THE INFLUENCE OF THREE INSTRUCTIONAL STRATEGIES ON THE
PERFORMANCE OF THE OVERARM THROW

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
The Degree of Doctor of Philosophy in the
School of Physical Activity and Educational Services at The Ohio State University

By

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* * * *

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ABSTRACT

The purpose of this study was to examine the influence of three instructional strategies on the performance of the overarm throw. A secondary purpose of the study is to examine the influence of gender and instruction on throwing performance. The three instructional strategies were a critical cue (CUE), a biomechanical (BP), and typical physical education approach (TPE). The CUE strategy consisted of three cues: laser beams, long step, and turn your hips fast. The BP strategy was a translation of biomechanical information into a four-stage strategy. The TPE strategy was based on Graham and colleagues (2001) critical elements. The dependent measures of throwing performance were body component levels, component levels during gameplay, and ball velocity. Participants (n=124) from six first and second-grade classes were systematically assigned to an instructional approach. Mean body component levels for the step, trunk, humerus and forearm along with mean recorded ball velocity were calculated from the 10 throwing trials at the pretest, posttest, and retention test. Additionally, participants’ body component levels for the step, trunk, and forearm demonstrated in a throwing game were correlated with the body component levels demonstrated during practice. A MANOVA with repeated measures on the last factor revealed a non-significant multivariate Group effect (p=.068). Examining posttest body component levels, a significant difference between the CUE and TPE strategy for the step component. A significant Group X Time
interaction ($p=.04$) with significant univariate Group X Time effects for the forearm ($p=.03$). A multivariate Time effect was found ($p=.068$) with significant univariate Time effects for the step, trunk, humerus, forearm, and ball velocity. Correlation coefficients between body component levels during practice and gameplay revealed the strongest relationship was for the trunk component, and the step component had the fewest significant relationships. Significant gender differences were present at the pretest with boys’ performance greater than girls for each dependent measure. Significant gender differences remained after instruction for each group for body components and ball velocity. Overall, the results suggest that any of the three strategies can positively influence more advanced body component levels and increase ball velocity.
To Katie, and the many others who have made a difference.
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CHAPTER 1

INTRODUCTION

Throwing and Fundamental Motor Skills

Throwing is a fundamental motor skill, and fundamental motor skills are the building blocks of more specific sport or game skills that are developed later in childhood (Payne & Isaacs, 2002). Players must be able to master these basic movement patterns before they can be utilized as specialized or complex movements in a game or activity. Throwing is an important and complex object control skill that is used extensively in sports such as baseball and softball. The basic overhand throwing motion is assimilated into a variety of sport skills such as spiking in volleyball, the tennis serve, and the overhead clear in badminton (Butterfield & Loovis, 1993; East & Hensley, 1985). The widespread use of throwing makes the ability to throw and to execute assimilations of the throwing motion skillfully a requisite to succeed and to enjoy many sports and games (Butterfield & Loovis, 1993; East & Hensley, 1985; Knudson & Morrison, 1996).

The complex nature of the overarm throw poses a challenge for both students and teachers. Many students, especially girls, experience difficulty in executing key aspects of the overarm throw (Rippee et al., 1990). Instruction is a key factor in the development of the throw because throwing will not develop into an advanced pattern unless it is instructed (Garcia & Garcia, 2002; Halverson & Roberton, 1979). Providing effective
instruction of the throw is important to physical educators because developing skilled and proficient throwers achieves one of the National Association for Sport and Physical Education (NASPE) Standards for Physical Education (NASPE, 1995). Developing skill and proficiency in fundamental motor skills is also important to teachers, parents, and students because of the physical, social, and emotional benefits that result from a more active, healthy lifestyle (Browning & Shack, 1990; McKenzie, Alcaraz, & Sallis, 1998).

To determine if instruction has an influence on throwing performance it is necessary to assess throwing performance. Throwing can be assessed using both process and product measures. The process measures or the qualitative measures of throwing assess the movements of the body when executing the throwing motion. One of the common ways to assess the throwing motion is Roberton and Halverson’s (1984) Developmental Sequences of the Overarm Throw. Product measures assess the outcomes of the body movement such as distance thrown, number of times hitting a target, and speed of the throw.

The common environment where many fundamental motor skills are instructed and practiced is elementary physical education. Elementary physical education teachers are often challenged by a gymnasium of students with a wide range of abilities and experiences (Oslin, Stroot, & Siedentop, 1997). In addition, teachers are often working against many contextual factors that might limit their effectiveness in teaching and developing movement skills (Oslin et al., 1997). These contextual factors include limited instructional time, large class size, and limited equipment. To overcome these factors, physical education teachers need instructional tools that can be used to provide effective
and efficient instruction of movement skills to meet the unique needs of each child. One way to develop tools for effective and efficient instruction is to consider the factors influencing the development of throwing.

**Constraints, Instruction, and Throwing**

The development of throwing occurs over time, as a result of the interaction between and within constraints (Newell, 1984, 1986). Under the Dynamical Systems Theory framework and Newell’s (1984, 1986) constraints model, instruction and practice can act as a constraint reducing the occurrence of immature patterns, while promoting the development and use of more advanced patterns. Developmentally appropriate instruction and practice to improve throwing performance can be structured to capitalize on the constraints influencing the overarm throw (Garcia & Garcia, 2002; Langendorfer, 1990; Roberton, 1978). This section will examine the three categories of constraints influencing the throw: (a) individual, (b) task, and (c) environmental.

**Individual Constraints and Gender Differences**

Individual constraints can be considered by a teacher as an awareness of the individual when planning developmentally appropriate instruction. One of the most influential individual constraints on throwing is gender. Throwing has the largest gender difference in performance of any fundamental motor skill, with the differences occurring earlier in development than any other fundamental motor skill (Nelson, Thomas, & Nelson, 1991; Thomas & French, 1985; Williams, 1996). Males consistently throw a greater distance (Thomas, Michael, & Gallagher, 1994), at a faster speed (Halverson, Roberton, & Langendorfer, 1982; Roberton, Halverson, Langendorfer, & Williams, 1979; Thomas & French, 1985), with better accuracy (Moore & Reeve, 1987; Moore, Reeve,
Pissanos, 1981; Thomas & French, 1985), and use a more advanced throwing pattern than girls (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002a; Sakurai & Miyashita, 1983; Thomas & Marzke, 1992). Gender differences persist and expand with age, and it is common to see high school, college, and even adult women throwing with an immature movement pattern (East & Hensely, 1985).

The underlying factors influencing gender differences have been researched and debated in the literature as being attributable to both biological factors (Nelson, Thomas, Nelson, Abraham, 1986; Nelson, et al., 1991; Thomas & Marzke, 1992; Yan, Payne, & Thomas, 2000), and environmental factors (Butterfield & Loovis, 1993; East & Hensley, 1985; Thomas & Marzke, 1992; Williams, 1996). The presence of instruction and practice, the quality of that experience, and the amount and type of feedback from the instructor could be contributing environmental factors to the reported gender differences (Browning & Shack, 1990; Dusenberry, 1952; Garcia & Garcia, 2002; McKenzie et al., 1998; Thomas et al., 1994). The persistent gender differences found have led some researchers to suggest gender differences could be due to differential effects of instruction on boys’ and girls’ throwing performance (Browning & Shack, 1990; Dusenberry, 1952; Garcia & Garcia, 2002; McKenzie et al., 1998; Thomas et al., 1994).

This study aims to examine the issue of gender in throwing because of the gender differences found and that girls’ performance has not “caught up” to the boys’ level of performance after instruction (Browning & Shack 1990; Dusenberry, 1952; Garcia & Garcia, 2002; McKenzie et al., 1998; Roberton et al., 1979; Thomas, et al., 1994). In some cases, the differences in throwing between boys and girls have expanded after
instruction, especially for the performance measures (Browning & Shack 1990; Dusenberry, 1952; Garcia & Garcia, 2002; McKenzie et al., 1998; Roberton et al., 1979; Thomas, et al., 1994).

**Instruction and Task or Environmental Constraints**

Instruction and practice are important to improving aspects of the overarm throw (Dusenberry, 1952; Halverson & Roberton, 1979). Instruction has been more successful in changing the form used to execute the throw than the product measures of throwing performance such as distance and velocity (Garcia & Garcia, 2002; Halverson, Roberton, Safrit, & Roberts, 1977; Halverson & Roberton, 1979). Instruction was not categorized under Newell’s original constraints model, but teachers and instructional programs can influence both task and environmental constraints. Task constraints are related to the goal of the activity, while environmental constraints are factors external to the performer that can be manipulated by a teacher. The following section describes instructional approaches and strategies, as well as their influence on the overarm throw.

**Instruction and Throwing**

Different types of instruction and practice such as critical cues, a biomechanical approach, and traditional approach have been successful in promoting the development of the throw (Adams, 2001; Dusenberry, 1952; Fronske, Blakemore, & Abendroth-Smith, 1997; Garcia & Garcia, 2002; Halverson et al., 1977; Halverson & Roberton, 1979; McKenzie et al., 1998; Oslin et al., 1997).

**Critical cues.** Critical cues are seen as a tool teachers can use to promote efficient and effective instruction of the overarm throw. Critical cues are short, concise phrases, often consisting of just one or two important phrases or words that convey the critical
elements of the movement to the student in an easily understood language (Landin, 1994). Critical cues create a shared language between the teacher and student to effectively communicate the key aspects of a skill. In throwing, researchers have found critical cues to be effective in changing various aspects of the throw (Adams, 2001; Fronske et al., 1997; Lorson, 2001; Oslin et al., 1997), and have found the use of critical cues to be more effective than verbal descriptions (Fronske et al., 1997). Research has demonstrated the relative effectiveness for cues targeting the step and trunk components (Fronske et al., 1997; Oslin et al., 1997), but there is still a need to determine effective cues for other components and aspects of the throw. A greater understanding of the influence of critical cues on other body components such as the humerus and forearm action along with critical cues for the sideways orientation is necessary. Expanding this content knowledge could help provide teachers with a content progression to teach the overarm throw. Future research must also examine the outcomes from using critical cues on product measures such as speed and distance. Furthermore, it is necessary to determine the impact of critical cues as a strategy to reduce potential gender differences in throwing. Finally, no evidence is available to understand the relationship between improvement in throwing form during practice and changes in the throwing motion used during gameplay.

**Biomechanics of throwing.** The study of biomechanics is another avenue to clarify and improve common instructional statements and practices (Stodden, 2002). The discipline of biomechanics has helped to determine the critical features of the throw such as the importance of the stepping action and trunk rotation, and has been helpful in clarifying and refining suggested instructional statements or cues. While biomechanical
efficiency is critical to forceful throwing, instructional programs using biomechanical
principles to teach the overarm throw have been limited (Stodden, 2002). Additionally
the use of this approach by physical education teachers is limited (Mosher & Schutz,
1983; Stodden, 2002). One possible reason is the useful information in the biomechanical
literature to improve the throw has not been communicated in an easily understood
language, or packaged into an instructional approach that can be used by teachers to
accommodate the wide range of abilities in a class. Instructional approaches based on
biomechanical principles could be a possible option for teachers to consider in providing
effective and efficient instruction of the overarm throw.

Stodden (2002) created an instructional approach based on biomechanical
principles that has received initial support. The instructional approach utilized key
biomechanical principles in a four step instructional progression to successfully promote
change in the throwing form and ball velocity of kindergarten children. The
biomechanical approach could be beneficial in teaching throwing but it is unknown
whether a physical education teacher is able to implement this instructional approach
effectively to improve the overarm throw in an elementary children.

Problem Statement

The overarm throw is instructed and developed in elementary physical education.
The instruction of the overarm throw has posed a difficult challenge for teachers who are
faced with meeting the needs of children with a wide range of ability levels, in
challenging conditions in physical education (large class size, limited instructional time,
limited equipment, etc). In addition, there is a need for teachers to develop strategies to
overcome significant gender differences in throwing between boys and girls. Critical cues
and the use of biomechanical principles are two instructional strategies that have the potential to improve both throwing form and ball velocity in boys and girls. Unknown are the effects of these two programs on throwing form, form used during gameplay, and ball velocity when implemented by a physical education teacher.

Purpose Statement

The purpose of this study is to examine the influence of three instructional approaches critical cues, biomechanical, and traditional on throwing performance in skill practice and game play. A secondary purpose of the study is to examine the influence of gender and the three different types of instruction on throwing performance during skill practice and game play.

Research Questions and Hypothesis

Research Questions 1 through 4 addresses with group differences in throwing performance. Research Questions 5 through 8 deals with Gender and Gender by Group differences in throwing performance.

Instructional Groups and Body Component Levels

1. What is the influence of instructional group (Critical Cue [CUE], biomechanical-based [BP], and typical physical education [TPE] on the four body component levels of throwing (step, trunk, humerus, and forearm) from the pretest to posttest to retention test (See Figure 1.1 for a graphical representation)?

H1 A pretest 3 Group X 2 Gender multivariate analysis of variance (MANOVA) will reveal a non-significant Group effect indicating no pretest differences between groups in body component levels.
Note. X = significant within group difference between testing session. O = non significant within group difference between testing session.

Figure 1.1: Graph of hypothesized with-in group and between group changes in body component levels by instructional group
H₂ A 3 Group X 3 Time X 2 Gender MANOVA with repeated measures on the last factor will reveal a significant multivariate Group X Time effect with follow-up univariate tests also revealing significant Group X Time effects for each component.

H₃ A 3 Group X 3 Time X 2 Gender MANOVA with repeated measures on the last factor will reveal a significant multivariate Group effect with significant univariate Group effects for the step, trunk, humerus, and forearm components at the posttest and retention test. If significant univariate tests are revealed, then the CUE and BP group will demonstrate significantly more advanced body component levels than the TPE group at the posttest and retention test.

H₄ A 3 Group X 3 Time X 2 Gender MANOVA with repeated measures on the last factor will reveal a significant multivariate Time effect with significant univariate Time effects for the four body components. Follow-up tests will reveal significant pretest to posttest changes in each of the body component levels for each of the CUE, BP, and TPE groups. If a significant pretest to posttest change is found, there will be no significant posttest to the retention test changes in body component levels for each group.

*Instructional Groups and Body Component Levels During Game Play*

2. What is the relationship between body component levels in practice and body component levels in gameplay at the pretest, posttest, and retention test for each group?
H₅ A moderate to strong (r=.40 or above) significant, positive correlation will exist between throwing performance in practice and throwing performance in a game for each group and for each component at the pretest, posttest, and retention test.

Differences Between Groups in Ball Velocity and Unrecorded Trials

3. What is the influence of instructional group (CUE, BP, TPE) on mean recorded ball velocity from the pretest to posttest to retention test?

H₆ A pretest 3 Group X 2 Gender analysis of variance (ANOVA) will reveal a non-significant Group effect indicating no significant pretest differences between groups in mean recorded velocity.

H₇ A 3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor will reveal a significant univariate Group X Time interaction for mean ball velocity.

H₈ A 3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor will result in a significant Group effect, with follow-up tests showing the BP and CUE groups having a significantly greater mean velocity score than the TPE group.

H₉ A 3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor will result in a significant Time effect for ball velocity. Within each group, follow-up tests will reveal significant differences in mean ball velocity from the pretest to the posttest, for each group. If a significant pretest to posttest change is found, there will be no significant posttest to the retention test changes in ball velocity for each group.
4. What is the influence of instructional group (CUE, BP, TPE) on the number of unrecorded trials from the pretest to posttest to retention test?

H_{10}  A pretest 3 Group X 2 Gender analysis of variance (ANOVA) will reveal a non-significant Group effect indicating no significant pretest differences between groups in unrecorded trials at the pretest.

H_{11}  A 3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor will reveal a significant univariate Group X Time interaction for unrecorded trials.

H_{12}  A 3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor will result in a significant univariate Group effect, with follow-up tests showing the BP and CUE groups having a significantly fewer unrecorded trials than the TPE group.

H_{13}  A 3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor will result in a significant univariate Time effect for unrecorded trials. Within each group, follow-up tests will reveal a significant decrease in unrecorded trials from the pretest to the posttest, for each group. If a significant pretest to posttest change is found, there will be no significant posttest to the retention test changes in unrecorded trials for each group.

Gender and Body Component Levels

5. What is the influence of instructional group (CUE, BP, TPE) and gender (Female, Male) on body component levels (step, trunk, humerus, and forearm) from the pretest to the posttest to the retention test?
H_{14} A pretest 3 Group X 2 Gender MANOVA will reveal a significant multivariate Gender effect with follow-up univariate analysis revealing a significant Gender effect for each body component.

H_{15} A pretest 3 Group X 2 Gender MANOVA will reveal a significant multivariate Group X Gender interaction with significant follow-up univariate Group X Gender interactions for each of the step, trunk, humerus, and forearm components at the pretest. Within one group, follow-up t-tests will reveal significant gender differences in each body component for each group at the pretest.

H_{16} A 3 Group X 3 Time X 2 Gender MANOVA with repeated measures on the last factor will reveal a significant multivariate Gender X Time effect. Follow-up univariate tests will reveal a significant Gender X Time effect for each component.

H_{17} A 3 Group X 3 Time X 2 Gender MANOVA with repeated measures on the last factor will reveal a significant multivariate Group X Gender X Time interaction with significant follow-up univariate Group X Gender X Time interactions for the step, trunk, humerus, and forearm components. Follow-up analyses will show there will be no gender differences in body components at the posttest both for overall gender, and for gender within each of the three groups. Additional follow-up analyses will show that within groups, there will be significant pretest to posttest changes in each body component level for each
gender within each group. If a significant pretest to posttest change is found, there will be no significant posttest to the retention test changes in body component levels for each gender within each group.

**Gender and Body Component Levels During Gameplay**

6. What is the relationship between body component levels in practice and body component levels in gameplay at the pretest, posttest, and retention test for each gender?

   \[ H_{18} \] A moderate to strong \((r=.40\) or above) significant, positive correlation will exist between throwing performance in practice and throwing performance in a game for each gender and group for each component at the pretest, posttest, and retention test.

**Gender Differences and Ball Velocity During Practice**

7. What is the influence of instructional group and gender on mean ball velocity from the pretest to posttest to retention test?

   \[ H_{19} \] A pretest 3 Group X 2 Gender ANOVA will reveal a significant Gender effect. Follow-up analyses will reveal males have a greater mean velocity than the girls at the pretest.

   \[ H_{20} \] A 3 Group X 2 Gender ANOVA at the pretest will result in a non-significant Group X Gender interaction.

   \[ H_{21} \] A 3 Time X 2 Gender ANOVA with repeated measures on the last factor will reveal a significant Gender X Time effect for ball velocity. Follow-up analyses will show significant differences between male and female ball velocity scores at the posttest and retention test. Additional follow-up analyses will show that both males and females will significantly improve mean ball velocity scores from the
pretest to posttest. If a significant pretest to posttest change is found, there will be no significant posttest to retention test changes in ball velocity.

H22 A 3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor will reveal a significant Group X Time X Gender interaction. Follow-up analyses will reveal that within each of the three groups there will be significant posttest gender differences. Additional follow-up analyses will show both males and females will significantly improve mean velocity scores from pretest to posttest. If significant, there will be no significant differences between posttest and retention tests.

8. What is the influence of group and gender on unrecorded trials?

H23 A pretest 3 Group X 2 Gender ANOVA will reveal a significant Gender effect. Follow-up analyses will reveal males have fewer unrecorded trials than the girls at the pretest.

H24 A 3 Group X 2 Gender ANOVA at the pretest will result in a non-significant Group X Gender interaction.

H25 A 3 Time X 2 Gender ANOVA with repeated measures on the last factor will reveal a significant Gender X Time effect for unrecorded trials. Follow-up analyses will show significant differences between male and female unrecorded trials at the posttest and retention test. Additional follow-up analyses will show that both males and females will significantly reduce the number of unrecorded trials from the pretest to posttest. If a significant pretest to posttest change is found, there will be no significant posttest to retention test changes in the number of unrecorded trials.
H₂₆ A 3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor will reveal a significant Group X Time X Gender interaction. Follow-up analyses will reveal that within each of the three groups there will be significant posttest gender differences. Additional follow-up analyses will show both males and females will significantly reduce the number of unrecorded trials from pretest to posttest. If significant, there will be no significant differences between posttest and retention tests.

Limitations of the Study

1. The inability of the radar gun to record a throw that is less than 25 miles per hour is a limitation of the ball velocity data. If a throw does not register on the radar gun, the participant was given a zero, which limits the ability to distinguish small changes in velocity for participants who threw below 25 miles per hour. The inability of the radar gun to detect throws less than 25 miles per hour necessitated the use of a mean velocity score consisting of a mean of all registered throws on the radar gun. The number of unrecorded trials during each session was also tracked and reported in the results section.

2. Another limitation is the BP instructional approach. This is a newly developed approach that has limited empirical evidence. The only study supporting the use of the approach was an unpublished dissertation (Stodden, 2002).

3. The experimental design in this study had a comparison group instead of a true control group. The TPE group received some form of instruction. A true control group would have received no instruction or practice in throwing.
4. Another limitation was the lack of randomization of participants. Participants were self-selected to the study by turning in a permission slip. The participants were not randomly assigned to one of the levels of the independent variable because the participants were also part of intact classes. The classes that were a part of the study were purposively assigned one level of the independent variable for each grade level (first and second grade).

5. A limitation of the dependent variable of components used during game play was the recording and analysis of only the first five trials. The researcher was unable to control the number of throws each participant threw during each game play session, thus the first five visible throws were used in analysis. The first five visible trials were used because there was a possibility of another participant blocking a clear view of the observed thrower.

6. A limitation of the results of the influence of the levels of the independent variable was the inability to control practice time spent in throwing activities outside of school. The study was conducted during the late spring during baseball season. The amount of practice time outside of school physical education was not controlled or tracked. It is possible that for individual children the influence of baseball season could have impacted the results of this study. Another associated concern is the differential levels of outside experiences between the CUE and BP groups, and the TPE groups. The teachers at both the Fiesta School and the Woodbine school noted that the participants from the Woodbine School participated in youth baseball more than participants at the Fiesta School (Mrs. Scarlet, personal communication, May 17, 2003; Ms. Gray, personal communication, May 23, 2003).
7. Another limitation was the inability to control the number of throws during practice sessions. The number of throwing trials during practice sessions varied across condition. The number of throws also varied across gender. The allocated time for throwing instruction and practice was the same for both groups, but the nature of the strategies the impacted the number of throws during each session.

8. Another limiting factor was the inability to control for teacher feedback during instruction. There was an emphasis to provide a realistic environment to test the effectiveness of the CUE and BP approaches, thus the teacher was not restricted in the type, use, or frequency of feedback during instruction. These instructional variables were monitored, but the experimenter could not control this factor.

**Delimitations of the Study**

1. The results of the study are limited to the participants in the study who are first and second grade children. The critical cues in this study also delimit the study as these cues were developed for these participants because they were formulated to be understood by this particular group.

2. The results of this study are delimited to the physical education program. The physical education program meets once every four days with the students. A program that meets more frequently or less frequently might have differing results. The teacher to student ratio within this program is 20:1 approximately. A larger ratio of students to teachers may have different results using either of the instructional programs.

3. Another delimitation of the study was the short time allocated to each instructional approach. Each approach was implemented over the course of 4 classes, each lasting 30 minutes. While this time frame is close to the usual time allotted to
throwing activities in these elementary physical education programs (Mrs. Scarlet, personal communication; Ms. Gray, personal communication), implementation of programs over a longer duration could have different results. More practice time could further develop the coordination of the movements of a forceful throw. Developing coordination takes many practice trials, thus an intervention with a longer duration may be more successful in changing product measures of throwing.

4. The results of this study are also delimited to these particular teachers. The study does not attempt to determine if other physical education teachers or preservice physical education teachers would expect similar results in using these instructional approaches. The teachers in this study are experienced teachers who have worked frequently with a university teacher education program either assisting in research projects or acting as a supervising teacher. Each teacher has clearly established rules and routines, which greatly reduced the amount of management concerns throughout the implementation of the study.

5. The findings of this study are also delimited to the task of the overarm throw for force. The instructional programs were designed specifically for the overarm throw for force. Similar results are not expected for the overarm throw for accuracy. There was no attempt to influence other fundamental motor skills with the instructional programs used in this study.

Basic Assumptions

The interventions used in this study are not expected to fully develop an advanced pattern of throwing as defined by Roberton and Halverson’s (1984) component approach in every child. With the limited amount of time allotted for the intervention and practice it was not a reasonable expected outcome of the instruction to have all students throwing
with the most advanced pattern. A goal of each of the programs was to promote the
development of the most advanced pattern for each individual child. An expectation of
this study is that each student should be able to at least demonstrate a pattern of throwing
that uses a contralateral stepping action toward the target after instruction.

Another assumption of this study is that maturation will not be a factor in the
improvement in the throw. The entire length of data collection, including retention test,
was approximately ten weeks. Ten weeks is not a length of time for significant
maturation effects (Malina & Bauchard, 1991).

An assumption of this study is that the TPE group is representative of typical
physical education. It was assumed that if throwing was instructed in elementary physical
education it would be similar to the instruction provided by the TPE group. The TPE
group could also be seen as typical instruction for throwing because it is similar to the
recommendations provided by the commonly used elementary methods textbook Graham

Definition of Terms

Ancillary Effects

Ancillary effects are the resulting changes in other components as a result of a change in
another component. The greatest ancillary effects are achieved in changes in the step and
backswing component (Oslin et al., 1997).
**Closed Position**

The alignment of a body segment that is parallel to a line from the body segment to the target (Stodden, 2002).

**Component Approach**

The component approach is a developmental sequence for the overarm throw describing changes in different body sections. A component is one particular body segment or a joint action of the body (Langendorfer & Roberton, 2002a). The component approach examines five components: step, trunk, backswing, humerus, and forearm.

**Component**

A particular body segment of the throw (Langendorfer & Roberton, 2002a).

**Constraint**

Constraints are boundaries or features that limit motion and reduce the number of possible configurations of a system (Newell, 1984, 1986). Constraints may enhance or restrict performance.

**Critical Features**

Critical features are the most important aspects of the skill that need to be performed a certain way to be successful. They are usually expressed in very technical biomechanical language (Knudson & Morrison, 1997).

**Environmental Constraints**

Environmental constraints are external to the organism. Environmental constraints are those that are not manipulated by the experimenter and are relatively time independent (Newell, 1984, 1986).
Individual Constraints

Individual constraints are internal or physical constraints. Learner constraints may also be called biological constraints (Newell, 1984, 1986).

Kinetic Link or Kinetic Chain Principle

The kinetic chain principle is the concept of linked body segments. The momentum from proximal segments will be transferred to more distal segment. In throwing the momentum is transferred from the trunk and pelvis to the more distal segments of the humerus, forearm, and wrist (Knudson & Morrison, 1996).

Level

A level is the description of the different movements within each component; each of these levels is organized in a hierarchal order from least mature to most mature (Roberton, 1978).

Mature Throwing Pattern for Velocity

The mature pattern of throwing for velocity includes:

1. A long contralateral step is a step the distance of over half the child’s standing height.

2. The use of a circular, downward backswing where the ball moves away from the intended line of flight to a position behind the head via a circular, down, and back motion, which carries the hand below the waist.

3. Differentiated rotation involves the pelvis preceding the upper spine in initiating forward motion.
4. Demonstrating humeral lag when the humerus moves forward horizontally aligned until ball release, but at the moment the shoulders (upper spine) reach front facing, the humerus remains within the outline of the body (as seen from the side).

5. Demonstrating delayed forearm lag, where the forearm delays reaching its final point of lag until the moment of front facing (Roberton & Halverson, 1984).

**Open Position**

The alignment of a body segment that is perpendicular to a line from the body segment to the target (Stodden, 2002).

**Process Measures of Throwing**

The process of measures of throwing is throwing form. Throwing form can be assessed using either a component or total body approach (Payne & Isaacs, 2002).

**Product Measures of Throwing**

Product measures of throwing include: ball velocity, throwing distance, and throwing accuracy measures such as the number of times the target was hit (Payne & Isaacs, 2002).

**Reliability**

Is the degree to which independent observers agree on what they have observed when using the same definitions and observing the same subjects (Siedentop, Touseignant, & Parker, 1982).
**Sequential Coordination**

Sequential coordination is the timing of segment actions to transfer energy to distal segments. Sequential coordination is necessary to take advantage of the kinetic link principle to transfer momentum to more distal segments (Knudson & Morrison, 1996).

**Task Constraints**

A task constraint is the focus or the goal of the activity and the specific constraints imposed. There are three categories of task constraints: 1) goal of the task; 2) rules specifying or constraining response dynamics; and 3) implements or machines specifying or constraining response dynamics (Newell, 1984, 1986).

**Training**

The process of developing interpretations of an observation system which requires learning a common set of concepts, a common symbol language, and a common set of decision conventions (Siedentop et al., 1982). Observers are trained to produce reliable data.

**Verbal Cues or Critical Cues**

Verbal cues are short, concise phrases, often consisting of just one or two important phrases or words that convey the critical elements of the movement to the student (Landin, 1994).
CHAPTER 2

REVIEW OF LITERATURE

Theoretical Framework

Dynamical systems theory and Newell’s constraints model provides the framework for this review of literature. This theory provides a useful framework to describe the dynamic nature of the development of throwing and to categorize the various factors influencing throwing. This review will focus on the importance of the throw, assessment of throwing performance, the development of advanced throwing patterns, and the factors influencing the development of advanced throwing patterns. The remainder of the section examines the instructional programs that have been successful in developing throwing.

Dynamical Systems Theory

Dynamical Systems Theory seeks to explain changes in motor performance and provides a useful framework to describe the many factors influencing the development of the throw. Dynamical Systems Theory is useful for not only describing changes in throwing, but also for considering the underlying factors influencing the throw.

Dynamical Systems Theory explains the development of human movement in terms of complex systems self-organizing into specific stable states or patterns under
certain boundary conditions (Payne & Isaacs, 2002). In Dynamical Systems Theory, a person is seen as a system comprised of multiple interacting subsystems such as experience, motivation, and strength. These subsystems interact and result in movement product. A change in any one subsystem can bring about changes in overall performance. Dynamical Systems Theory moves away from a more “hard-wired” notion of skill acquisition to a more flexible, context specific view of the processes involved in learning motor skills (Thelen & Ulrich, 1991). No two people are exactly alike in their overall development, and their motor skill development. Movement patterns do not develop in a series of highly predictable movements or levels, rather patterns change over time with certain probabilities (Clark & Phillips, 1993; Garcia & Garcia, 2002; Payne & Isaacs, 2002). Dynamical systems theory has major concepts that explain the acquisition of movement over time. These concepts include: (a) attractors, (b) phase shifts, (c) control parameters, and (d) the constraints model.

**Attractors.** Unlike stage theory, there are no prescriptive levels to follow for development in Dynamical Systems Theory. However, there are particular stable patterns demonstrated within and across individuals. These stable patterns of behavior that are observed across multiple trials and task conditions are called attractors (Clark and Phillips, 1993; Langendorfer & Roberton, 2002a). Langendorfer & Roberton (2002a) identified common attractors and attractor pathways for the development of throwing. The most common attractors for throwing for children 5.7 years to 13 years included: block rotation of the trunk (level 2), humerus oblique (level 1), and no forearm lag (level 1). Tied to the notion of attractors are attractor pathways, which are common patterns of change over time (Hamilton & Tate, 2002). A common attractor pathway for
throwing includes a contralateral step and assuming a body position of a sideways orientation to the target greatly increasing the occurrence of at least block rotation of the trunk (Garcia & Garcia, 2002). Langendorfer and Roberton identified another attractor pathway as the relationship between changes in the trunk component (no rotation to block rotation) and humerus component (humerus oblique to humerus aligned but independent). Attractor states and attractor pathways are not stable phenomena; they may change if the parameters in the system change. Attractors may change over time (age) due to the relationship between subsystems or constraints that also are changing over time.

*Phase shifts.* Under Dynamical Systems Theory, changes in movement patterns are driven by, and a result of the interaction of the factors influencing the system. In the Dynamical Systems Theory framework, movement systems seek new stable solutions in relation to the demands of the task and the environment. This process of moving from old forms of movement to new stable, efficient forms of movement is called a phase shift (Thelen & Ulrich, 1991). During phase shifts there is a great deal of variability prior to the qualitative change in the observed movement pattern (Langendorfer & Roberton, 2002a, 2002b; Southard, 2002). Variability in performance has been found in a number of throwing studies when the participants were going through phase shifts (Dusenberry, 1952; Garcia & Garcia, 2002; Halverson et al., 1977; Halverson & Roberton, 1979; Roberton, 1987). Variability in throwing patterns initially resulted in poor performance but then as the pattern restabilized into a new pattern the performance improved. For example, Dusenberry (1952) noted that radical changes in style (throwing form) during instruction usually resulted in poorer distance.
Control parameter. The factor believed to be primarily responsible for changes in a movement system is a control parameter. A control parameter can be any variable, that when scaled beyond some critical value allows the movement system to organize itself in a different way (Southard, 1998, 2002; Langendorfer & Roberton, 2002a, 2002b). Control parameters need not be task specific, they can be extrinsic or intrinsic to the individual and can be identified by determining the essential variables of the skill (Southard, 1998). Control parameters in throwing may include biomechanical factors (such as added weight to a body segment), or could include environmental factors such as ball size or weight (Southard, 2002). Control parameters identified for the overarm throw are the distance from the target and the size of the target (Hamilton & Tate, 2002), and the task of throwing for force (Southard, 1998). Both of these control parameters cause the movement system to reorganize itself in a different way when scaled to a critical value.

Constraints Model

The constraints model is a useful tool to organize the various factors influencing movement patterns. Newell (1984, 1986) developed a model that helped consider the emergence of movement patterns. As movement patterns develop over time the pattern exhibited is a result of the interaction of the constantly changing variables or factors. Constraints are defined as boundaries, parameters, or features that limit motion and reduce the number of possible configurations of a system (Newell, 1984, 1986). Under the Dynamical Systems framework, the movement pattern exhibited at a particular point in time is a result of the interaction between constraints, and the causes of development are not based on a single variable, but the interaction and the changing relationship...
between many variables (Langendorfer & Roberton, 2002b; Newell, 1984, 1986).
Constraints change throughout the lifespan influencing the appearance of certain
attractors. Additionally, the relationship and interaction between constraints also change,
thus increasing the likelihood of certain behaviors or attractors while reducing the
likelihood of other behaviors.

Newell (1984, 1986) organized constraints into three categories: individual, task,
and environment (See Figure 2.1 for a diagram of the Constraints Model). Individual
constraints, also termed learner or organismic constraints, are internal, biological, or
physical factors (Newell, 1984, 1986). Examples in throwing include body segment
length, body weight, muscular strength, and the ability to coordinate body segments
during the throwing motion. Environmental constraints are external to the learner.
Environmental constraints are those that are not manipulated by the experimenter and are
relatively time independent (Newell, 1984, 1986). Examples of environmental constraints
in throwing might include ball size or weight.

Task constraints are focused directly on the goal of the activity (Newell, 1984,
1986). There are three categories of task constraints: (a) goal of the task, (b) rules
specifying or constraint response dynamics, and (c) implements or machines specifying
or constraining response dynamics (Newell, 1984). Task constraints either specify or
limit the nature of the response that a performer is able to produce (Newell, 1984). The
task constraint receiving the most attention in the throwing literature is the relationship of
the task of throwing for force (speed), distance, and accuracy (Hamilton & Tate, 2002;
Langendorfer, 1990; Roberton, 1987). The task of throwing for force, distance, or
accuracy has a differential influence on the throwing pattern exhibited and the various
Figure 2.1 Summary of individual, task, and environmental constraints under consideration in the overarm throw.
performance measurements (Hamilton & Tate, 2002; Langendorfer, 1990). Critical cues or refining tasks could also be considered a task constraint because the cue can become the task goal that specifies or constrains the response dynamics.

Instruction was not clearly identified in Newell’s model as a task or environmental constraint. Teachers can manipulate task constraints, clarify the task, and arrange the practice environment. When considering an individual, the opportunities to practice throwing and the quality of instruction would be considered a constraint on the movement exhibited. When looking at the immediate instructional environment, instruction could be considered a task constraint because a teacher can provide or clarify the task goal. Throughout this literature review and for the purposes of this study, instruction and the quality of instruction (practice) will be considered an environmental constraint. For this study, instruction is considered an environmental constrain. The task constraint in this study will be the throw for force, and will be held constant in practice and data collection.

Fundamental Motor Skills

Fundamental motor skills are the building blocks of more specific sport or game skills developed later in childhood (Payne & Isaacs, 2002). Many complex skills used in games and sports are adaptations, combinations, and refinements of fundamental motor skills (Ignico, 1994). Fundamental motor skills include: walking, running, jumping, hopping, galloping, sliding, skipping, kicking, catching, striking, dribbling, and throwing. These fundamental motor skills can be categorized as either locomotor skills or object
control skills. Locomotor skills involve moving the body from one point to another such as galloping and skipping (Payne & Isaacs, 2002). Object control skills involve the manipulation of an object such as throwing and striking (Payne & Isaacs, 2002).

Movements are categorized by the muscle groups used to produce the movements. Use of large muscle groups is needed for gross movements, while use of small muscles or muscle groups are necessary for fine movements. Even though movements are categorized as gross or fine, very few are completely controlled by small or large muscle groups (Payne & Issacs, 2002). Throwing uses a combination of small and large muscle groups, throwing is considered a gross movement. Throwing is categorized as a gross movement because most of the significant muscle involvement is from the shoulders and legs. Throwing also has a fine motor component, the fine movements of the wrist and fingers are important in the accuracy of the throw (Payne & Isaacs, 2002).

Importance of Fundamental Motor Skills

Developing skill and proficiency in fundamental motor skills could lead to physical, social, and emotional benefits as a result of a more active, healthy lifestyle (Browning & Shack, 1990; McKenzie, et al., 1998). Children who develop motor skills grow in confidence, possibly leading to further participation in youth sports and physical activity (McKenzie et al., 1998). Conversely, poorly developed fundamental motor skills could lead to frustration and a feeling of incompetence causing some to abandon or reject sports (Browning & Shack, 1990; East & Hensley, 1985; McKenzie et al., 1998). Children who cannot throw or perform motor skills efficiently might face social ostracism (Frinske, et al., 1997). A child who has not developed adequate fundamental movements may exhibit a lower self-concept and poorer social development (Rimmer &
Kelly, 1989). Additionally, play and sports have a cultural importance, with object control skills being a regular part of the common activities available in the school and community (McKenzie et al., 1998).

*Importance of fundamental motor skills and physical education.* Physical education, especially during the elementary years, is the environment where many children practice and develop motor skill patterns (Graham, Holt/Hale, & Parker, 2001). Early, effective instruction is essential to the development of correct movement patterns, and to acquire more difficult or advanced movements used in sport and dance activities (Graham et al., 2001; Rimmer & Kelly, 1989). Early physical education experiences are also important as an influence of future attitudes toward physical activity later in life (Gabbard, 1995).

The development of fundamental motor skills in children is important to achieving outcomes such as influencing physical activity levels and to achieving the National Association for Sport and Physical Education (NASPE) standards. Specifically, developing skill and proficiency in movements such as throwing, aligns with the NASPE standards for physical education (NASPE, 1995). Developing skilled movers meets NASPE Standard 1, “Demonstrates competency in many movement forms and proficiency in a few movement forms.” The sample benchmarks provided by NASPE for Standard 1, specifically target the development of advanced movement patterns. Developing knowledge regarding the critical elements of the fundamental motor skills can help to meet NASPE Standard 2, “Applies involvement concepts and principles to the learning and development of motor skills.” Examples of how the development of fundamental motor skills can meet Standard 2 can be seen in early elementary children.
recognizing and applying some characteristics of mature fundamental motor skill patterns, developing a movement vocabulary, and identifying critical elements of a mature throw. Developing skilled and proficient movers could contribute to the achievement of other NASPE Standards (See Table 2.1 for a summary of the NASPE Standards). Overall, it is important for physical educators to develop skills that can be used as part of a physically active lifestyle at an early age, because there is a tendency for those who are more active during youth years to be more active than their non-active peers in adulthood (Malina, 1996).

Importance of Throwing. Throwing is one of the most important object control skills due to its extensive use in sports such as baseball and softball. The basic overhand throwing motion is also assimilated into a variety of sport skills such as spiking and serving in volleyball, the tennis serve, and the overhead clear in badminton (Butterfield & Loovis, 1993; East & Hensley, 1985). Throwing has a cultural and social significance, because throwing is a large part of the common activities available in the school and community (McKenzie et al., 1998). The widespread use of the throwing motion makes the ability to throw well a requisite to succeed and to enjoy these sports and games.

Assessment of Throwing Performance

To determine the changes in throwing, both process and product assessments of throwing performance are necessary. The following section discusses the assessment of throwing performance. Product measures are the end result or the movement outcome (Payne & Isaacs, 2002). Process measures assess the movement itself, with little or no attention to the product or end result (Payne & Isaacs, 2002).
Table 2.1. The National Standards for Physical Education (1995).

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Demonstrates competency in many movement forms and proficiency in a few movement forms.</td>
</tr>
<tr>
<td>2</td>
<td>Applies involvement concepts and principles to the learning and development of motor skills.</td>
</tr>
<tr>
<td>3</td>
<td>Exhibits a physically active lifestyle.</td>
</tr>
<tr>
<td>4</td>
<td>Achieves and maintains a health enhancing level of physical fitness.</td>
</tr>
<tr>
<td>5</td>
<td>Demonstrates responsible personal and social behavior in physical activity settings.</td>
</tr>
<tr>
<td>6</td>
<td>Demonstrates understanding and respect for differences among people in physical activity settings.</td>
</tr>
<tr>
<td>7</td>
<td>Understands that physical activity provides opportunities for enjoyment, challenge, self-expression, and social interaction.</td>
</tr>
</tbody>
</table>

Product measures

The product measures used to assess the development of throwing have been distance thrown, speed of the throw, and number of times a hitting a target (accuracy). Product scores are the end results or the outcome of the movement. Tests have been developed and utilized to assess the product measures of throwing such as the AAHPERD Softball Skill Test (Browning & Shack, 1990). A velocimeter and a radar gun have also been used as tools to assess ball velocity (Halverson et al., 1982). Radar guns have become accessible and a more feasible option for physical educators to assess the speed of the throw and as a way to provide performance feedback to throwers (Roberton & Konczak, 2001). Assessment of product scores provides important feedback to keep children motivated and interested in the activity. Tracking product scores can also be useful for teachers and researchers to determine the positive or negative influence of certain factors or constraints on the performance of the throw (Roberton & Konczak, 2001).

Process Measures and Developmental Sequences of Throwing

Product measures, while useful for providing knowledge of results, do not illuminate minor changes in the movements used to execute the throw. Researchers have noted that changes can occur in movement patterns, without the corresponding changes occurring in the product measures (Dusenberry, 1952; Halverson & Roberton, 1979; Halverson, et al., 1982; Halverson, et al., 1977). While the products of throwing, such as speed, distance, and accuracy are important for sports and games; the form used to produce the outcome is also of importance to physical educators and coaches. Physical educators seemed to be more concerned with the form utilized to execute the throw
because improving form will typically contribute to improved outcomes (Barrett & Burton, 2002). Another possible reason for this concern is because teachers have had greater success in changing throwing form rather than product scores in the limited instructional time available (Halverson & Roberton, 1979; Thomas et al., 1994).

Although there is a relationship between throwing products and throwing process, this relationship is not a linear one (Roberton & Konczak, 2001). Researchers and teachers should assess both product and process measures to detect small changes in throwing performance, and to provide specific, and motivating feedback to learners. The following sections will describe two approaches to assess throwing form. Each approach will be described along with advantages and disadvantages for each approach.

*Total Body Approach.* The total body approach to throwing describes the total body movement of all joints and segments into the characteristics of one stage. Change to a subsequent stage requires the simultaneous change in most of the components (Langendorfer & Roberton, 2002a). The total body approach uses Stage Theory as its theoretical framework. The most commonly used total body approach, and one of the first attempts at describing the development of throwing is from Monica Wild (1938). Wild (1938) examined the throwing pattern of 32 participants, a boy and a girl from each six month age level from the ages of 2 to 7, and then one boy and girl from each year from 7 to 12 years old. Analysis of throwing patterns revealed four stages of throwing (See Table 2.2 for a summary of Wild’s Stages). Seefeldt and Haubenstricker (1982) also proposed another commonly used total body approach with five stages.
**Stage I. Anteroposterior movements.** The reverse movement of the arm is either sideways-upward or forward upward usually to high above the shoulder, elbow much flexed. With the reverse arm movement, the trunk extends with dorsal flexion of ankles and carries the shoulders back. The trunk then straightens, carrying the shoulders forward, and flexes forward with plantar flexion of ankles as the arm swings forward over the shoulder and down in front. Elbow extension starts early. Movements of body and arm are almost entirely in the anteroposterior plane over feet, which remain in place; the body remains facing the direction of the throw all the time; the arm is initiating factor. There is trunk left rotation toward the end with the arm’s forward reach.

**Stage II. Horizontal body and arm movements.** The whole body rotates right, then left above the feet; the feet remain together in place. The arm moves either in a high oblique plane above the shoulder or in a more horizontal plane but with a forward downward follow-through. The elbow is much flexed; it may extend at once or later. The body changes its orientation and then reorientates to the throwing direction. The arm is the initiating factor.

**Stage III. Introduction of stepping (right foot-step-forward throw).** The weight is held back on the left rear foot as the spine rotates right and extends; the arm swings obliquely upward over the shoulder to a retracted position with elbow much flexed. The forward movements consist of a stepping forward with right foot, unilateral to the throwing arm, with spine left rotation, early turning of the whole body to a partial left facing and trunk forward flexion, while the arm swings forward either in an oblique-above-the-shoulder plane or in a sideways-around the-shoulder plane, followed by a forward downward movement of follow-through. Elbow extension does not start at once. This throw has both anteroposterior and horizontal features.

**Stage IV. The mature throw. (left-foot-step-forward).** Is the left-foot-step-forward throw with trunk rotation and horizontal adduction of the arm in the forward swing. Girls, in most cases, attained the body and foot movements, but incompletely developed forms of the arm movement. Others show decided regressions or retardations.

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*Note.* From *The behavior pattern of throwing and some observations concerning its course of development in children.* By M. Wild, 1938.

Table 2.2. Developmental stage sequence for the overarm throw (Wild, 1938).
Criticisms of the total body approach include a deterministic view of throwing development, and the inclusion of all body components into one category. The total body approach implies that all throwers look precisely the same within the same stage, when actually the movements within each stage could be quite different across throwers (Langendorfer & Roberton, 2002a). As a researcher, the total body approach is not as sensitive as the component approach in detecting minor changes in particular body components. This limits the ability of the total body approach to evaluate minor changes or changes occurring in specific components. Using the total body approach, a researcher would be unable to determine and describe the relationships between body segments. Another criticism of Wild’s total body approach is the comprehensiveness of Wild’s initial stages, and descriptions of each of the stages. After an analysis of Wild’s (1938) descriptions, Langendorfer & Roberton (2002a) suggested the mature pattern proposed by Wild might actually be an intermediate throw with only block rotation of the trunk. Wild (1938) was able to determine a difference between a non-rotating trunk and a rotating trunk, but was unable to discern block rotation from differentiation of the trunk because of a lack of a rear view and the technical limits at the time of the Wild study (Langendorfer & Roberton, 2002a). Despite the criticisms, Wild’s (1938) work should not be discounted because it laid the foundation for the qualitative analysis of throwing and portions of Wild’s descriptions are prevalent in many developmental sequences.

Component Approach. Roberton (1977) conceived a new developmental model by breaking the throw into body components (See Table 2.3 for a summary of the body component levels in throwing or Appendix A for a complete description of each component). The component approach focuses on five components of the overarm throw:
Foot (Step) Action

S1. No step.
S2. Homolateral step.
S3. Contralateral, short step.

Trunk (Pelvis-Spine) Action

T1. No trunk rotation.
T2. Upper trunk rotation or total “block” rotation.
T3. Differentiated rotation.

Preparatory Arm-Backswing Component

B1. No backswing.
B2. Elbow and humeral flexion.
B3. Circular, upward backswing.
B4 Circular, downward backswing.

Humerus (Upper Arm) Action During Forward Swing

H1. Humerus oblique.
H2. Humerus aligned but independent.
H3. Humerus lags.

Forearm Action Forward Swing

F1. No forearm lag.
F2. Forearm lag.
F3. Delayed forearm lag.


Table 2.3: Developmental sequences within components of the overarm throw for force. The population are described in the sequence (DiRocco & Roberton, 1981).
step, trunk, backswing, humerus, and forearm. The components are not perfectly correlated as suggested in the whole body approach, but are not totally independent (Langendorfer & Roberton, 2002a). Within the component approach, change in component levels can occur at different rates, and at different times, for different components. The component approach sequence, in contrast to stage theory, is seen as a guide for development and change in throwing, not a blueprint (DiRocco & Roberton, 1981). The component approach terms the different levels in each component as steps or levels, because “stage” seems to align with the prescriptive “stages and ages” connotation of the total body approach (Roberton, 1978). While developed under a stage theory approach, the current theoretical framework for the component approach is Dynamical Systems Theory and a probabilistic view of development. The component sequences are characteristic of the population, thus any person developing, or demonstrating a particular level is based on the laws of probability (Langendorfer & Roberton, 2002a). Dynamical Systems Theory provides a useful framework to describe the wide variety of possible configurations of the body components, and to examine the factors influencing the movement system including the influence of other body components on the throwing motion.

*Validation of component approach.* Roberton (1977) proposed that the validation of a developmental sequence requires the demonstration of comprehensiveness, stability, and intransivity. Intransivity means that all people are assumed to pass through all levels in an invariant order (Roberton, 1978). Stability is the notion that while an individual is in a specific level, the individual should exhibit behaviors predominantly from that level (Roberton, 1978). Comprehensiveness is demonstrated when all movements prevalent in
Longitudinal study is necessary to determine comprehensiveness and to support the accuracy of the sequence. Portions of the component model have been validated on comprehensiveness (DiRocco & Roberton, 1981; Roberton, 1977, 1978; Roberton & Langendorfer, 1980), and developmental validity (Roberton, 1978; Roberton & Langendorfer, 1980).

Roberton (1977) used a pre-longitudinal study to test the stability and intransivity of first grade children’s (n=73) humerus and pelvic-spine components across 10 trials. Roberton (1977) supported the component level sequence for the humerus component, but did not support the originally suggested eight pelvic-spine categories. The data for the humerus demonstrated stability, when children varied their movement pattern for the humerus component they varied only between their modal category and the next higher or lower level. Data for the pelvic-spine component did not demonstrate the same invariant order. Roberton’s (1977) work supported a component view of throwing development, but suggested further longitudinal study to validate the sequences for both the humerus and pelvic-spine categories for developmental validity.

Roberton (1978) validated portions of the component approach using longitudinal information. The longitudinal study used a within-year, across trial analysis to determine if the components met the criteria of stability and intransivity. Roberton (1978) initially examined the throwing patterns of 76 children as kindergarteners, first graders (n=76), and again as second graders (n=54). The results for the action of the humerus showed that at least 50 percent of the children’s trials were in one level during each year of the study.
Each year the children averaged 8 of 10 trials in their modal category for the humerus. If they varied to other categories they varied to adjacent categories. The humerus component affirmed the notions of level stability and intransitivity (Roberton, 1978).

The action of the forearm component demonstrated stability and intransitivity and received good support across the analysis of trials. The component showed stability in that each year the modal level occurred in at least 8 of 10 trials. If the child changed levels it was to an adjacent level. An important additional finding by Roberton (1978) highlighted the relationship between components; Roberton noted the second graders were reaching advanced humeral action before they were achieving advanced forearm action. This highlights the potential ancillary effects on the forearm component from the development of the humerus component. The longitudinal test supported the hypothesized level orderings for the forearm. Similar with the humerus component, the majority of children showed little developmental change in the forearm, and no child progressed through all three levels of the forearm component (Roberton, 1978).

The pelvic-spinal action did not meet stability or intransitivity in Roberton’s (1978) because in only two of the three years did all children have at least 5 of 10 trials in their modal level. The children also showed non-adjacent level variation or "skips" across trials. Common skips occurred from the level no trunk action to spinal rotation with pelvis stationary, from extension and/or flexion of the trunk to block rotation, block rotation to block rotation plus lateral flexion of the trunk, and spinal rotation with pelvis stationary to differentiated rotation. One-third of the children showed no developmental change in any of the levels studied, and few children were observed to go through every level. After this analysis, Roberton (1978) edited the trunk category to consist of three
levels ranging from no trunk action or forward-backward movements at level one, to block rotation in level two, to differentiated rotation at level three (Halverson, et al., 1982). Further longitudinal testing of the trunk component was needed to establish developmental validity (Roberton, 1978).

The comprehensiveness or the ability of the sequence to describe the movement patterns prevalent in the population was support by DiRocco & Roberton (1981). DiRocco & Roberton (1981) concluded from their work that the component approach was comprehensive in describing the throwing patterns of children with mental retardation. DiRocco and Roberton also noted that the sequence could be used as an instructional tool for assessment of student’s throwing ability.

Advantages and disadvantages. While the developmental validity of the component approach has not been established for all components, it remains the recommended qualitative analysis instrument, and an important tool for instructional planning and assessment of the overarm throw (DiRocco & Roberton, 1981). A recent motor development review found 24 studies had analyzed throwing from a component approach. The component approach is a recommended tool for researchers because individual body components and movement profiles or body patterns can be assessed to determine the relationships between and within components. Additionally, the component approach is more sensitive than the total body approach in detecting minor changes in throwing patterns (DiRocco & Roberton, 1981).

The component approach is also advantageous because it has been found to correlate with velocity (Atwater, 1979; Roberton & Konczak, 2001). Roberton and Konczak (2001) studied 17 girls and 22 boys longitudinally at age 6, 7, 8, and 13. The
dependent variables of ball velocity and throwing form (step, trunk, humerus, and forearm) were measured to determine the relationship between the two measures. The basic principle supported in this study was the relationship between process (components) and product (velocity) scores. Advanced process scores (more advanced movement patterns) resulted in superior outcomes, while primitive movements resulted in poorer outcomes (Roberton & Konczak, 2001). Roberton and Konczak (2001) highlighted the relationship by reporting the component sequences accounted for 69 to 85% of the variance in total velocity each year.

Another advantage of the component approach is that with minor modifications the component approach has been successfully used to assess throwing patterns of baseball players during a game (Barrett & Burton, 2002). Barrett and Burton (2002) modified Roberton’s (1982) component approach to include only the step, backswing and forearm components to assess form used during gameplay. Barrett and Burton (2002) examined 3,684 throws used by college baseball players over the course of seven games to determine the throwing form. Barrett and Burton categorized the throws by distance and concluded that players alter their patterns depending on the task demands. Barrett and Burton (2002) also determined the modified component approach for gameplay was a valid assessment, and sensitive to detect variations in throwing patterns used during gameplay. Barrett and Burton (2002) suggested the modified component approach for gameplay could be used to assess throwing of children in an authentic context, but there is still a need to determine the extent to which the Barrett and Burton (2002) sequence for gameplay can be used to assess components during game play in physical education.
One weakness of the component approach is the difficulty for practitioners to use the component approach to assess the arm components and higher levels of the trunk component. It is very difficult for practitioners to assess in real time using the component approach while instructing, or to analyze components without the assistance of videotape analysis. Attempts have been made to modify the component sequence so teachers and coaches can analyze the components without the assistance of a video camera (Mosher & Schutz, 1983), but the humerus and forearm remain difficult components to assess for practitioners without the use of videotape.

**Throwing Development**

A discussion of the phases of the throw, as well as the critical features of the throw sets the foundation to describe and explain the development of throw. Additionally, to understand throwing development it is important to examine the various influences on the throwing pattern exhibited. The constraints model provides structure to review of the various factors influencing throwing development. Understanding the factors influencing the throw will provide a backdrop to discuss the various instructional approaches to developing advanced throwing patterns. Collectively, this section addresses and reviews the throwing motion, discusses the factors influencing throwing development, and strategies used to develop advanced throwing patterns.

**Phases of the Throwing Motion**

Throwing consists of three phases: preparatory phase, execution (action) phase, and follow-through phase. The preparatory phase consists of all the movements directed away from the intended line of projection (Payne & Isaacs, 2001). The preparatory phase includes body positioning such as the sideways orientation and a contralateral stepping
pattern. The execution phase consists of the force production movements performed in the direction of the throw (Payne & Isaacs, 2001). The actions of the trunk, humerus, and forearm are part of the execution phase. The follow-through consists of all the movements after the release of the ball (Nichols, 1994). Researchers have determined that instruction has been most successful for the preparatory movements, and less successful in directly instructing the execution phase of the movement (Mosher & Schutz, 1983; Oslin et al., 1997; Stroot & Oslin, 1993).

**Critical Features**

Critical features are the most important aspects of the skill, and they need to be performed a certain way to be successful in the execution of the movement (Knudson & Morrison, 1996). Knudson and Morrison (1996) summarized the critical features of the throw to include: relaxation, leg drive and opposition, strong throwing position, sequential coordination, the angle of release, and inward rotation of the arm. Biomechanics and kinematic analysis of the throwing motion has been integral in describing the critical features of the throw.

Preparation of muscles and joints in a position to contribute to the performance of the throw is important for successful execution of the movement. Relaxation is key for muscles and joints to be able to contribute force, as rigidity would limit range of motion (Knudson & Morrison, 1996). Positioning the body, and relaxation in the musculature, can allow the body to take advantage of linear and angular momentum, which contributes to throwing performance.
Leg drive. Leg drive and stepping with opposition is an important critical feature that impacts other components of the throw (Knudson & Morrison, 1996; Oslin, et al., 1997). The throwers initial stance (non-throwing shoulder pointed to the target) and a contralateral step, sets up later rotation of the body and contributes a great deal of power for the throw (Knudson & Morrison, 1996). The sideways orientation to the target is suggested in many instructional programs and physical education textbooks (Graham et al., 2001; Fronske et al., 1997).

Leg drive contributes power to the throw only if proper alignment of the torso and pelvis is in a closed position. The closed position has the pelvis and upper torso (non-throwing side hip and shoulder) pointed toward the target. The closed position also helps to align the stride foot with the intended target (Stodden, 2002). The step or stride should be toward the intended target, as stepping away from the intended line would constrain trunk rotation. If the performer steps away from the intended line, the hips may prematurely rotate, reducing the ability to generate force from the trunk rotating. The step away from the intended line of flight toward the throwing side (i.e., to the right of the intended line of flight if the thrower is right handed) may also close the hips off to rotation.

After assuming the sideways orientation, the step and leg drive is a critical aspect. The suggested length of the stride is at least half of the thrower’s height (Roberton & Halverson, 1984). During the step toward the intended target the pelvis begins to slightly open, or rotate just before the foot contacts the ground (Stodden, 2002). This is the beginning of the lag phase; the upper torso does not rotate with the pelvis during this initial rotation allowing the thrower to use linear and angular momentum (Stodden,
Linear and angular momentum are important components of the kinetic link principle (Carr, 1997). Timing and coordination is key to capture linear and angular momentum (Carr, 1997).

**Strong throwing position.** Another critical feature is a strong throwing position of keeping the arm at a right angle to the spine forming an “L.” A strong position can maximize the speed transferred from the rotation of the trunk to the arm segments. This strong throwing position sets the stage to take advantage of the kinetic link principle (Stodden, 2002). Sequential coordination or timing of body segments can transfer energy from the proximal segments of the body to the more distal segments. When the body begins sequential rotation the energy is transferred from the legs and trunk to the more distal segments of the arm and could be the most important feature in developing elite levels of the overarm throw (Knudson & Morrison, 1996; Stodden, 2002).

**Rotational inertia and lag.** Inertia is the resistance to change (Carr, 1997). Rotational inertia is described as when rotating a body segment an individual applies a torque about an axis or joint (Stodden, 2002). During rotational inertia, the greater the mass of a segment and the further the mass is distributed from the axis of rotation, the greater the rotational inertia. Rotational inertia is important to the throw because rotational inertia is necessary for lag in the humerus and forearm. This lag is a result of the kinetic link and is necessary for the whip like action of the arm for increased velocity. As part of the kinetic chain, the momentum produced by the rotation of the pelvis and trunk have greater rotational inertia, and have smaller angular velocities due to their greater mass (Knudson & Morrison, 1996; Southard, 1998, 2002). The more massive slower moving parts (pelvis and torso) shift forward, while the lighter segments complete
their backward extension. The lag that appears in the humerus and forearm components is a result of the flexibility within the human body to allow the distal segments to lag behind the rotating pelvis and trunk (Stodden, 2002). The lag stretches the muscles and readies them for a powerful contraction during the execution of the throw (Knudson & Morrison, 1996; Southard, 2002). Proper preparatory positioning of the trunk and throwing arm, along with proper timing of the body segments, capitalizes on this transfer of momentum. Stodden, Fleising, McLean, Lyman, and Andrews (2001) studied proper positioning and determined that it led to an increase in maximum throwing velocity in baseball pitchers as a result of the transfer of momentum.

Release and follow-through. The ball release and the follow through are the last critical features to be executed in the throwing motion. The angle of release when throwing the ball in most sport situations is between 35 and 42 degrees (Dowell, 1978). Many young throwers throw at too high of an angle, decreasing the distance thrown, while increasing the time the ball is in the air (Knudson & Morrison, 1996). The follow-through is another critical feature and is described as the inward rotation of the arm that provides the final push for the ball. The inward rotation of the arm contributes force to the throw and is also important for injury prevention, allowing for safe dissipation of momentum from the thrower’s body.

Critical features are essential to the successful execution of the movement pattern. To identify critical features over developmental time it is important to study attractors and attractor pathways. Attractors and attractor pathways can be useful in determining ancillary effects. Ancillary effects are the influence of changing one aspect or component of the throw on other aspects of the throw. Attractors, attractor pathways, and ancillary
effects can shed light on the development of throwing, determine common avenues of change, and ultimately contribute to a development of a content progression for teaching the throw (Langendorfer & Roberton, 2002a, 2002b).

Attractors and Attractor Pathways

In throwing, Langendorfer and Roberton (2002a) studied attractor pathways and the overarm throw for the trunk, humerus, and forearm components. Langendorfer and Roberton (2002a) indicated that the strongest attractors for children of 5.7 years for the trunk, humerus, and forearm component were 2-1-1 (block rotation of the trunk, humerus oblique, no forearm lag), 2-2-1 (block rotation of the trunk, humerus aligned but independent, no forearm lag), and 2-2-2 (block rotation of the trunk, humerus aligned but independent, forearm lag). A moderately strong attractor at this age was the relatively primitive pattern of 1-1-1 (no trunk action, humerus oblique, no forearm lag). At age 6, the strongest attractors were 2-1-1, and 2-2-2. At age 7, 2-3-2 (block rotation of the trunk, humerus lags, and forearm lag) became a more stable attractor along with 2-1-1, and 2-2-2.

Based on this evidence, Langendorfer and Roberton (2002a) suggest the attractors and attractor pathways highlight the necessity of a rotating trunk for advanced arm action. The absence of a rotating trunk can act as a constraint, limiting the development of advanced movements of the humerus and forearm. The common attractors found by Langendorfer and Roberton (2002a) highlight the link between trunk rotation and levels of the humerus and forearm but unclear is the direction of the relationship between differentiated rotation of the trunk (level 3) and humeral lag (level 3). Humeral lag may be necessary to see differential rotation of the trunk, or differentiation of the trunk is
necessary to see humeral lag. Early in development it seems that at least block rotation of the trunk is necessary for humerus aligned but independent (level 2), but differentiation of the trunk (level 3) may appear after humeral lag is reached (Langendorfer & Roberton, 2002a). Other possible factors influencing the development of advanced levels of the trunk and humerus component could include the relationship between the backswing component and arm component levels, and the relationship between the backswing and the initiation of forward rotation (Langendorfer & Roberton, 2002a). Overall, studying attractors and attractor pathways can shed light on the development of throwing, as well as contribute to the development of a content progression for teaching the throw (Langendorfer & Roberton, 2002a, 2002b).

Ancillary Effects

Studying attractors and attractor pathways can also highlight ancillary effects, which are changes in non-targeted components as a result of a change in another component (Oslin, et al., 1997). Changes in one body component can act as a constraint on other body components, increasing the likelihood of occurrence of certain component levels while limiting the appearance of other component levels. Determining the components that produce the greatest ancillary effects can provide a hierarchy of components to target during instruction.

The step component and assuming a sideways orientation to the target prior to the execution of the throw appears to have the greatest ancillary effects (Garcia & Garcia, 2002; Oslin et al., 1997). The ancillary effects of a long step and a sideways orientation can “set up” the body for at least block rotation of the trunk, which in turn would “set up” advanced arm actions (Garcia & Garcia, 2002). The development of a rotating trunk is
also associated with changes in the humerus which is linked to the development of advanced forearm action (Langendorfer & Roberton, 2002a, 2002b). Oslin and colleagues (1997) suggest with these ancillary effects, instruction should focus on creating a step with opposition, then at least block rotation of the trunk, and then hoping for further ancillary effects in the arm components.

**Constraints Model and Throwing**

While attractors and ancillary effects highlight the relationship between components and throwing performance, the constraints model (Newell, 1984, 1986) provides a useful framework to discuss the various factors influencing the development of throwing. Individual, environmental, and task constraints have an impact on the development of the throw and the throwing pattern exhibited. Topics to be explored in this section will address these categories of constraints including such topics as gender differences in throwing, and the influence of instruction on throwing.

**Individual Constraints**

Individual or biological constraints are factors to consider when planning throwing activities and instruction, because many of these factors that cannot be changed by physical education teachers or coaches. Physical education teachers must be aware of individual constraints to provide developmentally appropriate instruction and practice. Developmentally appropriate instruction must consider the ability, body characteristics, and age of the individual (Payne & Isaacs, 2002).

Gender is a factor in the development of throwing, and for this study gender is considered an individual constraint. Gender differences in throwing are the largest of any fundamental motor skill and are present in throwing form, accuracy, and force (Nelson, et
Gender differences are categorized as an individual constraint because of the biological factors associated with gender differences. There are also environmental factors that could contribute to gender differences; these factors will be discussed when comparing the influences of both biological and environmental factors on the throw. The purpose of examining gender differences in this study is to raise awareness of the large persistent gender differences in throwing and the potential contributing factors to those differences.

**Gender Differences**

Throwing has the largest gender differences in performance than any of the other fundamental motor skills (Nelson, et al., 1991; Thomas & French, 1985; Williams, 1996). Gender differences exist for throwing distance, speed, accuracy, and form with boys outperforming girls at every age and in every category (Roberton & Konczak, 2001).

**Force.** Thomas and colleagues (1994) found the gender differences for throwing distance are three times the size of gender differences for other tasks. Morris, Williams, Atwater, and Wilmore (1982) found gender differences for distance from ages three to six were large enough that the performance of five and six year old girls was not significantly different from that of three and four year old boys. Thomas and French (1985) determined in a meta-analysis of 21 throwing studies (5 accuracy studies, 11 distance studies, and 5 velocity studies) that boys’ performance exceeded girls by 1.5 standard deviations as early as ages 4 to 7 years when throwing for force and distance. The gender differences increased rapidly and by age twelve years the boys were 3.5 standard deviations ahead of the girls for throwing speed.
Halverson and colleagues (1982), and Roberton and colleagues (1979) identified gender differences for velocity between boys and girls that continued to increase with age. Halverson and colleagues (1982) calculated a yearly rate of change of velocity for boys to be 5 to 8 ft./sec./year (Halverson et al., 1982). In comparison, the girls’ yearly rate of change was 2 to 3 ft./sec./year in kindergarten to second grade, and 2 to 4.5 ft/sec/year from third to seventh grade (Halverson et al., 1982; Roberton et al., 1979). In other countries gender differences also exist for distance and velocity. Sakurai & Miyashita (1983) found significant gender differences in Japanese children at age five, and for ages seven through nine.

**Accuracy.** Gender differences are not limited to only forceful throws because boys are more accurate than girls when throwing at targets (Moore & Reeve, 1987; Moore, Reeve, & Pissanos, 1981; Thomas and French, 1985). Moore and colleagues (1981) studied five intact kindergarten classes and determined significant gender differences with boys throwing farther and more accurately than girls. Moore and Reeve (1987) studied six boys and six girls in each of three age groups (5-6, 7-8, and 9-10 years old), and found that boys were more accurate than girls when throwing at three different size targets.

While the attributed factors for gender differences for forceful throws have been debated between biology and environment, accuracy differences have been attributed to environmental factors (Langendorfer, 1990). Environmental factors are the attributable cause because force was not a factor in the accuracy tasks. Biological factors, such as body size, segment length, and coordination have a great influence on throwing for force. Accuracy tasks requires the ability to adapt and change movement patterns to meet the
accuracy goal (Langendorfer, 1990). Boys are more accurate and appear to be better able
to adapt their movements to meet the demands of accuracy (Langendorfer, 1990). This
could be attributed to either boys having a more advanced movement pattern with more
movement options available to use under different conditions, or the boys having a
variety of throwing experiences that practice different movement options that can be used
under different task conditions (Langendorfer, 1990).

Form. Gender differences are prevalent not only in product measures, but also
process measures with girls lagging behind boys in throwing form (Butterfield & Loovis,
1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton,
2002a, 2002b; Sakurai & Miyashita, 1983; Thomas & Marzke, 1992). Gender differences
in form have also been found in other countries. Sakurai and Miyashita (1983) studied
180 children ages 3-9 in Japan and determined that males ages 5 to 8 had a more skillful
throwing action than females. When focusing on specific body components of the throw,
girls have been found to lag behind the boys in all body components of the throw
(Halverson et al., 1982; Nelson et al., 1991). Gender differences in form (body
components) could also be a factor in the prevalence of gender differences in the product
scores of throwing.

Biological and Environmental Factors. The factors contributing to gender
differences in throwing have been attributed to both biological and environmental factors
in the literature (East & Hensley, 1985; Nelson et al., 1986; Thomas & French, 1985).
Biological factors deal directly with individual constraints such as anthropometric
characteristics and neuromuscular coordination. Environmental factors include
socialization, opportunities to practice, and differential effects of instruction. Nelson and
colleagues (1986) suggested biological factors played a greater role in gender differences than environmental factors. The biological factors of joint diameters, shoulder/hip ratio, and sum of skinfolds accounted for 10% of the variance in gender differences (Nelson et al., 1986). Nelson and colleagues (1986) determined, with the same ANCOVA procedures, that only an additional 4% of the original 41% of the variance was explained by the environmental factor of playing with older children. More specific biological measures have been correlated with gender differences including: a moderate correlation between boys’ arm muscles and distance thrown (Nelson et al., 1991), boys having a greater external to internal rotation rate and girls having less of a maximum angle of twist (Thomas and Marzke, 1992), neuromuscular coordination (Yan et al., 2000), and body awareness (Garcia & Garcia, 2002).

Environmental factors influencing gender differences in throwing include: sociocultural influences, opportunities to practice throwing, and differential effects of instruction. Gender roles and gender identification play a key role in sociocultural influence. A child’s perception of their gender role influences choices for activities, toys, and games (Thomas & French, 1985). Socialization factors such as the limited prevalence of advanced female throwers to imitate, and girls noticing many females throwing with a less mature pattern with poorer performance when compared to boys, could also have an impact on gender differences (East & Hensley, 1985; Rippee et al., 1990). Socialization also plays a part in gender identification, with parents and friends the major socializing influence of gender identification (Payne & Isaacs, 2002). The key influencing agent for young girls are parents (East & Hensley, 1985), who seem to emphasize and encourage the development of skills for boys more than girls (Nelson et al., 1986; Thomas &
French, 1985; Thomas & Marzke, 1992). Additionally, fathers may be a large influence by pushing their daughters towards traditional female activities such as gymnastics or dance, while pushing their sons to be rough and tumble (Butterfield & Loovis, 1993; East & Hensley, 1985).

Sociocultural factors have an impact on gender differences in throwing by influencing the opportunity to participate and practice throwing (Butterfield & Loovis, 1993; Halverson et al., 1982; Thomas & Marzke, 1992). Organized activities, such as youth sport, can be another contributing environmental factor. Boys tend to have more organized experiences in throwing, in sports such as baseball (Butterfield & Loovis, 1993; Halverson et al., 1982; Thomas and Marzke, 1992). Along with more experience, Butterfield and Loovis (1993) suggest differences exist in the quality of throwing opportunities for boys and girls. Butterfield and Loovis contest that even though girls might participate in youth sports comparable to boys, they are not experiencing the same quality opportunities to develop their throwing skill.

Performance in throwing activities could be another factor influencing boys to practicing throwing activities, while pushing girls away from throwing activities (East & Hensley; Garcia & Garcia, 2002). East and Hensley (1985) speculated sociocultural factors have an early influence on participation in throwing activities, but as an individual becomes more proficient in throwing the performance-oriented factors supplant sociocultural factors. Performance-oriented factors, such as performance feedback, could be a very motivating factor in the boys’ continued involvement in throwing activities. These same factors push less skilled girls away from throwing activities, which contributes to the expanding gender differences over time (East & Hensley, 1985; Garcia
& Garcia, 2002). Garcia and Garcia (2002) noted that performance factors, along with teacher interactions play a role in gender differences. Girls seemed to be more motivated in throwing activities by the desire to please the teacher and had a greater interest in teacher verbal encouragement, stickers, and smiles. In contrast, boys were more motivated by the performance-oriented context and their performance, than teacher interactions. Garcia and Garcia (2002) and East and Hensley (1985) both noted performance factors were a greater influence for the more proficient movers.

Implications of these findings to physical education teachers are that to maintain the boys’ or more skilled performers’ motivation teachers could provide performance-oriented feedback. To maintain the boys’ or less skilled performers motivation teachers can interact and offer encouragement, while providing instruction to improve performance. These finding also have implications to physical education because if the performance-oriented outcome measures are assessed and stressed by the teacher, the gap between genders in throwing performance would theoretically expand because of the emphasis on performance. The influence of performance factors on gender differences highlights the importance of not only teaching throwing effectively, but to evaluate both product and process in the performance of the throw especially to young girls or children with immature patterns.

_Biology or Environment?_ Gender differences in throwing cannot be attributed to solely biological or environmental factors. Within the constraints model, both biological and environmental factors would have an influence on the development of throwing. The research on gender differences is of importance to this current study because of the possible differential effects instruction may have on gender. Research has found
persistent gender differences remain after instruction (Browning and Shack, 1990; Dusenberry, 1952; Garcia & Garcia, 2002; McKenzie et al., 1998; Thomas et al., 1994). This highlights the need to develop strategies in teaching the overarm throw that can help both boys and girls to improve their performance in the overarm throw.

Task Constraints

Task constraints are focused directly on the goal of the activity (Newell, 1984, 1986). A teacher can easily manipulate and/or highlight task constraints. Task constraints influence the throwing pattern utilized and different task goals yield different throwing patterns and performance (Barrett & Burton, 2002; Hamilton & Tate, 2002; Langendorfer, 1990).

The two major areas of research on task constraints and throwing include: force versus accuracy, and distance versus accuracy. For the task of throwing for distance and throwing for accuracy, Hamilton and Tate (2002) found that distance from the target was found to significantly impact the step, trunk, and humerus component. This supports distance from the target as a control parameter for the components of the step, trunk, and humerus. Hamilton and Tate (2002) did not find a significant influence of accuracy on body components. Hamilton and Tate (2002) hypothesized this could be the result of the throwing targets being too large to act as a constraint.

The force versus accuracy task constraint has received much more attention in motor development literature. Roberton (1987) determined the task constraints of force and accuracy influenced product scores. Roberton (1987) reported velocity was reduced by one developmental year when comparing a “throwing hard” condition versus an accuracy condition. However, Roberton (1987) found little change between tasks in
primitive throwers. Langendorfer (1990) determined that throwing for accuracy was characterized as developmentally meaningful for throwing form. Males improved close to one developmental level when changing from an accuracy goal to a force goal (Langendorfer, 1990). There was a significant difference between the force and accuracy task in the step, trunk, backswing, trunk, humerus, and forearm components. Lorson (2001) determined the task of “throwing hard” changed the step components compared to a group that did not receive the “throwing hard” prompt.

The change in advanced throwers and no change in primitive throwers in both the Langendorfer (1990) and Roberton (1987) studies can be attributed to more advanced throwers having more movement options available to meet task demands. Typically, more advanced throwers regress and use a more primitive option when the task permits such latitude, but a primitive thrower uses the same primitive movements across tasks (Langendorfer, 1990). The lack of change across tasks by primitive movers suggests primitive movers might not have the movement options available, or be receptive to change in task demands (Langendorfer, 1990).

The impact of the task on developmental levels and performance make it imperative for teachers and researchers to be keenly aware of task constraints. Teachers can use task constraints to their advantage to promote the use of the preferred or advanced movement pattern without direct instruction. The tasks practiced can influence the development of a mature throwing pattern. During initial instruction of the overarm throw the focus should be on throwing for force to evoke the most mature pattern (Barrett, 1995; Langendorfer, 1990; Roberton, 1987, 1996). As the throwing motion develops, the teacher can narrow the target focus, while continuing to emphasize
throwing “hard” to help develop both the accuracy and force components of the throw (Barrett, 1995; Langendorfer, 1990; Roberton, 1987, 1996). This will promote the use of a more advanced motion during practice and will allow the thrower to begin to develop a repertoire of movement patterns that can meet different task goals.

*Environmental Constraints*

Environmental constraints are factors external to the learner. There are other environmental constraints that influence throwing beyond the environmental factors discussed during the gender differences section. The environmental constraints described in this section have a more immediate influence on throwing performance. Teachers can change or influence environmental constraints in their selection of equipment. Ball size and weight can act as environmental constraints on throwing performance (Southard, 1998). Other activities that involve overarm throwing such as football, softball, or the javelin throw utilize many of the same mechanics and principles of throwing, but may show differences in the movement pattern due to the size, shape, or mass of the object thrown (Southard, 1998). The size, shape, and mass of the ball are important factors to consider and have been shown to change the development of the throwing motion (Southard, 1998). Environmental constraints can be used to improve throwing performance. Baseball coaches have used the mass of the ball as a training tool to increase ball velocity in pitchers (DeRenne, Tracey, and Dunn-Rankin, 1985).

*Instruction and Throwing*

Teachers and coaches can change and manipulate task and environmental constraints to promote the use of advanced movement patterns. A primary factor influencing throwing is the instructional strategy used and the tasks and activities selected
to help teachers develop advanced throwing patterns. This section will review the influence of instruction on the performance of the overarm throw. The first portion of this section will address general instruction that includes practice. These studies highlighted the importance of instruction and practice to improve the throw. Other aspects discussed in this section narrow the focus to the influence of teachers on throwing performance, and the ability of teachers to teach the overarm throw. The last topic of this section addresses critical cues, an instructional strategy that has been used by teachers to effectively and efficiently instruct the throw.

*Instruction and throwing performance.* A variety of instructional programs have improved both throwing form and throwing performance. Dusenberry (1952) studied the effects of instruction on throwing distance of 56 participants ranging in age from three to seven years. One group (n=28) received instruction and practice in throwing for twice a week over a period of three weeks, while the other group (n=28) received only practice. The instruction and practice group gained 4 feet in throwing distance and the practice group had a gain in scores of 1.33 feet. The results of the study indicated that specific training in throwing over a three-week period resulted in learning occurring at or above the effects of maturation and general practice. The results also indicated that boys (+3.95) improved more in distance thrown than girls with the same amount of training. Dusenberry (1952) noted that radical changes in “style” (pattern) were sometimes followed by poorer throws, which were observed to be due to lack of coordination of body parts.
Research has shown that general practice of the overarm throw without direct instruction or instruction of motor skills other than throwing did not significantly impact the development of the throw (Halverson & Roberton, 1979). Halverson and Roberton (1979) examined the influence of an eight-week movement program with overarm throwing instruction versus the same program with no throwing instruction. A comparison group, which did not receive either program, was also utilized to determine the influence of instruction on 45 kindergarten children. The group that received throwing instruction was significantly different from the other two groups on the components of the throw. Based on these findings, Halverson and Roberton determined throwing must be specifically targeted during instruction to improve throwing form.

Moore and Reeve (1987) studied five intact kindergarten classes to compare direct instruction to exploratory methods of instructing the throw. Both interventions occurred three times a week for four weeks. Participants were evaluated on throwing distance and accuracy. Moore and Reeve determined no significant difference in throwing performance between the two methods of instruction. No method was significantly more effective than the other, and both types of instruction were successful in changing performance. A limitation of Moore and Reeve’s (1987) study was the use of only product measures to assess changes in throwing as a result of instruction. The product measures may not have been sensitive to minor changes, and ceiling effects could have occurred for the distance measure.

Adams (2001) studied the differential effects of different types of modeling on the learning of the overarm throw. The three interventions were a correct model with verbal descriptions of critical elements, a learning model with verbal descriptions of key
elements, and verbal descriptions only. The learning model provided to the students contained missing or incorrect aspects of the throw that could be recognized by the learners. All participants, regardless of the model, improved from first session to the last session. Adams suggested that presenting a correct throwing model during instruction is not essential for learning the throw because a learning model was equally effective.

Not all instructional interventions have improved throwing performance. Browning and Shack (1990) studied 41, sixth-grade girls to determine if specific instruction of the throw would affect throwing performance. The instructional program provided “specific instruction” consisting of reminders about technique during gameplay and a written handout. Specific instruction did not significantly change throwing performance from pretest to posttest on the AAHPER Softball Skill Test. The lack of significant change could have been due to a poorly developed or implemented instructional program that focused on changing form but assessed the throwing product measures of distance, speed, and accuracy. Another possible explanation is the instructional intervention either did not provide enough practice, or the strategies to remind the participants about form were not effective enough to significantly impact throwing performance.

A trained instructor, either a physical education teacher or classroom teacher, can provide instruction to improve throwing performance. Graham and colleagues (1991) examined the influence of instruction provided by either a trained physical educator or a classroom teacher on first and third-graders’ qualitative and quantitative throwing performance. The physical education teachers in the study were provided an organized curriculum to follow for their physical education classes, whereas the classroom teacher
groups were instructed by classroom teachers with no organized curriculum to follow. Each of the schools in both the physical education and classroom teacher groups had similar equipment and facilities, the only differences were between the organized curriculum provided and the physical education specialists being trained. A total of 60 first and third graders from schools in two counties were examined longitudinally over the course of three years. Throwing performance was assessed on an accuracy task and for four qualitative aspects of the throw (sideways to target, backswing, trunk rotation, and weight transfer).

Graham and colleagues (1991) found the students who were taught by the classroom teacher had more sequential hip/shoulder rotation and were more skilled in throwing than throwers who were instructed by a trained physical educator. This finding may be troubling to some physical education teachers or teacher educators, but a possible explanation is the classroom teachers’ “recess like” physical education had more throwing activities overall, and more forceful throwing opportunities (ex. dodgeball). In contrast to the classroom teacher, the physical education specialist may have been more concentrated on the development of all motor skills, not just throwing (Graham et al., 1991).

McKenzie and colleagues (1998) found the throwers in the SPARK programs performed significantly better on distance and accuracy tasks compared to students in a regular physical education program. The trained classroom teacher class in SPARK performed better on distance and accuracy than the physical educator trained with SPARK. McKenzie and colleagues (1998) suggest object control and throwing skills can be improved using the SPARK program with either a trained physical educator or a
classroom teacher. Teachers, whether classroom or trained physical educators, can improve throwing performance using a packaged program such as SPARK. Without a packaged program, teacher’s knowledge and ability could become an important factor in developing and providing effective instruction.

*Teacher’s ability to instruct throwing.* The ability of teachers to provide appropriate instruction is a result of their content knowledge, pedagogical knowledge, and pedagogical content knowledge. Pedagogical content knowledge is the bridge over the gap between content knowledge and translated teaching actions (Walkwitz & Lee, 1992). A key question is whether teachers can use content knowledge about throwing to improve throwing performance. Mosher and Schutz (1983) suggest there is little evidence that teachers incorporate motor development sequences, an important part of a teacher’s content and pedagogical content knowledge, into their instructional practice. Teachers fail to use these sequences because they either evaluate on product scores, or need a camera to assist in accurately assessing body components (Mosher & Schutz, 1983). One strategy to develop teacher knowledge could be to provide training for teachers. Walkwitz and Lee (1992) found that improving content knowledge of teachers through a motor development orientation in the overarm throw improved teacher behaviors, which resulted in a significant impact on the stepping patterns of children.

The ability to analyze movement also plays a role in teacher’s ability to improve throwing in children (Stroot & Oslin, 1993). A teacher’s ability to qualitatively assess movements is important because it can inform or assist teachers in providing appropriate skill related feedback (Stroot & Oslin, 1993). Skill analysis can also be a useful tool to determine student achievement in formative assessments (Stroot & Oslin, 1993). Stroot
and Oslin (1993) determined that teachers might have the declarative knowledge of throwing, but were unable to accurately assess the throw and give appropriate feedback. Experience with the skill and providing feedback is a contributing factor to the skill analysis ability of the teachers in this study. Stroot and Oslin (1993) suggest that teachers might know the suggested cues, but not when to provide cues, which cues to provide, and who needs the cues. One avenue to improve the instruction of the overarm throw is for teacher preparation programs to focus on providing not only the necessary content knowledge, but also provide opportunities to utilize this knowledge in teaching throwing. The experience and practice of providing appropriate specific feedback on deficient components during teacher preparation can give future teachers experience to draw upon when teaching throwing in the future. Additionally, motor development and physical education researchers can better inform preservice teachers and practitioners about strategies and techniques to improve a variety of motor skills. There is a need to translate research findings into instructional strategies and information for teachers in an easily understood, user-friendly language to facilitate the use of research in practice.

Stodden (2002) developed and initially tested an instructional program that can be an example of translating research findings into an instructional approach. Stodden (2002) created an instructional approach grounded in key biomechanical principles and critical features of the throw. The biomechanical approach focused on capitalizing on the kinetic link principle, along with linear and angular momentum (Stodden, 2002). Capitalizing on the kinetic link principle and linear and angular momentum is achieved through proper positioning of the humerus, forearm, and wrist for momentum transfer during the throwing motion. The biomechanical approach (BP) is comprised of four
stages. The first stage emphasizes the correct positioning of the humerus and forearm during the arm cocking and arm acceleration phases of the throw. Stage II emphasizes forward linear momentum (stepping action) and forward flexion of the trunk. Stage III incorporates rotation of the trunk to help in the transfer of momentum. Stage IV combines forward linear movement (step) with the rotational movements of the trunk.

The BP approach is structured differently from traditional instructional programs of the throw. Traditionally instructional programs for the overarm throw have focused first on the step. Traditional approaches to the overarm throw have been successful in improving preparatory positioning and the step and trunk components, but have been less successful in changing the humerus and forearm components (Lorson, 2001; Oslin et al., 1997). The BP approach differs from traditional approaches because of a focus on the humerus and forearm during the initial stages. The humerus and forearm are part of the action phase and final phase of the throwing motion. While the biomechanical approach is not a true backward chaining sequence, it is a form of component specific instruction. Oslin and colleagues (1997) were successful in improving the overarm throw with component specific instruction using two forward chaining sequences.

The BP program seeks to improve the humerus and forearm by practicing and developing proper positioning of the humerus and forearm to develop those components. The BP program takes into account the developmental level characteristics described within Roberton and Halverson (1984) component approach. Each level of the BP program is based on the characteristics of the general description of the development of throwing (Stodden, 2002). The BP program follows a developmental progression for the least advanced throwing pattern (Stage I) to most advanced level (Stage IV). Stodden
(2002) views each level of the biomechanical approach as a completed throw, not as a component or aspect of the throw. Thus, the first stage of the program is a complete throwing motion, but is a low developmental profile consisting of only arm actions with no foot or trunk action. The BP program adds one concept at each Stage, adding the step and linear momentum to the proper positioning of the arm in Stage II, trunk rotation is added in Stage III, and the combination of a step and trunk rotation is developed in Stage IV. The focus on each level emphasizes learning and developing the key aspect of that stage. This allows the learner to focus on one aspect at a time, rather than learning all of the aspects of the throw together. Under Dynamical Systems Theory and the Constraints model, the program decreases the complexity and the number of factors influencing the throwing pattern, allowing the leaner to think and feel the targeted movement of the stage. This allows the learner to develop the concept, and then build on the concept in future stages.

Stodden (2002) found initial support for this instructional approach by comparing the changes in throwing performance between the biomechanical approach and a traditional instructional approach based on Graham and colleagues (2001) cues. The study examined the changes in body component levels and ball velocity in 34 kindergarten students. Findings revealed that females improved significantly in the humerus and forearm action, while the boys improved significantly in the humerus action. Stodden (2002) also determined that the females in the Graham group improved less than the males, suggesting differential effects of instruction on gender for the group that received the Graham and colleagues (2001) cues. The Graham group did realize a change in the gender differences for the stepping action from significant gender
differences at pretest to non significant at the posttest. The biomechanical group did not demonstrate any posttest gender differences in the form components of stepping action, trunk action, humerus action, and forearm action. There were continued gender differences in ball velocity for both groups. This initial testing of the biomechanical program suggests this program may be an option in providing effective and efficient instruction of the overarm throw, and as a means of providing instruction to reduce or eliminate gender differences. A limitation of the initial testing of the biomechanical-based instructional approach was that an expert researcher implemented the program. Unknown is whether a physical education teacher can implement this instructional approach effectively to improve the overarm throw in a class.

*Critical cues.* While researchers have determined instruction and practice have improved the throw, the recent focus has narrowed toward not only providing effective instruction, but also efficient instruction. Critical cues are tools that teachers can use to promote efficient and effective instruction. A critical cue is a key word or short phrase that communicates the critical elements of the skill in a descriptive language that is easily understood by the learner (Landin, 1994). Critical cues can also be called verbal cues or teaching cues. If the differentiation between critical cues and verbal cues is necessary, critical cues are verbal cues that contain the critical features of the skill (Knudson & Morrison, 1996).

Critical cues carry great importance to beginners during initial instruction and are one of the best forms of communication and feedback for performers (Parson, 1998). Cues provide a common vocabulary that is easily shared and communicated between the teacher and performers (Knudson & Morrison, 1996). The shared language created by
Cues can be used to enhance demonstrations or models, can create a shared language of critical features that could add to the students declarative knowledge about the skill, can be combined with self-talk strategies during practice (Anderson, Albrecht, & Vogel, 1999), and can be used in assessment.

Cues focus the learner’s attention on the key elements of the movement. The attentional demands are very high for beginning learners, and cues can help the learner focus on the key elements and dismiss the irrelevant stimuli. Cues allow the instructor to minimize information overload and to use the KISS principle to “Keep it short and simple,” (Graham et al., 2001). Phrases and cues can allow students to form a mental picture of the movement (Parson, 1998). Even if the cue does not contain a critical feature, cues can still be used to focus practice. For example, while dribbling a basketball students should focus on dribbling hip high. The students are given the cue “hip high.” The cue can be given during practice to remind the learner the focus of the practice (Parson, 1998). Cues are important communication tools that can present the critical feature concisely so the performer can remember the words or phrases during practice (Knudson & Morrison, 1996).

Effective critical cues can be designed and used by teachers. The process to develop cues consists of identifying the critical elements or features of the skill, and then translating those critical features into critical cues. Research has provided information and insight into many of the critical elements of motor skills. Developmental sequences and motor development research can assist teachers in specifying body components or movement to target during observations (Knudson & Morrison, 1996). Developmental sequences provide criteria to determine advanced movers, assess current performance.
levels, and provide insight for interventions to improve performance (Fronske, 1997; Payne & Isaacs, 2002). Roberton and Halverson’s (1984) Developmental Sequences for Component of the Overarm Throw for Force is an example of a detailed qualitative assessment that highlights the critical features of throwing and how these features may change developmentally. The problem facing teachers is that critical features are usually expressed in very technical language, which can be difficult for students to understand (Knudson & Morrison, 1996). The teacher must then translate those critical features into critical cues to be understood by their students. Critical cues are the translation and formulation of critical features into words and phrases in easily understood or very descriptive language (Knudson & Morrison, 1996).

Once the cue has been formulated there are suggestions for the use of cues during instruction. Fronske (1997) provides guidelines to follow when using critical cues: (a) formulate and prioritize cues, (b) keep cues and the total number of cues compact and concise with three effective cues being sufficient, (c) give only one cue at a time, (d) provide critical cues along with appropriate feedback at appropriate times, and (e) supplement with other positive encouragement. Knudson and Morrison (1996) offer another set of guidelines for the use of verbal cues. Teachers should attempt to keep the description of cues to less than six words, and keep the cues simple and concise during early instruction, adding detail and information later. Overall, it is important for the performer to get the critical features quickly in easily understood terms they can understand and to which they relate.
Teachers have long used critical cues to improve performance, but the cues suggested in the physical education texts and those used by practitioners have not been sufficiently studied to empirically determine cue effectiveness for particular throwing patterns. Research is limited on the overall effectiveness of the use of cues to improve performance, and specific effective cues for each particular motor skill (Masser, 1993). It appears that many of these cues were designed and developed for advanced and experienced performers, leaving teachers and coaches left to identify and develop their own effective critical cues for more novice performers (Fronske, et al., 1997; Masser, 1993; Stroot & Oslin, 1993). A need exists to empirically determine critical cues (Masser, 1993; Oslin, et al., 1997; Stroot & Oslin, 1993), and to develop a hierarchy of components or an ordering of critical features (or cues) to target during instruction of motor skills for children with a variety of ability levels.

Critical cues and motor skills. The effectiveness of critical cues as an instructional strategy has been examined in research. Masser (1993) studied the critical cues and first grade students’ achievement in the handstand and forward rolls. Masser examined the use of critical cues as part of refining tasks. The cues were a part of the young learner’s vocabulary and consisted of words and phrases that related to body parts. Masser (1993) found cues improved performance in the handstand and the forward roll. The critical cue helped to focus the students’ attention on the important critical features they needed to execute and improve their performance. Masser (1993) noted that critical cues carry cognitive importance in learning a motor skill; they provide the learner with information about important biomechanical actions they need to concentrate on while practicing the skill. The students were able to place the cue in long-term memory for later
retrieval to the cognitive level when the occasion demanded (Masser, 1993). Masser suggested the relevant cue becomes the dominant cognitive force and the irrelevant environmental cues are blocked out (Masser, 1993).

**Critical cues and throwing.** Research in throwing has determined many of the critical features of the throw, but has not provided background information for the development of cues and their specific influence on body components and throwing performance. Researchers have found cues to be effective for instructing the throw, and have begun to explore the influence of particular cues on body performance (Fronske et al., 1997; Lorson, 2001; Oslin et al., 1997). Fronske and colleagues (1997) used critical cues and a sideways orientation task to help third and fifth-graders with immature throwing patterns improve on throwing distance and the step and backswing component. The independent variable was the level of throwing instruction provided over nine days with one of the groups receiving instruction with critical cues. The other group received only managerial directions and received no specific feedback regarding the throw during instruction. The cues utilized in the study included: “take a big step toward the target with the foot opposite the throwing arm,” “take the arm straight down and then stretch it back,” and “release the ball when you see the fingers.” The dependent variables in the study were three throws for throwing distance, and five balls to assess throwing form using Roberton (1984) component approach. A criticism of Fronske and colleagues (1997) is the assessment of body components and distance occurred on separate trials. The longest of three throws was used for distance, and then five different throws not for distance were assessed to determine body component levels. The change in task constraints during the assessment of throwing limits the ability to connect the process and
product measures in this study. This limits the ability to determine the immediate
influence of cues on both process and product scores for the same task.

Fronske and colleagues (1997) determined the use of cues improved throwing
distance and form more than a group that did not receive specific instruction. The CUE
group threw a pretest mean of 624.62 inches (SD=78.92) and improved to 702.57
(SD=329.29). The Non-Cue group improved from 596.80 inches (SD=251.25) at the
pretest to 601.15 inches (SD=270.67) at posttest. For throwing form, the greatest
improvement for the CUE group was in the step component with the CUE group
improving from 1.71 to 3.76, while the Non-Cue group improved from 2.10 to 2.67.
There was also a significant gain in the arm component (CUE group from 2.82 to 4.57),
but not as great as the step component.

After the completion of the study Fronske and colleagues (1997, p. 94) recognized
some problems with their initial cues and suggested the following modifications: “(a)
Take a long step toward the target with the opposite foot of the throwing arm, (b) take the
arm straight down and stretch it way back to make an L with the arm (keep ball away
from head), (c) watch the target and release the ball when fingers are seen.” Fronske and
colleagues also suggested keeping formal instruction of the cues to three days, with
periodic reviews of the cues and incorporating lead-up and games highlighting the cues.
Another limitation of this study was the assessment of only the backswing and step
component. Both components are part of the preparation phase of throwing, thus it is
unclear as to the influence of the cues on the action components of throwing such as
trunk rotation, and the arm component of the humerus and forearm.
Oslin and colleagues (1997) examined component specific instruction (CSI) and cues to improve the overarm throw using a single subject, multiple-baseline design. CSI is similar to critical cues because instruction was focused on the critical features (components) of the skill, which were translated to critical cues. Oslin and colleagues (1997) used component specific instruction using either a force production sequence (FPS) or a forward chaining sequences (FCS) on body components. The children were randomly assigned to receive CSI in either FPS or FCS. The FPS was a hierarchy of components based on the force contributed. The FPS order included: foot position, pelvic spinal rotation (backswing), pelvic spinal rotation (forward swing), elbow position (backswing), and arm action (forward swing). The FCS listed the components in order that they occurred. The order of the components included: pelvic spinal rotation (backswing), elbow position (backswing), foot position, pelvic spinal rotation (forward swing), and arm action (forward swing).

The study examined 22 children, from ages 3-6. Instruction was in the form of component specific feedback that included augmented feedback, corrective feedback, and manual guidance based on the efficiency level of each child. The children worked one-on-one with the experimenter. The children received appropriate feedback following each trial. The feedback included the component that needed improvement in addition to the targeted component. After each throwing session, the throwing performance was analyzed to determine the intervention strategy for the next session. To move to the next condition of CSI, the child had to demonstrate a high level of efficiency or improvement to an intermediate level from a low level.
Overall, component specific instruction increased throwing efficiency, but there was no difference between a FPS and FCS. Oslin and colleagues (1997) determined after videotape analysis, the step and elbow/backswing had the greatest ancillary effects and may be critical components in the development of the throw. Oslin and colleagues also noted that the longer the step, the greater the degree of sequential rotation and humeral lag, but these ancillary effects declined with increasing efficiency in the throwing motion. The greatest gains in the other components occurred initially, and then gradually leveled off as the component increased in efficiency. Oslin and colleagues suggest future research needs to determine the potential of the step and elbow/backswing as critical components of the throw, and the use of critical cues as an efficient method of instruction. Using critical cues to focus attention on key components can provide the learner with the necessary information in an easily understood language and can help teachers provide efficient, effective instruction and overcome the contextual factors of the gym.

Summary

Throwing is one of the most researched fundamental motor skills. Throwing is important because of its use in sports and games or the assimilation of the throwing motion in the performance of other movement skills. The development of the throw and the factors influencing throwing development can be described using Dynamical Systems Theory and the constraints model (Newell, 1984, 1986) as a framework. Knowledge of individual constraints can provide a foundation of knowledge that can be used to structure developmentally appropriate instruction. Gender is considered an individual constraint, with significant gender differences in throwing revealing males outperform
females in all aspects of throwing. Tasks constraints can influence the movement pattern exhibited, a task of force, accuracy, or distance can significantly alter the movement pattern utilized by the thrower. Throwing for force appears to result in the most advanced movement patterns.

Instruction plays a key role in the development of throwing performance. Motor development research and biomechanical literature have identified critical features of throwing. These critical features of throwing can be translated into critical cues and/or instructional strategies for teachers. Critical cues have been found to be effective in improving throwing performance. Instructional strategies based on biomechanical principles have been found to be another method for effective and efficient instruction of the throw.
CHAPTER 3

METHOD

Research Design

The primary focus of this study is to determine the effects of three instructional approaches on the body components and ball velocity of throwing in individual skill practice, and body components of throwing during gameplay. A secondary focus of the study is to examine the effects of the instructional approaches on gender differences in throwing performance across the intervention period.

A quasi-experimental, multiple-time series design was utilized to examine the influence of these instructional approaches on the performance of body components and ball velocity of throwing during practice, and body components during gameplay. A multiple-time series design was selected to determine if the changes in throwing occurred from pretest to posttest to retention test. This design is advantageous because the design controls for testing history. All groups, including the Traditional Physical Education (TPE) group received a similar testing history. Also, the threats to internal validity for selection and maturation would be shown in the initial pretest.
Theoretical Framework

The theoretical framework for this study is Dynamic Systems Theory. Dynamic Systems Theory provides a framework to describe and explain the changes in motor skill development. Constraints are the various factors influencing the throwing pattern. These constraints have been sorted into the three categories of constraints including: individual, environment, and task. Figure 3.1 shows the categories of constraints and the various factors under consideration in this study for each category. There are constraints that can be manipulated by the investigator, such as environmental and task constraints, while individual constraints such as age and gender cannot be manipulated by the investigator. Gender is an independent variable of interest and age delimits the results of the study. In this study, the environmental factors of instruction and practice, in particular the type of instruction is of most interest. Another environmental factor is ball size, which was held constant in this study. The task constraint of throwing for force was held constant in this study during instruction, practice, and data collection.

Time Span of the Study

The study was conducted over the course of nine weeks. The study was initiated in mid-March and concluded with retention testing near the end of May. The time span of the study of nine weeks, is an insufficient length of time to see significant gains due to maturation (Maliana & Bauchard, 1991), thus an assumption of this study is that maturation is not a confound. The intervention sessions were conducted during regular physical education class time. Four class sessions were allocated for throwing
Figure 3.1 Summary of individual, task, and environmental constraints under consideration in this study.
instruction, with each of the instructional sessions for throwing lasting 30 minutes. The remainder of the 50 minute class session were spent in warm-up activities, fitness activities, and practicing other fundamental motor skills.

Setting

The setting for this study was a suburban midwestern school district. Participants in the study were drawn from two different public elementary schools in the Midwestern United States. In statistics obtained from the Ohio Department of Education (2002), the school district has a rating of effective and has met 25 of the 27 State Performance Indicators for 2002 based on student performance on the State’s proficiency tests (Ohio Department of Education, 2002). In this district, each student received physical education once every four school days for 50 minutes because each school has a four-day rotating schedule (A, B, C, D) for physical education. Each of the school settings had an experienced physical education teacher who works closely with the local university physical education teacher education program. Each class in the study also had a similar number of students in each class.

Fiesta School

The student population at Fiesta Elementary School is 416 children in grades K-5. There are 211 female students, and 205 male students. The student population is comprised of 321 Caucasian students, 11 African Americans students, 53 Asian Americans students, 11 Hispanic students, and 19 Multi-Racial students (Ohio Department of Education, 2002). The student to teacher ratio in physical education is 20.8 to 1 (Ohio Department of Education, 2002).
Physical Education Program. In this setting, the students have a physical education class once every four days for 50 minutes during each session (Mrs. Scarlet, personal communication, March 13, 2003). The typical class begins with a 10-minute warm-up and introduction where class attendance, flexibility activities, and fitness stations are completed. The remaining class time is spent focused on the lesson content. There is ample equipment available for the students within the class. The gymnasium is equipped with four basketball hoops, a climbing wall, and the students have periodically used pedometers and heart rate monitors during class (Mrs. Scarlet, personal communication, March 13, 2003).

Physical Education Teacher. The teacher for the BP and CUE groups is a veteran teacher of 25 years, with the last 17 years at the Fiesta school. Mrs. Scarlet has earned a Master’s Degree in Physical Education. The teacher has worked extensively with the local teacher training institution, and has been a cooperating teacher for 17 years.

Woodbine School

The student population at Woodbine Elementary School is 589 children in grades K-5. There are 299 female students, and 290 male students. The student population is comprised of 504 Caucasian students, 61 Asian American students, and 24 Multi-Racial students (Ohio Department of Education, 2002). The student to teacher ratio in physical education is 19.3 to 1 (Ohio Department of Education, 2002).

Physical Education Program. In this setting, the students have a physical education class once every four days for 50 minutes during each session (Ms. Gray, personal communication, March 24, 2003). The typical class begins with a 10-minute warm-up and introduction where class attendance, flexibility activities, and fitness
stations are completed. The remaining class time is spent focused on the lesson content. There is ample equipment available for the students within the class. The gymnasium is equipped with four basketball hoops, a climbing wall, and the students consistently use pedometers during class (Ms. Gray, personal communication, March 24, 2003).

**Physical Education Teacher.** The teacher for the TPE group is a veteran teacher of 17 years, with 16 years at Woodbine school. Ms. Gray is a licensed elementary physical education teacher and also has a Master’s Degree in Adapted Physical Education. Additionally, Ms. Gray has worked with the local university physical education teacher education programs as a cooperating teacher.

**Participants**

The participants in this study were students from three, first-grade and three, second-grade classes. Students were self-selected for the study by completing the required permission slip. Students were part of intact classes and these classes were purposively assigned to one of the three levels of the independent variable (instructional approach). Random assignment of individual participants to instructional approaches was not possible due to the nature of the education environment.

These classes were representative of typical first and second graders in this suburban school district. One first grade, and one, second grade class from the Fiesta School were assigned to the CUE group. One first, and one, second grade class from the Fiesta School were assigned to the BP group. The TPE group was comprised of one first-grade class and one, second-grade class from the Woodbine school. Table 3.1 displays the gender, age, and demographic information for each class receiving a level of the independent variable.
<table>
<thead>
<tr>
<th>Group</th>
<th>Critical Cues</th>
<th>Biomechanical</th>
<th>Typical PE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CUE1</td>
<td>CUE2</td>
<td>Total</td>
</tr>
<tr>
<td>n</td>
<td>19</td>
<td>22</td>
<td>41</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>10</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>Female</td>
<td>9</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>Mean Age</td>
<td>85.67</td>
<td>99.10</td>
<td>92.88</td>
</tr>
<tr>
<td>SD</td>
<td>4.10</td>
<td>5.33</td>
<td>8.20</td>
</tr>
<tr>
<td>Male</td>
<td>84.40</td>
<td>98.21</td>
<td>92.46</td>
</tr>
<tr>
<td>SD</td>
<td>3.89</td>
<td>4.71</td>
<td>8.18</td>
</tr>
<tr>
<td>Female</td>
<td>87.00</td>
<td>100.75</td>
<td>93.47</td>
</tr>
<tr>
<td>SD</td>
<td>3.84</td>
<td>5.65</td>
<td>8.45</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>American</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>5</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Hispanic</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>White</td>
<td>10</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Note.* Mean age is in months. Gender and Race is number of participants. CUE = Critical Cue group, BP = Biomechanical approach, TPE = Typical Physical Education.

Table 3.1: Gender, age, and demographics of participants by intervention group.
Data collected during the study were analyzed using both process and product measures of throwing. The process or qualitative measures assessed the throwing form used to execute the throw during practice and game play. The product or quantitative measures were the velocity of each throw during practice.

**Qualitative Measures of Throwing**

*Component Approach.* The Roberton and Halverson (1984) Developmental Sequences for the Components of the Overarm Throw for Force was used to analyze throwing trials during testing sessions. The component approach is a qualitative movement analysis tool comprised of five components: step, trunk, backswing, humerus and forearm (see Table 3.2 for a summary of the component approach). Each component is comprised of various levels, with each level representing a more advanced movement pattern or a closer approximation to an advanced throwing pattern.

The step and backswing component is comprised of four levels. The trunk, humerus, and forearm components each have three levels. The backswing component was not included for analysis in this study because of limited empirical support for developmental validity of the sequence (Roberton, 1978), and the backswing is not a targeted component in the instructional approaches.

*Component procedures.* Each participant completed 10 throws for force during each of the testing sessions (pretest, posttest, and retention). Two cameras, a rear view and a side view were positioned to capture each throwing trial. The rear VHS camera was positioned directly behind the thrower and the intended line of flight of the ball. The side
Foot (Step) Action

S1. No step.
S2. Homolateral step.
S3. Contralateral, short step.

Trunk (Pelvis-Spine) Action

T1. No trunk rotation.
T2. Upper trunk rotation or total “block” rotation.
T3. Differentiated rotation.

Preparatory Arm-Backswing Component

B1. No backswing.
B2. Elbow and humeral flexion.
B3. Circular, upward backswing.

Humerus (Upper Arm) Action During Forward Swing

H1. Humerus oblique.
H2. Humerus aligned but independent.
H3. Humerus lags.

Forearm Action Forward Swing

F1. No forearm lag.
F2. Forearm lag.
F3. Delayed forearm lag.


Table 3.2: Developmental sequences within components of the overarm throw for force.
view camera was a Panasonic Digital Camera and was positioned on the throwing arm side of the participant perpendicular to the approximate point of release. The cameras were focused to capture the participant’s total body throughout the throwing attempt. To facilitate a consistent camera position, the participants was told to stand inside of a large (3ft. by 5 ft.) box taped to the floor. The participants were reminded at the beginning of each session that they should stand inside the box before they throw the ball. They were also reminded that they could step on or over any line in the box while they threw the ball without penalty. The participants were instructed to throw the ball “as hard and as fast as they can” towards an unmarked curtain 25ft away. A prompt for “hard and fast” throws was given by the investigator before each throw.

The step, trunk, humerus, and forearm were the targeted components in analyzing the throw. During videotape analysis each throw was assessed individually, and then a component level was given for each component. Appendix B is an example of the data sheet used to record both body component levels and ball velocity during individual practice. After completing the analysis, the mean level for each component during the 10 trials for each session was calculated and used in data analysis.

Training. An observer analyzed each of the throwing trials during the testing sessions with a second observer used for interobserver agreement. The primary observer of the body component levels was the primary investigator for this study. The second observer was a graduate student in physical education. The primary observer was trained to assess body component levels for a previous study, but completed the training process because some time had past since the primary observer last used the component approach. The observers followed a training protocol to ensure the reliability of the
analysis of throwing trials. The observers first learned the descriptions of each level within each component. During the assessment of learning descriptions, the observers read descriptions of each level and placed the appropriate level in the associated blank. Each observer scored a 100% on the description assessment. The second step in training was to correctly identify the body component levels from a training video. The throwing trials on the videotape were previously analysis by an expert observer in the component approach. The newly trained observers recorded a body component level for each of the trials. After analysis, the trials were compared to the trained observer’s observations. The new observers reached the required level of at least 100% agreement with the expert on the training tape. Observer agreement was calculated by the percent agreement on the total number of trials. The newly trained observer achieved the 100% level of agreement necessary for the second step of training. After completion of the second step of training, interobserver agreement was periodically checked between the two trained observers.

*Interobserver Agreement.* Interobserver agreement was checked periodically to ensure that the observers did not “drift” from the original descriptions of the body component levels. A reliability check occurred during the pretest, posttest, and retention test on one-third of the throwing trials. The reliability check compared the results of the two independent observations. The two observers watched one-third of the total throwing trials together to determine interobserver agreement. A reliability coefficient was calculated by dividing the number of agreements by the total number of agreements and disagreements. A level of agreement was achieved between observers on one-third of the throwing trials viewed at the pretest (90.6%), posttest (93.2%), and retention test (91.9%).
Form used during game play. The purpose of assessing body components during gameplay was to determine if proposed changes in throwing form during practice translated into throwing performance during games. The instrument used in this study targets three body components: the relative foot/knee position, forearm, and trunk. The instrument (See Table 3.3 for the gameplay instrument) is a combination of Barrett and Burton’s (2002) gameplay instrument with a modification of the trunk component of Roberton & Halverson (1984) Component Approach.

Barrett and Burton’s (2002) game play instrument adapted Roberton’s (1982) component approach to analyze throwing patterns used by collegiate baseball players during gameplay. Barrett and Burton’s (2002) original instrument included three components: forearm, backswing, and relative foot-knee position. For this study the relative foot-knee position and forearm components were used in analyzing throwing form during game play, the backswing was not assessed. The backswing component of the Barrett and Burton (2002) game play instrument was not included in this study because the backswing was not a targeted component of any of the interventions, and was not assessed during testing trials. The relative foot-knee position is similar to the step component in Roberton (1982), but considers the position of the feet and knees during throwing rather than just the step or foot action (Barrett & Burton, 2002). Barrett and Burton (2002) had to consider the position of the knee because some throwing in baseball were completed from a kneeling position. In the Barrett and Burton (2002) gameplay instrument, the forearm component is comprised of only two levels instead of the three levels in Roberton. The forearm component was condensed to two levels because of difficulty in viewing advanced levels of forearm lag from variable camera angles and
<table>
<thead>
<tr>
<th>Component</th>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative foot-knee position</td>
<td>1</td>
<td>Feet and knees even.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Ipsilateral foot or knee forward.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Contralateral foot or knee forward.</td>
</tr>
<tr>
<td>Forearm</td>
<td>1</td>
<td>No forearm lag or forearm lag is greatest before shoulders are parallel.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Greatest forearm lag is not reached until shoulders are parallel.</td>
</tr>
<tr>
<td>Trunk</td>
<td>1</td>
<td>No rotation of the trunk</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Block or differentiated rotation of the trunk</td>
</tr>
</tbody>
</table>


Table 3.3: Levels of throwing form during gameplay.
difficulty in consistently capturing a side view of the throw at a 90° angle (Barrett & Burton, 2002). Barrett & Burton (2002) noted that while the consolidation of levels within the body components decreased the sensitivity of the instrument to detect small differences in the forearm component, the instrument was still able to detect differences in throwing patterns. The greatest loss of sensitivity in the gameplay instrument was found in the less advanced levels of the forearm and trunk components (Barrett & Burton, 2002).

For this study, the trunk component was added to the Barrett and Burton (2002) gameplay instrument as a component to be assessed during gameplay. The reason for including the trunk component was because the focus of both instructional approaches were to create at least block rotation of the trunk, necessitating the assessment of whether developing trunk rotation during instruction transferred to gameplay. Additionally, developing at least block rotation of the trunk is important to the development of the humerus and forearm (Langendorfer & Roberton, 2002a). The trunk component for gameplay was a variation of the Roberton and Halverson (1984) component approach, condensing the three levels of the trunk component into two levels (no rotation and rotation). This consolidation of the trunk component combined level 2 (block rotation) and level 3 (differentiated rotation). The consolidation of the trunk component is necessary for gameplay because of the inability to accurately and reliably differentiate between block and differentiated rotation of the trunk during gameplay, due to an inability to consistently capture a rear view of the thrower.
*Throwing game.* The throwing game was a variation of “clean out your backyard,” a game where participants threw balls from their half of the court to the other side of the court. The object of the game was to try to throw as many balls as possible from the throwing team’s side to the opposing team’s side. This game was selected because (a) it involved students throwing for force or distance, (b) did not involve throwing at targets, and (c) involved students moving through space before they threw the ball.

One third of the class was the offensive team and threw the balls from the hoola hoops. The other two thirds of the class were the defensive team and attempted to keep the balls out of their baseline area. Offensive players were reminded they must be in front of the baseline before they could throw the ball and cannot cross the centerline. Offensive players were also reminded that they could only have one ball in their hand at a time, and they must return to the hoola hoop to pick up another ball. Throwing within the throwing zone (between the baseline and the half-court line) and requiring the student to have only one ball at a time, forces the players to move through space before throwing the ball while still providing a task constraint to elicit hard and fast throws. Each participant was throwing in a group during game play for approximately three to five minutes. Balls were placed in hoola-hoops in the baseline area between the wall and the baseline. The hoola-hoop had a sufficient amount of yarn balls to be thrown during the game.

*Videotaping and coding procedures.* The players of the game were wearing numbered jerseys that corresponded to a participant identification number and helped the observers record the participant throwing the ball. During gameplay the investigator was
unable to control the number of trials each participant throws during the game, thus the first five visible trials were analyzed during gameplay. The first five visible trials were also used due to the possibility of another participant blocking a clear view of the targeted thrower. The mean component level for each component (relative foot/knee, trunk, forearm) were used in data analysis.

Each gameplay session was recorded by two cameras positioned on each side of the court to capture each throw. The cameras were focused to capture throws within the given quadrant of the gym (See Figure 3.2 for a drawing of the camera position within the court). The videotaped sessions were analyzed to determine the body component levels used during gameplay. The observers viewed the videotape and wrote the component level in the data sheet. The observers first watched the foot/knee position, then the trunk component, and lastly the forearm component.

Pilot testing of game play instrument. The procedures for videotaping the throwing game, and the coding of the gameplay instrument were pilot tested before the start of the study. The pilot testing involved third graders from the same school playing the “clean out your backyard” game. The videotape was reviewed to determine if the camera position was effective in capturing all of the student’s throws. After watching the videotape, the observers concluded the camera positions were appropriate, and the rules and procedures for gameplay were clear for participants in the throwing game. The instrument was also pilot tested to ensure there were no instances where an individual’s throwing pattern could not be coded using the game play instrument. After pilot testing, a clarification was added to the protocol when to code the relative foot/knee position. Foot/knee position was coded as soon as the arm begins to accelerate forward.
Training and interobserver agreement. The training procedures for the component approach for game play were similar to the body component training procedures. Clear understandings of the definitions were established. Then the newly trained observer, a graduate student in physical education teacher education, analyzed a sample of videotape, previously assessed by an expert observer (primary investigator). The percentage of agreement was calculated between the newly trained observer and the
expert observer for the training tape. The percentage of agreement of 100% on the training video was established for the gameplay instrument. Interobserver agreement was then periodically assessed on one-third of the trials during pretest, posttest, and retention test to determine if the two observers did not drift from the original definitions. Interobserver agreement was calculated at the pretest (82.09%), posttest (82.62%), and retention test (87.15%).

Quantitative Measures

A JUGS radar gun measured throwing velocity for the 10 practice trials that were used to determine body component levels at the pretest, posttest, and retention test. The radar gun was positioned approximately 25 feet directly in front of the participant behind a thin curtain. Immediately after each throwing attempt, the velocity of each throw was displayed on a small screen on the radar gun to be viewed by the recorder. The observer recorded the velocity in miles per hour on the data sheet without providing feedback to the participant regarding the speed of the throw.

The mean velocity of recorded testing trials was used in data analysis. Mean velocity was used because maximum velocity was not as sensitive in measuring changes in velocity because of ceiling effects. The mean of the recorded trials were used because the minimum velocity detected by the radar gun is 25 miles per hour. A throwing attempt of less than 25 miles per hour was recorded as a zero on the data sheet. The number of unrecorded trials would skew the mean velocity score for each session, thus unrecorded trials were not used in the calculation of the mean score. The number of unrecorded trials were calculated and analyzed to provide a context for the maximum ball velocity data. Tracking unrecorded trials provided some measure to detect changes in the maximum
velocity data for those throwers with immature patterns who were unable to consistently throw above 25 miles per hour. Tracking unrecorded trials also provided context as to the consistency of thrower to throw at a speed above 25 miles per hour.

Training and reliability. The principal investigator had experience in using the radar gun in the testing environment. The owner’s manual for the JUGS gun outlines the procedures for effective use of the radar gun. Procedures for using the radar gun were reviewed before the study. The placement of the radar gun in this study was in the recommended position directly in the path of the ball. The radar gun was locked into a tripod that was positioned in the intended line of flight of the ball (pointed toward the thrower). The radar gun was behind a bed sheet, thus the radar gun operator was in no danger of being hit by a ball. The operator recorded the speed from the previous trial, and then clicked the trigger to prepare for the next trial. The radar gun was checked periodically with a tuning fork to maintain a level of accuracy between +/− 1 mph with the speed stamped on the tuning fork (JUGS, 1999). The internal accuracy of the JUGS radar gun is +/− 0.4 mph, and the display accuracy is +/− 1 mph (JUGS, 1999).

Independent Variable – Throwing Instruction

Each group received one of three instructional approaches over the course of four instructional sessions: critical cue (CUE), biomechanical approach (BP), and typical physical education (TPE). The CUE approach was focused on developing the throw through three critical cues. The BP approach incorporated key biomechanical principles into a four-stage approach. The TPE group practiced the overarm throwing based on typical lessons provided by the physical education teacher. The TPE was intended to be representative of throwing instruction common to physical education.
Commonalities across Instructional Groups

Equal amounts of allocated time for throwing instruction and practice were provided for each of the groups. Allocated time for throwing instruction and practice was 30 minutes per class session. Each approach had four class sessions to teach throwing. Students in the groups had physical education once every four school days for a total of 120 minutes of allocated time for throwing instruction and practice. The actual time spent in throwing activities and instruction was determined by an observer of the class videotape using a stop watch. The actual amount of time spent in throwing instruction for each group is reported in Table 3.4. The small differences in actual instructional time were present due to the flow of the lesson. The introductions, instructions, or review of the lesson sometimes went slightly shorter or longer than intended. The station work and practice in the CUE and BP groups were designed to be similar. One class in the BP group had a shortened class session because of an assembly on the second day of instruction for the first grade class and the third day of instruction for the second grade class. The attendance rate for the CUE group was 96.22%, BP group was 90.4%, and for the TPE classes was 91.5%.

For external validity purposes and to maintain social validity, the teachers were not instructed to alter their typical interactions with the class. The teachers were trained to teach each of the interventions, but they were not instructed to alter or limit their feedback or interactions with the students in any fashion. If the teachers judged group or individual feedback to be necessary, the teacher was free to provide such feedback. The amount and type of feedback, and the interactions between teacher and student, were
### Table 3.4. Average number of minutes spent in throwing instruction and activity by group.

<table>
<thead>
<tr>
<th>Group</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUE1</td>
<td>30:40</td>
<td>30:35</td>
<td>29:40</td>
<td>30:35</td>
<td>2:01:30</td>
</tr>
<tr>
<td>BP1</td>
<td>30:50</td>
<td>27:35*</td>
<td>28:10*</td>
<td>30:35</td>
<td>1:58:10</td>
</tr>
<tr>
<td>TPE1</td>
<td>29:10</td>
<td>29:30</td>
<td>29:25</td>
<td>29:55</td>
<td>1:58:00</td>
</tr>
</tbody>
</table>

Note: * denotes a day where class session shortened by a school assembly.

assessed using the Observational Recording Record of Physical Educator’s Teaching Behavior (ORRPETB). The instrument was used to determine teacher behaviors, student behaviors, and teacher feedback.

**Practice Sessions.** The BP and CUE group followed the lesson plan provided by the researcher relative to their instructional approach. The TPE group followed a lesson plan developed by their teacher. Each group shared common practice activities. Throughout each practice session the teacher prompted, “Throwing hard and fast,” which promoted the practicing of the throw for force. The throw for force typically promoted the use of the most advanced component levels (Langendorfer, 1990), and is also the recommended task for beginning throwers (Barrett, 1995; Langendorfer, 1990; Roberton,
The TPE teacher was reminded during the development of lesson plans that the focus of the study was on the throw for force, and throwing for force should be practiced and prompted throughout the lesson activities.

The BP and CUE groups shared common practice activities and routines. Each day throwing was instructed the students performed activities associated with their instructional approach. The BP and CUE groups shared a common routine of introduction, introductory practice with the entire class, review of stations, throwing practice within stations, and then a brief review of the key points of the lesson. Despite the similarities there were differences in the drills and practice activities between the CUE and BP groups because of the emphasis on different targeted aspects of the throw. Table 3.5 shows a block plan of the activities of each throwing lesson and the mean minutes of each throwing session. See Appendix C for the complete lesson plans for each group.

Instructional Approaches

Critical cue (CUE) approach. The CUE approach emphasized three critical cues, each targeting key components of the preparatory movements of the throw. Critical cues to improve the overarm throw have been suggested in the literature (Fronske 1997; Graham et al., 2001), and their influence on the development of elementary children’s throwing patterns researched (Fronske et al., 1997; Lorson, 2001; Oslin et al., 1997). The critical cues in this study were similar cues to those in previous studies (Fronske et al., 1997; Lorson, 2001; Oslin et al., 1997), but have been slightly modified based on
<table>
<thead>
<tr>
<th>Group</th>
<th>Session 1</th>
<th>Session 2</th>
<th>Session 3</th>
<th>Session 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUE</td>
<td>Introduction to throwing and cues</td>
<td>Review laser beam cue into step.</td>
<td>Review cues, introduce untwist cue</td>
<td>Review cues</td>
</tr>
<tr>
<td></td>
<td>Laser Beam practice – students moving in space and then assuming “laser beam position” when prompted</td>
<td>Laser Beam and stepping practice</td>
<td>Class practice</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Station practice (6 minutes each)</td>
<td>Review laser beam and stepping practice</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introduction of Stations</td>
<td>Untwist cue</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Practice Stations</td>
<td>Class practice</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean Throwing Minutes = 30:40</td>
<td>Introduction of Stations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spider ball throw to wall – pointing laser beams</td>
<td>Station practice (6 minutes each)</td>
<td>Station practice</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Throwing practice with peer coaching</td>
<td>Mean Throwing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean Throwing Minutes = 30:35</td>
<td>Mean Throwing Minutes = 30:35</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Throwing practice with peer coaching</td>
<td>2. Throwing practice with peer coaching</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean Throwing Minutes = 30:40</td>
<td>Mean Throwing Minutes = 29:40</td>
<td></td>
</tr>
</tbody>
</table>

(Continued)

Table 3.5. Block plan and mean minutes of throwing instruction for the CUE, BP, and TPE instructional groups.
(Table 3.5 Continued)

<table>
<thead>
<tr>
<th>Group</th>
<th>Session 1</th>
<th>Session 2</th>
<th>Session 3</th>
<th>Session 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP</td>
<td>- Intro to throwing</td>
<td>- Review “L”</td>
<td>- Review “L” and</td>
<td>- Review Stage</td>
</tr>
<tr>
<td></td>
<td>- Intro “L” position</td>
<td>- Review “L” position</td>
<td>- stepping action</td>
<td>- III</td>
</tr>
<tr>
<td></td>
<td>- Class practice</td>
<td>- Introduce stage</td>
<td>- Introduce</td>
<td>- Introduce Stage</td>
</tr>
<tr>
<td></td>
<td>with “L” position – peer coaching</td>
<td>- II</td>
<td>- twisting action</td>
<td>- IV – step and</td>
</tr>
<tr>
<td></td>
<td>- Introduction of Stations</td>
<td>- Class practice</td>
<td>- Class practice of</td>
<td>- twisting action</td>
</tr>
<tr>
<td></td>
<td>- Station practice (6 minutes each)</td>
<td>- Station practice</td>
<td>- Introduction of Stations</td>
<td>- Introduction of Stations</td>
</tr>
<tr>
<td></td>
<td>1. Spider ball throw to wall – pointing laser beams</td>
<td>- Station practice (6 minutes each)</td>
<td>1. Spider ball throw to wall – pointing</td>
<td>- Station practice</td>
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<tr>
<td></td>
<td>(6 minutes each)</td>
<td>1. Spider ball throw to wall – pointing</td>
<td>1. Spider ball throw to wall – pointing</td>
<td>(6 minutes each)</td>
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<td></td>
<td>2. Throwing throw to wall – pointing laser beams</td>
<td>2. Throwing practice with peer coaching</td>
<td>2. Throwing practice with peer coaching</td>
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<td></td>
<td>(6 minutes each)</td>
<td>2. Throwing practice with peer coaching</td>
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**Mean Throwing Minutes**

- **bp**
  - Mean Minutes = 30:50
  - Mean Minutes = 29:00
  - Mean Minutes = 27:35

(Continued)
(Table 3.5 Continued)

<table>
<thead>
<tr>
<th>Group</th>
<th>Session 1</th>
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<th>Session 4</th>
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<tr>
<td>TPE</td>
<td>- Introduction of throwing</td>
<td>- Review</td>
<td>- Review</td>
<td>- Review</td>
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<tr>
<td></td>
<td>- Introduction of throwing cues</td>
<td>- Throwing practice – long throws to wall</td>
<td>- Practice – long throws to wall (long throws)</td>
<td>- Practice – long throws to wall (long throws)</td>
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<td></td>
<td>- Throwing game: Partner throw and catch</td>
<td>- Intro</td>
<td>- Peer of throwing game: Backboard tag</td>
<td>- Peer of throwing game: Backboard tag</td>
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<td>- Review and closure</td>
<td>- Mean Minutes = 28:55</td>
<td>- Review of throwing form</td>
<td>- Review of throwing form</td>
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<td>- Mean Minutes = 29:30</td>
<td>- Mean Minutes = 29:55</td>
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<td>- Review &amp; Closure</td>
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<td>- Mean Minutes = 29:10</td>
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research findings (Lorson, 2001) and to meet the needs of the participants of this study. Table 3.6 provides an overview of the part of the throw targeted, body components, the critical cue, and an explanation of the cue.

The cues in this instructional approach were focused on the preparatory position of a sideways orientation to the target, taking a long contralateral step, and developing trunk rotation. While these three cues were not the only three cues to use when teaching the throw, they had the potential to produce the greatest ancillary effects on the action components of the throw including the trunk, humerus, and forearm component (Langendorfer & Roberton, 2002a; Oslin et al., 1997). The critical cues were arranged in a hierarchy to take advantage of the ancillary effects from improving the targeted component. Changing body position to a sideways orientation positioned the body for a contralateral step. A contralateral step and a sideways orientation also produced a greater likelihood of a rotating trunk and possibilities of greater ancillary effects on other components such as the humerus and forearm (Oslin et al., 1997). A rotating trunk can produce ancillary effects on the humerus and forearm components (Langendorfer & Roberton, 2002a). The CUE approach focused on providing cues that could be addressed during the preparatory phase of the movement. The key to the CUE approach was to develop and enhance the preparatory movements in order to promote changes in the action components of the humerus and forearm, and to improve coordination of the movement with practice.

The CUE approach focused on first establishing a sideways to the target orientation. The initial lesson in the CUE group focused on the cue “pointing your laser beams.” The cue communicated to the learner the importance of a sideways orientation
<table>
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<tr>
<th>Part of throw Component</th>
<th>Body Component</th>
<th>Cue Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Body Position</td>
<td>Trunk</td>
<td>“Point your laser beams.” Instep of throwing side foot and non-throwing side shoulder/index finger pointing to the target.</td>
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<tr>
<td>2) Step</td>
<td>Step</td>
<td>“A big/large/long step toward your target.” A contralateral step (at least half of the thrower’s standing height toward the intended target.</td>
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<tr>
<td>3) Trunk Rotation</td>
<td>Trunk</td>
<td>“Untwist your hips and point your belly button to the target.” Rotating the lower body as the ball is released, at the completion of execution the bellybutton is pointed to the target.</td>
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</tbody>
</table>

Table 3.6: List of critical cues and part of throw and body component targeted.
By pointing the index finger of the non-throwing hand, and the instep of the throwing side foot (or rear foot when sideways) toward the intended target. Pointing the index finger toward the target ensured that the non-throwing side shoulder was pointed toward the target, while the instep of the rear foot constrained the learner to assume a sideways orientation with the lower body. The importance of the sideways orientation was to act as a constraint on the trunk and pelvis to increase the likelihood that the trunk and hips must rotate when executing the throwing motion.

The second cue targeted focused on “taking a long step toward the target.” Cueing the step has been one of the easiest for teachers to cue (Stroot & Oslin, 1993), and the most influential in improving the throwing form (Oslin et al., 1997). The portion of the cue that stated “toward the target,” was intended to have the thrower keep their hips closed and to prevent opening up the hips to premature hip rotation. Stepping away from the intended path of the ball could take away the potential for hip rotation.

The third cue targeted during the CUE intervention was the cue, “untwist your hips and point your belly button to the target.” Developing a rotating trunk and pelvis was necessary for advanced arm actions, and for greater ball velocity (Langendorfer & Robertson, 2002). Researchers have suggested the cues of “turn your hips fast,” and “untwist your hips” to emphasize the rotational aspect of the trunk. Research has also suggested cues should focus attention on the hips and away from the shoulder (Lorson, 2001).

Each day of instruction, one new cue was targeted for the CUE group. The teacher reviewed the previous session cues to remind the students of the previous cue, but the activities for that lesson focused around creating a shared language and practicing the
target cue for the lesson. Drills and activities during class sessions were structured to highlight those cues. See Appendix C for complete lesson plans for the day’s activity associated with each cue. The teacher presented the targeted cue to the entire class, but if the teacher determined an individual student, who may have progressed beyond the current targeted cue, needed to be given a cue from a future session the teacher provided such a cue to the individual.

The following description is an example of a lesson in the CUE approach that was focused on the sideways orientation. The teacher first introduced the cue to the class with a demonstration and direct instruction. The students then practiced the sideways orientation first by straddling a line, and then pointing their non-throwing index finger towards a target. The students then worked on moving in space, and then straddle a line to “point their laser beams” at a target. The participants then worked on pointing their laser beams without the assistance of a line. Lastly, the students practiced pointing both laser beams at the target before throwing the ball. The “laser beams” to be pointed were the non-throwing side shoulder/index finger and the instep of the throwing side foot. During the practice, the participants were prompted to point both of their laser beams before they can throw their ball. The teacher used peer assessment and peer coaching, along with group observation and individualized feedback to ensure that the students were assuming a sideways orientation. The teacher attempted to individualize instruction by providing feedback, cues, and reinforcement based on the needs of each student.

The teacher moved onto the next cue in the hierarchy when at least 80% of the students were demonstrating the cue correctly when prompted. The teacher first conducted a visual scan of the class for success, after visual scanning the teacher checked
with the investigator to see if 80% were demonstrating the cue before moving onto the next cue. There was no instance during the CUE group instruction where the teacher presented a different cue to the entire class before checking with and agreeing with the investigator to move onto the next cue.

**Biomechanical (BP) approach.** Biomechanical information has been useful in identifying critical features of the throw and determining the relationship between critical features. Efficiency in throwing is based on biomechanical efficiency, thus biomechanics can provide a foundation of knowledge to build instructional approaches. The BP approach was first developed and tested by Stodden (2002). The instructional approach emphasizes the development of the ability to coordinate segments of the body through a set of four instructional levels to develop the overarm throw (See Table 3.7 for the stages of the BP approach). The key focus areas of the approach were proper positioning of the humerus and forearm, developing linear momentum, and then adding the rotational components of the trunk and pelvis during the throwing motion. The BP approach focused on creating correct preparatory arm position to maximize the potential of the musculature and body segments to improve coordination. The preparatory position of the humerus and forearm was key in developing the ability to transfer momentum generated from larger, base segments (legs and trunk) to the more distal segments of the humerus, forearm, and wrist (Stodden, 2002). The BP approach was designed to reach the wide range and variability in throwing patterns. Stodden (2002) proposed that each stage in the instructional approach was designed for distinct developmental levels of throwing, but each stage of the approach could be implemented regardless of skill level due to the nature of the intervention. Stodden (2002) postulated that each stage of the intervention
<table>
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<th>Stage</th>
<th>Description</th>
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<tr>
<td>Stage I</td>
<td>Focused on developing the “L” position of the humerus and forearm. Thrower assumes a front facing position with the humerus and forearm in an “L” before executing the throw.</td>
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<tr>
<td>Stage II</td>
<td>Adds forward linear momentum and forward flexion with the execution of a contralateral step. Thrower is front facing with humerus and forearm in “L” shape. Thrower takes a long step and reaches as the ball is released.</td>
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<tr>
<td>Stage III</td>
<td>Develops rotation of the trunk components. Thrower assumes a sideways orientation, positions the humerus and forearm in an “L” position in preparation of the throw. Thrower rotates his/her trunk as the throwing motion is executed.</td>
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<tr>
<td>Stage IV</td>
<td>Thrower assumes sideways orientation and “L” position. Emphasis is placed on the stepping action or adding linear momentum with the rotating trunk.</td>
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Table 3.7. Summary of the four stages of the Biomechanical Model.
Provided useful information to all throwers regardless of skill level, and theoretically would not hinder throwing development even if the child’s movement were beyond the current stage of instruction.

The BP intervention takes into account the developmental level characteristics described within the Roberton and Halverson (1984) component approach. Each level of the BP approach was based on the characteristics of the general description of the development of throwing (Stodden, 2002). The BP approach followed a developmental progression for the least advanced throwing pattern (Stage I) to most advanced level (Stage IV). Stodden (2002) views each level of the approach as a completed throw, not as component or aspect of the throw. For example, the first stage of the approach is a complete throwing motion, but is a low developmental profile consisting of only arm actions with no foot or trunk action. The focus of each level emphasized learning and developing the key mechanical aspect of that stage. This allowed the learner to focus on one aspect at a time, rather than learning all of the aspects of the throw together. Under Dynamical Systems Theory and the Constraints model, the approach decreased the complexity and the number of factors influencing the throwing pattern, allowing the learner to think and feel the targeted movement of the stage. This allowed the learner to develop the concept, practice it, and then build on the concept in future stages. The key concept present throughout the biomechanical approach was proper positioning of the humerus and forearm. Each of the stages is described in greater detail in the next section.

*Stages of the Model.* The BP approach consisted of four stages; each stage is briefly described in this section. Stage I focused on proper positioning of the humerus and forearm during the action phase of the throw. Stage II focused on linear momentum
by adding a step in the direction of the target. Stage III emphasized assuming a sideways orientation to the target to develop rotation of the trunk. Stage IV combined linear momentum and rotation of the trunk by combining a contralateral step with the other actions learned in previous stages.

Stage I focused on familiarizing the learner with the correct position of the humerus and forearm during the action phase of the throw. This phase was termed the arm cocking and arm acceleration phase. During Stage I the thrower faces the target with the feet approximately shoulder width apart. The arm was to be in an “L” position, with the humerus abducted and elbow flexed at 90°, and the wrist was be in a neutral position with the ball (or palm) facing the target. The thrower executed the throw by reaching forward with the throwing hand toward the target while maintaining the “L” position with the humerus and forearm. Cues that were used by the teacher at Stage I were “make an ‘L’ with your arm,” and “reach and throw.”

Stage II of the approach emphasized forward linear momentum and forward flexion of the trunk. A step toward the target was incorporated in Stage II. The key point of this stage was to emphasize the transfer of momentum from the step to the trunk, and eventually to the ball. The thrower began in the same position as Stage I (facing the target and forming an “L” with the humerus and forearm). The teacher used modeling to show the long contralateral step and the reaching forward as far as possible, emphasizing the hip flexion. The follow-through, while not emphasized in this stage carried the throwing arm down and across the outside of the non-throwing hand knee. During stage II the back
foot may come off the floor for balance. Cues suggested for Stage II to communicate the critical elements might include the “L” position, “step and reach,” or “follow through with a flat back.”

Stage III incorporated the sideways orientation to develop the sequential rotation of the trunk component. This rotation of the trunk contributed the rotational momentum of the body segments learned in the previous levels. The body position for Stage III was a sideways orientation to the target with the non-throwing side shoulder, and the non-throwing side hip pointing toward the target. In the sideways orientation the thrower’s toes was also pointed perpendicular to the intended flight of the ball. This was the proper preparatory position to take advantage of rotational inertia, which © the momentum from the base segments to the more distal segments. Modeling for Stage III highlighted the rotation of the trunk. It was important that during Stage III the shoulders were not referenced as the focus of the rotation, only the trunk and pelvis initiated the rotation (Stodden, 2002). The shoulders may have rotated with the pelvis, but the movement was not initiated in the shoulders. Drills used during Stage III (See appendix D) worked on developing the rotation of the hips. Cues suggested for this stage were the statue position of the “L”, “untwist your hips fast,” “reach,” “follow-through.”

Stage IV added linear momentum with the rotating trunk. During this stage the focus was to first assume a sideways orientation, and then step with the foot opposite the throwing hand toward the target. This stage emphasized both linear and rotational components with the step and the rotating trunk from Stage III. Stage IV encompassed all of the aspects of the throw: the step, rotation, release, and follow-through.
IV the teacher modeled the long step and the rotation of the trunk. Cues for Stage IV
continued to emphasize the preparatory position of the “L,” “taking a long step,”
“twisting and reaching,” and “following through.”

Stodden’s (2002) initial implementation of the BP approach was to practice and
instruct each stage until at least 75% of the class is proficient in that stage. This approach
was implemented in this study in a similar manner, but at least 80% of the class
demonstrated proficiency in that level before advancing to the next level. The criterion
level of 80% was based on the criterion level of 80% success for academic learning time
(Siedentop, Tousignant, & Parker, 1982). The assessment of whether 80% of the class
demonstrated the particular stage was completed during live observation of the class
session. During practice an observer recorded whether or not students demonstrated
proficiency in that stage. The teacher gave a signal to the observer as to whether she
observed 80% of the class demonstrating the particular stage during class practice. The
observer then responded with a signal as to whether 80% had actually demonstrated the
particular stage during class practice. If the observer had not recorded 80%, the teacher
continued to instruct the particular stage and periodically check with the observer to see if
80% had been achieved. There were two instances where the teacher and investigator did
not have an agreement as to when to move on, each time the teacher provided her
students with more practice trials until receiving concurrence from the investigator to
move to the next stage. After completing a stage, the teacher reviewed aspects of the
stages periodically, as well as cued aspects from a previous stage during other stages in
the approach to keep the critical elements prevalent in the throwers mind and to correct
errors.
A regular physical education teacher implemented the BP approach. Similar to the CUE group, the teacher used demonstrations, modeling, and direct instruction to introduce each of the stages. The teacher also used relevant prompts, feedback, and cues to assist students in developing the movements of each stage. Drills and activities were constructed to highlight the targeted aspects of the stage. The drills and activities are outlined in each of the lesson plans. The teacher completed the BP approach as stated and achieved 100% on the Treatment Integrity Checklist. The investigator completed the Treatment Integrity Checklist during each instructional session. Refer to Appendix D for the scripted lesson plans for each stage. The class sessions were videotaped in case the treatment integrity needed to be reassessed.

*Traditional Physical Education (TPE) group.* The Traditional Physical Education (TPE) group received practice and instruction that was typical in elementary physical education. The TPE group instruction and practice in the overarm throw was based on an experienced teacher’s own lesson plans. The investigator had no influence on the content or construction of drills in the TPE. The only guidelines the TPE teacher followed was: (a) the teacher must teach the overarm throw for 30 minutes, (b) must provide instruction and/or practice focused on hard and fast throws, and (c) committed four lessons to the practice/instruction of the throw. The key aspects targeted in the TPE group were similar to the cues suggested by Graham and colleagues (2001): (a) side to target, (b) arm way back, (c) step with opposite foot, and (d) twist and throw hard. The investigator reviewed the lesson plans to check that 30 minutes of throwing instruction or practice was allocated.
and that “hard and fast” throws were targeted during practice. Table 3.5 included a block plan that summarizes the activities of the TPE group. See Appendix E for the complete lesson plans from the TPE group.

Treatment Integrity

Instructor Training

Critical Cue. The primary investigator provided a workshop to train the physical education teacher for the CUE group. The primary purpose of this training was to develop appropriate use of the critical cues. The training began with an overview of the three cues and the targeted aspects of the throw. The teacher was then shown a videotape of ten different children performing the overarm throw. The teacher responded with a cue from the study, and the targeted aspect. If any of the responses by the teacher were inappropriate for the demonstrated throwing pattern, the cue was reviewed and the throwing trial replayed. The teacher responded with the correct cue for nine of ten throwers. The incorrect trial was replayed and the teacher responded with the correct cue and a rationale for why that cue was correct.

Biomechanical Approach. The primary investigator provided another 45 minute workshop to train the physical educator of the BP group on the stages of the BP approach. The investigator taught the BP approach to the teacher. To check for understanding, and to provide additional practice the teacher then trained the investigator using the BP approach. The investigator provided feedback to the teacher after each stage of the BP approach. The investigator also answered any questions that may have arisen. The teacher of the BP group also practiced the approach with two other classes before teaching it to the experimental classes to identify any questions or problem areas, which
could then be clarified by the investigator. The investigator also videotaped these classes to review the class session with the teacher. The videotape was reviewed and the teacher provided correct demonstrations and appropriate cues and feedback for the BP approach. Any questions or concerns were addressed before the teacher presented the lessons to the experimental classes.

_Treatment Integrity Checklists_

Treatment integrity examines the extent to which the independent variable was implemented as intended. Treatment integrity for each group was assessed using a yes or no checklist. A “yes” is written in the blank if the teacher implemented all aspects of the statement as described. A “no” was written in the blank if the teacher had not implemented all of the aspects of the statement. The checklist for each group appears in Table 3.8. The checklist was completed via live observation during class instruction, analysis of these data showed that the instructors completed all lessons as planned.

_Instructional Variables_

The instructional variables of student behaviors, teacher behaviors, and interactions were assessed in each class session. The purpose of assessing the instructional variables was to describe the class context as no controls were put on the teachers as to the amount or type of feedback that could be given to the class.

_Instrumentation_

The Observational Recording Record of Physical Educator’s Teaching Behavior (ORRPETB) was selected to track the key instructional variables. The ORRPETB has the ability to record student behaviors (instructional climate), interactions, and teacher behavior (Stewart, 1989). The instrument is comprised of 27 categories of teacher
Procedural Reliability Check

Observer_______________________  IOA________________________
Date____________     Class Session #: __________

*Instructional Approach: CUE Group*

   a. Review of previous lesson key point
      1. Lesson 1 – no review
      2. Lesson 2 – review “point your laser beams.”
      3. Lesson 3 – review “point your laser beams,” and “take a long step.”
      4. Lesson 4 – review “untwist your hips,” “take a long step,” and “point your laser beams.”

_____ 2. Presentation of critical cue
   a. Introduction of cue
   b. Demonstration of cue
   c. Completion of class practice of cue.

_____ 3. Stations completed as described in the lesson plan.
   a. Time assigned to each station met.

_____ 4. Teacher provides review of targeted critical cue for the day.
   Lesson 1 – “point your laser beams.”
   Lesson 2 – “take a long step.”
   Lesson 3 – “untwist your hips.”

_____ 5. Highlights the importance of throwing “hard and fast” periodically during the lesson and practice.

(Continued)

Table 3.8 Treatment integrity checklists for the TPE, CUE, and BP groups.
Procedural Reliability Check

Observer_______________________ IOA________________________
Date____________ Class Session #: __________

Instructional Approach: BP Group

   a. Review of previous lesson key point
      1. Lesson 1 – no review
      2. Lesson 2 – review Stage I – proper L position
      3. Lesson 3 – review Stage II – linear moment after assuming proper L position
      4. Lesson 4 – review Stage III – rotation component “untwisting hips.”
      5. Lesson 5 – review Stage IV – stepping action with rotation component.

2. Presentation of focus of lesson: can use modeling, and manual guidance.
   Lesson 1 – Stage I - Proper L position of humerus and forearm during action phase
   Lesson 2 – Stage II - Linear momentum stepping toward target after assuming L position
   Lesson 3 – Stage III - Rotating the pelvis
   Lesson 4 – Stage IV - Forward step toward target and rotating trunk.

3. Practice focus of lesson until 80% of students demonstrate the aspect.

4. Highlights the importance of throwing “hard and fast” periodically during the lesson.

5. Stations completed as described in the lesson plan.
   a. Time assigned to each station met.

6. Teacher provides review of targeted aspect.
   Lesson 1 – Stage I - Proper L position of humerus and forearm during action phase
   Lesson 2 – Stage II - Linear momentum stepping toward target after assuming L position
   Lesson 3 – Stage III - Rotating the pelvis
   Lesson 4 – Stage IV - Forward step toward target and rotating trunk.
(Table 3.8 continued)

Procedural Reliability Check

Observer_______________________  IOA________________________
Date____________     Class Session #: __________

*Instructional Approach: TPE Group*

   a. Review of previous lesson key point

_____ 2. Prompts throwing “hard and fast” periodically during the lesson and
   throwing practice.

_____ 3. Activities completed as described in the lesson plan.
   a. Students complete session for designated time period.
behavior, 4 categories of student behavior, and 5 teacher-student behavior categories. Figure 3.3 is an example of the data sheet with a listing of each of the categories. The procedures used for the ORRPETB included recording the various categories on a data sheet. The coding of the ORRPETB used videotape analysis because of the number of categories that were coded during each interval. Video analysis provided a permanent record of the instructional session, and it provided the opportunity to watch the interval repeatedly when necessary. Two video cameras were positioned in the gym to allow the observer to view the entire gym.

The ORRPETB is an interval-recording instrument using a recommended five-second interval (Stewart, 1989). Five seconds of observation time were followed by five seconds of recording time. This was done to maintain a high correspondence between the recorded frequency and actual teacher behaviors (Stewart, 1989). Every tenth interval was a resting interval for ten seconds. The observer recorded a behavior during each interval for each of the categories of climate, behavior, and interaction. The observer recorded the behavior for each category that was most dominant during that interval. In terms of instructional climate or student behavior, 51% of the class must be engaged in that aspect for it to be recorded in that climate.

Categories. Climate, interactions, and teacher behavior were the three categories recorded during each five-second interval. Climate, or student behavior records what the students were doing (Stewart, 1989). The four categories of climate were instructional time, management time, activity time, and waiting time. Instructional time was the “period of time in the class when, theoretically, the opportunity for the student to learn is present” (Stewart, 1989, p. 250). During instructional time students can received
Observational Recording Record of Physical Educator’s Teaching Behavior (ORRPETB)

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Grade | Activity | Time Started | Time Finished |
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</tbody>
</table>

**Climate (C)**

- **Management**
  - M: Lecaturing or orienting
  - I: Nonfunctional

- **Instruction**
  - P: Teacher officiating
  - T: Teacher participation skill

- **Activity**
  - A: Asking questions
  - W: Answering questions

- **Waiting**
  - L: Listening

- **Interaction (I)**
  - M: Monitoring
  - N: Nonfunctional

- **Group**
  - G: Managing

- **Class**
  - C: Physical

- **Contact/Manual**
  - P: Physical contact

- **Male**
  - M: Guidance

- **Female**
  - F: Hustling

**Behavior (B)**

- LO: Praise
- AQ: Teacher participation skill
- WQ: Feedback general
- L: Skill feedback – specific
- MO: Corrective skill feedback
- MG: Other

- FG: Teacher officiating
- TP: Teacher participation skill
- FS: Feedback general
- CF: Corrective skill feedback
- TO: Other

- H: Teacher modeling
- SM: Student modeling


Figure 3.3. The Observational Recording Record of Physical Educator’s Teaching Behavior.
information verbally or nonverbally. To be recorded as instructional time, 51% or more
of the students were not engaged in physical activity. Examples of activities that were
recorded as instructional time include: listening to a lecture, watching a teacher or student
model a skill, and participating in a question and answer discussion (Stewart, 1989).
Management time was when the opportunity to learn was not present (Stewart, 1989). To
be coded as management time, 51% of the students were engaged in an activity that was
only indirectly related to the class learning activity. There were no demonstrations,
instructions, or practice during management time. Examples provided by Stewart (1989)
include: changing activities, listening for roll call, and setting up equipment. Activity
time was when 51% or more of the students were involved in actual physical movement
that was directly related to the goals of the lesson. Waiting time was recorded when 51%
of the students were prohibited from being categorized in any of the other classroom
climates. Waiting time was recorded when students were not in the other categories of
instruction, management, or activity time. Waiting time was not recorded when 51% of
the students were waiting in line to use equipment, rather management is the appropriate
category to record (Stewart, 1989). Examples for wait time included: waiting to repair
equipment, teacher interrupted by another teacher, parent, or an announcement over the
loudspeaker (Stewart, 1989).

Interactions were another category recorded by the ORRPETB. Interactions were
when the teacher interacted either verbally or nonverbally with a student or a group of
students, or responded to student behavior either verbally or nonverbally. The interaction
category was comprised of five categories: individual, group, class, male, and female.
Stewart (1989, p. 251) states there are two questions that are asked when the observer is
recording interactions: “What is the size of the group (individual, group, class)? Which gender is the interaction directed toward (male, female, or both)?” An interaction was recorded as “individual” if the teacher was only talking to one student. If the teacher was talking to more than one student, “group” was the appropriate category. Interactions were tracked in this study to keep track of interactions between the teacher and the boys and girls in the class.

Teacher behavior is the last major category observed by the ORRPETB. Teacher behaviors were the teacher reactions to student behavior. The categories included: lecturing, asking questions, answering questions, listening, monitoring, nonfunctional, managing, skill feedback, modeling, social behaviors, hustling, physical contact/manual guidance, teacher officiating, and teacher participating. Lecturing was described as when the teacher was communicating facts or opinions about the content or procedures. A teacher was “asking questions” when the teacher asked a student or a group of student’s questions about content or procedures. A teacher was “answering questions” when he/she responded to students’ questions. Listening was coded when the teacher was listening to the student’s question or response. A teacher was “monitoring” when observing the class without reacting to student behavior. Nonfunctional is a behavioral category recorded when the teacher behaviors were not related to the ongoing activities or the class. For example, if the teacher was talking to another teacher or to a student not in the class. Managing was the recorded teacher behavior when the teacher “expresses behaviors that are related to the class, but do not contribute to the educational outcomes (Stewart, 1989, p. 252).” Modeling was when a teacher showed a student or students the correct or incorrect way to perform a skill (Stewart, 1989). The modeling subcategories from the
original ORRPETB were condensed to only teacher modeling and student modeling to meet the needs of the study. Social behaviors were the teacher reactions to the social behaviors of students and included: general praise, specific praise, nagging, and getting nasty (Stewart, 1989). Skill feedback was a teacher behavior that contained the subcategories of corrective skill feedback (corrective skill feedback is corrective information given after an attempt), Skill feedback-general (general praise, either verbal or nonverbal, that occurred during or immediately following a skill attempt), or skill feedback-specific (specific, verbal praise that occurred during or following a skill attempt). One category modified from the Stewart’s original instrument was physical contact. The physical contact category was modified to physical contact/manual guidance (PC/MG). This category was recorded for a teacher using manual guidance to move a body part into proper position.

*Summarizing these data.* The coding record was transferred to a summary sheet at the completion of each observation. The summary sheet included each of the categories and subcategories. The observer recorded the frequency of intervals for each category during the class session. The percentage of interval occurrence was calculated by dividing the total number of observed intervals for the category by the total number of observed intervals.

*Training and interobserver agreement.* Two observers coded the instructional variables using the ORRPETB. The two observers were graduate students working towards a degree in physical education teacher education. Both observers were trained in the ORRPETB to a criterion of 95% accuracy. The observers undertook a three-step training process that was similar to the training process for Academic Learning Time in
Physical Education (ALT-PE) (Siedentop et al., 1982). First the observers studied the definitions of the ORRPETB. Then the observers were given a written test on the definitions of the ORRPETB (See Appendix F). The observer had to score 100% to move onto the next step. In the final step, the observers coded a 10-minute lesson using the ORRPETB. Observers met the required agreement level of 95% with the ORRPETB training tape. The level of agreement obtained in the training video was 96.2%. Interobserver agreement was then assessed for a total of one-third of all videotaped lessons at Session 1, 2, 3, and 4. Interobserver agreement was 83.89% at Session 1, 80.81% at Session 2, 93.56% at Session 3, and 89.7% at Session 4.

**Opportunities to Respond**

Another method of describing what students do in physical education is to observe the number of trials or responses. Opportunities to respond (OTR) was used to track the number of balls thrown during each session. Six participants (three boys and three girls) from each first and second grade class, were randomly selected to be observed during the class session. A response was recorded if the observed participant threw a ball. The quality of the response was not evaluated. A response was not recorded if the participant was modeling the throwing motion, a response was recorded if the ball was thrown.
Procedures

Data Collection

The investigator completed all procedures set forth by the Institutional Review Board of informed human subjects consent (See Appendix G). Consent was obtained through the school and the parent/guardian of each participant (See Appendix H). All participants returned a signed permission slip from their parent or guardian in order to participate in the study.

Each participant was pretested, posttested, and given a retention test for each dependent variable. The retention test was given two weeks after the posttest due to the approaching completion of the school year. Data regarding throwing form and ball velocity during practice were collected simultaneously. Data of throwing form used during gameplay were collected at another time during the participants’ physical education class. All data were collected by the principal investigator. See Table 3.9 for an overview of the dependent measures collected and the time period when the measure was collected.

*Form and velocity.* Form and velocity data were collected during the pretest, posttest, and retention test during the participant’s physical education class. Data was collected independent of other throwing activities and instruction, thus data collection at pretest, posttest, or retention test were not considered part of the four instructional sessions.
### Table 3.9. Overview of instrument and data collected during each session

<table>
<thead>
<tr>
<th>Session</th>
<th>Pretest</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Post</th>
<th>Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variable</strong></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Form during gameplay</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td><strong>Independent Variable</strong></td>
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<tr>
<td>ORRPETB</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention Integrity</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Form used during gameplay.** Data was collected for form used during gameplay at the pretest, posttest, and retention test independent of other class activities. The class session where data was collected during gameplay was not included as one of the four instructional days.

**Data Analysis**

Data collected during the initial pretest, the posttest at the completion of instruction, and the retention test were analyzed. Descriptive and inferential statistics were used to answer the research questions. Appendix I shows hypotheses, the data used for the analysis, the types of inferential statistics used to answer the research questions, and the steps involved in the process.
CHAPTER 4

RESULTS

The first portion of this chapter will address the ORRPETB data and the opportunity to respond data to provide context for the results of this study. The second portion of the chapter presents the research questions associated with the influence of the instructional strategies relative to group. The next portion of the chapter will address the research questions associated with gender differences in throwing performance (See Appendix I for a summary). Each section will examine the influence of instruction on body components during practice, the relationship between body components during practice and game play, and the influence of instruction on ball velocity and the number of unrecorded trials.

Instructional Variables

ORRPETB Data

The ORRPETB collected data regarding student behavior, teacher behavior and interactions. The student behavior and interaction data is presented in Table 4.1. Table 4.2 is a summary table for the teacher behaviors. The data is presented in percentage of interval occurrence. Differences exist between groups in student behaviors. The CUE group has the greatest percentage of activity time (55.4%) and the lowest percentage of
<table>
<thead>
<tr>
<th>Climate</th>
<th>CUE</th>
<th>BP</th>
<th>TPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>16.9</td>
<td>19.9</td>
<td>22.7</td>
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<tr>
<td>Range</td>
<td>8.0 - 22.6</td>
<td>16.2 - 25.5</td>
<td>9.2 - 40.0</td>
</tr>
<tr>
<td>Instruction</td>
<td>27.7</td>
<td>39.1</td>
<td>33.5</td>
</tr>
<tr>
<td>Range</td>
<td>23.4 - 33.2</td>
<td>22.3 - 63.4</td>
<td>26.8 - 40.6</td>
</tr>
<tr>
<td>Activity</td>
<td>55.4</td>
<td>41.0</td>
<td>43.4</td>
</tr>
<tr>
<td>Range</td>
<td>50.5 – 61.1</td>
<td>20.4 – 60.8</td>
<td>26.3 – 61.4</td>
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<tr>
<td>Waiting</td>
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<table>
<thead>
<tr>
<th>Interactions</th>
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<tbody>
<tr>
<td>Individual</td>
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<tr>
<td>Group</td>
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<tr>
<td>Range</td>
</tr>
<tr>
<td>Class</td>
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<td>Range</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Range</td>
</tr>
<tr>
<td>Females</td>
</tr>
<tr>
<td>Range</td>
</tr>
</tbody>
</table>

Note. Data represented is percentage of occurrence for total intervals observed. CUE = Critical Cue Group, BP = Biomechanical Approach, TPE = Typical Physical Education.

Table 4.1. Summary of climate and interactions by group.
<table>
<thead>
<tr>
<th>Teacher Behaviors</th>
<th>CUE</th>
<th>BP</th>
<th>TPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecturing</td>
<td>23.8</td>
<td>24.1</td>
<td>28.8</td>
</tr>
<tr>
<td>Range</td>
<td>17.8 – 27.7</td>
<td>19.9 – 29.4</td>
<td>21.5 – 36.5</td>
</tr>
<tr>
<td>Asking Questions</td>
<td>4.3</td>
<td>3.0</td>
<td>5.6</td>
</tr>
<tr>
<td>Range</td>
<td>2.0 – 8.9</td>
<td>0.5 – 3.8</td>
<td>2.3 – 10.1</td>
</tr>
<tr>
<td>Answering Questions</td>
<td>0.6</td>
<td>0.5</td>
<td>1.7</td>
</tr>
<tr>
<td>Range</td>
<td>0.0 – 2.0</td>
<td>0.0 – 1.4</td>
<td>0.7 – 3.3</td>
</tr>
<tr>
<td>Listening</td>
<td>1.8</td>
<td>2.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Range</td>
<td>0.0 – 3.1</td>
<td>1.1 – 6.0</td>
<td>2.4 – 8.8</td>
</tr>
<tr>
<td>Monitoring</td>
<td>15.2</td>
<td>12.4</td>
<td>15.5</td>
</tr>
<tr>
<td>Range</td>
<td>9.8 – 23.3</td>
<td>8.1 – 17.0</td>
<td>7.5 – 25.9</td>
</tr>
<tr>
<td>Nonfunctional</td>
<td>0.9</td>
<td>2.4</td>
<td>4.1</td>
</tr>
<tr>
<td>Range</td>
<td>0.0 – 2.5</td>
<td>0.0 – 4.1</td>
<td>0.6 – 10.5</td>
</tr>
<tr>
<td>Managing</td>
<td>3.1</td>
<td>1.2</td>
<td>9.0</td>
</tr>
<tr>
<td>Range</td>
<td>0.5 – 6.7</td>
<td>0 – 3.5</td>
<td>2.6 – 14.4</td>
</tr>
<tr>
<td>Physical Contact/</td>
<td>7.8</td>
<td>8.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Manual Guidance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>2.0 – 13.7</td>
<td>4.8 – 14.7</td>
<td>0.0 – 3.7</td>
</tr>
</tbody>
</table>

(Continued)

*Note.* Data represented is percentage of occurrence for total intervals observed.

Fb = feedback. CUE = Critical Cue Group, BP = Biomechanical Approach, TPE = Typical Physical Education.

Table 4.2. Summary data by group for teacher behaviors.
(Table 4.2 Continued)

<table>
<thead>
<tr>
<th>Teacher Behaviors</th>
<th>CUE</th>
<th>BP</th>
<th>TPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hustle</td>
<td>4.5</td>
<td>4.1</td>
<td>5.8</td>
</tr>
<tr>
<td>Range</td>
<td>3.9 – 5.6</td>
<td>2.1 – 7.6</td>
<td>0.0 – 10.6</td>
</tr>
<tr>
<td>Teacher Modeling</td>
<td>3.5</td>
<td>7.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Range</td>
<td>2.4 – 5.0</td>
<td>3.6 – 7.6</td>
<td>0.0 – 10.6</td>
</tr>
<tr>
<td>Student Modeling</td>
<td>4.0</td>
<td>3.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Range</td>
<td>2.8 – 6.2</td>
<td>1.4 – 5.2</td>
<td>0.0 – 1.9</td>
</tr>
<tr>
<td>Praise</td>
<td>2.0</td>
<td>2.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Range</td>
<td>1.0 – 3.0</td>
<td>0.0 – 2.0</td>
<td>0.0 – 2.0</td>
</tr>
<tr>
<td>Fb General</td>
<td>4.1</td>
<td>5.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Range</td>
<td>1.0 – 5.9</td>
<td>3.1 – 9.7</td>
<td>1.8 – 9.2</td>
</tr>
<tr>
<td>Fb Specific</td>
<td>10.6</td>
<td>8.6</td>
<td>3.7</td>
</tr>
<tr>
<td>Range</td>
<td>3.9 – 15.2</td>
<td>4.1 – 16.2</td>
<td>0.0 – 7.9</td>
</tr>
<tr>
<td>Corrective Fb</td>
<td>11.7</td>
<td>12.6</td>
<td>2.9</td>
</tr>
<tr>
<td>Range</td>
<td>7.5 – 17.2</td>
<td>9.1 – 15.1</td>
<td>0.6 – 8.8</td>
</tr>
<tr>
<td>Teacher Participating</td>
<td>0.0</td>
<td>0.0</td>
<td>3.1</td>
</tr>
<tr>
<td>Range</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0 – 10.4</td>
</tr>
</tbody>
</table>
instructional time (27.7%). The BP strategy had the highest percentage of instructional time (39.1%). The TPE had the highest percentage of managerial time (22.7%), and also had a higher percentage of instructional time (33.5%) than the CUE group (27.7%).

For teacher behaviors the BP (7.0%) and TPE (6.0%) groups had the highest percentage of teacher modeling. The CUE group had a lower percentage of teacher modeling (3.5%) but had a high percentage of feedback (14.7%) and corrective feedback (11.7%). The CUE (7.8%) and the BP (8.1%) groups both had higher percentage of manual guidance than the TPE group. The TPE group (28.8%) had the highest percentage of lecturing/orienteering.

Number of Throws during Practice

The number of throws during practice was calculated. The mean number of throws during each session are presented in Table 4.3. The BP group (41.72) had the highest mean number of throwing trials at each instructional session. The TPE group (33.54) had the second highest, while the CUE group (30.19) had the lowest mean number of throws during each session. When examining gender regardless of group, boys (37.14) had more throwing trials than girls (33.17). When examining group, boys had more throwing trials than girls in the BP and CUE groups. The TPE had a similar number of throws for boys (33.50) and girls (33.58).

Body Components During Individual Practice and Instructional Group

This portion of the results section will address the research question considering the influence of the instructional strategies on body components. Research question 1 determined if between group differences existed between the instructional groups (CUE, BP, and TPE) on the four body components of the overarm throw from pretest to posttest
<table>
<thead>
<tr>
<th></th>
<th>CUE</th>
<th>Biomechanical</th>
<th>Typical PE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Total</td>
</tr>
<tr>
<td><strong>Session 1</strong></td>
<td>Mean</td>
<td>31.83</td>
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<tr>
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<td>Range</td>
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<td>20-37</td>
</tr>
</tbody>
</table>

Table 4.3. Mean number of throwing trials for each group and gender during each instructional session.
to retention test. Table 4.4 shows the mean pretest, posttest, and retention test scores for each component by group. Figure 4.1 through 4.4 illustrates the pretest, posttest, and retention test means by group for the step, trunk, humerus and forearm components.

Hypothesis 1 explored whether group differences existed in body component levels at the pretest. A pretest multivariate analysis of variance (MANOVA) revealed a non-significant Group effect ($F[8, 230] = .83, p = .57, \eta^2 = .03$) at the pretest. Follow-up univariate tests showed there were no significant differences between groups for the step ($F[2, 119] = .46, p = .63, \eta^2 = .008$), trunk ($F[2, 119] = .33, p = .72, \eta^2 = .006$), humerus ($F[2, 119] = 1.39, p = .25, \eta^2 = .02$), and forearm ($F[2, 119] = .99, p = .37, \eta^2 = .017$) components. To examine if group differences occurred over time (Hypothesis 2) in throwing performance, a 3 Group X 3 Time X 2 Gender MANOVA with repeated measures on the last factor was conducted. A significant multivariate Group X Time interaction ($F[16, 210] = 1.77, p = .037, \eta^2 = .12$) was reported. Follow-up analysis revealed a significant univariate Group X Time interaction ($F[4, 222] = 2.95, p = .021, \eta^2 = .051$) for the forearm, and non-significant univariate Group X Time interactions for the step ($p = .062$), trunk ($p = .89$), and humerus ($p = .84$) components. Thus, group differences were found overtime for the forearm component but not for the other three components.

To examine Hypothesis 3, a 3 Group X 3 Time X 2 Gender MANOVA with repeated measures on the last factor revealed a non-significant multivariate Group effect ($F[8, 218] = 1.86, p = .068, \eta^2 = .06$). Since no significant multivariate Groups effects were found, there were also no significant univariate Group effects for the step ($p = .18$), trunk
<table>
<thead>
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<th>TPE</th>
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Table 4.4 Mean component levels for each group by each component at the pretest, posttest, and retention test.
Note. CUE = Critical Cue group, BP = Biomechanical approach, TPE = Typical Physical Education.

Figure 4.1 Mean step component at pretest, posttest, and retention for each group

Note. CUE = Critical Cue group, BP = Biomechanical approach, TPE = Typical Physical Education.

Figure 4.2 Trunk component at pretest, posttest, and retention test for each group
Note. CUE = Critical Cue group, BP = Biomechanical approach, TPE = Typical Physical Education.

Figure 4.3 Humerus component at pretest, posttest, and retention test for each group.

Note. CUE = Critical Cue group, BP = Biomechanical approach, TPE = Typical Physical Education.

Figure 4.4 Forearm component at pretest, posttest, and retention test for each group.
(p = .16), humerus (p = .13), and forearm (p = .87) components. However, when examining only posttest group differences, a 3 Group X 2 Gender MANOVA for the posttest data revealed a multivariate Group effect (F[8, 236] = 2.65, p = .008, η² = .08). Follow-up univariate analyses showed a significant Group effect for the step component (F[2, 123] = 3.64, p = .029, η² = .06). Examining the post-hoc tables revealed a significant difference (p = .022) between the CUE and TPE group in the step component. The CUE group had a mean step component level of 3.10 compared to the TPE mean step component level of 2.88. The other components of trunk (p = .35), humerus (p = .27), and forearm (p = .24) did not reveal significant differences between groups at the posttest. For the retention test, a non-significant multivariate Group effect (F[8, 236] = 1.13, p = .34, η² = .04) was found. There were also no significant univariate Group effects for the step (p = .23), trunk (p = .60), humerus (p = .29), and forearm (p = .87).

To address Hypothesis 4 and to determine the influence of the instructional strategies on body components across time, a 3 Group X 3 Time X 2 Gender MANOVA with repeated measures on the last factor was conducted and revealed a significant multivariate Time effect (F[8, 104] = 16.496, p = .000, η² = .559). Follow-up univariate analyses revealed significant Time effects for the step (F[2, 222] = 29.38, p = .21, η² = .06), trunk (F[2, 222] = 49.59, p = .000, η² = .31), humerus (F[2, 222] = 38.34, p = .000, η² = .26), and forearm (F[2, 222] = 24.60, p = .000, η² = .18) components. Since a Time effect was found for each component, each group was then selected and analyzed separately using a paired sample t-test to determine if significant differences in mean component levels were present from pretest to posttest. If significant pretest to posttest changes were found then posttest to retention test differences were examined. A
Bonferroni adjustment was calculated and the level of significance was established 
\( p \leq 0.0167 \) (\( p = 0.05/3 \)). Significant differences from pretest to posttest were found for each 
group. The CUE group improved significantly from pretest to posttest on the step 
component (\( t [37] = -2.80, p = 0.008 \) [2-tailed]), trunk (\( t [37] = -5.513, p < 0.000 \) [2-tailed]), 
and the humerus (\( t [37] = -4.217, p < 0.000 \) [2-tailed]). The BP group improved 
significantly from pretest to posttest in the step (\( t [39] = -3.072, p = 0.004 \) [2-tailed]), trunk 
(\( t [39] = -3.680, p = 0.001 \) [2-tailed]), humerus (\( t [39] = -4.322, p < 0.000 \) [2-tailed]), and 
forearm (\( t [39] = -4.540, p < 0.000 \) [2-tailed]). The TPE group improved significantly from 
pretest to posttest in the trunk component (\( t [40] = -5.846, p < 0.000 \) [2-tailed]), humerus (\( t 
[40] = -3.584, p = 0.001 \) [2-tailed], and forearm (\( t [40] = -2.420, p = 0.020 \) [2-tailed]). Since 
significant pretest to posttest differences existed, paired samples t-test were then 
conducted to determine if any changes occurred from posttest to retention test. All 
groups, CUE, BP, and TPE demonstrated no significant changes from posttest to 
retention test for these components. That is, the significant differences demonstrated 
between pretest and posttest in body components were maintained at the retention test.

*Summary of body components.* There were no significant differences in the step, 
trunk, humerus, and forearm between groups at the pretest. At the posttest, significant 
group differences existed for the step component between the CUE group and the TPE 
group. No significant group differences existed at the retention test for any of the 
components. A significant Group X Time effect was found along with follow-up 
significant univariate Group X Time effect for the forearm component, but not for the 
step, trunk, and forearm. A significant Time effect with follow-up significant univariate 
Time effects for the step, trunk, humerus, and forearm was found. Within each group,
significant changes occurred in body components from pretest to posttest. The CUE had significant pretest to posttest changes in the step, trunk, and humerus. There were no significant differences for the forearm component from the pretest to posttest for the CUE group. The BP group improved significantly in the step, trunk, humerus, and forearm components from pretest to posttest. The TPE group improved significantly in the trunk, humerus, and forearm. The TPE group did not have a significant difference from pretest to posttest for the step component. For all groups there were no significant changes in each body component from posttest to retention test indicating the learning that occurred from instruction was maintained for the retention test.

**Relationship between Components During Practice and Components at Gameplay**

The relationship between body components demonstrated during practice and those demonstrated during gameplay are explored in Research Question 2. Pearson-Product Moment correlation coefficients were calculated to determine the relationship between practice and gameplay. The components considered during practice were the step, trunk, and forearm. The components considered in the modified gameplay instrument were the foot/knee position, trunk, and forearm. The primary issue being analyzed here was the extent to which the three components shown in practice (step, trunk, and forearm) were able to be shown in gameplay. Tables 4.5 to 4.7 show the entire correlation matrix, however it is the diagonal of the correlation matrix which is of importance in answering Hypothesis 5. Overall, Hypothesis 5 stated that the matching components (ex. step during practice to foot/knee position during gameplay) would have a significant positive relationship. The relationships between practice and gameplay are presented separately for the CUE, BP, and TPE groups. Table 4.8 shows the mean body
### Table 4.5 Correlation coefficients of components during practice and components during gameplay for the Critical Cue group.

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<tr>
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<th>Step – Practice</th>
<th>Trunk-Practice</th>
<th>Forearm – Practice</th>
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<td>.529**</td>
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<td>.539**</td>
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Note: *$p \leq .05$, **$p \leq .001$. **Bold** are matching components.
Table 4.6 Correlation coefficients of components during practice and components during game play for the Biomechanical group.

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<td>Forearm-Game</td>
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<td>.644**</td>
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Note: *p < .05, **p < .001. Bold are matching components.
Table 4.7 Correlation coefficients of components during practice and components during gameplay for the Typical Physical Education group.

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Note: *p < .05, **p < .001. **Bold** are matching components.
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Table 4.8 Mean body component levels for the step, trunk, and forearm during game play by group.
component levels during gameplay for the pretest, posttest, and retention tests. The same
data for practice were previously shown in Table 4.3. Overall, the forearm and trunk
components demonstrated the stronger significant relationships between practice and
gameplay. The step component had the weakest relationships between practice and
gameplay.

*CUE group.* The CUE group had significant moderate to strong relationships in
eight of the possible nine matching component relationships at the pretest, posttest, and
retention test. The matching step components had a significant moderate relationship
during the pretest ($r=.41$) and posttest ($r=.42$), but not the retention test. The trunk
component had strong relationships at pretest ($r=.72$) and posttest ($r=.65$), and a moderate
correlation at the retention test ($r=.58$). The forearm component had moderate
relationships at the pretest ($r=.54$) and retention test ($r=.53$), and a significant low
correlation ($r=.21$) was present at the posttest.

*BP group.* The BP group had significant moderate to strong relationship in seven
of the possible nine matching component relationships at the pretest, posttest, and
retention test. The matching step components had a significant moderate relationship
during the pretest ($r=.49$), but not at the posttest and the retention test. The trunk
component had moderate relationships at pretest ($r=.59$) and posttest ($r=.58$), and a strong
correlation at the retention test ($r=.76$). For the forearm component a moderate
relationship existed at the pretest ($r=.55$), posttest ($r=.56$), and a strong relationship at the
retention test ($r=.64$).
**TPE group.** The TPE group had significant relationships in all nine of the matching component relationships at the pretest, posttest, and retention test. The matching step components had a significant moderate relationships during the pretest ($r=.54$) and retention ($r=.49$), and a low relationship at the posttest ($r=.35$). The trunk components had moderate relationships at pretest ($r=.56$), posttest ($r=.58$), and retention test ($r=.59$). The forearm component had strong relationships at the pretest ($r=.60$), posttest ($r=.74$), and a moderate relationship at the retention test ($r=.55$).

**Summary for practice and gameplay.** The trunk and forearm components seem to have the strongest relationship between practice and gameplay across groups. Both the trunk and forearm had nine of nine moderate to strong relationships between practice and gameplay. The step component was different having only six of nine moderate to strong relationships between practice and gameplay. Twenty four of the 27 relationships were significant with the step being the only component to have non-significant relationships.

**Differences Between Groups in Ball Velocity and Unrecorded Trials**

**Mean ball velocity.** Research question 3 examines whether group differences exist in mean recorded velocity scores from the pretest to the posttest to the retention test. The mean recorded velocity scores and the mean number of unrecorded trials for each group are reported in Table 4.9. A 3 Group X 2 Gender ANOVA on pretest velocity scores was used to determine if differences between groups existed at the pretest. The 3 Group X 2 Gender ANOVA revealed a non significant Group effect ($F[2, 117] = 8.77$, $p=.93$, $\eta^2=.001$) indicating no significant differences between groups in mean recorded velocity at the pretest. Hypothesis 7 explored whether groups differed over time for recorded
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Table 4.9 Mean velocity scores and mean number of unrecorded trials for each group at pretest, posttest, and retention test.
velocity. A 3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor found a non-significant Group X Time interaction ($F [4, 222] = .80, p=.53, \eta^2=.014$). That is, groups did not differ over time for mean velocity scores.

Hypothesis 8 examined significant differences between groups in mean ball velocity, and hypothesized the CUE and BP groups would have greater mean velocities compared to the TPE group at the posttest and retention tests. The 3 Group X 3 Time X 2 Gender ANOVA with repeated measures revealed a non-significant Group effect for ball velocity. That is, the groups were not significantly different in mean ball velocity. When examining Group differences in ball velocity at the posttest a 3 Group X 2 Gender ANOVA revealed a non-significant Group effect ($p=.38$). To examine group differences at the retention test, another 3 Group X 2 Gender ANOVA revealed no significant Group effects ($p=.75$) at the retention test.

To address Hypothesis 9 and to determine changes in ball velocity from pretest to posttest, a 3 Group X 3 Time X 2 Gender ANOVA with repeated measures was used. A significant Time effect ($F [2, 113] = 13.78, p=.000, \eta^2=.19$) was revealed for mean velocity scores. Since a significant Time effect was found, each group was selected and then paired-sample $t$-tests were used to determine if differences in ball velocity existed from pretest to posttest. If differences were found from pretest to posttest, another paired samples $t$-test was conducted to determine if significant changes occurred from posttest to retention test. The CUE group ($t [37] = -2.68, p=.01$ [2-tailed]), the BP group ($t [38] = -2.38, p=.022$ [2-tailed]), and the TPE group ($t [40] = -3.85, p=.001$ [2-tailed]) improved significantly from pretest to posttest in ball velocity. There were no significant changes in
mean ball velocity from posttest to retention test for all three groups (CUE $p=.69$, BP $p=.44$, TPE $p=.053$) suggesting the improvements made from instruction were maintained for the retention test.

Unrecorded Trials. Research question 4 examined whether group differences existed in the number of unrecorded trials from the pretest to the posttest to the retention test. The mean number of unrecorded trials for each group was previously reported in Table 4.9. A 3 Group X 2 Gender ANOVA was used to determine if differences between groups existed at the pretest. For Hypothesis 10, no significant pretest differences ($F[2,116] = .347, p=.71, \eta^2=.006$) were found between groups in the number of unrecorded trials at the pretest. A 3 Group X 3 Time X 2 Gender ANOVA with repeated measures was conducted to examine group differences over time. For Hypothesis 11, a significant Group X Time interaction ($F[4,228] = .2.80, p=.027, \eta^2=.047$) was found for the number of unrecorded trials suggesting groups were different over time. A non-significant Group effect ($F[2, 114] = .001, p=.999, \eta^2=.000$) was found, indicating there were no group differences in the number of unrecorded trials (Hypothesis 12). When examining Group differences in ball velocity at the posttest a 3 Group X 2 Gender ANOVA revealed a non-significant Group effect ($p=.57$). To examine group differences at the retention test, another 3 Group X 2 Gender ANOVA was conducted for the retention test and revealed no significant Group effects ($p=.75$).

For Hypothesis 13 a significant Time effect ($F[2, 114] = 32.87, p=.000, \eta^2=.37$) was found for mean number of unrecorded trials. To continue to explore Hypothesis 13, each group was selected and then paired-sample $t$-tests were used to determine if differences existed from pretest to posttest, and posttest to retention test. The CUE group
the BP group (t [38] = 2.93, \( p = .006 \) [2-tailed]), and the TPE group (t [40] = 5.30, \( p = .000 \) [2-tailed]) significantly reduced the number of unrecorded trials from pretest to posttest. The CUE and BP groups had no significant difference between the number of unrecorded trials from posttest to retention test, but the TPE had a significant (t [40] = -3.64, \( p = .001 \) [2-tailed]) increase in the number of unrecorded trials from 2.83 at the posttest to 4.07 at retention test.

**Ball velocity and unrecorded trials summary.** There were no significant differences in ball velocity between groups at the pretest, posttest, and retention test. A non-significant Group X Time interaction was found for ball velocity. No significant differences were found between groups for ball velocity at the posttest and retention test. A significant Time effect was found, with each group significantly improving in the ball velocity from the pretest to posttest. The CUE and BP group did not significantly change in ball velocity from posttest to retention test, but the TPE had a significantly lower mean velocity at the retention test than the posttest.

For unrecorded trials there were no significant differences between groups at the pretest, posttest, and retention test. A significant Group X Time interaction was found for unrecorded trials suggesting groups were different over time. There was a significant time effect for unrecorded trials with the each group (CUE, BP, and TPE) having significantly fewer unrecorded trials from pretest to posttest. From posttest to retention test, the CUE and BP groups had no significant changes in the number of unrecorded trials, but the TPE had a significant increase in the number of unrecorded trials from posttest to retention test.
Gender Differences and Instructional Strategies

Body Component Levels

Research question 4 determined if gender differences in body component levels for each group from the pretest to the posttest to the retention test. Table 4.10 displays the mean body component levels during practice for each gender. Table 4.11 displays the mean body component levels for each group by gender.

To explore Hypothesis 14 and to determine if gender differences were present at the pretest regardless of group, a 3 Group X 2 Gender MANOVA on pretest body component levels was conducted. A significant main effect for Gender ($F[4,111] = 21.78, p=.000, \eta^2 =.44$) was found. Univariate follow-up tests revealed a significant Gender effect for the step ($F[1,120] = 68.77, p=.000, \eta^2 =.38$), trunk ($F[1,120] = 61.71, p=.000, \eta^2 =.35$), humerus ($F[1,120] = 17.98, p=.000, \eta^2 =.14$), and forearm ($F[1, 120] = 17.58, p=.000, \eta^2 =.13$) at the pretest.

Hypothesis 15 explored if gender differences in body components existed between groups at the pretest. A non-significant multivariate Group X Gender interaction was found ($F[8,224] = .736, p=.66, \eta^2 =.03$). Follow-up univariate tests revealed non-significant Group X Gender interactions for the step ($p=.37$), trunk ($p=.64$), humerus ($p=.36$), and forearm ($p=.72$) components.

To further explore the Gender differences for each group at the pretest, follow-up $t$-tests were conducted to determine if significant gender differences existed within each group. The alpha level was established at 0.013 after a Bonferroni adjustment ($p = .05/4 = 0.013$). The CUE group had significant gender differences at the pretest for the step ($t[37] = 3.85, p=.000$ [2-tailed]) and trunk ($t[37] = 3.57, p=.001$ [2-tailed]) component. No
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Table 4.10 Mean component levels for practice and gameplay for each gender at the pretest, posttest, and retention test.
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Table 4.11 Mean component levels for each group by gender for the step, trunk, humerus, and forearm.
Significant gender differences were present for the humerus ($p = .22$) and forearm ($p = .05$). Significant gender differences were present at the pretest for the BP group in the step ($t_{[38]} = 5.54, \ p = .000 \ [2\text{-tailed}]$), trunk ($t_{[38]} = 4.70, \ p = .000 \ [2\text{-tailed}]$) and humerus ($t_{[38]} = 2.94, \ p = .006 \ [2\text{-tailed}]$) component, but not the forearm component. Significant gender differences were also present for the TPE for the step ($t_{[39]} = 5.04, \ p = .000 \ [2\text{-tailed}]$), trunk ($t_{[39]} = 5.53, \ p = .000 \ [2\text{-tailed}]$), humerus ($t_{[39]} = 3.51, \ p = .001 \ [2\text{-tailed}]$), and forearm ($t_{[39]} = 3.06, \ p = .004 \ [2\text{-tailed}]$) components. Where significant gender differences existed for body components, males demonstrated higher component levels than the females.

To explore Hypothesis 16 and gender differences over time, a 3 Group X 3 Time X 2 Gender MANOVA with repeated measures on the last factor was conducted. A significant multivariate Gender X Time effect was found ($F_{[16, 210]} = 1.769, \ p = .000, \ \eta^2 = .43$). Univariate tests revealed a significant Gender X Time effect for the step ($F_{[2,222]} = 37.59, \ p = .000, \ \eta^2 = .253$) and forearm ($F_{[2,222]} = 5.11, \ p = .007, \ \eta^2 = .04$) components, but non-significant Gender X Time effects for the trunk ($p = .35$) and humerus ($p = .07$). To further explore the changes for males and females from pretest to posttest, paired samples t-test were conducted. Males improved significantly in the trunk ($t_{[65]} = -7.35, \ p = .000 \ [2\text{-tailed}]$), humerus ($t_{[65]} = -6.05, \ p = .000 \ [2\text{-tailed}]$), and forearm ($t_{[65]} = 3.70, \ p = .000 \ [2\text{-tailed}]$), but not in the step ($p = .74$). Females improved significantly in the step ($t_{[52]} = -5.59, \ p = .000 \ [2\text{-tailed}]$), trunk ($t_{[52]} = -5.02, \ p = .000 \ [2\text{-tailed}]$), humerus ($t_{[52]} = -3.86, \ p = .000 \ [2\text{-tailed}]$), and forearm ($t_{[52]} = -3.68, \ p = .001 \ [2\text{-tailed}]$).
To explore Hypothesis 17, whether over time groups and gender are different, a 3 Group X 3 Time X 2 Gender MANOVA with repeated measures on the last factor was conducted. A significant multivariate Group X Time X Gender effect was found ($F_{[16,210]} = 2.09, p = .01, \eta^2 = .14$) with a significant univariate Group X Time X Gender effect for the forearm component ($F_{[4,222]} = 2.74, p = .03, \eta^2 = .05$). Non-significant univariate Group X Time X Gender effects were found for the step ($p = .35$), trunk ($p = .08$), and humerus ($p = .49$).

To further explore whether gender differences were present at the posttest, a follow-up 3 Group X 2 Gender MANOVA was conducted. There was a significant multivariate Gender effect at the posttest ($F_{[4, 114]} = 13.08, p = .000, \eta^2 = .32$). Univariate tests revealed a significant gender effect at the posttest for the step ($F_{[1, 123]} = 8.89, p = .003, \eta^2 = .07$), trunk ($F_{[1, 123]} = 47.32, p = .000, \eta^2 = .29$), humerus ($F_{[1, 123]} = 25.71, p = .000, \eta^2 = .18$), and forearm ($F_{[1, 123]} = 18.90, p = .000, \eta^2 = .139$) components. There was a non-significant multivariate Group X Gender effect ($F_{[8, 230]} = 1.10, p = .36, \eta^2 = .04$) at the posttest. To determine gender differences within each group at the posttest, t-tests were conducted with a Bonferroni adjustment of the alpha to $p = 0.013 (p = .05/4)$. The CUE group had significant gender differences at the posttest for the trunk ($t_{[38]} = 3.75, p = .001$ [2-tailed]) and forearm ($t_{[38]} = 3.04, p = .004$ [2-tailed]), but did not have significant gender differences for the step ($p = .28$) and humerus ($p = .07$) component. The BP group had significant gender differences for the trunk ($t_{[40]} = 4.25, p = .000$ [2-tailed]) and humerus ($t_{[40]} = 3.12, p = .003$ [2-tailed]), but did not have significant differences for the step ($p = .07$) and forearm ($p = .15$). The TPE group had
significant gender differences at the posttest for the trunk \((t [39] = 4.00, p = .000 [2-tailed])\), humerus \((t [39] = 3.89, p = .000 [2-tailed])\), and forearm \((t [39] = 3.45, p = .001 [2-tailed])\), but not for the step \((p = .04)\).

To explore gender differences at the retention test, a follow-up 3 Group X 2 Gender MANOVA was conducted. There was a significant multivariate Gender effect at the retention test \((F [4, 109] = 15.48, p = .000, \eta^2 = .36)\). Univariate tests revealed a significant gender effect at the posttest for the step \((F [1, 118] = 5.52, p = .021, \eta^2 = .05)\), trunk \((F [1, 118] = 60.60, p = .000, \eta^2 = .35)\), humerus \((F [1, 118] = 28.67, p = .000, \eta^2 = .20)\), and forearm \((F [1, 118] = 36.32, p = .000, \eta^2 = .25)\). There was no significant multivariate Group X Gender effect at the retention test \((F [8, 220] = 1.58, p = .13, \eta^2 = .05)\).

To determine gender differences within each group at the retention test, t-tests were conducted with a Bonferroni adjustment of the alpha to \(p = 0.013 (p = .05/4)\). The prediction for the retention test scores was that gender differences in components would persist for the TPE group, but not for the CUE and BP groups. In contrast to the prediction, no significant gender differences were found for the CUE group at the retention tests for the step \((p = .35)\), trunk \((p = .15)\), humerus \((p = .30)\), and forearm \((p = .045)\). Significant gender differences were present for the BP group at the retention test for the trunk \((t [37] = 6.32, p = .000 [2-tailed])\), humerus \((t [37] = 3.19, p = .003 [2-tailed])\), and forearm \((t [37] = 4.07, p = .000 [2-tailed])\) components, but non-significant differences were found for the step \((p = .43)\). The TPE group followed the predicted
pattern of gender differences, with gender differences found for the step (t [39] = 2.38, 
\( p = .022 \ [2\text{-tailed}] \)), trunk (t [39] = 5.31, \( p = .000 \ [2\text{-tailed}] \)), humerus (t [39] = 6.04, \( p = .000 \ [2\text{-tailed}] \)), and forearm (t [39] = 4.64, \( p = .000 \ [2\text{-tailed}] \)) components at the retention test.

To further explore Hypothesis 17 the influence of instruction on each gender
within each group over time was examined. Each group was selected and then paired
samples t-tests for each gender were conducted to determine if significant changes
occurred across time for each component with a Bonferroni adjustment of the alpha to
\( p = 0.013 \) (\( p = .05/4 \)). The males in the CUE group improved significantly in the trunk (t
[22] = -4.53, \( p < .000 \ [2\text{-tailed}] \)) and humerus (t [22] = -3.36, \( p = .003 \ [2\text{-tailed}] \))
components, but not in the step (\( p = .75 \)) and forearm (\( p = .064 \)) components from pretest to
posttest. The females in the CUE group improved significantly in the step (t [15] = -3.81,
\( p = .002 \ [2\text{-tailed}] \)), and trunk (t [15] = -3.14, \( p = .007 \ [2\text{-tailed}] \)) components from pretest
to posttest, but not the humerus (\( p = .025 \)) and forearm (\( p = 1.00 \)) components. The males in
the BP group had a significant change in the trunk (t [22] = -4.59, \( p < .000 \ [2\text{-tailed}] \)),
humerus (t [22] = -3.87, \( p = .001 \ [2\text{-tailed}] \)), and forearm (t [22] = -2.91, \( p = .008 \ [2\text{-tailed}] \))
components from pretest to posttest, but not the step (\( p = .73 \)) component. The BP females
in the BP had a significant change in the step (t [16] = -3.73, \( p = .002 \ [2\text{-tailed}] \)) and
forearm (t [16] = -4.38, \( p < .000 \ [2\text{-tailed}] \)) components, but not in the trunk (\( p = .47 \)) and
humerus (\( p = .93 \)) components. For the TPE group the males had significant changes in the
step (t [20] = -3.02, \( p = .007 \ [2\text{-tailed}] \)), trunk (t [20] = -3.49, \( p = .002 \ [2\text{-tailed}] \)), and
humerus (t [20] = -3.12, \( p = .005 \ [2\text{-tailed}] \)), but not in the forearm components (\( p = .19 \)).
The TPE females had a significant change in the trunk ($t \ [19] = -4.99, p < .000 \ [2\text{-tailed}]$), but not in the step ($p = .031$), humerus ($p = .053$), and forearm ($p = .023$) components from pretest to posttest.

To explore whether changes in body components remained consistent from posttest to retention test, paired samples t-tests were conducted for each gender within each group. The only significant changes found in the forearm component from posttest to retention test. The BP group females had a significant decrease in forearm component level ($t \ [16] = -3.76, p = .002 \ [2\text{-tailed}]$) from posttest to retention test. The TPE males had a significant increase in forearm component levels ($t \ [20] = -2.85, p = .010 \ [2\text{-tailed}]$) from posttest to retention test.

**Summary.** Significant gender differences were present in all components at the pretest regardless of group. Significant gender differences between boys and girls remained after instruction for the step, trunk, humerus, and forearm. Significant gender differences were also found at the retention test for the step, trunk, humerus, and forearm. Both males and females improved from pretest to posttest for the trunk, humerus, and forearm. Males did not have a significant change in the step component from pretest to posttest, but females did have a significant change in the step from pretest to posttest.

The influence of the instructional strategies on gender differences in body component levels was also examined. At the pretest, gender differences were found for the CUE group for the step and trunk, but not for the humerus and forearm. The BP group had significant gender differences at the pretest in the step, trunk, humerus, but not in the forearm. The TPE group had significant gender differences at the pretest in the step,
trunk, humerus, and forearm. No significant Group X Gender interaction was found, thus the genders within each group were not significantly different at the pretest, but each group still had gender differences present at the retention test.

To examine the influence of instruction on gender differences, a significant multivariate Group X Time X Gender was found with significant univariate tests found for only the forearm. Examining the gender differences for each group at the posttest, no significant Group X Gender interaction was found, thus the genders within each group were not significantly different at the posttest. Gender differences were present for each group at the posttest. Follow-up $t$-tests revealed gender differences at the posttest for the CUE group in the trunk and forearm, but not the step and humerus. The BP group had gender differences in the trunk and humerus, but not for the step and forearm at the posttest. Gender differences were present for the TPE group for the trunk, humerus, and forearm, but not the step component. A significant Gender effect was also found at the retention test, but the genders within each group were not significantly different. Follow-up $t$-tests revealed no significant gender differences for the CUE group for the step, trunk, humerus, and forearm. The BP had significant gender differences in the trunk, humerus, and forearm, but not the step component. The TPE group had significant gender differences in the trunk, humerus, and forearm but not in the step component.

While gender differences were present at the pretest, posttest and retention test, each gender with each group had significant changes in body components after instruction. The CUE boys improved in the trunk and humerus, while the girls improved in the step, trunk, and humerus. The BP boys improved in the trunk, humerus, and forearm from pretest to posttest, while the girls significantly improved in the step and
forearm. The TPE boys had significant changes in the step, trunk, and forearm components from pretest to posttest, while the girls had significant changes in the step, trunk, and forearm.

*Relationship between Components during Practice and Gameplay by Gender*

Research question 6 explored the relationship between body component levels at practice and gameplay for each gender and group. Table 4.12 displays the mean component score for the step, trunk, and forearm during gameplay by group and gender. Table 4.10 had previously displayed the mean body component levels for each gender regardless of group at the pretest, posttest, and retention test. The primary issue being analyzed in this research question, just as with group differences, is the extent to which the three components in practice are shown in gameplay. Tables 4.13 to 4.15 show the entire correlation matrix for each gender, but it is the diagonal of the matrix which is of importance to Hypothesis 18. Hypothesis 18 predicted significant moderate to strong (.40 or higher) positive correlations between matching component levels for each gender. The most commonly correlated component for males was the forearm component with 6 of 9 possible relationships moderate to strong correlations. The trunk was the second most common with 3 of 9 relationships, while the step had only one significant correlation for males. For the females the trunk was the most common with 6 of 9 possible correlations were significant moderate to strong correlations. The forearm had five relationships, while the step had only one significant relationship for females.
<table>
<thead>
<tr>
<th></th>
<th>CUE Males</th>
<th>CUE Females</th>
<th>Biomechanical Males</th>
<th>Biomechanical Females</th>
<th>Typical PE Males</th>
<th>Typical PE Females</th>
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<tr>
<td></td>
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<td>M  SD</td>
<td>M  SD</td>
<td>M  SD</td>
<td>M  SD</td>
<td>M  SD</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<tr>
<td>Forearm</td>
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<td>1.45 0.41</td>
<td>1.07 0.19</td>
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<td></td>
<td></td>
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<tr>
<td>Step</td>
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<td>Forearm</td>
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<td>1.15 0.35</td>
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<tr>
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<td>1.79 0.28</td>
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Table 4.12 Mean body component level during gameplay by group and gender.
<table>
<thead>
<tr>
<th>Males</th>
<th>PreSt</th>
<th>PreTr</th>
<th>PreFo</th>
<th>Females</th>
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<th>PreTr</th>
<th>PreFo</th>
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<td>PreGpSt</td>
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<td>.462*</td>
<td>.140</td>
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<td>.132</td>
<td>-.019</td>
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<tr>
<td>PreGpTr</td>
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<td>.746**</td>
<td>.521*</td>
<td>PreGpTr</td>
<td>.435</td>
<td>.482*</td>
<td>.028</td>
</tr>
<tr>
<td>PreGpFo</td>
<td>.379</td>
<td>.613*</td>
<td>.683**</td>
<td>PreGpFo</td>
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<td>.546*</td>
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<table>
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<th>PoTr</th>
<th>PoFo</th>
<th>Females</th>
<th>PoSt</th>
<th>PoTr</th>
<th>PoFo</th>
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<td>.613*</td>
<td>.612*</td>
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<tr>
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<td>.555*</td>
<td>.541*</td>
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<tr>
<td>PoGpFo</td>
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<td>.574*</td>
<td>.663**</td>
<td>PoGpFo</td>
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<td>.457</td>
<td>.637*</td>
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<table>
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<th>ReTr</th>
<th>ReFo</th>
<th>Females</th>
<th>ReSt</th>
<th>ReTr</th>
<th>ReFo</th>
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<td>.267</td>
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<tr>
<td>ReGpTr</td>
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<td>.462*</td>
<td>.062</td>
<td>ReGpTr</td>
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<td>.568*</td>
<td>.440</td>
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<td>ReGpFo</td>
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<td>.638**</td>
<td>.354</td>
<td>ReGpFo</td>
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Table 4.13 Critical Cue group correlation coefficients between body components of throwing during practice and those during gameplay.
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<th>PreFo</th>
<th></th>
<th>PreSt</th>
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<td></td>
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<td></td>
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<td>-.206</td>
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<td>PreGpFr</td>
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<td>.611*</td>
<td><strong>.869</strong>**</td>
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<td><strong>Females</strong></td>
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<td>.194</td>
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<td>PoGpTr</td>
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<td>.163</td>
<td>PoGpTr</td>
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<tr>
<td>PoGpFo</td>
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<td>.424*</td>
<td><strong>.473</strong>*</td>
<td>PoGpFo</td>
<td>.196</td>
<td>.513*</td>
<td><strong>.706</strong>**</td>
</tr>
<tr>
<td><strong>Males</strong></td>
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<td></td>
<td></td>
<td><strong>Females</strong></td>
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<td>ReGpSt</td>
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<td>-.060</td>
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<td>ReGpFo</td>
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<td>.451</td>
<td><strong>.510</strong>*</td>
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</table>

**Note:** PreGpSt = Pretest gameplay step, PreGpTr = Pretest gameplay trunk, PreGpFo = Pretest gameplay forearm, PoGpSt = Posttest gameplay step, PoGpTr = Posttest gameplay trunk, PoGpFo = Posttest gameplay forearm, ReGpSt = Retention gameplay step, ReGpTr = Retention gameplay trunk, ReGpFo = Retention gameplay forearm, PreSt = Pretest step, PreTr = Pretest trunk, PreFo = Pretest forearm, PoSt = Posttest step, PoTr = Posttest trunk, PoFo = Posttest forearm, ReSt = Retention step, ReTr = Retention trunk, ReFo = Retention forearm.

Table 4.14 Biomechanical group correlation coefficients between components during practice and gameplay.
<table>
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<td>PreGpTr</td>
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<td>.337</td>
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<tr>
<td>PreGpFo</td>
<td>.250</td>
<td>.307</td>
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<table>
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<tr>
<th></th>
<th>Males</th>
<th>Females</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>PoGpSt</td>
<td>PoGpTr</td>
</tr>
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<td></td>
<td>-.064</td>
<td>.100</td>
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<td></td>
<td>.137</td>
<td>.300</td>
</tr>
<tr>
<td></td>
<td>.255</td>
<td>.498*</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ReGpSt</td>
<td>ReGpTr</td>
</tr>
<tr>
<td></td>
<td>-.076</td>
<td>-.161</td>
</tr>
<tr>
<td></td>
<td>-.105</td>
<td>-.161</td>
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<tr>
<td></td>
<td>.243</td>
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*Note: PreGpSt = Pretest gameplay step, PreGpTr = Pretest gameplay trunk, PreGpFo = Pretest gameplay forearm, PoGpSt = Posttest gameplay step, PoGpTr= Posttest gameplay trunk, PoGpFo = Posttest gameplay forearm, ReGpSt= Retention gameplay step, ReGpTr= Retention gameplay trunk, ReGpFo = Retention gameplay forearm, PreSt= Pretest step, PreTr= Pretest trunk, PreFo= Pretest forearm, PoSt= Posttest step, PoTr= Posttest trunk, PoFo= Posttest forearm, ReSt= Retention step, ReTr= Retention trunk, ReFo= Retention forearm.

Table 4.15 Typical Physical Education group correlation coefficients between components during practice and gameplay.
**CUE group.** Overall, the CUE group males had five moderate to strong significant relationships, while females had 4 of 9 relationships. No significant relationship existed in the step component for males and females in the CUE group at the pretest, posttest, or retention test. The matching trunk components had a significant moderate to strong relationship at the pretest, posttest, and retention test for both males and females in the CUE group. The forearm components were correlated for the males at the pretest and posttest, while females were correlated at the posttest.

**BP group.** Overall, the BP group males had three moderate to strong significant relationships, while females had 5 of 9 relationships. The males and females had no significant correlation for the step component at the pretest and posttest. At the retention test the males had a moderate significant correlated but not the females. No significant correlations were found for the male’s trunk component at the pretest, posttest, and retention test. The BP females had significant trunk correlations at the posttest and retention test. The males forearm component was correlated at the posttest and retention test, while the females forearm component was correlated at the pretest, posttest, and retention test.

**TPE group.** Overall, the TPE group males had two moderate to strong significant relationships, while females had 3 of 9 relationships. For the TPE group, the step component was not related at the pretest, posttest, and retention test. For the females the step was correlated at the retention test. The TPE males had no significant trunk correlations, while the females had significant relationships at the posttest. For the forearm component, males had significant correlation at the pretest and posttest, while the females were significantly correlated at the pretest.
Summary for practice and gameplay. The prevalence of significant positive relationships was not common for each gender. Overall, the males had six significant moderate to strong relationship, while the females had five. The forearm component seemed to be more closely related for both males and females in all groups than the trunk and step. The step component was the least frequent with only one correlation for both males and females across groups.

Gender Differences and Ball Velocity by Group

Research question 7 and 8 explores whether gender differences existed within each group at the pretest, posttest, and retention test for mean ball velocity and the mean number of unrecorded trials. Table 4.16 summarizes mean ball velocity and unrecorded trials for each gender. Table 4.17 summarizes the mean ball velocity and unrecorded trials for each group and gender. For ball velocity, Hypothesis 19 predicted a significant Gender effect at the pretest with males having a greater mean velocity than females. A 3 Group X 2 Gender ANOVA revealed a significant Gender effect at the pretest ($F[1,117] = 60.18, p=.000, \eta^2 =.35$). Follow-up analysis $t$-tests revealed that overall males threw faster than females at the pretest regardless of group ($t[115] = 7.91, p=.000$ [2-tailed]).

Hypothesis 20 predicted a non-significant Group X Gender effect at the pretest. A 3 Group X 2 Gender ANOVA revealed a non-significant Group X Gender effect at the pretest ($F[2, 117] = 0.93, p=.40, \eta^2 =.02$), thus the genders within each group were not significantly different from the genders in the other groups at the pretest.
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<td>SD</td>
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<td>9.63</td>
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<td>Retention Velocity</td>
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<td>19.36</td>
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<td>SD</td>
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<td>3.53</td>
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Table 4.16 Mean recorded velocity scores and mean unrecorded trials for each gender.
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<td>Males</td>
<td>Females</td>
<td>Males</td>
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<td>20</td>
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<td>3.91</td>
<td>6.80</td>
<td>2.89</td>
</tr>
</tbody>
</table>

Table 4.17 Mean recorded velocity scores and mean unrecorded trials for each group by gender.
Follow-up analyses revealed significant gender differences at the posttest ($F[1, 117] = 28.83, p=.000, \eta^2 =.20$) and retention test ($F[1, 117] = 52.73, p=.000, \eta^2 =.31$), with males having a higher mean recorded velocity than females. Follow-up paired samples $t$-tests were used to determine changes in ball velocity for both boys and girls from pretest to posttest, and posttest to retention test. Both males ($t[64] = 3.74, p =.000$ [2-tailed]) and females ($t[51] =-4.71, p =.000$ [2-tailed]) improved from pretest to posttest. Paired samples $t$-tests revealed no significant changes in the ball velocity from posttest to retention test for males ($p =.27$) but significant changes for females ($t[51] =2.41, p =.02$ [2-tailed]).

To further examine gender differences by group (Hypothesis 22), a 3 Group X 3 Time X 2 Gender ANOVA was used to examine whether over time, groups and genders are different. A non-significant Group X Time X Gender interaction was found ($F[4, 222] = 2.29, p=.06, \eta^2 =.04$). Within each group, significant gender differences were explored using $t$-tests to compare males and females. For the CUE group significant gender differences were found at the posttest ($t[36] = 2.93, p=.006$ [2-tailed]), and retention test ($t[36] = 2.75, p=.009$ [2-tailed]). For the BP group, significant differences were found between males and females at the posttest ($t[37] = 2.62, p=.013$ [2-tailed]), and retention test ($t[37] = 5.12, p<.000$ [2-tailed]). For the TPE group significant differences between males and females were found at the posttest ($t[39] = 4.64, p<.000$ [2-tailed]), and retention test ($t[39] = 4.71, p<.000$ [2-tailed]).

Hypothesis 22 further predicted significant changes in mean ball velocity for each group and gender from pretest to posttest, but no significant change from post to retention. A significant Time effect was found ($F[2,222] = 17.49, p=.000, \eta^2 =.14$) for
mean recorded ball velocity. To further explore the Time effect, paired sample t-tests with a Bonferroni adjustment ($p=.05/2 = .025$) were used to determine if significant changes occurred in mean recorded velocity. For the CUE group, significant changes in mean ball velocity were found for the males ($t[21] = -2.66, p=.015$ [2-tailed]), but not for the females ($p=.049$). The predicted changes in ball velocity did not occur for the BP group for both boys ($p=.08$) and girls ($p=.07$). The TPE group did not have significant changes in mean recorded ball velocity for males ($p=.031$) but had significant changes for females ($t[19] = -4.00, p=.001$ [2-tailed]). No significant changes in ball velocity occurred for each group and gender from posttest to retention test for each group.

Research question 8 explored the same questions as research question 7, but for the mean number of unrecorded trials. Hypothesis 23 predicted a significant Gender effect at the pretest. A 3 Group X 2 Gender ANOVA revealed a significant Gender effect at the pretest ($F[1,117] = 86.79, p=.000, \eta^2 = .44$). A follow-up t-test revealed males had significantly fewer unrecorded trials ($t[115] = 1.11, p=.000$ [2-tailed]) than females at the pretest regardless of group. For Hypothesis 24, a non significant Group X Gender interaction was found at the pretest ($F[2, 117] = 1.07, p=.35, \eta^2 = .02$), thus the genders within each group were similar at the pretest.

To explore Hypothesis 25 a 3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor was conducted. A non significant Gender X Time interaction was found ($F[2, 222] = 2.04, p=.132, \eta^2 = .02$) for unrecorded trials. Follow-up analyses found a significant Gender effect for the posttest ($F[1,117] = 67.75, p=.000, \eta^2 = .38$), and retention test ($F[1,117] = 86.79, p=.000, \eta^2 = .37$). Regardless of group, boys had significantly fewer unrecorded trials at the posttest, and retention test.
To further examine group and gender differences over time (Hypothesis 26), a 3 Group X 3 Time X 2 Gender ANOVA was used to examine whether over time, groups and genders are different. A non-significant Group X Time X Gender interaction was found \((F[4, 222] = 1.63, p=.17, \eta^2=.03)\). Within each group, significant gender differences were explored using \(t\)-tests with a Bonferroni adjustment \((p=.05/2=.025)\) to compare males and females. Follow-up \(t\)-tests showed that the CUE group males had significantly fewer unrecorded trials at the posttest \((t[36] = -3.98, p=.000 \text{ [2-tailed]})\) and retention test \((t[36] = -2.93, p=.006 \text{ [2-tailed]})\) than the females. BP group males also had significantly fewer unrecorded trials at the posttest \((t[37] = -5.79, p=.000 \text{ [2-tailed]})\) and retention test \((t[37] = -5.29, p=.000 \text{ [2-tailed]})\) than females. TPE group males had significantly fewer unrecorded trials at the posttest \((t[39] = -6.79, p=.000 \text{ [2-tailed]})\) and retention test \((t[39] = -6.38, p=.000 \text{ [2-tailed]})\) than females.

Further exploring the changes in each gender within each group over time in unrecorded trials (Hypothesis 26), a significant Time effect \((F[1,111] = 23.13, p=.000, \eta^2 =.17)\) was found for unrecorded trials. Follow-up paired samples \(t\)-test for each group and gender with a Bonferroni adjustment \((p=.05/2=.025)\) were used to determine changes in unrecorded trials for each gender within each group. Significant changes for the CUE group were present for both boys \((t[21] = 4.567, p<.000 \text{ [2-tailed]})\) and girls \((t[14] = 3.17, p=.007 \text{ [2-tailed]})\) from pretest to posttest. For both boys \((p=.08)\) and girls \((p=.07)\) in the BP group there were no significant changes in the number of unrecorded trials from pretest to posttest. The TPE group had significant changes for the girls \((t[19] = 5.64, p<.000 \text{ [2-tailed]})\) but not the boys \((p=.032)\) and from pretest to posttest. There
were no significant changes from post to retention test for the CUE and BP group boys and girls and the TPE boys. However, the girls in the TPE group had a significant decrease (t [19] = -3.50, p=.002 [2-tailed]) from posttest to retention test.

Summary. Significant gender differences existed at the pretest with males having a greater mean recorded velocity and fewer unrecorded trials than females. The genders within each group were not significantly different from each other at the pretest. After instruction, males continued to have significantly greater mean recorded velocity and fewer unrecorded trials than females regardless of group. The same pattern was present for the retention test regardless of group. Looking at changes from pretest to posttest, males and females both improved in mean ball velocity and reduced the number of unrecorded trials.

Further exploration of the gender differences within each group found gender differences at the pretest, posttest, and retention test for the CUE, BP, and TPE groups. Males in the CUE, BP, and TPE groups threw faster and had fewer unrecorded trials at the pretest, posttest, and retention test. The significant gender differences present at the pretest were not eliminated after instruction for each group. Within each group, there were significant changes for each gender in ball velocity and unrecorded trials. The males in the CUE group increased ball velocity, and reduced the number of unrecorded trials from pretest to posttest. The CUE group females did not significantly change in ball velocity but significantly reduced the number of unrecorded trials from pretest to posttest. The BP males and females did not significantly change in their mean recorded ball velocity or the number of unrecorded trials. The TPE males had a significant change in
ball velocity from pretest to posttest, and significantly reduced the number of unrecorded trials from pretest to posttest. The TPE females also had significant changes in ball velocity and reduced the number of unrecorded trials from pretest to posttest.
CHAPTER 5

DISCUSSION

The purpose of this study was to examine the influence of three instructional strategies (CUE, BP, TPE) on throwing performance during skill practice and gameplay. A secondary purpose of the study was to examine the impact of the different types of instruction on gender differences in throwing form, form used during gameplay, and ball velocity. The first section of the discussion focuses on the nature of the instructional environment across the three groups. The data from the ORRPETB and number of throwing trials during each session will be discussed to examine differences and similarities among groups. The second section will focus on the influence of the instructional strategies on the body components during practice, the relationship between body components during practice and gameplay, and ball velocity. The next section of the discussion will focus on gender differences in throwing performance and the influence of the instructional strategies on gender differences. Finally, the implications of these results to physical education teachers, along with recommendations for future research in throwing will be discussed in the concluding section.
The ORRPETB instrument (Stewart, 1989) was used to systematically assess the instructional variables of the classroom environment. The ORRPETB was used to track key instructional variables such as teacher behaviors (See Table 4.1, p. 126 for teacher behavior summary table), student behaviors, and teacher-student interactions (see Table 4.2, p. 125 for student behavior and teacher-student interaction summary table). The purpose of these data was not to evaluate the effectiveness of the teachers in this study; rather to provide a context to frame the results of this study.

Differences existed between the CUE, BP, and TPE groups in teacher behaviors, student behaviors, and interactions. Two teachers implemented the instructional strategies, one teacher for the CUE and BP groups, and one teacher for the TPE group. Given this organization, it is not possible to determine whether the differences found in the classroom environment were a result of the individual teacher’s personal approach to teaching or a product of the instructional strategy.

For student behaviors, the CUE group had the greatest percentage of activity time (55.3%), and the TPE group had the second highest percentage of activity time (43.4%). The CUE group had the highest percentage of activity time and the lowest percentage of instructional time (16.9%). The percentage of time devoted to activity and instruction for the CUE group could have been influenced by the use of the three critical cues. From the student behavior data it seems the critical cues efficiently communicated information to students in an easily understood manner reducing the time necessary for instruction. The BP group had the least amount of activity time (41.0%), but had the greatest percentage of instructional time (39.1%). The BP group could have had more instructional time due
to the need to directly instruct the key aspects of the BP strategy. Since this strategy concentrates on key biomechanical aspects of the throw, and presents the throw in a manner different from typical instruction of throwing (Stodden, 2002), more instructional time could have been necessary for the BP strategy. The TPE group had the highest percentage of management time (22.7%), and the second highest percentage of time devoted to instruction (33.5%) and activity (43.4%). The time required to organize equipment and players for games could have been an influence on the higher percentage of management time.

The student behavior or climate data may be comparable with the ALT-PE research. Siedentop and Tannehill (2000) summarized effective teaching and the percentage of time spent in aspects of student behavior. Similarities exist between ALT-PE and the ORRPETB instrumentation in the areas of activity time and instructional time. The two instruments are different in that ORRPETB does not examine academic learning time, and the definitions for management and waiting are different. For example, the ORRPETB designates waiting in line as management, while ALT-PE would code this behavior as waiting. The recommendation for each category of the percentage of allocated time for physical education is 25% waiting, 20 to 25% for management, information (15 to 30%), and activity time is 50% (Siedentop & Tannehill, 2000). Siedentop and Tannehill (2000) added that often the actual amount of time teachers spend doing these different tasks is different from the recommended percentages. Students often spend a larger amounts of time waiting in lines and spend less time in activity than the recommendations (Siedentop & Tannehill, 2000). Comparing the recommendations to the percentages in this study, there was a higher percentage for time spent in instruction for
this study. The percentage of activity time in this study was similar to the recommended time with the CUE group higher than the 50% recommendation. It is not appropriate to compare the percentages in this study to the norms for teachers as only time spent in throwing instruction was considered, thus activities such as warm-up were not included in these data.

For teacher behaviors, the CUE group had a lower percentage of teacher modeling (3.5%) compared to the BP group (7.0%) and TPE (6.0%) group. The CUE group also had the lowest percentage of lecturing (23.8%) compared to the BP (24.1%) and TPE group (28.8%). The CUE group could have spent less time in lecturing and modeling because of the creation of a shared language through the use of the three main critical cues. The CUE group had a high percentage of specific feedback (10.6%) and corrective feedback (11.7%), thus the teacher was providing information to students by using feedback more often than lecturing.

The BP group had a higher percentage of teacher modeling (7.0%) than the other groups. This could be due to the need to frequently demonstrate the proper positioning of body segments during each stage. Additionally, since the BP strategy is different from the typical approach to teaching the throw frequent teacher modeling was necessary.

The teacher behaviors in the TPE group were more monitoring (15.5%) and lecturing (28.8%) with less amounts of feedback. The TPE strategy presented all of the key aspects of the throw during the first class, which required more lecturing to explain those key aspects. The organization of equipment and players for throwing games used in the TPE strategy may have necessitated more lecturing. The TPE strategy had a high
level of monitoring because the teacher was monitoring throwing activities during game-like activities. The TPE teacher gave feedback to students while monitoring, but not at as high of a level as the CUE and BP groups.

The CUE (11.7%) and BP (12.6%) strategies had a higher percentage of corrective feedback, specific feedback, and manual guidance than the TPE group. The use of physical contact/manual guidance might have been necessary in the CUE and BP groups to ensure proper positioning of the body to execute the technical aspects of the throw. The teacher of the CUE and BP groups may have also decided to intervene on performance with feedback and manual guidance rather than group lecture.

The teacher-student interaction data showed a higher percentage of individual interactions for the CUE (31.8%) and BP groups (32.0%), than the TPE group (17.2%). The TPE (47.7%) group had a higher percentage of class interactions compared to the CUE (34.3%) and BP (35.2%) groups. The interaction data provides further context for the teacher behaviors, the CUE and BP groups were more likely to receive individual feedback, whereas the instruction for the TPE group was more at the class level through modeling or lecturing. The percentage of teacher-student interactions (individual or group) with only one gender (male-only or female-only) provided some context to the interaction data. The CUE and BP groups had a greater percentage of female only interactions than male-only interactions. The TPE group had similar percentage of female and males only interactions. Interactions with the teacher could be one factor influencing gender differences, with girls being more motivated by interactions with the teacher (Garcia & Garcia, 2002).
Throwing trials during practice. The number of throwing trials varied across conditions and gender. The factors influencing these differences are not within the scope of this study. Future research is needed to determine whether the teacher, the strategies, or other environmental factors are influencing these differences between groups and genders. The BP group had the highest number of throwing trials during each session, and the CUE group had the lowest number of throwing trials. On average the males and females in the BP group had 10 more trials per session than the CUE group and the TPE group (TPE girls were an exception). The difference between the CUE and the BP group could be due to the teacher choosing to use guided practice during practice time rather than individual practice. The guided practice could have limited the number of trials for the CUE group, but the teacher chose to use guided practice to correct errors or to reteach deficient areas (Mrs. Scarlet, personal communication, May 18, 2003).

Gender differences in the number of throwing trials during practice existed. Boys had a higher mean number of the throwing trials during practice than girls. Gender differences in throwing trials during practice were present for the CUE and BP groups, but were not present for the TPE group. Teachers should be aware of these differences in practice trials and design tasks and environments motivate for both boys and girls to engage in throwing practice. Teacher interactions and performance-oriented factors have been identified as influential factors in gender differences in throwing practice (Garcia & Garcia, 2002). Teachers might provide tasks for student that are motivated by performance factors, while providing encouragement and interacting with those students who are motivated by interactions with the teacher.
Summary. These data from the ORRPETB instrument and the throwing trials during practice suggest the individual participants in this study were impacted differently by the instructional strategies. These data suggest the strategies were implemented at the individual level, rather than a class level. The variability in the interactions, teacher behaviors, and the number of trials during practice suggests the strategies were processed and implemented at the individual level, and thus the unit of analysis in this study should be the individual rather than the class or group. Additionally, the theoretical framework of Dynamical Systems Theory would support this view as it examines the development of movement and the factors influence development from an individual, context specific view. That is, no two people are exactly alike in their overall development, and in the factors influencing motor skill development. Thus each individual’s throwing pattern is differentially influenced by the strategies based on the interaction between and within constraints. The instructional strategies of this study were one factor that influenced the development of more advanced throwing performance.

Dynamical Systems Theory

The influence of the strategies on throwing performance can be described using the principles of Dynamical Systems Theory. In Dynamical Systems Theory, the movement system is comprised of multiple interacting subsystems. A change in any one subsystem can bring about changes in overall performance. The instructional strategies used in this study perturbed the movement system toward more advanced throwing patterns.
The influence of the strategies can be discussed by examining common movement patterns and common changes in movement patterns. The examination of body component levels at the pretest, posttest, and retention test revealed dynamic attractors for the overarm throw similar to previous research for this age group (Langendorfer & Roberton, 2002). Common attractors for the step, trunk, humerus, and forearm were found at the pretest. A common attractor for the boys was a contralateral stepping action with block rotation of the trunk. For girls the common attractor at the pretest was an ipsilateral stepping pattern with no rotation of the trunk. Instruction was able to perturb the movement pattern for girls to cause a phase shift to a more advanced movement pattern at the posttest. Instruction seemed to perturb the movement system to promote a phase shift from an ipsilateral step to contralateral step. Instruction did not perturb the movement system for the boys, thus the contralateral stepping pattern was still present at the posttest. At the posttest, block rotation of the trunk was a stronger attractor for both boys and girls. Block rotation appears to have a deep attractor well because block rotation was prevalent not only in practice but also during gameplay. That is, even when task constraints changed, block rotation remained the attractor state. The deep attractor well for block rotation of the trunk is also seen by the consistency in the movement pattern across task and environmental constraints.

Common attractors for both boys and girls in the humerus and forearm components at the pretest were less advanced levels of humerus oblique and no forearm lag. Instruction seemed to perturb the boys’ movement system to produce more advanced humerus and forearm patterns, while girls’ humerus and forearm levels did not improve. Factors internal to the individual could be a contributor to the change or lack of change in
the humerus and forearm components. The humerus and forearm components are linked
with the step and trunk components, changes in the step and trunk have ancillary effects
on the humerus and forearm. That is, the change to more advanced levels of the step and
trunk may have had ancillary effects that increased the likelihood of more advanced
humerus and forearm movements. Two examples of the ancillary effects can be found in
this study. Boys had a contralateral stepping action at the pretest, and developed more
advanced trunk rotation at the posttest which could have influenced the development of
more advanced humerus and forearm levels (Langendorfer & Roberton, 2002). Girls had
improvement in the step component, which produced ancillary effects that increased the
prevalence of more advanced levels in the trunk component. The improvement in the
trunk component was not as advanced as the boys and was still demonstrating variability,
thus ancillary effects from the developing trunk did not translate to more advanced
humerus and forearm movements. It may be that more practice is necessary to develop
the trunk component and the coordination of body segments to have ancillary effects in
the humerus and forearm components. Future research should examine this issue.

Constraints Model. The results of this study illustrates the influence of constraints
on the movement pattern exhibited. There are three categories of constraints: individual,
task, and environmental. The individual constraints were not specifically examined in this
study, but the results support gender as a factor influencing the development of the
overarm throw. The influence of the instructional strategies as a constraint can be
categorized as both a task and environmental constraint. The instructional strategies could
be seen as an environmental constraint when discussing the impact of the strategies on
student behaviors, teacher behaviors, and interactions. The instructional strategies could
also act as an environmental constraint by influencing the amount of time spent in throwing activities and the number of practice trials. The instructional strategies could have also influenced teacher behaviors such as feedback, which is also considered an environmental factor in the development of more advanced patterns. The instructional strategies could act as a task constraint by influencing the activities of the class. While the task constraint of the throw for force was held constant for each strategy, specific daily instructional tasks may have provided a secondary task constraint in the drills, activities, and cue provided. The task goal for the performer was to not only throw hard and fast but to meet the requirements of the drill, activity, or cue. For example, the laser beam cue acts as an additional task constraint because to complete the task the thrower must throw hard and assume the laser beams position to meet the goal of the task.

The influence of task constraints on body component levels was also illustrated in the throwing game. The goal of the game was to throw as many balls as possible to the other side of the gym. The rules of the game stipulated that players could possess only one ball at a time, thus players had to run back for another ball. The rules of the game acted as a task constraint, increasing the prevalence of an ipsilateral stepping action. Contralateral stepping action was an attractor during practice trials, but in the throwing game the contralateral step was not as common. The task goal of throwing as many balls as possible to the other side may have exerted a greater influence (constraint) on the stepping motion than the goal of executing proper throwing form. Many players executed the throwing motion while running, thus did not have a contralateral step. Due to the impact on the step component, it is important to consider the role task constraints play when engaging in this throwing game. A teacher might want to add a secondary task
constraint such as proper stepping action or a sideways orientation before executing the throw. While the task constraints had an impact on the step, the task did not have an impact on the trunk component. The task goal of throwing balls to the other side required large amounts of force, which required rotation of the trunk, thus block rotation of the trunk was common in practice and gameplay. Additionally, block rotation of the trunk seemed to have a deep attractor well, thus the task constraints of the game might not have been great enough to perturb the system toward different trunk movements.

Influence of Strategies on Body Component Levels

The results indicated that there were no significant differences between instructional groups for the trunk, humerus, and forearm components at the pretest. Thus, groups were statistically similar at the pretest. This lack of pretest differences may be because the participants in this study were similar; they were from two schools from the same school district within the same community and were within a close proximity to each other (approximately five miles apart). The non-significant differences at the pretest show the TPE group was a good comparison group at the pretest for the CUE and BP groups.

There were no significant differences found between groups at the posttest for the trunk, humerus, and forearm components. The lack of significant difference between the groups could be attributed to the fact that all groups received some form of instruction on throwing for the same amount of time. The CUE, TPE, and BP groups all received practice and instruction on the overarm throw for force for 120 minutes. While the strategies were different in the methods used to improve the critical elements, each sought to promote more advanced movements of the throwing pattern by targeting critical
elements of the overarm throw. Additionally, the instruction and practice for all groups was provided by trained and knowledgeable teachers who implemented the strategies as intended as evidenced by the procedural reliability checks and the ORRPETB data. Each teacher also provided feedback and modeling to improve various aspects of throwing. The strategies were also similar in that the tasks provided by the teachers during practice were effective in developing the overarm throw. The tasks used during instruction for each strategy are examples of environmental engineering, which is describe as carefully developed environmental situations that challenge a child to develop motor maturity and skill, but not frustrate the child by over-challenge (Halverson, 1966).

The one significant difference between groups in body components was between the CUE and TPE groups in the step component. The CUE group had a more advanced stepping action than the TPE group at the posttest. No other significant between group differences on body component levels existed at the posttest or retention test. Differences between the CUE and TPE group in the step component could be attributed to the laser beam cue. The “laser beams” cue (sideways orientation) could have had a greater impact on the sideways orientation and the stepping action for the CUE group than the “side to target,” and “long step” cues were for the TPE group. The laser beam cue seems to be the likely contributor, because the TPE group received instruction in the step (long step) and sideways orientation (non-throwing arm side to target). Another possible contributor could have been the consistency in the feedback using this cue. The CUE group had a higher percentage of teacher behaviors that involved feedback than the TPE group. While the TPE strategy provided useful information on the sideways orientation and stepping, it might not have been communicated in a descriptive language that resonated with this
group of students as well as the laser beam cue appeared to have resonated with the CUE group. Additionally, the ORRPETB data showed the CUE group had more feedback than the TPE group, thus it could be that the CUE group received more consistent critical cues directed at the stepping action/sideways orientation than the TPE group.

Overall, each instructional strategy had a positive impact on body components from pretest to posttest. The findings of this study support Halverson and Roberton’s (1979) findings that if the throw is instructed, various body components will improve. Finding significant changes in body component levels from pretest to posttest for the BP and CUE group suggest that a teacher who is trained to implement either the CUE or BP strategy can improve the overarm throw. Finding no significant differences between groups, except between the CUE and the TPE group for the step component at the posttest, was similar to the findings of Stodden (2002) who found no significant difference between a biomechanical strategy and a Graham group. Since the specific changes in each body component from pretest to posttest were different for each group, the influence of each strategy on body components will be addressed separately in the following sections.

*CUE group.* The CUE group had a mean pretest component profile of 2.81 for the step, 1.58 for the trunk, 1.38 for the humerus, and 1.35 for the forearm. After instruction the mean component profile was 3.10 for the step, 1.89 for the trunk, 1.65 for the humerus, and 1.45 for the forearm. This posttest mean body component profile could be described as a contralateral step, with a likelihood of trunk rotation with humerus oblique and no forearm lag. The posttest profile shows a greater likelihood of contralateral step, block rotation of the trunk and humerus oblique than the pretest. The findings of this
study for the trunk, humerus, and forearm supports the findings of Langendorfer and Roberton (2002a) that a common attractor for the trunk, humerus, and forearm for children ages 5.7-13 is block rotation of the trunk (level 2), humerus oblique (level 1), and no forearm lag (level 1). The body component levels for the step component in this study are more advanced than Fronske and colleagues (1997) who found that after 120 minutes of instruction using critical cues the step improved from 1.71 to 2.10.

The CUE group improved significantly from pretest to posttest in the step, trunk, and humerus. When compared to the TPE group, the CUE group was significantly more advanced in the step component at the posttest. The improvements in the step and trunk components were expected because this strategy targeted the sideways orientation, stepping action, and trunk rotation. The intent of the CUE approach was to target the step and trunk components and then hope for ancillary effects in the humerus and forearm components. The changes demonstrated in the humerus component from pretest to posttest may provide some evidence of ancillary effects. That is, the influence of more advanced levels of the step and trunk perturbing the humerus component toward a more advanced body component level. The link between more advanced levels of the trunk component to more advanced levels of the humerus component in this study is in line with the literature (Langendorfer & Roberton, 2002a; Roberton, 1977). Oslin and colleagues (1997) also used component specific instruction and found similar ancillary effects from changes in the step component to other body components.

The ancillary effects from changes in the step, trunk, and humerus did not reach the forearm component, as the CUE group did not have significant change in the forearm component from pretest to posttest. The limited change in the forearm could be due the
changes in the humerus and trunk components were relatively recent with high levels of variability in the movements. Additionally, the changes in the trunk and humerus component were not consistently at the most advanced level (level 3), and the variability in the trunk and humerus components could have acted as a constraint on the development of the forearm component. More practice time is needed to develop the coordination of the trunk and humerus necessary for forearm lag.

**BP group.** The BP group demonstrated a mean component profile of 2.64 for the step, 1.53 for the trunk, 1.26 for the humerus, and 1.19 for the forearm at the pretest. The BP group at the pretest demonstrated a throwing motion that was likely to be a contralateral step with some prevalence of block rotation of the trunk, with humerus oblique and no forearm lag. The component levels for the pretest were slightly lower than Stodden (2002) who found mean component levels for 18 kindergarten children at the pretest for the biomechanical group to be 2.81 for the step, 2.00 for the trunk, 1.36 for the humerus, and 1.51 for the forearm. This study’s pretest body component profiles would also support Langendorfer and Roberton’s (2002a) common attractors for the trunk (level 2), humerus (level 1), and forearm (level 1).

After instruction, the mean component profile for the BP group in this study was 2.98 for the step, 1.77 for the trunk, 1.52 for the humerus, and 1.54 for the forearm. After instruction the BP group was more likely to demonstrate a contralateral step, block rotation of the trunk, an increased prevalence of humerus aligned but independent, and some forearm lag. The posttest body component levels were slightly lower than Stodden
Stodden’s (2002) biomechanical approach was a 3.21 for the step, 2.00 for the trunk, 2.16 for the humerus, and 1.92 for the forearm.

While the BP group was not significantly different from the other groups in body components, the BP strategy was successful in promoting change to a more advanced level for the step, trunk, humerus, and forearm components from pretest to posttest. The humerus and forearm components are part of the action phase of the throw, and have been more difficult to instruct (Lorson, 2001; Oslin et al, 1997). The BP strategy is different from other instructional approaches because of the emphasis on proper positioning of the humerus and forearm, and the focus on the development of temporal aspects of the throw. This is in contrast to the CUE and TPE strategies where the initial focus was on the step. The emphasis during Stage I was on the proper positioning (“L” position) of the humerus and forearm (humerus at a right angle to the trunk, and the forearm at a right angle with the humerus). While the emphasis during the remaining stages of the BP strategy targeted areas such as the stepping action, rotation of the trunk, and the coordination of body segments, the emphasis before each throw was still proper positioning of the humerus and forearm in the “L” position. The emphasis during instruction and practice was intended to have the throwers “feel” the proper positioning of the humerus and forearm. Consequently this strategy was successful in changing the humerus and forearm components from the pretest to the posttest. Stodden (2002) found similar significant changes in the humerus and forearm components from pretest to posttest after using a biomechanical strategy. The emphasis on the arm components and developing timing of body components during each of the stages also focused teacher
feedback on those components. Stodden (2002) suggests the biomechanical strategy reduces the demand for the practitioner to possess large amounts of procedural and content knowledge in throwing because all students in the class would demonstrate the same body component profile during practice in the biomechanical strategy. From anecdotal notes, the teacher using in the BP strategy in this study commented that the emphasis on the humerus and forearm during Stage I and II gave her a different perspective in teaching the throw, and helped her to provide feedback to the humerus and forearm (Mrs. Scarlet, personal communication, May 23, 2003).

While the emphasis of the BP strategy is on the humerus and forearm, the BP strategy was also successful in significantly changing the step and trunk from pretest to posttest. This supports Stage III and Stage IV of the program, which targeted the step and trunk components (linear momentum and sequential rotation). Stages III and IV were similar to other approaches to instructing the throw, with the emphasis on the sideways orientation and the stepping action. During Stage III the targeted area was trunk rotation thus cues such as “untwist your hips” were used to increase the prevalence of trunk rotation. During Stage IV the emphasis was on developing a long step, thus “long step and untwist your hips” was a cue that was used to combine the trunk rotation with a contralateral stepping action. Overall, the results of the study suggest the BP strategy seems to be an effective tool to promote the development of a more advanced throwing motion, especially for the humerus and forearm because of the emphasis on these components and developing timing of body components throughout instruction and practice.
The findings for the BP group were similar to Stodden (2002) in that the mean component levels increased from pretest to posttest. The results from this study initially supports Stodden’s (2002) notion that the BP strategy seems to not negatively influence advance throwers because all body components increased from pretest to posttest. Future research examining individual attractors and attractor pathways is necessary to determine whether or not the BP strategy negatively influenced advanced throwers. The group statistics used in this study may mask some of the individual changes in body components.

*TPE group.* The TPE group demonstrated a mean component profile of 2.64 for the step, 1.53 for the trunk, 1.26 for the humerus, and 1.19 for the forearm at the pretest. The TPE group at the pretest demonstrated a throwing motion that was likely be contralateral step with some prevalence of block rotation of the trunk, with humerus oblique and no forearm lag. The pretest mean component levels were lower than Stodden’s (2002) group of 15 kindergarten children in the “Graham” group who had 2.84 for the step, 2.00 for the trunk, 1.56 for the humerus, and 1.58 for the forearm at the pretest. The mean component profile at the posttest for the TPE group in this study was 2.88 for the step, 1.91 for the trunk, 1.64 for the humerus, and 1.37 for the forearm. After instruction the TPE group was more likely to demonstrate a contralateral step, block rotation of the trunk, an increased prevalence of humerus aligned but independent, and some prevalence of forearm lag. The mean body component profiles would support Langendorfer and Roberton’s (2002a) common attractors for the trunk (level 2), humerus (level 1), and forearm (level 1). These posttest levels are also lower compared to Stodden
(2002) who found his mean posttest component profile for the Graham group to be 3.31 for the step, 2.00 for the trunk, 1.75 for the humerus, and 1.75 for the forearm. The TPE strategy in this study was similar to Stodden’s (2002) Graham group.

The TPE strategy used Graham and colleagues (2001) textbook as a resource in determining the critical elements to target during instruction: side to target, arm way back, step with the opposite foot, and twist and throw hard. The TPE strategy presented all of the critical elements first, and then practiced the throwing in game-like activities such as backboard tag. The teacher for the TPE group gave class feedback regarding the critical elements while monitoring games. The teacher interacted with students on an individual level, but not as often as with the entire class.

The TPE group was not significantly different than the other two instructional groups in the trunk, humerus, and forearm, but the TPE strategy had a lower mean step level at the posttest than the CUE group. Additionally, the TPE group did not have a significant change from pretest to posttest for the step component. As discussed with the CUE group, the TPE cue of side to target and step with opposite foot may need to be translated into more descriptive cues (e.g. long step) to resonate with different learners and contexts. No significant changes in the step could be due to many of the participants in the TPE already demonstrating a contralateral step prior to instruction, thus significant changes were not expected from contralateral short step (level 3) to contralateral long step (level 4) because a long step was not targeted in the strategy.

These findings for the TPE group support the use of the Graham and colleagues’ (2001) information to develop various aspects of the throwing motion. This finding is important because the Graham and colleagues (2001) text is a common resource for
content knowledge of fundamental motor skills for many preservice teachers and teacher training programs to develop fundamental motor skills in elementary school physical education.

**Gender Differences in Body Components**

Gender is an important variable to examine for the overarm throw because throwing has the largest gender difference of any fundamental motor skill and the differences occur earlier in development than any other fundamental motor skill (Nelson, Thomas, & Nelson, 1991; Thomas & French, 1985; Williams, 1996). Boys are more advanced than girls in throwing form and the outcome measures of throwing such as distance, speed, and accuracy (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002a; Sakurai & Miyashita, 1983; Thomas & Marzke, 1992). Gender differences persist and expand with age, and it is common to see even adult women throwing with an immature movement pattern including an ipsilateral step (East & Hensely, 1985). Since gender differences persist and expand over time it is important to examine the influence of instruction as a factor in reducing gender differences.

Gender differences were present at the pretest regardless of group for the step, trunk, humerus, and forearm components. Gender differences at the pretest were expected and align with previous findings of gender differences for each body component (Halverson et al., 1982; Nelson et al., 1991), and for overall throwing form (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002a, 2002b; Sakurai & Miyashita, 1983; Thomas & Marzke, 1992). Boys were more advanced in body component levels than girls at the pretest. Boys
demonstrated a mean component profile of 3.08 for the step, 1.80 for the trunk, 1.49 for the humerus, and 1.40 for the forearm. The boys’ throwing motion would be likely to be a contralateral stepping motion with block rotation of the trunk, with some occurrence of humerus aligned but independent and no forearm lag. Girls demonstrated a mean component profile of 2.29 for the step, 1.67 for the trunk, 1.17 for the humerus, and 1.11 for the forearm. The throwing motion for girls at the pretest would be likely to have an ipsilateral stepping motion with block rotation of the trunk, with humerus oblique and no forearm lag.

Regardless of strategy, gender differences remained for each body component after 120 minutes of instruction and practice. The persistent gender differences after instruction with boys outperforming girls, is similar to previous findings in the literature (Browning and Shack, 1990; Dusenberry, 1952; Garcia & Garcia, 2002; McKenzie et al., 1998; Thomas et al., 1994). Even though gender differences were not eliminated after instruction, instruction was successful in changing both boys and girls body component levels from pretest to posttest. Boys demonstrated a mean component profile at the posttest of 3.08 for the step, 2.06 for the trunk, 1.77 for the humerus, and 1.60 for the forearm. The boys significantly improved in the trunk, humerus, and forearm components from pretest to posttest but were unable to shift from a contralateral short step to a contralateral long step. The boys’ throwing motion after instruction appears to be a contralateral stepping motion with block rotation of the trunk, with greater occurrences of humerus aligned but independent and forearm lag. Girls had more advanced mean body component levels for the step, trunk, humerus, and forearm at the posttest than the
pretest. Girls demonstrated a posttest mean component profile of 2.87 for the step, 1.59 for the trunk, 1.39 for the humerus, and 1.26 for the forearm. The throwing motion for girls appears to be a contralateral step, but some occurrences of ipsilateral stepping motion would be present. The throwing motion would also consist of some block rotation of the trunk, with humerus oblique and no forearm lag.

While gender differences remained at the posttest, instruction was able to develop more advanced body component levels for girls. Thomas and colleagues (1994) had similar findings that girls do show improvement in the step and trunk components after specific instruction. Instruction can improve aspects of the overarm throw for both boys and girls, but the girls did not “catch-up” to the level of the boys after 120 minutes of instruction.

*Gender Differences within Group*

The changes in body components for both boys and girls varied within each group. Gender differences were present at the pretest for each group in the step and trunk components. Gender differences in the humerus and forearm varied for each group. The influence of a particular instructional strategy on male’s and female’s throwing performance for each group will be discussed.

*CUE group.* The CUE group had significant gender differences at the pretest for the step and trunk, but not for the humerus and forearm. Posttest gender differences were found for the trunk and forearm components, but not the step and humerus. Gender differences were not found for the step component because the CUE girls had significant improvements in the step component. The increase prevalence of a contralateral step for
females at the posttest brought the girls up to the performance level of their male counterparts. The CUE strategy and its emphasis on the step and trunk could be influencing more advanced levels for CUE females.

The changes in the step component could have had ancillary effects on the trunk component as both boys and girls improved in trunk component levels from pretest to posttest. The improvement in the trunk component for females from pretest to posttest could be due to the emphasis on the step and trunk components in the CUE strategy. The laser beam cue for sideways orientation along with the step and trunk rotation cue (turn your hips fast) could have produced more advanced trunk rotation. The improvement in the trunk component for the girls from pretest to posttest did not exceed that of the boys thus gender differences remained. Persistent gender differences in the trunk could be due to the boys having a more advanced step action at the pretest, thus the boys could focus on the trunk movements during practice. In contrast since changes in the step component were relatively recent, some variability in the girls’ step component could have influenced the trunk component. Despite the improvement in the trunk component for girls, boys were still more likely than girls to exhibit more advanced trunk rotation compared to females.

For the humerus component, no significant gender differences were present at the pretest because both males and females had mean humerus levels between level 1 and 2. The males improved significantly from pretest to posttest but females did not. The improvement in the humerus component for males was not large enough to create significant gender differences. The improvement in the male’s humerus component could
be linked to the males having a greater prevalence of at least block rotation of the trunk. Block rotation of the trunk (level 2) is necessary to have more advanced levels in the humerus component (Langendorfer & Roberton, 2002a).

For the forearm component, there were no gender differences at the pretest, but significant differences were present at the posttest. Males were more advanced in the forearm component than females. Neither males nor females improved significantly from pretest to posttest, but the non-significant improvement of the males resulted in gender differences. The body component levels demonstrated in the forearm component may be linked with the humerus and trunk component, since boys were more advanced in the trunk component, it could have influenced the forearm component (Langendorfer & Roberton, 2002a).

**BP group.** The BP group had significant gender differences at the pretest for the step, trunk, and humerus. At the posttest, gender differences for the BP group were present for the trunk and humerus, but not for the step and forearm components. Finding gender differences at the posttest for the trunk and humerus was in contrast to Stodden (2002), who found no gender differences for the step, trunk, humerus, and forearm between kindergarten boys and girls after using a biomechanical strategy.

For the step component gender differences were present at the pretest for the BP group, but no significant gender differences were found at the posttest. Girls in the BP group in this study had significant changes in the step from pretest to posttest. The changes in the step support Thomas and colleagues (1994) findings that with specific instruction girls can improve in the step component. Specific instruction of the stepping action occurred at Stage II, III, and IV of the BP program and the results suggest these
stages were successful in producing changes in the step for girls. No significant changes from pretest to posttest were found for the step component for BP males. This could be attributed to the BP males already demonstrating a contralateral step at the pretest.

For the trunk component significant gender differences were present at the pretest and posttest. The BP girls did not have a significant improvement, while the boys had a significant improvement in the trunk component. Girls might not have been as influenced to change the trunk component in Stage III and IV of the BP strategy because the concentration for the BP girls might have been more focused on proper positioning of the humerus and forearm. Additionally rotational aspects of the throw were part of the later stages of the strategy, which could have limited the practice time devoted to developing coordination of the trunk.

For the humerus component there were no significant gender differences at the pretest, but significant gender differences were present at the posttest. The males in the BP group improved significantly from pretest to posttest, which could account for the posttest gender differences. BP females did not have significant changes in the humerus component. Gender differences and the changes for each gender in the humerus component could be linked with the trunk component. The males had more advanced trunk rotation, which is necessary for more advanced levels of the humerus. The limited of change in the BP females’ humerus component could be due to the lower mean trunk component levels demonstrated by the BP females. The lower mean trunk component levels may have acted as a constraint, which limited the appearance of more advanced movements of the humerus.
No significant gender differences were found in the forearm component at the pretest and posttest for the BP group. Both males and females demonstrated more advanced levels of the forearm component at the posttest than the pretest. The more advanced levels of the forearm for both males and females supports the use of the BP strategy to develop more advanced levels of the forearm component. Finding significant changes for the BP females from pretest to posttest for the forearm were somewhat surprising since no significant changes were occurring for the humerus. The body component levels of the humerus and forearm are closely related (Langendorfer & Roberton, 2002a), thus changes one component should influence the other. Changes in the humerus component from pretest to posttest should have translated into changes in the forearm component. It could be that more practice time is needed to see changes in the forearm component.

TPE group. Gender differences were prevalent at the pretest for the TPE group for the step, trunk, humerus, and forearm. At the posttest, gender differences remained for the trunk, humerus, and forearm. No significant gender differences were found at the posttest for the step component. These findings are similar to Stodden (2002) who found the Graham and colleagues (2001) cues successful in erasing gender differences for the step, but not the humerus and forearm. Boys in the TPE group had significant changes in the step, trunk, and humerus from pretest to posttest. TPE girls had significant changes in only the trunk component from pretest to posttest.

Gender differences were present at the pretest for the step component, but were not apparent at the posttest. The elimination of significant gender differences for the step component could be due to girls demonstrating a slightly more advanced stepping motion
while the boys demonstrated a less advanced step at the posttest. For the TPE boys the mean step component level actually significantly decreased from pretest to posttest, but closer examination of the mean component level suggests TPE boys were still stepping with opposition at the posttest. The changes to a lower mean component level for TPE males in the step could be traced to a lower occurrence of a contralateral long step (level 4). The TPE girls did not significantly change in the step, and their mean component level suggests not all girls were consistently stepping with opposition after TPE instruction.

Pretest gender differences remained at the posttest for the trunk component. The TPE males the mean trunk increased from pretest to posttest. This is similar to Stodden (2002) who saw more advanced trunk component levels in kindergarten boys who received similar instruction. The TPE girls also had a significant increase in the trunk from pretest to posttest. The significant increase in the trunk component is similar to Thomas and colleagues (1994) who found that with instruction girls can improve in the trunk component.

Pretest gender differences in the humerus component remained significant at the posttest. TPE males had a significant increase in the mean body component level for the humerus, while the females did not have a significant change. The improvement for the boys and not for the girls in the humerus is a contributor to the persistent gender differences. The gender differences in the humerus component could be due to the gender differences in the trunk component. Because the trunk has ancillary effects on the humerus component (Langendorfer & Roberton, 2002a) the gender differences in the
trunk would influence gender differences in the humerus. Since boys were more likely to have a rotating trunk, boys were more likely to demonstrate humerus aligned but independent (level 2).

Significant gender differences were found at the pretest for the forearm component, with the significant gender differences still present at the posttest. Both males and females had no significant changes in the forearm component from pretest to posttest. The persistent gender differences at the posttest could be due to little change for both boys and girls in the forearm component from pretest to posttest.

The persistent gender differences between boys and girls in the TPE group could have been influenced by environmental factors within the physical education environment. One environmental factor could be the practice activities in the TPE group. The practice activities in the TPE group were in a game-like context, thus the emphasis was on performance-oriented factors which boys could have benefited from more than the girls (Garcia & Garcia, 2002). Garcia and Garcia (2002) suggested boys are motivated by performance factors, while females are motivated by teacher interactions. Garcia and Garcia (2002) also suggest teacher interactions may be one factor influencing gender differences. The ORRPETB data revealed that the CUE and BP group teacher interacted more frequently with females (1.30) than males (.92). The males (0.52) and females (0.58) in the TPE group had similar interaction rates with the teacher. The higher rates of teacher-student interactions for females in the CUE and BP groups could play a role in the ability of the BP and CUE strategies in reducing gender differences. Initial analysis using the ORRPETB did not examine the content of these interactions with each gender, such as the amount of individual feedback, modeling, answering or asking.
questions to boys or girls. Thus no clear conclusions can be drawn at this time about the influence of teacher interactions and gender differences. Future research must address teacher behaviors, student behaviors, and the content of teacher-student interactions when examining the influence of instruction on gender differences in the overarm throw. The biological and the environmental factors outside of physical education (practice and activity time in throwing) may exert a greater influence on gender differences in throwing performance than 120 minutes of instruction. However, these issues were not within the scope of this study and should be addressed in future research.

**Relationship between Components during Practice and Gameplay**

The relationships between body component levels during practice and gameplay were examined in this study to determine the similarities between body component levels in practice and games. Examining body components during practice and gameplay can be useful to determine the transfer from practice to a game context. Additionally, to effectively participate in sports and games it is necessary to demonstrate advanced forceful throwing pattern within a game context. Studying practice and gameplay can also be useful to examine the influence of task constraints on body components.

The relationship between matching components of the step, trunk, and forearm during practice and game play were under consideration. The next portion of this discussion will focus on the influence of the instructional strategies on the relationship between practice and gameplay, and the influence of gender and group. Overall, the trunk and forearm components had the most frequent moderate to strong relationships. The step component was least likely to have significant relationships between matching components during practice and gameplay.
Step. The step component had the fewest number of significant relationships between practice and gameplay. The reasons for the lack of significant relationships at the posttest and retention tests could be due to the task constraints of the game. The object of the game, to throw as many balls as possible “hard and fast” to the other side of the gym, may have acted as a control parameter that influenced the stepping action during gameplay to differ from practice. Running back and forth between the throwing line and the area to pick up the balls may have impacted the stepping motion, as the concern for throwing as many balls as possible may have been more pressing than executing proper stepping action.

The relationship between body component levels during practice and gameplay were varied between groups for the step component. The step had significant correlations at the pretest and posttest for the CUE group, but a significant correlation coefficient was not present at the retention test. The presence of moderate to strong relationships for the step component at the pretest and posttest suggest there were similarities for the CUE group in the stepping action during practice and gameplay, but it was not consistent to the retention test. The BP group also had significant positive correlation coefficients for the step components at the pretest, but did not have a significant correlation at the posttest and retention test. The change from significant relationship before instruction to non-significant relationships at the posttest and retention tests might suggest the possibility that the BP strategy could have an influence in the lack of significant relationships between practice and gameplay. That is, changes in the step could have occurred during practice but not in gameplay. The TPE group step components were significantly correlated at the pretest, posttest, and retention test. The consistent relationships for the
TPE group step components are different from both the BP and CUE groups. The consistent relationships could be due to the practice activities of the TPE group were more “game like,” increasing the likelihood of transfer to gameplay. In contrast, the practice activities of the CUE and BP group targeted specific body components during skill practice.

*Trunk.* The trunk component had consistent relationship across practice and gameplay. The trunk components had a consistent relationship because the strong attractor of block rotation for the trunk component for practice and gameplay (Langendorfer & Roberton, 2002a). The strong attractor for the trunk component would be hypothesized to remain consistent across tasks and environments (Hamilton & Tate, 2002). For the CUE, BP, and TPE groups the trunk component was a strong correlation, further supporting the development of a rotating trunk to be consistent across practice and gameplay. The findings for the trunk component suggest the trunk may develop a deeper attractor earlier than the step, and the trunk demonstrates more consistency between practice and gameplay than the step component. Since the trunk component has a deep attractor well, the movement is more stable across task and environmental constraints. For example once a student achieves block rotation (level 2), block rotation would be consistent across different tasks and environments. Another explanation for the consistency in the trunk component is the task constraints of the throwing game did not have as great an influence on the trunk component as the step component. The rules of the game to run to retrieve another ball before each throw did not seem to effect trunk rotation but influenced a stepping motion different from the one used in practice.
Forearm. The forearm component had significant correlations at the pretest, posttest, and retention test. The frequent significant relationships for the forearm components could be due to the demonstration of low levels of the forearm component across practice and gameplay. The less advanced forearm component levels demonstrated seems to be a deep attractor. That is, the forearm component levels are consistent across task constraints.

Overall, the high percentage of correlated matching components during practice and gameplay suggest the task constraints of the throwing game and practice were similar in promoting “hard and fast” throws. The task constraints of the game may have had a greater influence on the step than the other components. The throwing game used in this study might be a basic game that practices hard and fast throws in a “game-like” environment. This game might be a useful lead-up game to practice throwing in a game context that allows for a number of opportunities to throw for each player.

The videotape analysis of the throwing components during gameplay suggests that the step, trunk, and forearm components can be assessed in a game-like context. The modified gameplay instrument used in this study might be another tool to assess the overarm throw. Future research is needed to determine whether teachers can use the instrument to assess throwing form.

Groups. For each body component the groups shared many commonalities in the body component for the relationships between practice and gameplay. There was one difference of note between the groups. The TPE group was the only group with significant positive correlations between all matching components at the pretest, posttest, and retention test. A possible reason for the significant relationships between all
matching components could be the practice activities in the TPE group may have been more “game like,” thus increasing the connection between body components in practice and gameplay. The TPE group played games such as backboard tag and partner passing during their practice rather than targeting aspects of the throwing motion. The TPE group was the only group with consistent relationships between practice and gameplay for the step at the pretest, posttest, and retention test. The “game like” practice conditions may have helped those in the TPE group who were developing advanced stepping action in practice more likely to demonstrate a similar pattern during gameplay.

**Group and gender.** While a number of significant relationships existed between matching components during practice and gameplay when examining groups, fewer significant correlations were present when group and gender was considered. Overall, the significant relationships that existed for group and gender would support the group findings. The trunk component was the most common relationship, demonstrating significant relationships in body components in practice and gameplay. This finding suggests the trunk develops a deep attractor well and the task constraints of the game did not significantly influence the trunk during gameplay. The step had the fewest number of significant relationships further supporting the task constraints of the game of running back and forth to pick up a new ball may have had an influence on the stepping action during the game.

Future research is necessary for a number of relationships found for both males and females to determine the factors influencing the relationships. Further study of body components during gameplay is necessary to explain why the TPE group had the most
significant relationships for the step, trunk, and forearm when considering group, but when gender and group was considered the TPE group had the fewest significant correlations.

Ball Velocity and Unrecorded Trials

Ball velocity is a product measure of the overarm throw for force. Tracking product scores can be useful for teachers and researchers to determine the positive or negative influence of certain factors or constraints on the performance of the throw (Roberton & Konczak, 2001). The product measures of the overarm throw, such as distance, speed, and accuracy, are also important in sports and games. Players must be able to execute a forceful throw in sports and games to quickly move a ball over a distance. The ability to execute an advanced throwing motion capable of generating a forceful throw is necessary to be an effective player in sports such as baseball and softball.

Assessing ball velocity and body components is important to determine the influence of instruction on the overarm throw. A connection exists between body component levels and ball velocity (Roberton & Konczak, 2001). Primitive movements produce poor outcome measures, while advanced movements produce superior outcomes (Roberton & Konczak, 2001). While a connection exists between process and product measures, the influence of instruction has not been consistent in changing both body components and ball velocity. Halverson and Roberton (1979) found instruction had influenced the body component levels but not ball velocity. From a practitioner perspective, process and product measures provide useful information. Product measures are a common source of feedback to the learner regarding success, and teachers use
process measures to assess movement patterns and provide feedback based on the learner’s movement (Roberton & Konczak, 2001). Describing changes in both throwing form and ball velocity can be useful to describe the influence of instruction on both the movement and the movement product. The product measure assessed in this study was mean recorded ball velocity. Since the radar gun could only record trials above 25 miles per hour, the mean number of unrecorded trials were tracked and used to provide context for the ball velocity data. The number of unrecorded trials is used to track changes for those low skilled throwers who could not consistently produce throws above 25 miles per hour.

**Ball Velocity between Groups**

Statistical analyses revealed no significant differences between instructional groups in mean recorded velocity and unrecorded trials at the pretest. As with the body component data, these data showed that the CUE (24.34 mph), BP (23.04 mph), and TPE (23.25 mph) groups were similar prior to instruction. Roberton and Konczak (2001) reported similar mean ball velocities for six year olds (23.47 mph) and seven year olds (26.48 mph). Stodden (2002) found the ball velocity for kindergarten children to be 22.06 mph for the biomechanical group and 21.61 miles per hour for the Graham group.

At the posttest no significant differences existed between the CUE (27.72 mph), BP (26.93 mph), and TPE (29.80 mph) groups. Stodden (2002) also found a biomechanical strategy (21.05 mph) did not result in significantly greater velocity than his Graham group (21.52 mph) at the posttest. Statistical analyses also revealed no significant differences between instructional groups in unrecorded trials at the pretest. As
with the ball velocity, these data showed that the CUE (5.41), BP (4.67), and TPE (4.90) groups were similar prior to instruction. After instruction no significant difference between the CUE (2.82), BP (3.54), and TPE (2.83) groups at the posttest.

No significant differences between groups in ball velocity were similar to the non-significant differences between groups in body components. Significant differences between groups in ball velocity were not expected based on the relationship between body components and ball velocity (Roberton & Konczak, 2001). Non-significant between group differences in body components would suggest there would be non-significant differences in ball velocity in this study. The non-significant differences could be due to all groups receiving some form of throwing instruction for the same amount of time. The CUE, TPE, and BP groups all received practice and instruction on the overarm throw for force for 120 minutes. A trained and knowledgeable teacher provided the instruction and practice. Additionally, each strategy practiced the overarm throw for force, and participants were consistently prompted to “throw hard and fast.” Each strategy emphasized the critical elements of the overarm throw with each teacher providing feedback and modeling to improve various aspects of throwing. While the strategies were different in the methods used to improve the critical elements of the throw, each sought to promote more advanced movements of the throwing pattern and greater ball velocity.

*Within group changes in ball velocity.* Statistical analyses revealed significant changes in ball velocity and the number of unrecorded trials for each group from pretest to posttest. The CUE, BP, and TPE groups all significantly improved their mean velocity score from pretest to posttest. This finding is in contrast to Halverson & Roberton (1979)
and Stodden (2002) who found no significant changes in ball velocity after instruction. The CUE, BP, and TPE groups all reduced the number of unrecorded trials from pretest to posttest, thus each instructional strategy was effective in increasing the number of trials above 25 miles per hour. The reduction in the number of unrecorded trials suggests that those participants who threw below 25 miles per hour before the start of instruction were more consistently able to throw above 25 miles per hour after instruction. At the pretest variability in the throwing pattern or stability in a less advanced throwing pattern was present. This variability would have a negative impact on outcome measures such as ball velocity. The increase in ball velocity and the reduction of unrecorded trials suggests that participants were undergoing a phase shift to a more advanced throwing motion that became more stable with practice. With stability in the throwing motion, throwers were able to more consistently produce throws above 25 miles per hour. Overall, each instructional strategy had increased ball velocity and reduced the number of unrecorded trials, but the changes in ball velocity were not differential between groups.

**Gender Differences in Ball Velocity and Unrecorded Trials**

Gender differences between males and females existed at the pretest in ball velocity. Males had a mean velocity of 30.45 miles per hour, while females had a mean velocity of 14.87 miles per hour. This finding aligns with the large gender differences in throwing performance measures in the literature (Thomas et al., 1994, Morris et al., 1982; Thomas and French, 1985; Halverson et al., 1982; Roberton et al., 1979). Gender differences also existed in the number of unrecorded trials, with girls (7.85) more likely than boys (2.69) to have an unrecorded trial. While significant gender differences existed,
there were no significant between-group differences for each gender. The boys in each
group were not different from the boys in the other groups in ball velocity or unrecorded
trials, and the girls in each group were not different from each other at the pretest.

After instruction it was hypothesized that the gender differences for ball velocity
and unrecorded trials would be reduced to a level of non-significance. Instruction has
been seen as one key environmental factor in reducing or eliminating gender differences
(Thomas & Marzke, 1992). Analysis revealed that gender differences in ball velocity and
unrecorded trials remained after instruction at the posttest and retention test. The
instructional strategies were not able to catch the girls up to the level of the boys in ball
velocity after the four instructional sessions. These findings are similar to previous
findings that instruction did not eliminate significant gender differences for the
performance measures of the overarm throw (Browning & Shack, 1990; Dusenberry,
1952; McKenzie et al., 1998; Stodden, 2002; Thomas et al., 1994). The persistent gender
differences after instruction could be due to the relatively short duration of instruction
and practice. A large amount of time is needed to develop the coordination of body
segments necessary to increase ball velocity. Under Dynamical Systems Theory,
instruction would perturb the movement system (throwing motion), and the movement
system would then experience variability. With practice the movement pattern would
begin to stabilize and exhibit consistency. The stability in the movement and improved
coordination of body segments could result in greater velocity. Based on the results of
this study, instruction appears to have perturbed the system to produce variability, and
has provided enough practice to produce some stability in the movement. The short
duration of instruction and practice was not enough for functionality, where the new movement pattern translated into increased ball velocity. Overall, these findings suggest that the environmental factor of instruction is only one factor contributing to gender differences, there are other biological and environmental factors beyond the scope of this study that influence gender differences in ball velocity.

**Group and Gender Differences in Ball Velocity**

Examining the impact of each strategy on gender, none of the instructional strategies were able to eliminate the significant gender differences in ball velocity. Stodden (2002) found similar results for kindergarten children after instruction using a biomechanical and a Graham approach. From pretest to posttest the CUE group mean recorded ball velocity increased for males, but did not significantly change for females. The CUE girls did not significantly change their mean recorded ball velocity even though had improved in the step and trunk components. Thomas and colleagues (1994) reported similar findings for females of significant changes in body components but non-significant changes in ball velocity after instruction. While females did not improve in velocity, the results of this study found the CUE females significantly reduced the number of unrecorded trials. This suggests the CUE strategy was more successful in producing consistency in throws above 25 miles per hour for females than increasing the mean ball velocity. This may be an early sign of the quantitative changes necessary to eventually increase mean velocity scores.

A factor in the boys improving in velocity would be boys had a more stable movement pattern for the step and trunk prior to instruction, thus instruction and practice could have helped to develop coordination of body segments leading to increased
velocity. When examining the CUE females, significant changes were occurring for body components as a result of instruction, thus variability in body components could have limited the ability to produce forceful throws. Girls may eventually see changes in ball velocity, but the timing and coordination necessary takes considerable practice (DiRocco & Roberton, 1981; Yan et al, 2000).

For the BP group, gender differences were present at the pretest and posttest. Both the boys and the girls did not significantly change their ball velocity from pretest to posttest. Stodden (2002) also did not find a significant increase in ball velocity from pretest to posttest. The boys and girls in the BP group had no significant changes in the number of unrecorded trials from pretest to posttest. Future research needs to examine whether or not the BP strategy improves ball velocity, and when the BP strategy begins to impact ball velocity. Since the BP strategy focuses on the coordination of body segments and more advanced humerus and forearm movements, a significant impact on ball velocity is expected, but the functional application of the coordination of the body segments developed in the BP strategy may take longer than the 120 minutes of instruction and practice provided in this study.

The TPE group had significant gender differences at the pretest and posttest. In the TPE group, girls had significantly increased their recorded ball velocity from pretest to posttest, but lost this increase from posttest to retention test. The TPE females had significant decrease in the number of unrecorded trials from pretest to posttest, and posttest to retention test. The TPE girls were able to more consistently throw above 25
miles per hour after instruction. TPE Males had no significant changes in ball velocity from pretest to posttest. While the males had no significant increase in ball velocity, they still outperformed females in the CUE group.

Overall the findings for ball velocity and unrecorded trials would support previous research that large gender differences exist in performance measures of the overarm throw. Instruction has not “caught up” the girls to the level of boys in performance measures of the overarm throw in four instructional sessions. The overall improvement for both males and females regardless of the instructional strategy used suggests instruction can help to improve velocity for both boys and girls, but it is unclear whether instruction within the time constraints of physical education can overcome the large gender differences in the overarm throw.

**Implications and Future Research**

The findings of this study can be useful in informing practitioners about strategies to use to develop the overarm throw. The findings of this study also suggest a number of areas to further explore to determine the influence of instruction on the overarm throw. This section will first address the implications of this study to physical education teachers for body component, body components during gameplay, and gender differences. The final section will offer suggestions for future research.

**Implications to Physical Education Teachers**

The findings from this study suggest instruction and practice in the overarm throw consisting of 120 minutes (four, 30 minute sessions) can improve the throwing motion and ball velocity of first and second grade children. Teachers with training in the CUE or BP strategies can have a positive impact on throwing performance as a result of the
instruction. Using the strategies to target specific aspects of the throw during practice can help teachers to identify and intervene on aspects of the throwing motion that need to be improved. The BP strategy was particularly helpful in translating complex biomechanical information into a four-stage strategy that could be used by a practitioner. The information within the BP strategy was particularly helpful for the teacher in identifying and correcting errors in the positioning of the humerus and forearm during practice (Mrs. Scarlet, May 31, 2002). Although the teacher of the BP group was experienced and considered a master teacher, she had not previously focused on the action component of the humerus and forearm.

Overall, the different approaches to teaching the overarm throw were effective in promoting change in body components, but the influence of each strategy on body components differed. The BP strategy, with its emphasis on proper positioning of the humerus and forearm was effective in changing humerus and forearm. Providing instruction that has improved the humerus and forearm component is important because the humerus and forearm components have been difficult to instruct (Lorson, 2001; Stroot & Oslin, 1993). Teachers should consider the issue of arm action in the force production phase of throwing as they embark on teaching throwing. The TPE findings support the use of the Graham and colleagues (2001) textbook as a resource to use for developing more advanced throwing motion. Teachers can modify and adapt the Graham and colleagues’ (2001) cues to meet the needs of their students. The “laser beam” cue used in the CUE group is an example of a modification of the Graham and colleagues (2001) “side to target” cue to develop the sideways orientation and more advanced levels of the step. Teachers might use different aspects of each of these strategies to develop
more advanced throwing pattern. For example, combining the critical cues used in the CUE strategy with the BP strategy might be an effective way to develop the humerus and forearm components, while communicating critical elements necessary to execute more advanced stepping action and trunk rotation in a descriptive and easily understood language.

Using the strategies to improve body components also translated into improvement in mean recorded ball velocity and reduced the number of unrecorded throws below 25 miles per hour. This is important to teachers as force production can result in greater distance thrown, which is important in games like softball and baseball. Continued practice may be necessary to further develop coordination in the throwing motion to continue to increase ball velocity for both boys and girls.

Gender differences exist in throwing performance with boys out performing girls in throwing form and ball velocity. Physical educators have a responsibility to ensure that both males and females in their classes receive appropriate instruction to develop the overarm throw. Teachers must prepare for a wide range of abilities in the overarm throw, thus a range of instructional tasks and activities must be provided in class to meet the needs of both boys and girls. The persistent gender differences after instruction highlights the need to examine throwing games and activities that are part of the curriculum to be sure girls can be successful in the game environment.

While gender differences remained after a relatively short period of instruction, both boys and girls improved in the throwing form and ball velocity. The strategies used in the study improved various aspects of throwing performance. Consistent instruction and practice in the overarm throw over the course of the elementary physical education
curriculum is needed to continue to improve body components and ball velocity in girls and boys. It is recommended that throwing units be taught two to three times over the school year, or at the very least be taught every year during elementary school.

The strategies used to instruct motor skills can have an impact on teacher behaviors such as feedback and manual guidance. The strategies may also influence student behaviors, such as activity time and instructional time. Teachers should consider the impact instructional strategies have on activity time and instructional time. Teachers can also consider the impact the strategies have on teacher behaviors such as feedback and interactions with students. Considering the impact of the strategy on the instructional environment is important to matching the strategy with the needs of the students. If faced with limited time, the CUE strategy might be used to provide more activity time to practice the throw. If more time is available for instruction, the BP strategy is useful for developing the humerus and forearm components.

Teachers can use the throwing game from this study to practice “hard and fast” throws in a game-like context. If the emphasis during instruction is to develop the overarm throw for force, this is a lead up game with a low level of organization and many opportunities to respond. The modified gameplay instrument was an effective tool to assess body component levels during gameplay, capturing the throwing patterns used within the game context. Since the modified gameplay instrument was effective in evaluating body components, it can be a tool for teachers to use to assess whether students can apply skills and knowledge learned in practice to a game context. Teachers need to consider task constraints of the games and activities used in throwing. Task constraints may have an influence on certain body components that might significantly
influence the movement to a less advanced level. Since the task constraints had an impact on the step component, teachers may need to prompt proper stepping action during gameplay.

Future Research

1. Further examination of the influence of these strategies on body component levels is necessary to identify the ancillary effects of the strategies. Identifying attractors and attractor pathways in each of the strategies will be useful in describing the influence of instruction on body components. Examining an individual’s change in body components using component profile mapping could also identify the impact of the strategies on different skill levels of throwers. Examining individual attractor and attractor pathways will be useful in determining whether the BP strategy negatively influences advanced performers.

2. Additional research involving larger numbers of participants at different ages and from different schools should be conducted for each of the instructional strategies. This research will be important in determining the influence of each of the strategies on throwing performance. Additionally, this research will be important in identifying the influence of the instructional strategies on instructional variables and the number of throwing trials during practice.

3. Future research can study the influence of the instructional strategies longitudinally, that is examining the influence of the strategies across the elementary physical education curriculum. Examining the influence of the programs over the course of the curriculum may shed light on whether the CUE, TPE, or BP strategies can be used
to overcome the persistent gender differences in throwing. The longitudinal study of the instructional strategies is also useful in determining the amount of practice needed to develop coordination for advanced levels of the humerus and forearm.

4. Future research can continue to explore critical cues and instructional strategies that translate biomechanical information into instructional strategies that are effective in developing more advanced movement patterns for fundamental motor skills. In addition to developing new strategies, many of the critical cues and instructional strategies suggested in textbooks and practitioner journal articles needs to be examined empirically to determine their specific influence on movement patterns.

5. Future research can explore the ability of preservice and inservice teachers to use the CUE and BP strategies to improve throwing performance in physical education. Future research might examine the influence of teacher training in the CUE and BP strategies on content knowledge in the overarm throw, ability to analyze the throwing motion, ability to provide appropriate corrective feedback, and the ability to implement the strategies to improve throwing performance.

6. Further study of the gameplay instrument is necessary to further examine the usefulness of the instrument in assessing body components during gameplay from an empirical and practical perspective.

7. Future research can use the gameplay instrument to examine the influence of different games and task constraints on body components.
8. Further understanding of the environmental and biological factors influencing the
gender differences in throwing form and the product measures of throwing is necessary.
Future research examining environmental factors can focus on the factors outside of
physical education such as sociocultural influences on activity choices outside of physical
education.

9. Future research examining the influence of instruction on gender differences must
explore the influence of teacher behaviors and interactions on the performance of the
overarm throw for boys and girls.

10. In order to improve the research design of this study, replication utilizing random
assignment of participants to groups should be conducted. Additionally, the
implementation of these strategies from different instructors is necessary to determine
teacher effects on the influence of the strategies on throwing performance.
LIST OF REFERENCES


APPENDIX A

DEVELOPMENTAL SEQUENCES FOR COMPONENTS OF THE OVERARM THROW FOR FORCE.
Foot (Step) Action

**S1. No step.** The child throws from the initial foot position.

**S2. Homolateral step.** The child steps with the foot on the same side as the throwing hand.

**S3. Contralateral, short step.** The child steps with the foot on the opposite side from the throwing hand.

**S4. Contralateral, long step.** The child steps with the opposite foot a distance of over half the child’s standing height.

Trunk (Pelvis-Spine) Action

**Trunk-1 (T1) No trunk action or forward-backward movements.**
Only the arm is active in force production. Sometimes, the forward thrust of the arm pulls the trunk into a passive left rotation (assuming a right-handed throw), but no twist-up precedes that action. If trunk action occurs, it accompanies the forward thrust of the arm by flexing forward at the hips. Preparatory (trunk) extension sometimes precedes forward hip flexion.

**T2. Upper trunk rotation or total “block” rotation.** The spine and pelvis both rotate away from the intended line of flight and then simultaneously begin forward rotation, acting as a unit or “block.” Occasionally, only the upper spine twists away, then toward the direction of force. The pelvis, then, remains fixed, facing the line of flight, or joins the rotary movement after forward spinal rotation has begun.

**T3. Differentiated rotation.** The pelvis precedes the upper spine in initiating forward rotation. The thrower twists away from the intended line of ball flight and, then, begins forward rotation with the pelvis while the upper spine is twisting away.

(Continued)

Appendix A. Developmental Sequences for Component of the Overarm Throw for Force.
Appendix A (continued)

Humerus (upper arm) action during forward swing.

**H1. Humerus oblique.** The humerus moves forward to ball release in a plane that intersections the trunk obliquely above or below the horizontal line of the shoulders. Occasionally, during the backswing, the humerus is placed at a right angle to the trunk, with the elbow pointing toward the target. It maintains this fixed position during the throw.

**H2. Humerus aligned but independent.** The humerus moves forward to ball release in a plane horizontally aligned with the shoulder, forming a right angle between humerus and trunk. By the time the shoulders (upper spine) reach front facing, the humerus (elbow) has moved independently ahead of the outline of the body (as seen from the side) via horizontal adduction at the shoulder.

**H3. Humerus lags.** The humerus moves forward to ball release horizontally aligned, but at the moment the shoulders (upper spine) reach front facing, the humerus remains within the outline of the body (as seen from the side). No horizontal adduction of the humerus occurs before front facing.

Forearm action forward swing.

**F1. No forearm lag.** The forearm and ball move steadily forward to ball release throughout the throwing action.

**F2. Forearm lag.** The forearm and ball appear to ‘lag’, i.e., to remain stationary behind the thrower or to move downward or backward in relation to her/him. The lagging forearm reaches its furthest point back, deepest point down, or last stationary point before the shoulders (upper spine) reach front facing.

**F3. Delayed forearm lag.** The lagging forearm delays reaching its final point of lag until the moment of front facing.

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<th>Pretest</th>
<th>Posttest</th>
<th>Retention</th>
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APPENDIX C

CRITICAL CUE INSTRUCTIONAL STRATEGY LESSON PLANS
Critical Cue Group Lesson Plan

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
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<tr>
<td>1</td>
<td>1st and 2nd</td>
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Skills Previously Developed by Students
- None

Motor Instructional Objectives/Student Learning Outcomes

1) By the end of the lesson, the students will be able to execute the critical cue “Point your laser beams.”
2) Students will be able to stand sideways to the target before executing an overhand throw.

Cognitive Instructional Objectives/ Student Learning Outcomes

1) By the end of the lesson, the students will be able to execute the critical cue “Point your laser beams.”

Equipment/Resources Needed

1) Tennis Balls
2) Spider Balls (Suction cup balls)
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up – Bell</td>
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</tbody>
</table>
| 0:10-0:15| Introduction to throwing
Demonstration of the throw
Introduction of the “Point your laser beams.” (story about magic laser beams in your body that will help you throw better). | Teacher/Student Demonstration of throwing motion and critical cue               |
| 0:15-0:20| **Part I.**
Laser Beam Practice – students will move around the gym and on teacher signal will point their laser beams at a target (basketball hoop or shape on wall). Students will say “laser beams” before the signal to move again.

**Part II.**
Students will move in space with bean bag, on when signaled students will stop, point laser beams, and then throw the bean bag from a hot spot to the closet target on the wall after saying “laser beams.” | Game of Stop and Go  
Music will be used as stop/start signal  
Hot spot in rectangle shape around gym |
| 0:21-0:28| Introduction of practice stations                                                    |                                                                              |
| 0:28-0:45| **Practice stations**                                                                | Rotate on Teacher signal for throwing stations  
*Station 1 –*  
Target will be wall  
Student will throw bean bag or ball  
Partner will stand on hot spot to watch thrower  
*Station 3 - Climbing wall Rotate between partners between when finished with one activity – ex. finish one trip on wall climber, go to other fitness station. |
| 0:45-0:50| Review cue, clean up and closing                                                    |                                                                              |

**Total Planned Throwing Instruction - 30 Minutes**
**Critical Cue Group Lesson Plan**

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
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</table>

**Skills Previously Developed by Students**
- Sideways orientation – “Pointing Laser Beams”

**Motor Instructional Objectives/Student Learning Outcomes**

1) By the end of the lesson, the students will be able to execute the overarm throw with a long contralateral step

2) Student will demonstrate the sideways orientation prior to executing the overarm throw.

**Cognitive Instructional Objectives/Student Learning Outcomes**

1) By the end of the lesson, the students will be able to execute the critical cue “Take a long step.”

**Equipment/Resources Needed**

1) Tennis Balls
2) Spider Balls (Suction cup balls)
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
</tr>
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<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up</td>
<td></td>
</tr>
<tr>
<td>0:10-0:14</td>
<td>Review of Laser Beams</td>
<td>Teacher/Student Demonstration of throwing motion and critical cue</td>
</tr>
<tr>
<td></td>
<td>Introduction of the “Take a long step.”</td>
<td></td>
</tr>
<tr>
<td>0:14-0:22</td>
<td>Laser Beam Practice – students will move around the gym and on teacher signal will</td>
<td>Game of Stop and Go</td>
</tr>
<tr>
<td></td>
<td>point their laser beams at a target. Students will say “laser beams” before the</td>
<td>Music will be used as stop/start signal</td>
</tr>
<tr>
<td></td>
<td>signal to move again. Part II. Students will point their laser beams and then take</td>
<td>Hot spot in rectangle shape around gym</td>
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<tr>
<td></td>
<td>a step when throwing the bean bag</td>
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<tr>
<td>0:21-0:25</td>
<td>Introduction of other FMS or practice stations</td>
<td></td>
</tr>
<tr>
<td>0:25-0:46</td>
<td>Practice stations</td>
<td>Station 1 – Student will straddle black line that is perpendicular to the</td>
</tr>
<tr>
<td></td>
<td>7 minutes at each station</td>
<td>target and point his/her laser beams and then take a long step</td>
</tr>
<tr>
<td></td>
<td>Station 1 – Practice Throwing</td>
<td>▪ Target will be wall</td>
</tr>
<tr>
<td></td>
<td>(Laser beams with line)</td>
<td>▪ Student will throw bean bag or ball</td>
</tr>
<tr>
<td></td>
<td>▪ Throw 5, partner throws 5 (Repeat)</td>
<td>▪ Partner will stand on hot spot to watch thrower</td>
</tr>
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<td></td>
<td>▪ How many times did your partner take a long step?</td>
<td>▪ Station 3 – Climbing wall</td>
</tr>
<tr>
<td></td>
<td>Station 2 – Throwing</td>
<td>Rotate between partners between when finished with one activity – ex. finish</td>
</tr>
<tr>
<td></td>
<td>▪ Ten throws with partner and then rotate</td>
<td>one trip on wall climber, go to other fitness station.</td>
</tr>
<tr>
<td></td>
<td>Station 3 – Climbing Wall</td>
<td></td>
</tr>
<tr>
<td>0:46-0:50</td>
<td>Clean up and closing</td>
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**Total Throwing Instruction – 30 minutes**
Critical Cue Group Lesson Plan

<table>
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<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
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<td>3</td>
<td>1\textsuperscript{st} and 2\textsuperscript{nd}</td>
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</table>

Skills Previously Developed by Students

- Sideways orientation – “Pointing Laser Beams
- Contralateral Step

Motor Instructional Objectives/Student Learning Outcomes

1. At the completion of the lesson the students will rotate their hips while executing the throwing motion.
2. Students will use a contralateral step when executing the overarm throwing motion.
3. Students will demonstrate the sideways orientation prior to executing the overarm throw

Cognitive Instructional Objectives/Student Learning Outcomes

1) By the end of the lesson, the students will be able to execute the critical cue “Untwist your hips.”

Equipment/Resources Needed

Tennis Balls
Spider Balls (Suction cup balls)
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
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<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up – warm up trunk with twisting activities using the broomstick</td>
<td></td>
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<tr>
<td>0:10-0:15</td>
<td>Review Laser Beams</td>
<td>Teacher/Student Demonstration of throwing motion and critical cue</td>
</tr>
<tr>
<td>0:15-0:21</td>
<td>Untwisting Hip practice.</td>
<td>CUE “Throw hard and untwist hips to point your belly button to the target”</td>
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<tr>
<td></td>
<td>Point laser beams and then untwist</td>
<td>Hot spots in a circular or rectangle shape</td>
</tr>
<tr>
<td>0:24-0:45</td>
<td>Practice stations</td>
<td>Station 1 – Student will straddle black line that is perpendicular to the target and point his/her laser beams and then take a long step Target will be wall Student will throw bean bag or ball Partner will stand on hot spot to watch thrower</td>
</tr>
<tr>
<td></td>
<td>7 minutes at each station</td>
<td>Station 2 – Throwing Test 10 throws on video – with Lorson</td>
</tr>
<tr>
<td></td>
<td><strong>Station 1</strong> – Practice Throwing – “Untwist your hips” (Laser beams with line)</td>
<td>Station 3 – Climbing wall Rotate between partners between when finished with one activity – ex. finish one trip on wall climber, go to other fitness station.</td>
</tr>
<tr>
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<td>Throw 5, partner throws 5 (Repeat)</td>
<td>Station 4 – Fitness Station - Bell</td>
</tr>
<tr>
<td></td>
<td>How many times did your partner untwist and finish with their belly button at their target?</td>
<td>Station 4 – Fitness Station - Bell</td>
</tr>
<tr>
<td>0:45-0:50</td>
<td>Clean up and closing</td>
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</table>

**Total Throwing Instruction – 30 minutes**
Critical Cue Group Lesson Plan

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
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<td>4</td>
<td>1st and 2nd</td>
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</table>

Skills Previously Developed by Students
Sideways orientation
Stepping action
Rotating trunk

Motor Instructional Objectives/Student Learning Outcomes
At the completion of the lesson the students will execute an overarm throw that includes a sideways orientation, a long contralateral step, and a rotating trunk.

Cognitive Instructional Objectives/Student Learning Outcomes
By the end of the lesson the students will be able to recall the critical cues of “Point your laser beams,” “Take a long step,” and “Untwist your hips.”

Equipment/Resources Needed
1) Tennis Balls
2) Bean bags (if necessary)
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<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
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<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up</td>
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</tr>
<tr>
<td>0:10-0:15</td>
<td>Review of the three critical cues</td>
<td>How should you stand before you throw the ball? “Laser Beams” After your laser beams, what should you do next? After you step what should you do to throw hard and fast? Teacher/Student Demonstration of throwing motion and critical cue</td>
</tr>
<tr>
<td>0:15-0:18</td>
<td>Review Practice Stations</td>
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<tr>
<td>0:18-0:42</td>
<td>Practice stations</td>
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<td></td>
<td>- 6 minutes at each station</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 1</strong> – Practice Throwing – “Untwist your hips” (Laser beams with line)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Throw 5, partner throws 5 (Repeat)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- How many times did your partner untwist and finish with their belly button at their target?</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 2</strong> – Throwing Test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 10 throws on video – with Lorson</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 3</strong> – Wall Climb</td>
<td></td>
</tr>
<tr>
<td>0:45-0:50</td>
<td>Clean up and closing Review cue</td>
<td>Review Critical Cues – Student/Teacher demonstration of throwing motion and critical cues.</td>
</tr>
</tbody>
</table>

**Total Throwing Instruction – 30 minutes**
APPENDIX D

BIOMECHANICAL STRATEGY LESSON PLANS
Biomechanical Group Lesson Plan

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; and 2&lt;sup&gt;nd&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Skills Previously Developed by Students
- None

Motor Instructional Objectives/Student Learning Outcomes

By the end of the lesson students will demonstrate the “L” with their humerus and forearm at a 90° angle to the spine.

Cognitive Instructional Objectives/Student Learning Outcomes

1) By the end of the lesson, the students will be able to assume the “L” position.

Equipment/Resources Needed

Tennis Balls
Spider Balls (Suction cup balls)
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
<th>Teaching Cues</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:10-0:15</td>
<td>Introduction to throwing</td>
<td><em>Remember 80% of the class must demonstrate the level before moving on</em> Teacher/Student demonstration of stage</td>
<td>“Make an L”</td>
</tr>
<tr>
<td></td>
<td>Demonstration of the throw</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Introduction of the “L” position</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:15-0:25</td>
<td>“L” practice – Show both with and without a ball</td>
<td></td>
<td>Prompt “<strong>Hard and Fast</strong>” throws.</td>
</tr>
<tr>
<td></td>
<td>Part I. With instructor modeling the students will face the target and make an L with their arm. They will simulate the end of the throwing motion.</td>
<td></td>
<td>“L to Pocket”</td>
</tr>
<tr>
<td></td>
<td>Part II. The students will assume the proper positioning of the humerus and forearm. Students will then execute the final phase of the throw.</td>
<td></td>
<td>Try to hear the “Whoosh” of your arm</td>
</tr>
<tr>
<td></td>
<td>** If 80% of the students are demonstrating level 1, the teacher will introduce level 2 which is stepping and throwing***</td>
<td></td>
<td><strong>If level 2, prompt stepping action – “Step and reach”</strong></td>
</tr>
<tr>
<td>0:25-0:30</td>
<td>Introduction of stations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:30-0:45</td>
<td>Practice stations (5 minutes at each stage)</td>
<td>Station 1 – Throwing from the “L” position (5 throws and rotate with partner) How many times did your partner point his/her laser beams?</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 2 – Throwing Test (10 throws on video) with partner</strong></td>
<td>Station 2 – Throwing from hot spots – 3 hot spot, student will throw 5 balls toward wall, then partner will throw 5. (If level 2 is already presented prompt the step)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 3 – Climbing Wall (non-throwing)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:45-0:50</td>
<td>Clean up and closing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Review cue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Total Throwing Time – 30 minutes

Biomechanical Group Lesson Plan

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1st and 2nd</td>
</tr>
</tbody>
</table>

Skills Previously Developed by Students
- “L” position of the humerus and forearm

Motor Instructional Objectives/Student Learning Outcomes

By the end of the lesson, students will take a contralateral step when throwing the ball.

Cognitive Instructional Objectives/Student Learning Outcomes

By the end of the lesson students will recall that they must step with the foot opposite their throwing hand when executing the throwing motion.

Equipment/Resources Needed

Tennis Balls
Spider Balls (Suction cup balls)
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
<th>Teaching Cues</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:10-0:21</td>
<td>Review L position</td>
<td>Class demonstrates L</td>
<td>“Long step and throw.” “Step and reach”</td>
</tr>
<tr>
<td></td>
<td>Introduction or review of the “Stepping action.”</td>
<td>Teacher will lead the class in stepping action.</td>
<td>Remember the thrower is facing the target (both shoulders pointed toward the target).</td>
</tr>
<tr>
<td></td>
<td>Part II. The students will assume the proper positioning of the humerus and forearm.</td>
<td>Part II. Circle or square formation with the students facing the wall (with their backs to the inside of the circle.</td>
<td>Prompt “Hard and Fast” throws.</td>
</tr>
<tr>
<td></td>
<td>Then the students will step and reach as they throw the ball.</td>
<td></td>
<td>“L to Pocket”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Try to hear the “Whoosh” of your arm</td>
</tr>
<tr>
<td>0:21-0:26</td>
<td>Introduction of stations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:26-0:45</td>
<td>Practice stations (7 minutes at each stage)</td>
<td>Station 1 – Throwing from hot spots – 3 hot spot, student will throw 5 balls toward wall, then partner will throw 5. (If level 2 is already presented prompt the step)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 1</strong> – Throwing from the “L” position (5 throws and rotate with partner)</td>
<td>Station 3 - Climbing wall Rotate between partners between when finished with one activity – ex. finish one trip on wall climber, go to other fitness station.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 2</strong> – Throwing (10 throws on video with partner)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 3</strong> – Climbing Wall (non-throwing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:45-0:50</td>
<td>Clean up and closing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Throwing Time** – 30 minutes
Biomechanical Group Lesson Plan

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; and 2&lt;sup&gt;nd&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Skills Previously Developed by Students
- L position
- Stepping action

Motor Instructional Objectives/Student Learning Outcomes
At the completion of the lesson, the students will demonstrate a throwing motion after assuming a sideways orientation

Cognitive Instructional Objectives/Student Learning Outcomes
By the end of the lesson, the students will recall the importance of assuming a sideways orientation before they throw the ball..

Equipment/Resources Needed
- Tennis Balls
- Spider Balls (Suction cup balls)
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
<th>Teaching Cues</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:10-0:20</td>
<td>Review L position, Review step Demonstration of sideways orientation</td>
<td></td>
<td>“Make an L”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Sideways to Target”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Untwist your hips”</td>
</tr>
<tr>
<td>0:20-0:25</td>
<td><strong>Part I.</strong></td>
<td>Game of Stop and Go</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sideways Practice – students will move around the gym and on teacher signal will stand sideways at a target (basketball hoop or shape on wall). Students will say “sideways before the signal to move again.**</td>
<td>Music will be used as stop/start signal</td>
<td></td>
</tr>
<tr>
<td>0:25-0:30</td>
<td>Introduction of stations</td>
<td>Hot spot in rectangle shape around gym</td>
<td></td>
</tr>
<tr>
<td>0:30-0:45</td>
<td>Practice stations (5 minutes at each stage)</td>
<td><strong>Station 1</strong> – Throwing from hot spots – 3 hot spot, student will throw 5 balls toward wall, then partner will throw 5. (If level 3 is already presented prompt the sideways orientation – see lesson plan 3 – straddle line)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 1</strong> – Sideways orientation. Students will straddle a line and then execute the throwing motion (they will be reminded to make an “L” before they throw the ball.) **</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 2</strong> – Throwing Test (10 throws on video)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 3</strong> – Climbing Wall (non-throwing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:45-0:50</td>
<td>Clean up and closing Review cue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Throwing Time – 30 minutes**
Biomechanical Group Lesson Plan

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; and 2&lt;sup&gt;nd&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Skills Previously Developed by Students
- “L” position
- Step
- Sideways Orientation

Motor Instructional Objectives/Student Learning Outcomes
At the completion of the lesson, the student will execute a throwing motion after making an L with their humerus and forearm, sideways orientation, and stepping with the foot opposite the throwing hand.

Cognitive Instructional Objectives/Student Learning Outcomes
At the completion of the lesson the students will recall the key components of making an “L”, stepping, and the sideways orientation.

Equipment/Resources Needed
Tennis Balls
Spider Balls (Suction cup balls)
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
<th>Teaching Cues</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:10-0:17</td>
<td>Review all of the previous aspects &amp; introduce level 4 (Sideways orientation and stepping practice)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:17-0:23</td>
<td><strong>Part I.</strong> Sideways Practice – students will move around the gym and on teacher signal will stand sideways at a target (basketball hoop or shape on wall). Students will say “sideways before the signal to move again. <strong>Part II.</strong> Students will move in space with bean bag, on teacher cue students will stop, stand sideways, and then throw the bean bag from a hot spot to the closet target</td>
<td>Game of Stop and Go</td>
<td>Music will be used as stop/start signal Hot spot in rectangle shape around gym</td>
</tr>
<tr>
<td>0:23-0:28</td>
<td>Introduction of stations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:28-0:46</td>
<td>Practice stations (6 minutes at each stage)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Station 1</strong> – Sideways orientation. Students will straddle a line and then execute the throwing motion (they will be reminded to make an “L” before they throw the ball. Students will throw Station 2 – Throwing Test (10 throws on video) Station 3 – Climbing Wall (non-throwing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:46-0:50</td>
<td>Clean up and closing Review cue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Throwing Time** – 30 minutes
APPENDIX E

TYPICAL PHYSICAL EDUCATION LESSON PLANS
Typical Physical Education Group Lesson Plan

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1st and 2nd</td>
</tr>
</tbody>
</table>

Skills Previously Developed by Students
-None
-

Motor Instructional Objectives/Student Learning Outcomes

Students will be able to demonstrate the proper technique for the overhand throw

Cognitive Instructional Objectives/Student Learning Outcomes

Students will be able to verbalize the important cues for the overhand throw.

Equipment/Resources Needed

Tennis Balls
Vinyl Baseballs
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
<th>Teaching Cues</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00-</td>
<td>Warm-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:10</td>
<td>Introduction to throwing Demonstration of the throw Students will raise the hand they throw with and take off the opposite shoe and place it on the wall Students demonstrate throwing motion with imaginary ball</td>
<td>Students sit on floor. After taking off their shoe students will stand on the black line facing the teacher</td>
<td>Side to target Arm way back Step with opposite foot Twist and throw hard</td>
</tr>
<tr>
<td>0:20-</td>
<td>Students will throw vinyl baseballs to wall using the overhand throwing motion standing at least 10 paces from the wall. Students will back up each time they hit the wall</td>
<td>Students will retireve the ball and continue to throw to wall</td>
<td></td>
</tr>
<tr>
<td>0:30-</td>
<td>Review proper catching skills High catch – thumbs together Low catch – pinkies together</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:35-</td>
<td>Game – Catch and Change If you catcha ball from your partner, change sides. Keep track of how many times you change sides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:45-</td>
<td>Clean up and closing Review cue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Allocated Throwing Time = 30 minutes**
## Typical Physical Education Group Lesson Plan

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1st and 2nd</td>
</tr>
</tbody>
</table>

**Skills Previously Developed by Students**

- Side to target
- Arm way back
- Step with opposite foot
- Twist and throw hard

**Motor Instructional Objectives/Student Learning Outcomes**

Students will be able to demonstrate the proper technique for the overhand throw.

**Cognitive Instructional Objectives/Student Learning Outcomes**

Students will be able to verbalize the important cues for the overhand throw.

**Equipment/Resources Needed**

- Tennis Balls
- Vinyl Balls
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
<th>Teaching Cues</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:10-0:17</td>
<td>Introduction and review of throwing</td>
<td>Students sit on floor. After taking off their shoe students will stand on the black line facing the teacher</td>
<td>Side to target Arm way back Step with opposite foot Twist and throw hard</td>
</tr>
<tr>
<td>0:17-0:28</td>
<td>Students will throw vinyl baseballs to wall using the overhand throwing motion standing at least 10 paces from the wall. Students will back up each time they hit the wall</td>
<td>Students will retrieve the ball and continue to throw to wall</td>
<td></td>
</tr>
<tr>
<td>0:28-0:38</td>
<td>“Knock Out” – Teams will try and “knock out” of bounds their large cage ball by moving it with hard and fast throws</td>
<td>Two teams on each side of the gym. Cage ball in the center on poly spot. Cage ball must move past sideline.</td>
<td>High catch – thumbs together Low catch – pinkies together</td>
</tr>
<tr>
<td>0:38-0:40</td>
<td>Review and Clean up</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Allocated Throwing Time = 30 minutes**
Typical Physical Education Group Lesson Plan

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1\textsuperscript{st} and 2\textsuperscript{nd}</td>
</tr>
</tbody>
</table>

Skills Previously Developed by Students
- Throwing – side to target, arm way back, step with opposite foot, twist and throw hard.
- Catching - High Catch and Low Catch

Motor Instructional Objectives/Student Learning Outcomes
Students will use throw using correct form: side to target, arm way back, step with opposite foot, twist and throw hard.

Students will throw at large targets using hard, long throws, and correct form

Cognitive Instructional Objectives/Student Learning Outcomes
Students will give peer feedback on their overhand throw

Equipment/Resources Needed
Tennis Balls
Vinyl Baseballs
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
<th>Teaching Cues</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up &amp; Stretching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:10-0:15</td>
<td>Review Cues and Demonstration of Throwing and Catching</td>
<td>Students sit on floor. After taking off their shoe students will stand on the black line facing the teacher</td>
<td>Side to target Arm way back Step with opposite foot Twist and throw hard</td>
</tr>
<tr>
<td>0:15-0:25</td>
<td>Throws for force and distance -</td>
<td>Students will line up at the center line and throw balls, trying to hit the backboard on the other side of the room. Trying to hit either side or end baskets.</td>
<td></td>
</tr>
<tr>
<td>0:25-0:40</td>
<td>Game – Backboard tag Class is divided into two teams</td>
<td>Each time will line up on either side of the center line. On “go” they will retrieve one ball and throw it to the other side of the court If the ball is caught the player transfers over to the other team. If a play hits the backboard all players return to their original teams.</td>
<td>High catch – thumbs together Low catch – pinkies together</td>
</tr>
<tr>
<td>0:35-0:45</td>
<td>Review Critical Cues for Throwing</td>
<td></td>
<td>Side to target Arm way back Step with opposite foot Twist and throw hard</td>
</tr>
</tbody>
</table>

**Total Allocated Throwing Time = 30 minutes**
Typical Physical Education Group Lesson Plan

<table>
<thead>
<tr>
<th># Lesson in Unit</th>
<th>Grade/s Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1st and 2nd</td>
</tr>
</tbody>
</table>

Skills Previously Developed by Students
Throwing – side to target, arm way back, step with opposite foot, twist and throw hard.

Catching - High Catch and Low Catch

Motor Instructional Objectives/Student Learning Outcomes
Students will throw using correct form: side to target, arm way back, step with opposite foot, twist and throw hard.

Students will throw at large targets using hard, long throws and correct form.

Cognitive Instructional Objectives/ Student Learning Outcomes
Students will give peer feedback to their partner on their overhand throw using the cues for the overhand throw.

Equipment/Resources Needed
Tennis Balls
Vinyl Baseballs
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
<th>Teaching Cues</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00-0:10</td>
<td>Warm-up &amp; Stretching</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 0:10-0:15 | Review Cues and Demonstration of Throwing and Catching | Students sit on floor. After taking off their shoe students will stand on the black line facing the teacher | Side to target
Arm way back
Step with opposite foot
Twist and throw hard |
| 0:15-0:21 | Overhand throw practice with a partner                 | Students will line up across the gym and throw at large targets on the wall   |                                                                               |
| 0:21-0:28 | Drawing of the ready position for the overhand throw on the targets. | Each student will draw the position for the overhand throw using a marker.   | High catch – thumbs together
Low catch – pinkies together |
| 0:28-0:38 | Overhand throwing peer assessment – students will place an “X” next to the critical element demonstrated. Students will throw the ball 12 times. | Students will work in pairs to check each others throwing motion. One partner watches as the other throws | Side to target
Arm way back
Step with opposite foot
Twist and throw hard |
| 0:38-0:40 | Review critical features of the throw               | Teacher/student demonstration                                               |                                                                               |

**Total Allocated Throwing Time = 30 minutes**
APPENDIX F

OBSERVATIONAL RECORDING RECORD OF PHYSICAL EDUCATOR’S
TEACHING BEHAVIOR DEFINITIONS
Climate (Student Behavior)

Climate (student behavior) is the indirect assessment of teacher performance by recording what the students are doing (Stewart, 1989).

Instructional Time

Instructional time is the “period of time in the class when, theoretically, the opportunity for the student to learn is present” (Stewart, 1989, p. 250). During instructional time students can receive information verbally or nonverbally, and 51% or more of the students are not engaged in physical activity (Stewart, 1989).

Management Time

Management time is when the opportunity to learn is not present and the activity is only indirectly related to the class learning activity (Stewart, 1989).

Activity Time

Activity time is when 51% or more of the student are involved in actual physical movement that is directly related to the goals of the lesson.

Waiting Time

Waiting time is when 51% of the students are prohibited from being categorized in any of the other classroom climates. Waiting time is not considered students are waiting in line to use equipment; rather management is the appropriate category (Stewart, 1989).

Interactions

Interactions are another category recorded by the ORRPETB, and are described as when the teacher interacts either verbally or nonverbally with a student or a group of students, or responds to student behavior either verbally or nonverbally.
Individual Interaction

An interaction is recorded as “individual” if the teacher is only talking to one student.

Group Interaction

If the teacher is talking to more than one student, “group” will be the appropriate category.

Teacher Behavior

Teacher behaviors are the teacher reactions to student behavior.

Lecturing

Lecturing is described as when the teacher is communicating facts or opinions about the content or procedures.

Asking Questions

A teacher is “asking questions” when the teacher asks a student or a group of student’s questions about content or procedures.

Answering Questions

A teacher is “answering questions” when he/she responds to students’ questions.

Listening

Listening is coded when the teacher is listening to the student’s question or response.

Monitoring

A teacher is “monitoring” when observing the class without reacting to student behavior.
Nonfunctional

Nonfunctional is a behavioral category recorded when the teacher behaviors are not related to the ongoing activities or the class. For example if the teacher is talking to another teacher or to a student not in the class.

Managing

Managing is the recorded teacher behavior when the teacher “expresses behaviors that are related to the class, but do not contribute to the educational outcomes (Stewart, 1989, p. 252).

Corrective Skill Feedback

Corrective skill feedback is corrective information given after an attempt.

Skill feedback-general

General praise, either verbal or nonverbal, that occurs during or immediately following a skill attempt.

Skill feedback-specific

Specific, verbal praise that occurs during or follow a skill attempt.

Modeling

Modeling is when a teacher shows a student or students the correct or incorrect way to perform a skill (Stewart, 1989).

Social behaviors

Social behaviors are the teacher reactions to the social behaviors of students and include: general praise, specific praise, nagging, and getting nasty (Stewart, 1989).
Hustling

Hustling is when a teacher uses verbal statements or gestures to activate or intensify previously directed behavior.

Appropriate punishment

Appropriate punishments are specific penalties imposed by the teacher on those students who break class rules by exhibiting disruptive or deviant behaviors.

Physical Contact/Manual Guidance

Physical contact category was modified to physical contact/manual guidance (PC/MG) and is recorded when a teacher using manual guidance to move a body part into proper position.

Teacher Officiating

The teacher acts as an official during a game or activity, and his or her behavior cannot be classified in another category.

Teacher Participating

The teacher participates in a game or activity and is not involved in the teaching process.
APPENDIX G

HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD APPROVAL TO CONDUCT RESEARCH
APPENDIX H

SAMPLE PARENT CONSENT LETTER AND PERMISSION FORM
February, 13, 2003

Dear Parent and Child:

My name is Kevin Lorson. I am a PhD student enrolled in the Sport and Exercise Education program at The Ohio State University under the supervision of Dr. Jackie Goodway. As part of my studies, I am interested in studying effective instruction of the overarm throw.

We are requesting your permission for your child to participate in a study conducted at your child’s school during physical education. Mrs. Bell has agreed in principle to work with me on this study during your child’s physical education class. This study “The Influence of a Critical Cue or Biomechanical Instructional Program on the Performance of the Overarm Throw during Practice and Gameplay” will be conducted during physical education class. The purpose of this study is to gather information to improve instruction of the overhand throw in elementary children. Throwing is a fundamental motor skill that is used in variety of sports and games. The goal of this study is to develop effective and efficient strategies and instructional programs to improve the overarm throw. Your child may benefit from this study by improving an important fundamental motor skill. Physical education teachers may also benefit by learning effective and efficient strategies for teaching movement skill to children.

The participants for this study will be three first and second grade classes. They will participate in five throwing sessions during physical education class. The sessions will be conducted during class time after spring break. With parental consent, the participants will be videotaped during the testing sessions. The videotapes will only be used by the researcher to study each child’s throwing mechanics. While participating in this study, the child’s risk of injury is no greater than that of any typical physical education activities.

The results of this study may be published, but the school or student names will never be mentioned. All information about your students and school will be kept confidential. The student’s participation in this study is voluntary, and is in no way connected to his/her standing in physical education. A student can be withdrawn from the study at any time.

We believe your students will enjoy and benefit from participating in this study. Please keep this letter for further reference. Please sign and return the yellow sheet to your child’s teach as soon as possible. Thank you for you time. If you have any questions you can reach Kevin Lorson at 486-6175 or Dr. Goodway at 292-8393.

Sincerely,

Dr. Jackie Goodway                        Kevin Lorson
goodway-shiebler.1@osu.edu              lorson.2@osu.edu
APPENDIX I

DATA ANALYSIS TABLE
Body Components During Individual Practice

Research Question 1. What is the influence of instructional group (Critical Cue [CUE], biomechanical-based [BP], and typical physical education [TPE] on the four body component levels of throwing (step, trunk, humerus, and forearm) from the pretest to posttest to retention test?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₁ A pretest multivariate</td>
<td>Pretest</td>
<td>3 Group X 2</td>
<td>1) Determine if a significant multivariate group effect exists.</td>
</tr>
<tr>
<td>analysis of variance</td>
<td>mean</td>
<td>Gender MANOVA</td>
<td>2) Examine follow-up univariate Group effect for each component. If significant univariate tests are found, examine post-hoc tables for significant differences between groups at the pretest.</td>
</tr>
<tr>
<td>non-significant Group effect</td>
<td>component</td>
<td></td>
<td></td>
</tr>
<tr>
<td>indicating no pretest</td>
<td>levels</td>
<td></td>
<td></td>
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<tr>
<td>differences between groups</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>in body component levels.</td>
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</tr>
</tbody>
</table>

Appendix G. Hypothesis, data use, type of analysis and steps of analysis.
<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂ A MANOVA with repeated measures on the last factor will reveal a significant multivariate Group X Time effect with follow-up univariate tests also revealing significant Group X Time effects for each component.</td>
<td>Pretest and posttest mean component levels</td>
<td>MANOVA with repeated measures</td>
<td>1) Determine significant Group X Time effect with multivariate test. 2) Examine follow-up univariate tests for Group X Time differences for each component.</td>
</tr>
<tr>
<td>H₃ A MANOVA with repeated measures on the last factor will reveal a significant multivariate Group effect with significant univariate Group effects for the step, trunk, humerus, and forearm components at the posttest and retention test. If significant univariate tests are revealed, then the CUE and BP group will demonstrate significantly more advanced body component levels than the TPE group at the posttest and retention test.</td>
<td>Pre- and Posttest mean component levels for the step, trunk, humerus, and forearm</td>
<td>MANOVA with repeated measures</td>
<td>1) Determine significant Group effect with multivariate test. 2) Examine follow-up univariate test for Group differences for each component at the posttest and retention test. 3) Examine post-hoc tables to determine where the differences between groups on each component exists.</td>
</tr>
</tbody>
</table>
(Appendix I Continued)

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₄ A MANOVA with repeated measures on the last factor will reveal a significant multivariate Time effect with significant univariate Time effects for the four body components. Follow-up tests will reveal significant pretest to posttest changes in each of the body component levels for each of the CUE, BP, and TPE groups. If a significant pretest to posttest change is found, there will be no significant posttest to the retention test changes in body component levels for each group.</td>
<td>Pretest, posttest, and retention test mean component levels for the step, trunk, humerus, and forearm.</td>
<td>1) 3 (Group) X 3 (Time) X 2 (Gender) MANOVA with repeated measures</td>
<td>1) Multivariate test to determine if a significant Time effect exists. 2) Univariate tests to determine body components with Time effect. 2) Paired samples t-test to determine significant changes in body components from pretest to posttest, and posttest to retention test for each group. Bonferroni adjustment of alphas level to ( p = 0.0167 ) (0.05/3 = 0.0167)</td>
</tr>
</tbody>
</table>

(Continued)
(Appendix I Continued)

*Instructional Groups and Body Component Levels During Game Play*

**Research Question 2.** What is the relationship between body component levels in practice and body component levels in gameplay at the pretest, posttest, and retention test for each group?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H5 A moderate to strong ( r = .40 ) or above significant, positive correlation will exist between throwing performance in practice and throwing performance in a game for each group and for each component at the pretest, posttest, and retention test.</td>
<td>1) Mean body component levels of the step, trunk, and forearm at the pretest, posttest, and retention test.</td>
<td>Pearson product-moment correlation</td>
<td>1) Calculate Pearson product moment correlation coefficient between pretest, posttest, and retention test body component levels in practice and gameplay by individual component and group.</td>
</tr>
<tr>
<td></td>
<td>2) Mean body component levels during gameplay for the foot/knee position (step), trunk rotation, and forearm at the pretest, posttest, and retention test.</td>
<td></td>
<td>2) Determine strength of correlation and significant correlation coefficients at an alpha level of .05 and .001.</td>
</tr>
</tbody>
</table>

(Continued)
Differences Between Groups in Ball Velocity and Unrecorded Trials

Research Question 3. What is the influence of instructional group (CUE, BP, TPE) on mean recorded ball velocity from the pretest to posttest to retention test?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₆ A pretest Group X Gender analysis of variance (ANOVA) will reveal a non-significant Group effect indicating no significant pretest differences between groups in mean recorded velocity.</td>
<td>Mean ball velocity at the pretest</td>
<td>Gender ANOVA</td>
<td>1) Determine if a significant group effect exists at the pretest. 2) If significant, post-hoc follow-up tests with Tukey HSD will be used to determine the significant differences between groups.</td>
</tr>
<tr>
<td>H₇ A Group X Gender X Time ANOVA with repeated measures on the last factor will reveal a significant univariate Group X Time interaction for mean ball velocity.</td>
<td>Mean ball velocity recorded at the pretest, posttest, and retention test</td>
<td>Gender ANOVA with repeated measures on the last factor</td>
<td>1) Determine significant Group X Time effect.</td>
</tr>
</tbody>
</table>
(Appendix I Continued)

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H₈</strong> A Group X Gender X Time ANOVA with repeated measures on the last factor will result in a significant Group effect, with the BP and CUE groups having a significantly greater mean velocity score than the TPE group.</td>
<td>Mean ball velocity recorded at the pretest, posttest, and retention</td>
<td>3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor</td>
<td>1) Determine a significant Group effect. 2) Follow-up ANOVAs to determine significant differences between groups at posttest and retention test.</td>
</tr>
<tr>
<td><strong>H₉</strong> A Group X Gender X Time ANOVA with repeated measures on the last factor will result in a significant Time effect for ball velocity. Within each group, follow-up tests will reveal significant differences in mean ball velocity from the pretest to the posttest, for each group. If a significant pretest to posttest change is found, there will be no significant posttest to the retention test changes in ball velocity for each group.</td>
<td>Mean ball velocity recorded at the pretest, posttest, and retention</td>
<td>1) 3 Group X 3 Time X 2 Gender ANOVA</td>
<td>1) Determine significant Time effect. 2) If significant, select group data for paired sample t-test. Bonferroni adjustment: ( p = \frac{.05}{3} = 0.0167 )</td>
</tr>
</tbody>
</table>

(Continued)
Research Question 4. What is the influence of instructional group (CUE, BP, TPE) on the number of unrecorded trials from the pretest to posttest to retention test?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₁₀</td>
<td>A pretest Group X</td>
<td>Number of unrecorded</td>
<td>Gender analysis of variance (ANOVA) will reveal a non-significant Group effect indicating no significant pretest differences between groups in unrecorded trials at the pretest.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 Group X 2</td>
<td>Gender</td>
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<tr>
<td></td>
<td></td>
<td>Gender analysis</td>
<td>ANOVA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>trials at the pretest</td>
<td></td>
</tr>
<tr>
<td>H₁₁</td>
<td>A Group X Time X</td>
<td>Number of unrecorded</td>
<td>Gender ANOVA with repeated measures on the last factor will reveal a significant univariate Group X Time interaction for unrecorded trials.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 Group X 3</td>
<td>Gender</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time X 2</td>
<td>ANOVA</td>
</tr>
<tr>
<td></td>
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<td>trials recorded at the pretest,</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Gender</td>
<td>ANOVA with repeated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>posttest, and</td>
<td>repeated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>retention test</td>
<td>measures on the last factor</td>
</tr>
</tbody>
</table>

(Continued)
(Appendix I Continued)

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₁₂ A Group X Gender X Time</td>
<td>Number of unrecorded</td>
<td>3 Group X 3 Time</td>
<td>1) Determine a significant Group effect.</td>
</tr>
<tr>
<td>ANOVA with repeated measures on the last factor will result in a significant univariate Group effect, with follow-up tests showing the BP and CUE groups having a significantly fewer unrecorded trials than the TPE group.</td>
<td>pretest, posttest,</td>
<td>ANOVA with repeated measures on the last factor ANOVAs to determine significant differences between groups at posttest and retention test.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>trials at the pretest,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and retention test</td>
<td>3 Group X 2 Gender ANOVA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>for posttest and retention test.</td>
<td></td>
</tr>
<tr>
<td>H₁₃ A Group X Gender X Time</td>
<td>Number of unrecorded</td>
<td>1) 3 Group X 3 Time</td>
<td>1) Determine significant univariate Time interaction.</td>
</tr>
<tr>
<td>ANOVA with repeated measures on the last factor will result in a significant univariate Time effect for unrecorded trials. Within each group, follow-up tests will reveal a significant decrease in unrecorded trials from the pretest to the posttest, for each group. If a significant pretest to posttest change is found, there will be no significant posttest to the retention test changes in unrecorded trials for each group.</td>
<td>pretest, posttest,</td>
<td>2) Paired samples t-test</td>
<td>2) If significant, select group data for paired sample t-test.</td>
</tr>
<tr>
<td></td>
<td>trials at the pretest,</td>
<td>Time X 2 Gender ANOVA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and retention test</td>
<td>for posttest and retention test.</td>
<td></td>
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<td></td>
<td>t-test</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3) Bonferroni adjustment – (p=.05/3 = 0.0167)</td>
</tr>
</tbody>
</table>
Gender and Body Component Levels

Research Question 5. What is the influence of instructional group (CUE, BP, TPE) and gender (Female, Male) on body component levels (step, trunk, humerus, and forearm) from the pretest to the posttest to the retention test?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H14 A pretest MANOVA</td>
<td>Pretest mean</td>
<td>3 Group X 2 Gender</td>
<td>1) Determine if a significant multivariate Gender effect exists.</td>
</tr>
<tr>
<td>will reveal a significant multivariate Gender effect</td>
<td>component</td>
<td>MANOVA</td>
<td>2) Follow-up univariate test for Gender effect for each component.</td>
</tr>
<tr>
<td>levels for the step, trunk, humerus, and forearm</td>
<td>for each body component.</td>
<td></td>
<td>3) If significant univariate effects are found, examine post-hoc table.</td>
</tr>
</tbody>
</table>
(Appendix I Continued)

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H15 A pretest</td>
<td>Pretest mean</td>
<td>3 Group X 2 Gender</td>
<td>1) Determine if a significant Group X Gender interaction exists for each component at the pretest. Within one group, follow-up t-tests will reveal significant gender differences in each body component for each group at the pretest.</td>
</tr>
<tr>
<td>MANOVA will reveal a significant multivariate Group X Gender interaction with significant follow-up univariate Group X Gender interactions for each of the step, trunk, humerus, and forearm.</td>
<td>component levels for the step, trunk, humerus, and forearm.</td>
<td>MANOVA</td>
<td>2) Follow-up univariate test for Group X Gender effect for each component at the pretest.</td>
</tr>
</tbody>
</table>

3 Group X 2 Gender MANOVA

1) Determine if a significant Group X Gender interaction exists for each component at the pretest.

2) Follow-up univariate test for Group X Gender effect for each component at the pretest.

3) If significant differences are found, follow-up t-tests will reveal significant gender differences in each body component for each group at the pretest.
(Appendix I Continued)

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_{16}$ A Group X Time X Gender MANOVA</td>
<td>Pretest, posttest, and retention test mean</td>
<td>3 Group X 3 Time X</td>
<td>1) Determine if a significant multivariate Gender X Time effect. Follow-up univariate tests will reveal a significant multivariate Gender X Time effect. Follow-up univariate tests will reveal a significant multivariate Gender X Time effect. Follow-up univariate tests will reveal a significant multivariate Gender X Time effect. Follow-up univariate tests will reveal a significant multivariate Gender X Time effect. Follow-up univariate tests will reveal a significant multivariate Gender X Time effect. Follow-up univariate tests will reveal a significant multivariate Gender X Time effect.</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>Data Used</td>
<td>Type of Analysis</td>
<td>Steps of Analysis</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------</td>
<td>------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>$H_{17}$ A Group X Time X Gender</td>
<td>Posttest</td>
<td>3 Group X 3</td>
<td>- Determine if a significant multivariate interaction exists.</td>
</tr>
<tr>
<td>MANOVA with repeated measures and Time X 2 Gender</td>
<td>retention</td>
<td>MANOVA with Group X Time X Gender</td>
<td>Follow-up univariate test for Group X Time X</td>
</tr>
<tr>
<td>on the last factor will reveal a significant multivariate Group X test</td>
<td>repeated</td>
<td>interaction</td>
<td>for the step, trunk, humerus, and forearm.</td>
</tr>
<tr>
<td>Gender X Time interaction with component measures.</td>
<td></td>
<td></td>
<td>- 3 Group X 2 Gender</td>
</tr>
<tr>
<td>significant follow-up univariate levels for 3 Group X 2 test</td>
<td>determine gender differences</td>
<td>MANOVA at posttest revealed significant multivariate Gender effect, follow-up univariate tests for</td>
<td></td>
</tr>
<tr>
<td>Group X Gender X Time the step, Gender</td>
<td>posttest, and</td>
<td>Gender effect for each component. Follow-up t-tests to determine gender differences at the posttest and retention test for each group.</td>
<td></td>
</tr>
<tr>
<td>interactions for the step, trunk, trunk, MANOVA step, trunk, humerus, and humerus, forearm.</td>
<td>t-tests to</td>
<td></td>
<td>Repeat process for retention test.</td>
</tr>
<tr>
<td>Follow-up analyses will show there will be no gender differences in body components at the posttest and both for overall gender, and for gender within each of the three groups. Additional follow-up analyses will show significant within group pretest to posttest changes in each body component level for each gender within each group. Tere will be no significant posttest to the retention test changes in body component levels.</td>
<td>MANOVA</td>
<td>within each group</td>
<td>Repeat process for retention test.</td>
</tr>
</tbody>
</table>
Gender and Body Component Levels During Gameplay

Research Question 6. What is the relationship between body component levels in practice and body component levels in gameplay at the pretest, posttest, and retention test for each gender?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H18</td>
<td>1) Mean body component levels of the step, trunk, and forearm sorted by group and gender.</td>
<td>Pearson product-moment correlation</td>
<td>1) Calculate Pearson product-moment correlation coefficient. 2) Determine strength of correlation and significant correlation coefficients at an alpha level of .05.</td>
</tr>
<tr>
<td></td>
<td>2) Mean body component levels during gameplay for the foot/knee position, trunk rotation, and forearm sorted by group and gender.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
**Gender and Ball Velocity**

*Research Question 7.* What is the influence of instructional group and gender on mean ball velocity from the pretest to posttest to retention test?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H_{19} ) A pretest Group X Gender ANOVA will reveal a significant Gender effect.</td>
<td>Mean ball velocity recorded at the pretest.</td>
<td>3 Group X 2 Gender ANOVA</td>
<td>1) 3 X 2 ANOVA to determine Gender effect at the pretest for ball velocity. Follow-up analyses will reveal males have a greater mean velocity than the girls at the pretest.</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H21 A Time X Gender</td>
<td>Mean ball velocity recorded at the pretest, posttest, and retention test.</td>
<td>3 Group X 3 Time X 2 Gender ANOVA with repeated measures on the last factor</td>
<td>1) Determine if a significant Gender X Time effect exists for ball velocity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2) Follow-up ANOVA to determine gender differences for each group at the posttest and retention.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3) Follow-up paired samples t-test to determine significant changes in mean ball velocity from pretest to posttest, and non-significant changes in posttest to retention test for each group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Additional follow-up analyses will show that both males and females will significantly improve mean ball velocity scores from the pretest to posttest. If a significant pretest to posttest change is found, there will be no significant posttest to retention test changes in ball velocity.</td>
</tr>
</tbody>
</table>

(Continued)
(Appendix I Continued)

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_{22}$ A Group X Time X</td>
<td>Mean ball</td>
<td>Group X Time X</td>
<td>1) Determine if a significant Group X Time X Gender interaction.</td>
</tr>
<tr>
<td>Gender ANOVA with</td>
<td>velocity recorded at the posttest, and</td>
<td>Gender ANOVA with repeated measures on the last factor will reveal a significant Group X Time X Gender interaction. Follow-up analyses will reveal that within each of the three groups there will be significant posttest gender differences. Additional follow-up analyses will show both males and females will significantly improve mean velocity scores from pretest to posttest. If significant, there will be no significant differences between posttest and retention tests.</td>
<td>2) Select each group and use follow-up t-tests to determine gender differences with each of the three groups.</td>
</tr>
</tbody>
</table>

(Continued)
Research Question 8. What is the influence of group and gender on unrecorded trials?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H23 A pretest Group X Gender ANOVA will reveal a significant Gender effect. Follow-up analyses will reveal males have fewer unrecorded trials than the girls at the pretest.</td>
<td>Number of unrecorded trials at the pretest.</td>
<td>3 X 2 ANOVA</td>
<td>1) 3 X 2 ANOVA to determine Gender effect at the pretest for ball velocity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Follow-up t-test</td>
<td></td>
</tr>
<tr>
<td>H24 A Group X Gender ANOVA at the pretest will result in a non-significant Group X Gender interaction.</td>
<td>Number of unrecorded trials at the pretest.</td>
<td>3 X 2 ANOVA</td>
<td>Determine significant Group X Gender interaction.</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Data Used</th>
<th>Type of Analysis</th>
<th>Steps of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_{25}$ A Time X Gender ANOVA with repeated measures on the last factor</td>
<td>Unrecorded trials at the pretest, posttest, and retention test</td>
<td>$3$ (Group) X $2$ (Time) X $2$ (Gender) ANOVA with repeated measures on the last factor</td>
<td>1) Determine if a significant Gender X Time effect exists for ball velocity.</td>
</tr>
<tr>
<td>will reveal a significant Gender X Time effect for unrecorded trials.</td>
<td></td>
<td></td>
<td>2) Follow-up ANOVA to determine gender differences for each group at the posttest and retention test.</td>
</tr>
<tr>
<td>Follow-up analyses will show significant differences between male and female unrecorded trials at the posttest and retention test. Additional follow-up analyses will show that both males and females will significantly reduce the number of unrecorded trials from the pretest to posttest. If a significant pretest to posttest change is found, there will be no significant posttest to retention test changes in the number of unrecorded trials.</td>
<td></td>
<td></td>
<td>3) Follow-up paired samples t-test to determine significant number of unrecorded trials from pretest to posttest, and non-significant changes from posttest to retention test for each group.</td>
</tr>
<tr>
<td><strong>Hypothesis</strong></td>
<td><strong>Data Used</strong></td>
<td><strong>Type of Analysis</strong></td>
<td><strong>Steps of Analysis</strong></td>
</tr>
<tr>
<td>----------------</td>
<td>---------------</td>
<td>----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>$H_{28}$ A Group X Time X Gender</td>
<td>Unrecorded trials at the pretest, posttest, and retention test.</td>
<td>Group X Time X Gender interaction.</td>
<td>1) Determine if a significant Group X Time X Gender interaction.</td>
</tr>
<tr>
<td>ANOVA with repeated measures on the last factor will reveal a significant Group X Time X Gender interaction.</td>
<td>followed-up ANOVA to determine gender differences with each of the three groups.</td>
<td>2) Select each group and use follow-up ANOVA to determine gender differences with each of the three groups.</td>
<td></td>
</tr>
<tr>
<td>Follow-up analyses will reveal that within each of the three groups there will be significant posttest gender differences.</td>
<td>Follow-up paired-samples t-test.</td>
<td>3) Examine ANOVA analysis for a significant Time effect. Select each group and gender and use follow-up Paired samples t-test to determine significant changes in number of unrecorded trials for each gender with each group from pretest to posttest, and non-significant changes from posttest to retention test.</td>
<td></td>
</tr>
<tr>
<td>Additional follow-up analyses will show both males and females will significantly reduce the number of unrecorded trials from pretest to posttest. If significant, there will be no significant differences between posttest and retention tests.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX J
SUMMARY OF RESULTS
**Body Components During Individual Practice**

*Research Question 1.* What is the influence of instructional group Critical Cue [CUE], biomechanical-based [BP], and typical physical education [TPE] on the four body component levels of throwing (step, trunk, humerus, and forearm) from the pretest to posttest to retention test?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₁ A pretest multivariate analysis of variance (MANOVA) will reveal a non-significant Group effect indicating no pretest differences between groups in body component levels.</td>
<td>Hypothesis Accepted</td>
</tr>
<tr>
<td>H₂ A MANOVA with repeated measures on the last factor will reveal a significant multivariate Group X Time effect with follow-up univariate tests also revealing significant Group X Time effects for each component.</td>
<td>Hypothesis Rejected</td>
</tr>
</tbody>
</table>

(Continued)

Appendix J. Summary of Hypothesis and Results
Hypothesis

H3   A MANOVA with repeated measures on the last factor will reveal a significant multivariate Group effect with significant univariate Group effects for the step, trunk, humerus, and forearm components at the posttest and retention test. If significant univariate tests are revealed, then the CUE and BP group will demonstrate significantly more advanced body component levels than the TPE group at the posttest and retention test.

Results

Hypothesis Rejected – when pretest, posttest, and retention test considered

- Non-significant multivariate Group effect
- Non-significant univariate Group effect for step, trunk, humerus, and forearm

When considering only posttest:

- Significant multivariate Group effect
- Significant univariate Group effect for step with significant difference between CUE and TPE groups in the step component.
- Non-significant univariate Group effect for trunk, humerus, and forearm

When considering only retention test:

- Non-significant multivariate Group effect
- Non-significant univariate Group effects for step, trunk, humerus, and forearm
### Hypothesis Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
</table>
| H₄ A MANOVA with repeated measures on the last factor will reveal a significant multivariate Time effect with significant univariate Time effects for the four body components. Follow-up tests will reveal significant pretest to posttest changes in each of the body component levels for each of the CUE, BP, and TPE groups. If a significant pretest to posttest change is found, there will be no significant posttest to the retention test changes in body component levels for each group. | Hypothesis Rejected  
- Significant multivariate Time effects found  
- Significant univariate Time effect for step, trunk, humerus, and forearm components  
Paired sample t-tests revealed significant changes for each group from pretest to posttest:  
- CUE - step, trunk, and humerus  
- BP – step, trunk, humerus, and forearm  
- TPE – trunk, humerus, and forearm  
Posttest to Retention test changes:  
- Non-significant difference from posttest to retention test |

(Continued)
Instructional Groups and Body Component Levels during Game Play

Research Question 2. What is the relationship between body component levels in practice and body component levels in gameplay at the pretest, posttest, and retention test for each group?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H5 A moderate to strong ($r = .40$ or above) significant, positive correlation will exist between throwing performance in practice and throwing performance in a game for each group and for each component at the pretest, posttest, and retention test.</td>
<td>Hypothesis Rejected – Significant Correlations:</td>
</tr>
</tbody>
</table>
| • CUE | o Pretest – step, trunk, forearm  
| | o Posttest – step, trunk, forearm  
| | o Retention – trunk, forearm |
| • BP | o Pretest – step, trunk, forearm  
| | o Posttest – trunk, forearm  
| | o Retention – trunk, forearm |
| • TPE | o Pretest - step, trunk, forearm  
| | o Posttest - step, trunk, forearm  
| | o Retention - step, trunk, forearm |

(Continued)
Differences between Groups in Ball Velocity and Unrecorded Trials

Research Question 3. What is the influence of instructional group (CUE, BP, TPE) on mean recorded ball velocity from the pretest to posttest to retention test?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₆ A pretest Group X Gender analysis of variance (ANOVA) will reveal a non-significant Group effect indicating no significant pretest differences between groups in mean recorded velocity.</td>
<td>Hypothesis Accepted</td>
</tr>
<tr>
<td>H₇ A Group X Gender X Time ANOVA with repeated measures on the last factor will reveal a significant univariate Group X Time interaction for mean ball velocity.</td>
<td>Hypothesis Rejected</td>
</tr>
</tbody>
</table>

(Continued)
### Hypothesis Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
</table>
| H8: A Group X Gender X Time ANOVA with repeated measures on the last factor will result in a significant Group effect, with the BP and CUE groups having a significantly greater mean velocity score than the TPE group. | Hypothesis Rejected
- Non-significant Group effect when examining pretest, posttest, and retention
- Examining only posttest: Non-significant Group effect
- Examining only retention test: Non-significant Group effect |
| H9: A Group X Gender X Time ANOVA with repeated measures on the last factor will result in a significant Time effect for ball velocity. Within each group, follow-up tests will reveal significant differences in mean ball velocity from the pretest to the posttest, for each group. If a significant pretest to posttest change is found, there will be no significant posttest to the retention test changes in ball velocity for each group. | Hypothesis Accepted
- Significant Time effect
- Paired Samples t-test revealed significant pretest to posttest changes in ball velocity for CUE, BP, and TPE groups
- Posttest to Retention test:
- Non-significant changes for CUE, BP, and TPE groups |
Research Question 4. What is the influence of instructional group (CUE, BP, TPE) on the number of unrecorded trials from the pretest to posttest to retention test?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
</table>
| H<sub>10</sub> A pretest Group X Gender analysis of variance (ANOVA) will reveal a non-significant Group effect indicating no significant pretest differences between groups in unrecorded trials at the pretest. | Hypothesis Accepted  
  ▪ Non-significant Group effect at the pretest |
| H<sub>11</sub> A Group X Time X Gender ANOVA with repeated measures on the last factor will reveal a significant univariate Group X Time interaction for unrecorded trials. | Hypothesis Accepted  
  ▪ Significant univariate Group X Time interaction found |
| H<sub>12</sub> A Group X Gender X Time ANOVA with repeated measures on the last factor will result in a significant univariate Group effect, with follow-up tests showing the BP and CUE groups having a significantly fewer unrecorded trials than the TPE group. | Hypothesis Rejected  
  ▪ Non-significant Group effect found  
  ▪ Examining posttest only:  
    o Non-significant Group effect  
  ▪ Examining retention test only:  
    o Non-significant Group effect |

(Continued)
### Hypothesis Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H13</strong> A Group X Gender X Time ANOVA with repeated measures on the last factor will result in a significant univariate Time effect for unrecorded trials. Within each group, follow-up tests will reveal a significant decrease in unrecorded trials from the pretest to the posttest, for each group. If a significant pretest to posttest change is found, there will be no significant posttest to the retention test changes in unrecorded trials for each group.</td>
<td>Hypothesis Rejected</td>
</tr>
<tr>
<td></td>
<td>- Significant univariate Time effect found</td>
</tr>
<tr>
<td></td>
<td>- Paired Samples t-test revealed significant pretest to posttest changes in ball velocity for CUE, BP, and TPE groups</td>
</tr>
<tr>
<td><strong>Gender and Body Component Levels</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Research Question 5.</strong> What is the influence of instructional group (CUE, BP, TPE) and gender (Female, Male) on body component levels (step, trunk, humerus, and forearm) from the pretest to the posttest to the retention test?</td>
<td></td>
</tr>
<tr>
<td><strong>Hypothesis</strong></td>
<td><strong>Results</strong></td>
</tr>
<tr>
<td><strong>H14</strong> A pretest MANOVA will reveal a significant multivariate Gender effect with follow-up univariate analysis revealing a significant Gender effect for each body component.</td>
<td>Hypothesis accepted</td>
</tr>
<tr>
<td></td>
<td>- Significant multivariate Gender effect found at the pretest</td>
</tr>
<tr>
<td></td>
<td>- Significant univariate Gender effect for the step, trunk, humerus, and forearm</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>Results</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| H₁₅ A pretest MANOVA will reveal a significant multivariate Group X Gender interaction with significant follow-up univariate Group X Gender interactions for each of the step, trunk, humerus, and forearm components at the pretest. | Hypothesis rejected  
- Non-significant Group X Gender interactions found  
- Non-significant Group X Gender interactions for the step, trunk, humerus, and forearm  
- t-tests revealed significant gender differences for each group at the pretest |
| Within one group, follow-up t-tests will reveal significant gender differences in each body component for each group at the pretest. |  
- CUE – step and trunk  
- BP – step, trunk, and humerus  
- TPE – step, trunk, humerus, and forearm |
| H₁₆ A Group X Time X Gender MANOVA with repeated measures on the last factor will reveal a significant multivariate Gender X Time effect. | Significant multivariate Gender X Time interaction found  
- Significant univariate Gender X Time interaction found for the step and forearm  
- Non-significant univariate Gender X Time interaction for trunk and humerus  
- Paired samples t-tests revealed significant changes from pretest to posttest  
  o Males - improved in the trunk, humerus, and forearm  
  o Females – improved in the step, trunk, humerus, and forearm |

(Continued)
Hypothesis Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H17 A Group X Time X Gender</td>
<td>Hypothesis Rejected</td>
</tr>
<tr>
<td>MANOVA with repeated measures on the last factor will reveal a significant</td>
<td>• Significant multivariate Group X Time X Gender effect found</td>
</tr>
<tr>
<td>multivariate Group X Gender X Time interaction with significant follow-up</td>
<td>• Significant univariate Group X Time X Gender effect for the forearm component</td>
</tr>
<tr>
<td>univariate Group X Gender X Time interactions for the step, trunk, humerus,</td>
<td>• Non-significant Group X Time X Gender effect for the step, trunk, humerus, and forearm</td>
</tr>
<tr>
<td>and forearm components. Follow-up analyses will show there will be no</td>
<td></td>
</tr>
<tr>
<td>gender differences in body components at the posttest both for overall</td>
<td></td>
</tr>
<tr>
<td>and for gender within each of the three groups. Additional follow-up</td>
<td></td>
</tr>
<tr>
<td>will show that within groups, there will be significant pretest to posttest</td>
<td></td>
</tr>
<tr>
<td>changes in each body component level for each gender within each group. If</td>
<td></td>
</tr>
<tr>
<td>a significant pretest to posttest change is found, there will be no</td>
<td></td>
</tr>
<tr>
<td>posttest to the retention test changes in body component levels for each</td>
<td></td>
</tr>
<tr>
<td>gender within each group.</td>
<td></td>
</tr>
<tr>
<td>Gender Differences at the posttest for each group:</td>
<td></td>
</tr>
<tr>
<td>• CUE – trunk and forearm</td>
<td></td>
</tr>
<tr>
<td>• BP – trunk and humerus</td>
<td></td>
</tr>
<tr>
<td>• TPE – trunk, humerus, and forearm</td>
<td></td>
</tr>
<tr>
<td>Examining only retention test:</td>
<td></td>
</tr>
<tr>
<td>• Significant multivariate Gender effect</td>
<td></td>
</tr>
<tr>
<td>• Significant univariate Gender effect for the step, trunk, humerus, and</td>
<td></td>
</tr>
<tr>
<td>forearm</td>
<td></td>
</tr>
<tr>
<td>• Non-significant multivariate Group X Gender interaction at the retention</td>
<td></td>
</tr>
<tr>
<td>Gender Differences at the retention test for each group:</td>
<td></td>
</tr>
<tr>
<td>• CUE – step, trunk, humerus, and forearm</td>
<td></td>
</tr>
</tbody>
</table>
Hypothesis Results

H$_{17}$ Continued

- BP – trunk, humerus, and forearm
- TPE – step, trunk, humerus, and forearm

Changes in body components over time for each gender:

Pretest to posttest:

- CUE Males - improved in the trunk and humerus
- CUE Females – improved in the step and trunk
- BP Males – trunk, humerus, and forearm
- BP Females – step and forearm
- TPE Males – step, trunk, and humerus
- TPE females – trunk

Changes from posttest to retention test:

- BP females – significant decrease in forearm component

(Continued)
Gender and Body Component Levels during Gameplay

Research Question 6. What is the relationship between body component levels in practice and body component levels in gameplay at the pretest, posttest, and retention test for each gender?

Hypothesis Results

H18 A moderate to strong (r=.40 or above) significant, positive correlation will exist between throwing performance in practice and throwing performance in a game for each gender and group for each component at the pretest, posttest, and retention test.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant Correlations:</td>
<td></td>
</tr>
</tbody>
</table>
| • CUE Males | ▪ Pretest – trunk, forearm  
▪ Posttest – trunk, forearm  
▪ Retention - trunk |
| • CUE Females | ▪ Pretest – trunk  
▪ Posttest – trunk, forearm  
▪ Retention – trunk |
| • BP Males | ▪ Pretest – none  
▪ Posttest – forearm  
▪ Retention – step and forearm |
| • BP Females | ▪ Pretest – forearm  
▪ Posttest – trunk, forearm  
▪ Retention – trunk, forearm |
| • TPE Males | ▪ Pretest – forearm  
▪ Posttest – forearm  
▪ Retention – none |
| • TPE Females | ▪ Pretest – forearm  
▪ Posttest – trunk  
▪ Retention – step |
Gender and Ball Velocity

Research Question 7. What is the influence of instructional group and gender on mean ball velocity from the pretest to posttest to retention test?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₁₉ A pretest Group X Gender ANOVA will reveal a significant Gender effect.</td>
<td>Hypothesis Accepted</td>
</tr>
<tr>
<td>Follow-up analyses will reveal males have a greater mean velocity than the girls at the pretest.</td>
<td></td>
</tr>
<tr>
<td>H₂₀ A Group X Gender ANOVA at the pretest will result in a non-significant Group X Gender interaction.</td>
<td>Hypothesis Accepted</td>
</tr>
</tbody>
</table>

(Continued)
Hypothesis Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
</table>
| H21 A Time X Gender ANOVA with repeated measures on the last factor will reveal a significant Gender X Time effect for ball velocity. Follow-up analyses will show significant differences between male and female ball velocity scores at the posttest and retention test. Additional follow-up analyses will show that both males and females will significantly improve mean ball velocity scores from the pretest to posttest. If a significant pretest to posttest change is found, there will be no significant posttest to retention test changes in ball velocity. | Hypothesis Accepted

- Significant Time X Gender interaction found
- Considering only posttest Significant Gender effect found
- Considering only retention test – significant Gender effect found
- Paired sample t-tests revealed significant changes from pretest to posttest, and posttest to retention test:
  - Males and Females improved from pretest to posttest
  - Females improved from posttest to retention test
  - Non-significant differences for Males

(Continued)
### Hypothesis Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
</table>
| $H_{22}$ A Group X Time X Gender ANOVA with repeated measures on the last factor will reveal a significant Group X Time X Gender interaction. Follow-up analyses will reveal that within each of the three groups there will be significant posttest gender differences. | Hypothesis Rejected  
- Non-significant Group X Time X Gender interaction  
- $t$-tests revealed significant gender differences for each group at the posttest, and retention test  
- Significant Time effect found  
- Paired samples $t$-test revealed significant changes from pretest to posttest, and posttest to retention test:  
  - Significant pretest to posttest changes:  
    - CUE Males, TPE Females  
  - Significant posttest to retention test changes:  
    - None |

(Continued)
Research Question 8. What is the influence of group and gender on unrecorded trials?

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H23 A pretest Group X Gender ANOVA will reveal a significant Gender effect. Follow-up analyses will reveal males have fewer unrecorded trials than the girls at the pretest.</td>
<td>Hypothesis Accepted</td>
</tr>
<tr>
<td>▪ Significant Gender effect</td>
<td></td>
</tr>
<tr>
<td>▪ Males had fewer unrecorded trials than females at the pretest</td>
<td></td>
</tr>
<tr>
<td>H24 A Group X Gender ANOVA at the pretest will result in a non-significant Group X Gender interaction.</td>
<td>Hypothesis Accepted</td>
</tr>
<tr>
<td>▪ Non-significant Group X Gender interaction</td>
<td></td>
</tr>
<tr>
<td>H25 A Time X Gender ANOVA with repeated measures on the last factor will reveal a significant Gender X Time effect for unrecorded trials. Follow-up analyses will show significant differences between male and female unrecorded trials at the posttest and retention test. Additional follow-up analyses will show that both males and females will significantly reduce the number of unrecorded trials from the pretest to posttest. If a significant pretest to posttest change is found, there will be no significant posttest to retention test changes in the number of unrecorded trials.</td>
<td>Hypothesis Rejected</td>
</tr>
<tr>
<td>▪ Non-significant Gender X Time interaction</td>
<td></td>
</tr>
<tr>
<td>▪ Follow-up analysis found significant Gender effect at posttest and retention test</td>
<td></td>
</tr>
<tr>
<td>▪ Paired samples t-test revealed males and females had significantly reduced the number of unrecorded trials from pretest to posttest</td>
<td></td>
</tr>
<tr>
<td>▪ No significant change was found from posttest to retention</td>
<td></td>
</tr>
</tbody>
</table>
### Hypothesis Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H26 A Group X Time X Gender</td>
<td>Hypothesis Rejected</td>
</tr>
<tr>
<td>ANOVA with repeated measures on the last factor will reveal a significant Group X Time X Gender interaction. Follow-up analyses will reveal that within each of the three groups there will be significant posttest gender differences. Additional follow-up analyses will show both males and females will significantly reduce the number of unrecorded trials from pretest to posttest. If significant, there will be no significant differences between posttest and retention tests.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-significant Group X Time X Gender interaction</td>
</tr>
<tr>
<td>t-tests to explore gender differences within each group:</td>
<td></td>
</tr>
<tr>
<td>Posttest Gender Differences: CUE, BP, TPE</td>
<td></td>
</tr>
<tr>
<td>Retention Gender Differences: CUE, BP, TPE</td>
<td></td>
</tr>
<tr>
<td>Significant Time Effect</td>
<td></td>
</tr>
<tr>
<td>Paired samples t-test revealed significant changes from pretest to posttest, and posttest to retention test:</td>
<td></td>
</tr>
<tr>
<td>Significant pretest to posttest changes:</td>
<td></td>
</tr>
<tr>
<td>CUE Males, CUE Females, TPE Females</td>
<td></td>
</tr>
<tr>
<td>Significant posttest to retention test changes:</td>
<td></td>
</tr>
<tr>
<td>TPE Females</td>
<td></td>
</tr>
</tbody>
</table>