one selected for phases of movement analysis.

Time in Phases of Movement

Once the phases of movement were established, the time in each phase of movement was calculated. The time in each phase was determined by visual observation on the video and counting the number of frames on the video it took from the defined beginning and ending points for each phase. The time (seconds) was calculated by taking the number of frames counted and dividing it by the digital recorders frame rate (60 frames/s). For example, if the number of frames to move from the beginning to end of the approach phase was 10 frames, the time would be determined by dividing 10 frames by the frame rate (10 frames divided by 60 frames/s). Therefore the time in the approach phase for that throw would be 0.166 s.

Ball Velocity

During the same throwing session used for phases of movement and with the use of a second digital video camera, ball velocity was obtained. A separate camera was placed perpendicular to the action of the ball, which had the exact distance of the neutral

area (6 m) in the camera's field of view. During the same throwing session used for the phases of movement, the velocity of the goalball throw was calculated by viewing the number of frames it took for the ball to cross over the length (6 m) of the neutral area of the goalball court (see Figure 1). The ball velocity was calculated by dividing the distance of throw (neutral zone of 6 m) by time (seconds). Time was calculated by counting the number of frames it took for the ball to travel across the 6 m distance and dividing it by the digital video frame rate (60 frames/s). The highest velocity of the three throws was recorded.

Physical/Motor Fitness Components

Field based tests took place to determine physical (i.e., flexibility, power, and strength) and motor (i.e., balance) components. Height and weight were also measured at this time. All athletes were measured wearing their uniforms and protective gear (e.g., knee pads) as there was not enough free time in between games for athletes to change in and out of equipment; therefore body mass index (BMI) was not calculated.

Flexibility. The sit and reach test was used to measure flexibility. While in stocking feet, the athletes sat in position with one leg extended straight out to the sit and reach box and the other knee bent so the foot was flat on the floor beside the straight leg. The athletes were instructed to reach as far forward while bending at the waist with their hands in front and on top of each other sliding on the top of the sit and reach box. Both the left and right leg were evaluated and the highest of the three scores was recorded.

Power. The vertical jump test was used to determine power. Athletes were instructed to stand with their feet flat on the floor and dominate side to the wall while

reaching as high as possible with the closest hand to the wall marking the wall with a piece of chalk. Reach height was recorded at the highest point that their fingertips could mark the wall with the chalk. Athletes stepped one elbow length away from the wall and jumped vertically as high as possible attempting to touch the wall with the piece of chalk leaving a mark at the highest point of the jump. The highest point recorded determined the jump height. The difference in meters between the reach height and the jump height was recorded (Karakaya & Ergun, 2009). The highest of the three scores was recorded and used for data.

Strength. Dynamic strength of the upper body was measured by the fitness-ball distance throw. Athletes were instructed to throw a 3 kg fitness-ball forward using a two handed chest pass motion the same way in basketball, from a sitting (i.e., in a chair) and standing position. The longest distance in meters was measured from the starting position to the first touch of the ball to the floor. The longest distance of three throws was recorded for both sitting and standing measurements. This protocol was taken from the study by Hakkinen, Holopainen, Kautiainen, Sillanpaa, & Hakkinen (2006).

Balance. The dynamic one leg stance (DOLS) test was used to determine balance (Blomqvist & Rehn, 2007). The DOLS has five levels. Athletes started the DOLS on their left leg performing three attempts on each level following three attempts on the right leg. The DOLS was completed two times (sighted and blindfolded). The best level achieved was recorded for each leg. The following are the criteria and levels of the DOLS (see Table 4). To move to a higher level, athletes needed to meet the criteria of the lower level. Each level has listed one specific measure that needs to be met, except for Level 4

which has two alternative options. To move forward past Level 4, athletes must have met the criteria of at least one of the two alternative options that are present for Level 4. If they met the criteria for at least one of the two alternative options, they received a four and moved towards Level 5 (S.Blomqvist, personal communication, February 25, 2010).

Table 4

Dynamic One Leg Stance Balance Test

Level	Description
1	Unable to stand on one leg for 10 s.
2	Able to stand on one leg for 10 s but shows movement in the arms, body and legs.
3	Able to stand on one leg for 10 s without any movements
4	Alternative 1: Able to stand on one leg and rotate the trunk with arms in front of the body to 45° left and right. Alternative 2: While standing on one leg, able to dip head sideways at least five times 45° both left and right.
5	Able to stand on one leg and raise foot on the toes for 10s.

Note: Blomqvist & Rehn, 2007.

Design and Analysis

This study had several types of data analysis. Descriptive statistics (mean and standard deviation) reported the athletes' demographics (gender, age, years of experience, height, and weight). Descriptive statistics (frequencies, means, and percentages) reported the game analysis, throwing tendencies and the phases of movement. A Pearson

correlation determined if there was a relationship in the time spent in each phase with the ball velocity of the traditional and spin throw.

To address research question 4, a Pearson correlation coefficient was used to determine if there was a relationship between the physical/motor fitness components of men and women and the velocity of the goalball throw for both traditional and spin throw. All of the variables were categorized as ratio data. The following seven dependent variables were correlated to the ball velocity of the traditional and spin throw: (a) height, (b) weight, (c) sit and reach scores for both left and right leg, (d) vertical jump score, (e) sitting fitness ball throw score, (f) standing fitness ball throw, and (g) DOLS balance score for each test (i.e., left and right foot sighted, and left and right foot blindfolded).

To address research question 5, a 2 x 2 ANOVA general linear model repeated measures design was used. This two-way design had two independent variables, (gender) with two levels (male and female), and type of throw with two levels (traditional and spin throw). The between factor was gender while the within factor was type of throw. There was one dependent variable (ball velocity). Statistical analyses used SPSS 15.0. Alpha was set at the .05 level of significance. Post hoc tests compared all the different groups determining where the differences occurred.

CHAPTER IV

RESULTS

The content in this chapter will cover the results obtained based on the specified research questions of the study. The results will be outlined in the following order: (a) demographics, (b) game statistics and throwing tendencies, (c) phase of movement of the goalball throw, (d) time spent in phases of throwing movement, (e) ball velocity, (f) physical/motor fitness components, (g) correlations between ball velocity and physical/motor fitness components, and (h) differences in ball velocity between type of throw and gender.

Demographics

A total of 29 goalball athletes (17 male, 12 female) participated in the study. Descriptive statistics are displayed in Table 5 including the group means and standard deviation (*SD*) for age, years of experience, height and weight for both males and females.

Table 5

Athletes Demographics

Gender	N	Age (years)	Years of Experience	Height (cm)	Weight (kg)
Males	17	26.58 (7.41)	7.44 (5.03)	176.57 (7.38)	93.98 (16.51)
Females	12	21.08 (6.01)	7.75 (4.69)	163.46 (5.11)	69.32 (10.41)

Note: SD are in parentheses.

Game Statistics and Throwing Tendencies

Game statistics and throwing tendencies were documented to determine the frequencies and percentages of traditional and spin goalball throws for men and women along with the outcomes of each throw (i.e., goal scored, out of bounds, or penalty called). In addition, penalty shots were recognized and the throwing outcomes recorded of those penalty shots (i.e., goal scored, out of bounds, or penalty called). As stated previously, the researchers were only interested in the outcome of a throw during game play and the outcome of a penalty shot. The types of penalties were not a focus of the study.

All of the men's and women's goalball games were digitally recorded and reviewed. There were a total of 15 men's and 8 women's teams observed. Bracket round robin games were two 7-min halves while medal round games were two 10-min halves. If ever there was a 10 goal differential during the game, that game was terminated; this occurred one time for the women.

Men's Games

There were 17 men's games digitally recorded and reviewed to determine the game statistics and throwing tendencies. A total of 2103 throws were observed with 1164 traditional throws, 899 spin throws, and 40 other throws. Other throws were defined as any other type of throw than the traditional or spin which may have occurred. For example when the athlete was under time constraint, a seated push throw may have occurred and would have been documented as other. For the purpose of this study, other throws were only counted for total number of throws. Only throwing outcomes for the

traditional and spin throw were used for data analysis. The percentage of traditional throws was 55.3% versus 42.7% spin throws. Table 6 reports the throwing frequencies, percentages and outcomes (goal scored, out of bounds, penalty called) for all of the men's games reviewed.

Table 6

Throwing Frequencies, Percentages and Outcomes for Men's Games

Type of Throw	Frequency	Goals	Out	Penalty
Traditional	1164 (55.3%)	77 (6.6%)	178 (15.3%)	28 (2.4%)
Spin	899 (42.7%)	81 (9.0%)	116 (12.9%)	31 (3.4%)
Total	2063	158	294	39

Men's penalty shots. Penalty shots were accounted for in the total number of throws for the game; however statistics for penalty shots were also documented separately. A penalty shot was given to a team when the opposing team was called for a personal or team penalty. The men had a total of 66 penalty shots. Of those 66 penalty shots, 33 were traditional throws and 33 were spin throws. The outcome of the 33 penalty shots using the traditional throw were 16 throws were a goal, six throws went out, and one throw resulted in another penalty being called. Out of the 33 spin penalty shots, 17 throws were a goal, three throws went out and one resulted in a penalty. Table 7 describes the outcome of the men's penalty shots by percentage.

Table 7

Men's Penalty Shots

Type of Throw	Percentage of Throw	Goals	Out	Penalty
Traditional	50.0%	48.5%	18.2%	3.0%
Spin	50.0%	51.5%	9.1%	3.0%

Women's Games

There were a total of 15 woman's games digitally recorded and reviewed to determine the game statistics and throwing tendencies. A total of 1763 throws were observed with 1720 traditional throws, 27 spin throws, and 16 other throws. The percentage of traditional throws was 97.6% versus 1.5% spin throw. Throwing frequencies, percentages and outcomes for the women are reported in Table 8.

Table 8

Throwing Frequencies, Percentages and Outcomes for Women's Games

Type of Throw	Frequency	Goals	Out	Penalty
Traditional	1720 (97.6%)	82 (94.7%)	195 (11.3%)	8 (0.4%)
Spin	27 (1.5%)	3 (11.1%)	2 (7.4%)	0 (0%)
Total	1763	85	197	8

Women's penalty shots. The women had a total of 12 penalty shots. Of those 12 penalty shots, 12 were traditional throws and zero using a spin throw. The outcome of the 12 penalty shots using the traditional throw were seven throws were a goal and zero went out, or called as a penalty. Table 9 describes the outcome of the women's penalty shots by percentage.

Table 9

Breakdown of Women's Penalty Shots

Type of Throw	Percentage of Throw	Goals	Out	Penalty
Traditional Throw	100.0%	58.3%	0.0%	0.0%
Spin Throw	0.0%	0.0%	0.0%	0.0%

After reviewing the championship (bronze and gold medal) games for men and women, the men threw more times compared to the women. The men had a frequency of 313 for total throws while the women had a frequency of 278 for total throws. Table 10 documented the throwing outcomes that were observed in only the bronze and gold medal games.

Table 10

Throwing Outcomes for Bronze and Gold Medal Games

	Men				Women			
Throw	Frequency	Goals	Out	Penalty	Frequency	Goals	Out	Penalty
Traditional	140	5	7	1	273	11	21	0
Spin	168	9	17	2	4	0	0	0
Totals	313	14 (4%)	21 (7%)	3 (1%)	278	11 (4%)	21 (8%)	0 (0%)

Phases of Movement of the Traditional and Spin Goalball Throw

Descriptive analysis will report the phases of movement determined for the traditional and spin goalball throw. Once these phases of movement were defined, time in each phase was established and reported. In addition, a correlation of the time spent in each phase to the ball velocity of each type of throw was calculated.

After reviewing Carr's (2004) model of sports skills and the phases presented in bowling (Grinfelds & Hultstrand, 1996), the phases of movement for the goalball throw were developed. While Carr's (2004) model for sports skills analysis has four phases of movement (i.e., preparatory movements, windup, force producing movements, and follow through), the phases presented for bowling had six phases (i.e., stance, pushaway, approach, swing, delivery, and follow through). In the current study, phases of movement of the goalball throw have been developed with a total of three phases: (a) preparatory, (b) approach, and (c) follow through. There are two subset phases within the approach phase, wind up and delivery.

After reviewing video of the athletes throwing the goalball, the traditional and spin throw consist of the same three phases of movement: (a) preparatory, (b) approach, and (c) follow through. Generally, the preparatory phase included the athlete locating the beginning stance position with their head in a neutral to forward position followed by initiating the first step into the approach phase. For the purpose of the study, the preparatory phase was defined as the initial foot movement of the first step, and ending at the heel strike of that same first step.

The approach phase was described in two subset phases: (a) wind up and (b) delivery. The total approach phase begins at the end of the preparatory phase (i.e., the heel strike of the foot of the first step) through ball release. The wind up phase is similar to the swing phase in bowling (Grinfelds & Hultstrand, 1996) where the ball is swung back with the arm in a pendulum motion to the height of the backswing. The delivery phase began from the top of the backswing forward ending at ball release.

The follow through phase was described from ball release through a point when the trailing foot moved forward and touched the ground. After the ball was released there was a shift in body weight and the athlete's momentum continued forward causing the throwing arm and body to travel in the forward direction. These phases were defined and also used to determine the time within each phase and are further discussed in the section heading time spent in phases of movement.

As stated above, the phases of movement for the traditional and spin throw are the same, but the elements can differ among the type of throw. The elements within the preparatory phase were the same for the traditional and spin goalball throw. The

preparatory phase consisted of athlete's gaining balance in a beginning stance. Several different positions were observed in this phase. Some athletes stood up straight holding the ball with two hands in front of their chest. Other athletes held the ball with two hands down by the ground bending their body forward. Each athlete had their own beginning stance position leading to the initial first step of their throw.

Within the approach phase, observation of the traditional throw demonstrated the athlete traveling in a forward linear motion but the spin throw revealed a 360° rotational spin. The approach of the traditional or spin throw could have several steps and a range of different step counts was observed such as using two, three, four, or five step approach. If an athlete demonstrated both types of throw they used the same step count approach for each. The majority of athletes threw using a four-step approach ($n = 15$), followed by the three-step approach ($n = 9$), five-step approach ($n = 2$), two-step approach ($n = 1$), and two athletes threw without using any type of stepping approach (i.e., in stance, or jump). Table 10 describes the phases of movement for the traditional and spin goalball throw and the elements occurring within each phase. These elements, previously determined in a study (Bowerman & Davis, 2010) were refined and redefined for the present study.

Table 11

Phases of Movement and Elements of the Traditional and Spin Goalball Throws

Phases of Movement	Elements
Preparatory Phase	• Head position neutral to forward • Beginning balanced stance • Holding the ball ready • Initiating the first step of the approach
Approach	
1. Wind-up	• The approach (e.g., three-step or four step) either linear or rotational • Extend throwing arm back to highest point of backswing
2. Delivery	• Forward motion of the throwing arm • Accelerating body segments from legs to throwing arm • Bending knees and lowering body and shoulder of throwing arm to the ground for ball release
Follow-through	• Shift in body weight • Bringing throwing arm and body forward after ball release

Although it was not measured, visual observation of athletes travelling across the team and landing area was obtained. As stated earlier, when the ball is thrown, it must be rolling or at least come into contact with the floor before it crosses over the line of the neutral area (see Figure 1). Therefore, the athletes must throw the goalball from between their own goal line to the neutral area (6 m). Using different step approaches, athletes were observed travelling across the team and landing area at various distances. It was observed on the video that some athletes travelled the distance up to the line of the neutral area before ball release covering the greatest distance possible (6 m), while others

travelled less distance before ball release. The athlete's location at the time of ball release varied.

Time Spent in Phases of Movement

After the phases of movement were defined, the time in each of the following phases were measured on all athletes: (a) preparatory, (b) approach, and (c) follow-through. The approach phase included both the wind-up and delivery subsets. Table 11 lists the phases of movement of the goalball throw and the defined beginning and ending points of each phase. These beginning and ending points were used when calculating the time in each phase. Table 12 reports the mean time calculated for all athletes' phases of movement for both the traditional and spin throw.

Table 12

Beginning and Ending Points within the Phases of the Goalball Throw

Phase of Movement	Movements Defining Phases
Preparatory Phase	• Initial foot movement • Heel strike of first step
Approach Phase 1) Wind Up Phase 2) Delivery Phase	• Heel strike of first step • Ball release from hand
Follow through Phase	• Ball release from hand • Forward first touch of the trailing foot

Table 13

Mean Time(s) in each Phase during a Traditional and Spin Goalball Throw

Movement Phase	Traditional Throw ($N = 29$)	Spin Throw ($n = 10$)
Preparatory	0.22 (0.06)	0.23 (0.06)
Approach	0.67 (0.18)	0.71 (0.17)
Follow-through	0.27 (0.08)	0.24 (0.04)
Total time of the throw	1.16 (0.19)	1.18 (0.16)

Note: *SD* are reported in parentheses.

Using a Pearson correlation, the following items recorded in time were correlated to the ball velocity: (a) preparatory phase, (b) approach phase, (c) follow-through, and (d) total time of throw for both the traditional and spin throw. The ball velocity of the traditional throw ($n = 29$) was significantly correlated ($p < .05$) to the time of the approach phase ($r = .38$). Although this was reported to be significant, a value of .38 is not considered to be a strong correlation. No other variables were significantly correlated to the ball velocity of either the traditional or spin goalball throw.

Ball Velocity

The ball velocity was determined for both males and females and each type of throw. Each participant performed a traditional goalball throw and if the athlete performed a spin throw in their normal game repertoire, the ball velocity for the spin throw was also recorded. Table 13 reports the mean ball velocity for the traditional and spin goalball throw by gender. There were 17 males (17 traditional throws, 6 spin throws) and 12 females (12 traditional throws, 4 spin throws). In general, the group means for

males were faster than the females for both the traditional and spin throw. Described as a total group the spin throw was faster compared to the traditional throw. The mean ball velocity of the traditional goalball throw (n = 29) was 20.68 m/s (SD = 5.34) and the mean ball velocity of the spin goalball (n = 10) was 25.52 m/s (SD = 6.42). Mean ball velocity for the total group using both types of throws was used for the correlation between ball velocity and physical/motor fitness components (see Table 15).

Table 14

Mean Ball Velocity by Gender and Total Group for Traditional and Spin Throw.

Group	Traditional	Spin
Males (n = 17, 6)	22.74 (5.42)	29.98 (3.57)
Females (n = 12, 4)	17.75 (3.74)	18.83 (1.72)
Total Group (n = 29, 10)	20.68 (5.34)	25.52 (6.42)

Note: Ball velocity is reported in m/s. *SD* are reported in parentheses.

Physical/Motor Fitness Components

The following components were measured on all athletes: (a) flexibility on the right and left leg, (b) vertical jump, (c) seated medicine ball throw, (d) standing medicine ball throw, and (e) the DOLS balance test for the right and left leg sighted, and blindfolded. Table 14 reports the mean data and SD on all variables for the total group (N = 29).

Table 15

Mean Scores for Physical/Motor Fitness Components for all Athletes

Component	Score (SD)
Flexibility right leg (cm)	31.99 (7.61)
Flexibility right leg (cm)	32.81 (7.07)
Vertical jump (m)	0.37 (0.11)
Seated medicine ball throw (m)	5.02 (1.32)
Standing medicine ball throw (m)	6.60 (1.75)
DOLS left foot sighted	2.15 (0.92)
DOLS right foot sighted	2.31 (0.97)
DOLS left foot blindfolded	2.00 (0.75)
DOLS right foot blindfolded	2.00 (0.71)

Note: $N = 29$

Correlation of Physical/Motor Fitness Components and Ball Velocity

The Pearson correlation was calculated on all physical/motor fitness components to the ball velocity for both the traditional and the spin goalball throws using all athletes (including men and women). There were a total of 29 athletes who completed all testing components, however only 10 athletes performed an additional spin throw. Both males and females were included in the correlation. Results from the Pearson Correlation illustrated that the ball velocity of the traditional throw ($N = 29$) was significantly correlated to the height ($r = .67$), weight ($r = .67$), vertical jump ($r = .72$), seated medicine ball throw ($r = .77$), and the standing medicine ball throw ($r = .78$) at the .01 significance level, and weight ($r = .41$) at the .05 significance level. The ball velocity of

the spin throw (n = 10) was also significantly correlated to the height (r = .89), weight (r = .89), vertical jump (r = .77), the medicine ball seated throw (r = .85), and the medicine ball standing throw (r = .82) at the .01 significance level. No other variables were found significant (see Table 15).

Table 16

Correlation between Ball Velocity and Physical/Motor Fitness Components

Components	Traditional Throw (N = 29)	Spin Throw (n = 10)
Year of Experience	.297	-.024
Height	.667**	.888**
Weight	.406*	.218
Flexibility Right Leg	.060	.161
Flexibility Left Leg	.058	.251
Vertical Jump	.717**	.765**
Seated Med. Ball Throw	.767**	.846**
Standing Med. Ball Throw	.784**	.819**
DOLS Sighted (Left)	.270	-.307
DOLS Sighted (Right)	.371	-.145
DOLS Blindfold (Left)	.239	-.601
DOLS Blindfold (Right)	.208	-.470

Note: ** $p < .01$, *$p < .05$

Differences in Ball Velocity between Type of Throw and Gender

A 2 x 2 general linear model repeated measures ANOVA was completed with the type of throw (traditional and spin) as the within-subjects factor and gender (male and female) as the between-subjects factor. For the ANOVA only athletes who threw both

the traditional and spin throw were used for statistical analysis therefore, there were six males and four females used for this analysis. Refer to Table 16 for group means.

Table 17

Ball Velocity Group Means used for ANOVA

	Ball Velocity	
Gender	Traditional Throw	Spin Throw
Males ($n = 6$)	25.81 m/s	29.98 m/s
Females ($n = 4$)	21.21 m/s	18.83 m/s

Test of within-subjects effects resulted in a significant interaction between type of throw and gender, $F(1,8) = 33.17$, $p = .001$. Pairwise comparisons were used for post hoc test comparing all the different groups. Figure 3 displays the mean ball velocity of both types of throws by gender demonstrating the interaction. Based on observation of Figure 3 and evaluating the group means (see Table 16); the ball velocity for the males was faster than the females for both types of throws. The difference in groups is found between genders because the males had a faster ball velocity in their spin throw compared to their traditional throw. This was not the same for the females who had a slower ball velocity in their spin throw compared to their traditional throw.

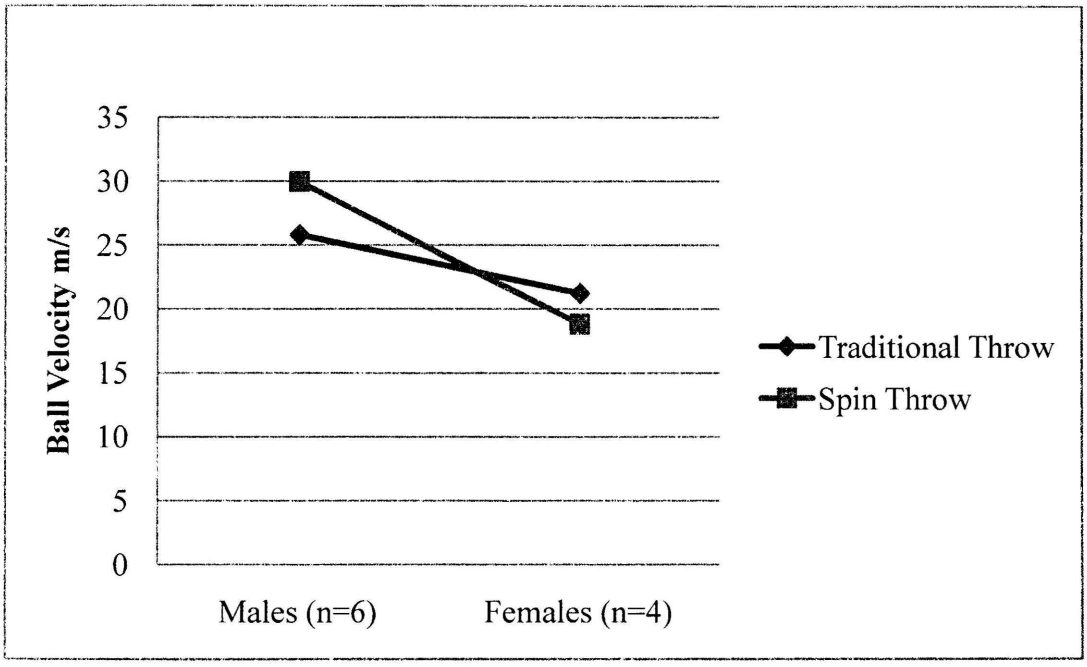


Figure 3. Mean ball velocity for the different types of throws and gender.

Therefore, to address the three hypotheses related to research question five, it is stated to: (a) Ho: Reject the hypothesis stating there are no significant differences in velocity between gender (male and female), $F(1,8) = 20.16$, $p = .002$, (b) Ho: Accept the hypothesis stating there are no significant differences in velocity between the types of throw (traditional and spin), $F(1,8) = 2.47$, $p = .155$, and (c) Ho: Reject the hypothesis stating there is no significant interaction between gender and types of throw, $F(1,8) = 33.17$, $p < .001$.

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to describe and compare the game and throwing variables of the traditional versus spin throw in goalball to determine their correlations to ball velocity. The results of the current study will be discussed in the following sections: (a) discussion, (b) conclusions, and (c) recommendations.

Discussion

The discussion of findings will be addressed in the following order: (a) game statistics and throwing tendencies, (b) phases of movement, (c) time in phases of movement, (d) ball velocity, and (e) correlation between ball velocity and physical/motor fitness components. When discussing the findings of the current study, literature related to throwing in able-bodied sports will be compared to the current findings.

Game Statistics and Throwing Tendencies

The game statistics and throwing tendencies for the men's and women's games were documented (see Tables 6 - 9). For the men's games, it was reported that the percentage of the total throws performed using the traditional throw (55.3%) compared to the spin throw (42.7%) was close to equal. It was also reported that a higher percentage of goals scored for men were from a spin throw (9.0%) compared to the traditional throw (6.6%). For the men, using a spin throw appears to have more of an offensive playing advantage in a game because more goals were scored and the ball went out of bound

fewer times, meaning it was more accurate than the traditional throw. This gives more opportunities for a team to score a point and make an offensive play. More penalties were called from using a spin throw (3.4%) compared to the traditional throw (2.4%). This is still a low percentage of error, but coaches can use this information for player development and future practices.

The game statistics and throwing tendencies for the women were different than the men. The majority of the time, women threw the goalball using a traditional throw (97.6%) compared to a spin throw (1.5%). However, it was difficult to compare the percentage of throwing outcome because the number of throws in each type (traditional = 1720, and spin = 27) was skewed. When comparing the men's and woman's total games, the men use the spin throw more frequently. The men had an almost equal percentage of throws using traditional and spin throw, while the majority of throws completed by the women were the traditional throw. This could imply that the men have received either more practice using the spin throw or have achieved the ability and technique required to perform the throw before the women. Compared to men's sports, women often have fewer teams, less coaches available, less practices, or sport opportunities. In the current study, there were 15 men's teams observed, while only 8 woman's team competing in the tournament. Some of these reasons could be a possible explanation of why the women are not at the same level of throwing as observed in the men.

Within the men's goalball games, there is possibly more need to perform the spin throw because of increased performance outcomes (e.g., increased accuracy and more goals scored) suggesting it has become one desired method of throwing. Throwing

velocity and accuracy are two aspects of the skill that are critical in throwing a goalball. Because of the nature of the sport, tracking the specific zones (i.e., 1, 2, 3, 4, or 5) that an athlete was aiming for was not documented however ball accuracy described as in-bounds, was recorded. Ball velocity was also determined and will be discussed later in this chapter.

When the bronze and gold medal games were reviewed, it was reported that the men threw more total times (men 313, women 278) and scored more goals than the females (men 14, women 11). Since the length of time for the championships games were equal for men and women the results suggest that the men play at a faster pace throwing more times in the same amount of minutes played. Knowing the nature of the game offensive and defensive play requires athletes to move quickly from the blocked position on the ground to recovery back on their feet in a position to return the throw and challenge's an athlete's physical fitness level. Physical fitness can be a factor when analyzing the amount of throws completed, accuracy of the throw and the amount of errors made (out of bounds or penalties called) in each game. Results from the championship games reported (see Table 10) that the men are throwing more frequently compared to the women with less percentage of error (i.e., ball goes out of bounds). This could suggest that physical fitness is a factor in men's and women's games. In the study by Bowerman and Davis (2010) men had greater leg strength compared to women. In a study by Lieberman and McHugh (2001), health related fitness of children (9 – 19 years) resulted in more boys passing the one-mile walk/run test compared to the girls. In the present study, women may lack in their level of strength and endurance which could

contribute to the slower paced game and increased amount of errors. Goalball coaches should continue to work on physical fitness as it is an important aspect of any sport.

One purpose of the current study was to collect game statistics and throwing tendencies in goalball athletes. Information gained from documenting these data can provide coaches with directions for practice interventions and reason to practice different type of throws in goalball (e.g., traditional or spin throw). Coaches can continue to track both individual and team game statistics and throwing tendencies in goalball to find outcome profiles during competitive play contributing to increased performance (Malone, et al. 2000). Information from this study also reinforces further investigation of the spin throw explaining the major gender differences viewed using this type of throw.

Phases of Movement

A descriptive task analysis of the goalball throw was conducted to determine the phases of movement in both the traditional and spin goalball throw. Table 10 describes the phases of movement of the throw and the elements that occur within each phase. A total of three phases were identified through observation for the goalball throw: (a) preparatory, (b) approach, and (c) follow-through, with two sub-set phases in the approach phase identified as wind-up and delivery. The phases of movement are similar to those reported in a study conducted by Bowerman and Davis (2010) which was the only previous study to identify the phases of movement for the goalball throw.

In bowling, the four step approach is the most common footwork pattern observed however, there are several other patterns used such as the one, three, five or seven step approach (Grinfelds & Hultstrand, 1996; Schmottlach & McManama, 2002; Strickland,

1996). Bowling level and performance abilities factor into which type of an approach is utilized and can be used as a model for the goalball throw. In the current study, it was observed that a one, three or four step approach was present in delivering both types of the goalball throws. In bowling, the purpose of the approach is to gain momentum to transfer to the ball at release. Time and distance are two factors that are considered when creating momentum. The greater distance travelled in the shorter amount of time would create more momentum (Grinfelds & Hultstrand, 1996). In the current study, it was observed that athletes travel forward different distances in the approach phase before delivery and ball release. Although the time in each phase of movement was determined, the distance travelled was not measured in the current study. The use of a calibrated throwing area using 3-D video would allow for points of the athlete to be digitized determining the exact distance travelled (Malone et al. 2002).

The purpose of determining phases of movement in the goalball throw was purely descriptive and was meant to provide a foundation for research. Understanding the phases of movement of the goalball throw and the elements that occur in each phase is significant for coaches when developing their athlete's skill level and increasing performance. Although the current study only used field based 2-D video, phases of the traditional and spin goalball throw were described through visual observation in a 2-D video. A limitation to this method, is the use of the 2-D video because the traditional and spin goalball throw is not a 2-D movement, therefore future studies should conduct a clinical kinematic and kinetic analysis of the goalball throw using 3-D video analysis to verify phases of movement. Literature review from traditional able-bodied sports (e.g.,

shot put throw, discus throw) could support such research (Coh et al. 2008; Yu et al. 2002). In the rotational shot put throw technique, the distance thrown is a result of the force exerted to the shot in the release velocity, angle of release, and height of release (Coh et al.). Understanding the throwing mechanics in goalball can improve training programs for coaches and athletes.

Time in Phases of Movement

The time in each phase of movement of the goalball throw was determined (see Table 12) and correlated to the ball velocity of the throw. The only phase that was significantly correlated to ball velocity was the approach phase of the traditional throw ($r = .38, p < .05$). No other time spent in each phase of movement was found significantly related to the ball velocity. A value of .38 is not considered a strong correlation, however the time spent in a phase of movement has been found to relate to the performance of a throw in the glide shot put (Young, 2007). As previously stated above, the method in determining the time in each phase was taken from field based 2-D video. A camera filming rate of 60 frames/s is not very fast and could contribute to the lack of correlations found with other phases of movement and ball velocity. A clinical analysis using a faster camera rate, would allow for a more accurate measurement to determine the duration of each phase. Another reason that could contribute to the current results is the variations observed of the athlete performing the throw. Several different step approaches were used which could influence the time spent in each phase of movement.

In a study by Werner, Suri, Guido, Meister & Jones (2008) relationships between ball velocity and pitching mechanics in 54 collegiate baseball pitchers was investigated.

Similar to the current study, these authors' defined the phases of the baseball pitch (i.e., temporal phase, cocking phase, acceleration phase, and follow through phase) by describing specific beginning and ending points of each phase. For example, the temporal phase was defined as the moment of stride foot contact to the instant of maximum shoulder external rotation. Results of this correlation study were reported and ball velocity was related to having a larger body mass, and a shorter time in the temporal phase as well as other biomechanical parameters not related to the present study. Based on these data, the authors recommended improving training programs with the results in mind to increase the ball velocity and performance of collegiate pitchers. Using the methods from the present study as foundational research, similar studies could be conducted for goalball athletes and the goalball throw.

Ball Velocity

In general as a total group ($N = 29$), the males had a faster ball velocity than women for both traditional and spin throw (see Table 13). These results were expected as throwing velocities have been reported higher for men than women in other sports such as cricket (Freeston, Ferdinands & Rooney, 2007). In the current study, the spin throw was faster (25.52 m/s) than the traditional throw (20.68 m/s). These results could explain the higher frequency of the spin throw observed by the men compared to women. It was also determined that the men's games were at a faster pace than the women's games during championship games, and a spin throw is thrown with a faster velocity. A faster throw would be harder to block and defend which gives the offensive team a greater opportunity to score. From a coach's point of view, an athlete must be able to perform

the spin throw with sufficient technique maintaining balance, and generating ball velocity resulting in throwing accuracy otherwise, it may not be considered advantageous to use the spin throw over a traditional throw. However, if the athlete is able to carry out the throw with those components it is a stronger offensive play to use the spin throw. On average results of the current study indicated an increase in velocity by 5 m/s while using the spin throw.

Speed and accuracy are two components of any type of throw. In goalball, as stated above, an increased ball velocity of the throw is valuable; however accuracy of the throw is critical. The ball must remain in bounds to be considered a quality throw and good offensive opportunity. Flyger et al. (2006) discussed the speed versus accuracy trade-off found in pitching a softball. These authors stated that speed and precision are negatively related. In the present study, accuracy was not measured because it was unknown which zone (see Figure 2) the athlete was aiming for when throwing. Still, if an athlete throws at a high velocity but is not able to keep the ball in bounds the gains achieved from the higher velocity are lost from lack of accuracy.

Comparison in ball velocity between groups. The repeated measure ANOVA resulted in a significant interaction between type of throw and gender $F(1,8) = 33.17$, $p = .001$. The men ($n = 6$) threw a faster spin throw compared to their traditional throw, while the women ($n = 4$) threw a slower spin throw compared to their traditional throw (see Figure 3). The results of the current study are similar to Freeston et al. (2007) who studied throwing velocity in male and female cricket players. Significant differences in maximal throwing velocity were found in gender as males threw faster than the females. Freeston

et al. suggested that gender, training volume, and training experience all influence the mean throwing velocity in cricket players. The training volume of the goalball athletes were not accounted for in the present study. The years of experience of each athlete was documented but results indicated no significant influence was found related to the ball velocity of the throw.

In the current study, the sample size included in the ANOVA presents a limitation. There were a total of 10 athletes (6 males, and 4 females) who each threw both the traditional and spin goalball throw. With these low numbers, it was not expected to see a significant interaction, nonetheless an interaction was found. If there were a larger sample size of athletes who threw both types of throws, statistical power in the ANOVA would be greater and more sensitive analysis could have been conducted.

Correlation between Ball Velocity and Components

The Pearson correlation was calculated to determine which physical/motor fitness components were related to the ball velocity for the traditional and spin throw. It was determined that height, weight, vertical jump, and the seated and standing medicine ball throw were all significantly correlated to both the ball velocity of the traditional and spin throw (see Table 16). These results advocate that ball velocity is related to the components of strength and power. This was similar to the findings of the study by Bowerman and Davis (2010) that identified ball velocity was related to leg strength for males as well as different walking variables (i.e., walking speed and step length) when grouped by athlete classification. In the current study, height and weight of the athletes were related to ball velocity of the traditional throw. Werner et al., (2008) found a larger

body mass to be related to ball velocity in collegiate baseball pitchers. These authors suggested that the larger athlete would throw with greater ball velocity because a larger body mass could be indicative of more strength. In goalball athletes, results imply that a greater weight could contribute to an increase in ball velocity because a larger mass should be able to generate more force during an approach, which transfers into the release of the ball during the goalball throw.

In another study investigating influences on ball velocity in male cricket players (Glazier, Paradisis, & Cooper, 2000), correlations between ball release speed and the horizontal velocity during the pre delivery phase were found significant ($r = .73$, $p < .05$). This was a kinematic analysis which differs from the present study. Instead of calculating ball velocity specifically using the ball like the current study, Glazier et al. measured the ball velocity by using velocity of the throwing arm at the point of ball release. These results are also comparable to the study conducted by Bowerman and Davis (2010).

Similar conclusions related to ball velocity and strength were establish in both an able bodied throwing sport and the goalball throw. In a study conducted on a team of male handball players (Marques, van den Tillaar, Vescovi, & Gonzalez-Badillo, 2007), throwing velocity was correlated to strength, power, and bar velocity in the bench press. Results indicated that ball velocity of the over arm throw was significantly related to maximum strength of a 1 maximum repetition ($r = .64$), peak bar velocity ($r = .56$) and peak power ($r = .58$) suggesting that strength and power of the upper body influence the ability to throw at a higher velocity in team handball players. Comparable to the current analysis, a significant correlation was found between the seated and standing medicine

ball throw to the ball velocity of both the traditional and spin throw (see Table 15). These results can translate into coaching strategies for goalball athletes and that the use of resistance training exercises may be beneficial in increasing ball velocity.

Conclusions

Within the limitations of the present study several areas related to the sport of goalball have been examined. These included areas related to the traditional and spin throw such as throwing tendencies, ball velocity, and phases of movement. In addition, a relationship between physical and motor fitness components and the ball velocity were determined.

Currently there is limited research related to goalball athletes and sports performance. More research should be conducted to further support the findings of the current study using a larger sample size of both men and women elite athletes. Overall, the main conclusions of the present study related to types of goalball throws were that the spin throw was observed more in men's competition while the women were predominately competing using a traditional throw. On average, the men had a faster ball velocity than the women in both types of throws. The spin throw resulted in a higher ball velocity than the traditional throw, perhaps implying a need for athletes to learn and practice this type of throw to improve throwing performance.

The phases of movement for the traditional and spin throw were identified through a descriptive task analysis. Three phases of movements for the goalball throw were identified as: (a) preparatory, (b) approach, and (c) follow through. The rationale to this field based analysis was to provide future investigators with a foundation of the phases of

movement observed in the goalball throw. Continued investigation in a clinical setting using 3-D videography is recommended to confirm the current data.

Lastly, significant correlations between ball velocity and physical and motor fitness components (i.e., fitness-ball distance throws and vertical jump) were evident in both the ball velocity in the traditional and spin throw. Training programs designed for goalball athletes should incorporate these aspects of physical fitness, specifically exercises related to muscular strength/endurance and power.

Recommendations

Based on the results of the current study the following recommendations are suggested to goalball coaches and researchers for future investigations:

- The spin throw in male and female athletes should be put into practice or continued to be a part of training, focusing on balance and accuracy while maintaining ball velocity.
- Resistance training programs designed for goalball athletes should be implemented to increase the ball velocity of their throw addressing areas of muscular strength and power.
- A need for research using clinical 3-D kinematic analysis on the goalball throw should be completed to determine phases of movement in the traditional and spin throw
- Research investigating which kinematic parameters of the traditional and spin goalball throw influence the performance (e.g., accuracy and velocity) should be

established such as distance travelled during the approach, the angular velocities of joints, maximum angle of backswing, or optimal height of ball release.

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APPENDIX A

Institutional Review Board (IRB) Approval Letter

TEXAS WOMAN'S UNIVERSITY
DENTON DALLAS HOUSTON

Institutional Review Board
Office of Research and Sponsored Programs
P.O. Box 425619 Denton, TX 76204-5619
940 898 3378 Fax 940-898 3416
e-mail IRB@twu.edu

February 5, 2010

[redacted]

Dear Ms. Bowerman:

Re *A Description and Comparison of the Traditional and Spin Goalball Throw Related to Ball Velocity*

The above referenced study has been reviewed by the TWU Institutional Review Board (IRB) and appears to meet our requirements for the protection of individuals' rights.

If applicable, agency approval letters must be submitted to the IRB upon receipt PRIOR to any data collection at that agency. A copy of the approved consent form with the IRB approval stamp and a copy of the annual/final report are enclosed. Please use the consent form with the most recent approval date stamp when obtaining consent from your participants. The signed consent forms and final report must be filed with the Institutional Review Board at the completion of the study.

This approval is valid one year from January 22, 2010. According to regulations from the Department of Health and Human Services, another review by the IRB is required if your project changes in any way, and the IRB must be notified immediately regarding any adverse events. If you have any questions, feel free to call the TWU Institutional Review Board.

Sincerely,

Dr. Kathy DeOrnellas, Chair
Institutional Review Board - Denton

enc.

cc. Dr. Charlotte Sanborn, Department of Kinesiology
Dr. Ron Davis, Department of Kinesiology
Graduate School

APPENDIX B

Participant Consent Form

TEXAS WOMAN'S UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

Title: A description and comparison study of the traditional and spin goalball throw related to ball velocity.

Investigator: Stephanie J. Bowerman, MS ..... sbowerman@twu.edu [redacted]
Advisor: Ronald Davis, PhD ..... rdavis4@twu.edu

Explanation and Purpose of the Research

You are being asked to participate in a study for Stephanie Bowerman's dissertation at Texas Woman's University. The purpose of this study is three fold: a) to determined game statistic analysis of goalball via field performance, b) to identify the phases of movement of a traditional and spin goalball throw , and c) to describe and compare the physical characteristics of men and women goalball athletes relating to ball velocity. You are being asked to participate in this study because you are an experienced goalball athlete.

Description of Procedures

Complete goalball games will be electronically recorded (digital video camera) for game analysis to determine performance tendencies and statistics. The camera will be set up perpendicular to the goalball court. The entire court will be in the field of view in order to see both offensive and defensive game play. The type of throw, the zones in which the ball was thrown from and to, and outcome of the throw (e.g., goal, or penalty) will be recorded on the Bowerman Goalball Game Score Sheet (BGGSS).

To determine the velocity of the goalball throw, you will throw the goalball three times during a separate throwing session and not during a game. You will be instructed to throw the ball on the goalball court using both a traditional and spin throw. One practice trial will be given for each type of throw. The velocity of the three throws will be electronically recorded and the velocity will be calculated by dividing the distance of throw (neutral zone of 6m by time of recording rate (frames counted/60 frames/s). The mean velocity of the three throws will be recorded.

Field based test will be taken to determine height, weight, flexibility, power, strength, and balance. Height and weight will be measured to determine your body mass index . The sit and reach test will be used to measure flexibility. While in a sitting position with your legs extended, you will be instructed to reach as far as possible with your hands forward along the sit and reach box. The highest of three scores will be recorded.

The vertical jump test will be used to determine power. You will be instructed to stand with your feet flat on the floor and dominate side to the wall reaching as high as possible with the closest hand to the wall marking the wall with a piece of chalk. Reach height will be recorded at the highest point that your fingertips mark the wall with the chalk. You will step away from the wall and jump vertically as high as possible attempting to touch the wall with the piece of chalk marking the wall at the highest point of the jump. The highest point recorded will be the jump height. The difference between the reach height and the jump height will be recorded (Karakaya, 2009).

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Initials

A dynamic strength of the upper body will be measured by the fitness-ball distance throw. You will be instructed to throw a 3 kg fitness-ball forward with two hands from a sitting and standing position. The longest distance (m) will be measured from the starting position. The longest distance of 3 throws will be recorded for both sitting and standing measurements (Hakkinen et.al., 2006).

The dynamic one leg stance (DOLS) test will be used to determine balance. The DOLS has five levels. You will start the DOLS on your left leg performing three attempts on each level following three attempts on the right leg. The following are the criteria and levels of the DOLS: 1) Unable to stand on one leg for 10 s, 2) Able to stand on one leg for 10 s but shows a lot of movement in the arms, body and legs, 3) Able to stand on one leg for 10 s without any movements, 4) Alternative 1: Able to stand on one leg and rotate the trunk with arms in front of the body to 45° left and right, Alternative 2: while standing on one leg, dip your head sideways at least five times 45° both left and right, 5) Participant is able to do all of the above criteria when standing on one leg and raise foot on the toes for 10s. To move to a higher level, you will need to score satisfactorily and meet the criteria of the lower level. The best value will be recorded for each leg.

Potential Risks

A possible risk related to participation in this project is the loss of confidentiality. Confidentiality will be protected to the extent that is allowed by law. A code number will be assigned and used on all data recording documents. Only the investigators will have access to the data. All data will be stored in the investigators office (Pioneer Hall, room 119 E) at Texas Woman's University (TWU) in a locked filing cabinet. All data collected on hard copy will be destroyed by a shredder and digital data will be deleted. Electronic recording will be used for determining the game statistic analysis, phases of movement of the goalball throw, and velocity of the ball. The recording will be destroyed upon completion of the study. There is a potential risk of loss of confidentiality in all email, downloading and internet transactions. All emails will be deleted upon completion of the study. All data will be destroyed 5 years after completion of the study.

Potential risks that are associated with the participation in this research are possible game like injuries, possible muscle soreness, risk of coercion, and loss of anonymity. To decrease the risks of game like injuries, it will be encouraged to wear protective equipment (i.e., knee pads). A proper warm-up will occur before the test to minimize this. If muscle soreness occurs, participants will be encouraged to drink plenty of water, continue with light stretching, and apply ice to area.

To reduce the risk of coercion, it will be clearly explained to the coaches and athletes that participation in the study is completely voluntary. You will be asked and only willing participants will sign the consent form and participate in the study. It will be clearly explained to the coaches and all participants that withdrawal from the study can occur at any time without penalty or coercion from the coach to remain in the study.

All data collected will be completely confidential and remain anonymous. The use of codes will be used and there will be no identification of participants by name in the data, however due to the setting of the tournament, people present will know who is participating in the study. If you do not want anyone to know you are involved in the study, you should choose not to be a participant.

_____
Initials

A sighted counselor will accompany you during all assessments. You may ask questions and/or may drop out of the research at any time of the study. The researchers will try to prevent any problem that could happen because of this research. You should let the researchers know at once if there is a problem and they will help you. However, TWU does not provide medical services or financial assistance for injuries that might happen because you are taking part in this research.

Participation and Benefits

Participation in this research project is voluntary and you may withdraw from participation in the study at anytime without any penalty. The benefit to this study is gaining direct knowledge on a game statistics in goalball. For example, understanding the percentage of goals scored for each type of throw (traditional vs. spin) executed. Gaining additional knowledge on sports performance variables related to the velocity of a goalball throw would be beneficial to coaches and athletes for training purposes and designing training specific training programs. Contact the primary research investigator via email or phone to inquire about the results of the study.

Questions Regarding the Study

You will be given a copy of this signed and dated consent form to keep. If you have any questions about the research study you should ask the researchers; their phone numbers are at the top of this form. If you have questions about your rights as a participant in this research or the way this study has been conducted, you may contact the Texas Woman's University Office of Research and Sponsored Programs at 940-898-3378 or via e-mail at IRB@twu.edu.

_____

Name of Participant

_____ _____

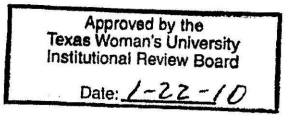
Signature of Participant Date

Narrator Fill Out the Portion Below (9)

I, _____ verbally read the consent to participate research form to _____. I verbally read all of the contents of the consent form and ensured that the participant understand the purpose, procedures, risks, benefits, and who to contact if he/she had any questions regarding the study.

_____ _____

Signature of narrator Date



*If you would like to know the results of this study tell us where you want them to be sent:

Email: _____

or

Address:

_____

_____

_____

APPENDIX C

Game Data Tracking Sheet

Game Data Tracking Sheet

______________________ vs ________________________

Date: ________________________

Place: ____

Team Name (jersey color):

Goals Scored:

Type of Throw	Outcome	Type of Throw	Outcome	Type of Throw	Outcome	Type of Throw	Outcome

Any notes on reverse.

Legend:
T = Traditional Throw
S = Spin Throw
O = Other type of Throw
B = Blocked

Record:
Type of Throw (traditional, spin or other)
Outcome (blocked, goal, out, highball, long ball)
Penalty Throw

APPENDIX D

Raw Data for Research

Data Set for Men's Physical/Motor Components and Ball Velocity

Age	Yrs Exp	Ht(cm)	Wgt (kg)	Flex(R)	Flex(L)	VJ	SitMThr	StandMThr	Bal_S (L)	Bal_S (R)	Bal_B (L)	Bal_B (R)	Vel_T	Vel_S
34	6	173.99	89.55	19	17	0.57	5.85	7.32	3	3	2	2	22.5	.
33	2	180.34	93.64	36	35	0.22	3.5	4.7	1	1	1	2	13.85	.
44	15	170.18	85.00	34.75	42	0.36	4.6	5.6	.	.	1	1	15.65	.
19	6	170.18	113.18	30.5	32	0.27	4.6	7.1	2	1	1	2	16.36	.
19	3	166.37	122.73	32.5	32.5	0.34	5.25	6.45	2	2	2	2	17.14	.
37	19	172.72	67.73	37.5	36	0.52	7.1	9.5	2	2	2	2	25.71	27.69
20	4	187.96	123.18	29.5	34.5	0.41	8	9.5	4	3	4	3	32.73	.
28	16	170.18	99.55	49	47	0.5	7.6	8.8	1	1	1	1	25.71	.
28	9	180.98	88.64	33	34	0.49	5.25	8	1	1	1	1	25.71	32.73
29	4	165.1	85.00	21	26.5	0.41	5.8	7.75	1	1	1	1	20	.
26	3	179.07	109.09	18	19	0.39	5.87	8	2	2	2	1	21.18	.
30	6	178.44	107.73	24	22	0.3	5.8	8.1	2	3	2	1	20	24
20	4	171.45	107.27	35	33	0.21	4.59	5.4	.	.	2	2	18.95	.
18	4	185.42	75.00	35	35	0.59	6.2	8.6	3	3	2	3	25.71	30
19	6	177.8	70.45	31	34	0.49	4.4	9.1	3	4	3	3	27.69	.
25	11	180.98	103.18	32	33	0.53	6.76	7.4	2	4	2	2	30	32.73
23	8.5	190.5	85.00	36	37.5	0.46	6.93	8.8	2	2	2	2	27.69	32.73

Note: Yrs Exp = years experience, Ht = height, Wgt = weight, Flex (R) = flexibility for the right leg, Flex (L) = flexibility for left leg, VJ = vertical jump, SitMThr = sitting medicine ball throw, StandMThr = standing medicine ball throw, Bal_S (L) = DOLS for left leg sighted, Bal_S (R) = DOLS for right leg sighted, Bal_B (L) = DOLS left leg blindfolded, Bal_B (R) = DOLS for right leg blindfolded, Vel_T = ball velocity for the traditional throw, and Vel_S = ball velocity for the spin throw.

Data Set for Women's Physical/Motor Components and Ball Velocity

Age	Yrs Exp	Ht(cm)	Wgt (kg)	Flex(R)	Flex(L)	VJ	SitMThr	StandMThr	Bal_S (L)	Bal_S (R)	Bal_B (L)	Bal_B (R)	Vel_T	Vel_S
16	5	157.48	62.73	24.5	27	0.31	4.3	5.8	2	2	2	3	15.65	.
24	13	162.56	69.55	36	37	0.31	3.85	5	1	2	2	1	16.36	.
31	15	173.99	75.45	32	32	0.29	4.45	5.3	4	4	2	2	21.18	.
16	4	158.75	49.77	44.5	43.5	0.37	3.55	4.55	2	3	2	2	17.14	.
20	7	161.29	61.59	35	35.5	0.3	3.45	3.83	3	2	2	2	13.85	.
16	8	163.83	71.82	39	38	0.45	3.8	4.9	2	2	2	2	20	18.95
16	2	163.2	66.36	42	41.5	0.24	3.65	5.7	2	2	4	2	15	.
18	3	165.1	60.00	24.5	28	0.25	3.74	4.1	.	.	2	2	10	.
19	7	162.56	76.36	35	35.5	0.33	4.45	5.75	1	2	2	3	21.18	20
34	16	172.72	90.91	37	35	0.29	4.2	6.3	2	2	2	3	22.5	20
20	4	160.02	76.36	19.5	22	0.33	4.4	6	2	2	2	2	18.95	.
23	9	160.02	70.91	25	26.5	0.28	3.6	4.15	4	4	3	3	21.18	16.3

Note: Yrs Exp = years experience, Ht = height, Wgt = weight, Flex (R) = flexibility for the right leg, Flex (L) = flexibility for left leg, VJ = vertical jump, SitMThr = sitting medicine ball throw, StandMThr = standing medicine ball throw, Bal_S (L) = DOLS for left leg sighted, Bal_S (R) = DOLS for right leg sighted, Bal_B (L) = DOLS left leg blindfolded, Bal_B (R) = DOLS for right leg blindfolded, Vel_T = ball velocity for the traditional throw, and Vel_S = ball velocity for the spin throw.

Men's Games Throwing Frequencies

Game Stats for Men										
	Total Throw	Trad Throw	Trad Goal	Trad Out	Trad Pen	Spin Throw	Spin Goal	Spin Out	Spin Pen	Other Throw
Wrecking Crew Black										
game 2	81	5	0	0	0	74	4	5	1	2
game 3	81	2	0	0	0	79	4	8	1	0
game 7	55	1	0	1	0	54	3	3	1	0
game 12	58	7	1	0	0	51	5	9	1	0
Wrecking Crew Red										
game 14	62	53	4	7	5	8	0	4	0	1
Atlanta										
game 2	80	53	0	2	1	26	0	7	1	1
game 5	58	47	6	8	1	11	1	2	0	0
game 14	63	45	5	7	0	18	3	3	1	0
Venom										
game 1	77	20	1	2	0	55	5	5	0	2
game 3	80	12	0	2	1	65	5	10	0	3
game 4	60	13	0	0	1	47	10	3	3	0
game 8	57	9	1	2	0	48	6	8	1	0
game 9	68	10	2	1	0	55	6	5	4	3
Quebec										
game 1	75	62	4	3	0	13	0	0	0	0
game 8	55	51	0	10	1	3	0	1	0	1
game 10	59	48	9	1	2	11	2	0	0	0
game 16	55	51	5	66	0	4	1	0	0	0
Nova Scotia										
game 4	60	56	5	3	1	4	0	1	0	0
game 6	59	56	6	6	0	2	0	0	1	1
game 12	58	52	2	4	2	6	0	2	0	0

Men's Games Throwing Frequencies Continued

Utah										
game 5	56	15	0	1	1	41	3	11	2	0
game 15	54	25	2	2	1	29	7	4	1	0
Tennessee										
game 6	57	52	1	9	1	0	0	0	0	5
game 11	63	57	3	7	3	1	0	1	0	5
Florida										
game 7	56	7	0	3	0	45	4	4	1	4
Kentucky										
game 9	68	34	2	2	1	31	1	4	4	3
game 17	56	35	1	3	0	16	4	1	0	5
Northern California										
game 10	57	38	3	6	1	19	1	4	3	0
game 17	58	35	1	5	2	23	1	1	3	0
New York										
game 11	63	57	8	5	1	5	2	0	1	1
New Jersey										
game 13	53	51	1	1	1	1	0	0	0	1
South Florida										
game 13	54	9	1	0	0	44	2	8	0	1
game 15	55	54	3	6	1	0	0	0	0	1
Illinois										
game 16	52	42	0	3	0	10	1	2	1	0
	Total Throw	Trad Throw	Trad Goal	Trad Out	Trad Pen	Spin Throw	Spin Goal	Spin Out	Spin Pen	Other Throw
TOTALS	2103	1164	77	178	28	899	81	116	31	40

Men's Games Penalty Throws

Men's Games Penalty Throws

	Trad pen shot	Trad goal	Trad out	Trad penalty	Spin pen shot	Spin goal	Spin out	Spin penalty
Wrecking Crew Black								
game 2	0	0	0		2	1	0	
game 3	0	0	0		1	0	0	
game 7	0	0	0		2	1	0	
game 12	0	0	0		2	2	0	
Wrecking Crew Red								
game 14	2	0	0	1	0	0	0	
Atlanta								
game 2	0	0	0		1	0	0	
game 5	5	2	2		0	0	0	
game 14	2	1	0		2	2	0	
Venom								
game 1								
game 3	0	0	0		1	0	0	
game 4	0	0	0		1	0	0	
game 8	0	0	0		1	1	0	
game 9	0	0	0		6	4	0	1
Quebec								
game 1	0	0	0		0	0	0	
game 8	1	0	0		0	0	0	
game 10	5	5	0		0	0	0	
game 16	1	1	0		0	0	0	
Nova Scotia								
game 4	4	3	0		0	0	0	
game 6	1	0	1		0	0	0	
game 12	1	0	1		0	0	0	

Men's Games Penalty Throws Continued

Utah								
game 5	0	0	0		1	1	0	
game 15	1	0	1		2	0	0	
Tennessee								
game 6	1	0	0		0	0	0	
game 11	2	0	0		0	0	0	
Florida								
game 7	0	0	0		1	1	0	
Kentucky								
game 9	1	0	0		3	0	2	
game 17	0	0	0		5	4	1	
Northern California								
game 10	1	1	0		1	0	0	
game 17	0	0	0		0	0	0	
New York								
game 11	3	1	1		0	0	0	
New Jersey								
game 13	0	0	0		0	0	0	
South Florida								
game 13	0	0	0		1	0	0	
game 15	2	2	0		0	0	0	
Illinois								
game 16	0	0	0		0	0	0	
	Trad pen shot	Trad pen shot goal	Trad pen shot out	Trad pen shot penalty	Spin pen shot	Spin Pen goal	Spin pen out	Spin pen shot penalty
	33	16	6	1	33	17	3	1

Women's Games Throwing Frequencies

Woman's Game Stats										
	Total Throws	Trad throw	Trad Goal	Trad Out	Trad Pen	Spin Throw	Spin Goal	Spin Out	Spin Pen	Other throw
New Jersey										
game 1	58	57	2	5	0	1	0	0	0	0
game 10	70	66	5	6	0	4	1	0	0	0
game 12	70	66	0	6	0	4				
game 14	68	64	3	5	0	3	0	0	0	1
KZOO										
game 1	56	54	1	11	0	1	0	0	0	1
game 3	43	43	10	10	0	0	0	0	0	0
game 7	51	51	0	6	0	0	0	0	0	0
game 11	74	74	0	11	0					
Colorado										
game 2	54	53	4	4	1	1	0	0	0	0
game 6	53	52	6	3	0	1	0	0	0	0
game 9	35	31	8	1	1	4	2	1	0	0
game 13	69	64	4	5	0	4	0	1	0	1
game 15	70	70	4	7	0					
Glasa										
game 2	55	55	0	10	0	0	0	0	0	0
game 4	60	59	1	8	1	0	0	0	0	1
game 8	50	49	0	11	0	0	0	0	0	1
Tennessee										
game 3	40	38	0	3	1	0	0	0	0	2
game 9	35	32	0	4	2	0	0	0	0	3

Women's Games Throwing Frequencies Continued

	Total Throws	Trad throw	Trad Goal	Trad Out	Trad Pen	Spin Throw	Spin Goal	Spin Out	Spin Pen	Other throw
KZOO Kraze										
game 4	58	58	5	4	1	0	0	0	0	0
game 5	57	56	1	10	0	0	0	0	0	1
game 6	52	51	0	6	1	0	0	0	0	1
game 10	70	69	0	7	0	0	0	0	0	1
Georgia										
game 5	59	59	10	4	0	0	0	0	0	0
game 8	50	50	4	3	0					
game 11	76	74	2	8	0	2	0	0	0	0
game 13	70	68	1	8	0	1	0	0	0	1
game 14	70	70	4	2						
Ontario										
game 7	51	50	2	10	0	0	0	0	0	1
game 12	69	68	5	10	0	0	0	0	0	1
game 15	70	69	0	7	0	1	0			
Totals	1763	1720	82	195	8	27	3	2	0	16

Women's Game Penalty Throws

Woman's Game Stats

	Trad pen shot	Trad goal	Trad out	Trad penalty	Spin pen shot	Spin goal	Spin out	Spin penalty
New Jersey	2	1	0					
game 1								
game 10								
game 12								
game 14								
KZOO								
game 1	2	2	0					
game 3								
game 7								
game 11								
Colorado								
game 2	1	1	0					
game 6	1	1	0					
game 9								
game 13								
game 15								
Glasa	1							
game 2	1							
game 4	1							
game 8								

Women's Game Penalty Throws Continued

Tennessee								
game 3	1							
game 9								
KZOO Kraze	1	1						
game 4								
game 5								
game 6								
game 10								
Georgia								
game 5								
game 8	1	1						
game 11								
game 13								
game 14								
Ontario								
game 7								
game 12								
game 15								
	Trad pen shot	Trad goal	Trad out	Trad penalty	Spin pen shot	Spin goal	Spin out	Spin penalty
Totals	12	7	0	0	0	0	0	0