2000

Three-Dimensional Kinematics of the Overarm Throwing Motion in Children Ages 2 to 7

Katherine A. Hagen
University of North Dakota

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THREE-DIMENSIONAL KINEMATICS OF THE OVERARM THROWING
MOTION IN CHILDREN AGES 2 TO 7

by

Katherine Hagen
Bachelor of Science in Physical Therapy
University of North Dakota, 1999

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
2000
This Independent Study, submitted by Katherine A. Hagen in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

[Signatures]

Faculty Preceptor

Graduate School Advisor

Chairperson, Physical Therapy
**PERMISSION**

<table>
<thead>
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<td>Physical Therapy</td>
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Signature  
Katharine A. Hagen

Date  
Nov. 23, 1999
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ABSTRACT

**Background and Purpose:** Throwing is a meaningful play activity that encourages social interaction, develops the sequencing of motor skills, and signals the onset of toddlerhood. Little published data clearly documents the three-dimensional kinematics of the progression of the overarm throwing motion in children. The purpose of this study is twofold: 1) To explore the biomechanical differences in the overarm throwing techniques of children between the ages of two and seven, and 2) To compare the kinematics of dominant versus non-dominant arm throws in children between the ages of two and seven. **Methods:** 1) Nine children, 6 males and 3 females, were classified into 3 age groups (2-3 years, 4-5 years, 6-7 years) and then videotaped while performing 6 overarm throws, 3 with each arm. 2) The Peak Motus Software was used to digitize and analyze the reflective markers on the resultant video and create data sets for each child. Five variables were analyzed: type of throw, time of throw, ball velocity, maximum shoulder abduction, and elbow flexion at release. **Results:** 1) Older children consistently used the more mature 'dynamic' and 'sequentially-linked' throwing techniques, while the younger children were variable in their approaches. 2) The 6-7 year-olds took the longest time to throw and had the greatest time difference between arms (0.23 sec.) 3) Ball velocity increased with age, with the greatest mean difference between arms (2.68 m/s) occurring in the 6-7 year-olds. 4) The same group also averaged the largest amount of shoulder abduction (dominant = 60.8°/non-dominant =
70.9°). 5) The 4-5 year-olds demonstrated the greatest amount of elbow flexion at release, and the largest mean difference (8.6°) between arms. **Conclusion:** Overall, children use a wide variety of throwing techniques when completing an overarm throw. There is a tendency for an increase in biomechanical differences between arms as the child ages. In general, this differentiation of arms, into dominant and non-dominant, begins to affect the quality of throw in children between the ages of 5 and 6. More studies are needed with a larger number of subjects and equal sample sizes to obtain statistically significant results.
CHAPTER I
INTRODUCTION

Throwing is an integral part of a child’s development. It is a meaningful play activity that encourages social interaction, develops the sequencing of motor skills, and signals the onset of toddlerhood. Most humans favor one hand for the performance of skilled motor tasks. Onset of hand preference can occur as early as 12 months, and is usually confirmed by the age of three. Hand dominance in the adult is what distinguishes the balanced and graceful throwing of one arm from the awkward and unwieldy motions of the other. Research suggests this contrast originates from the superior performance of a cerebral hemisphere. The inconsistency observed in a young child’s throwing action demonstrates the variable nature of early motor development, and suggest a lack of practiced cerebral dominance. When does the overall inconsistency of a young child’s throwing behavior begin to differentiate into the normal adult pattern?

Problem Statement

Little published data exists that clearly documents the three-dimensional kinematics of the progression of the overarm throwing motion of children.
Purpose of Study

The purpose of this study is twofold: 1) to explore the biomechanical differences in the overarm techniques of children between the ages of two and seven, and 2) to compare the kinematics of dominant arm throws versus non-dominant arm throws in children between the ages of two and seven.

Significance of Study

The data collected will provide information concerning the three-dimensional kinematics of overarm throwing in children. The data will be used to compare the motion of right and left arms in each subject and to differentiate those motions across three age groups: 2-3 years, 4-5 years, and 6-7 years. The results of this study will be a reference for any person seeking information on the normal development of motor skills in children.

Research Questions

1. Are there kinematic differences in the overarm throwing motions of children between the ages of two and seven?
2. Are there measurable kinematic differences between throws performed with the dominant versus the non-dominant arm in children between the ages of two and seven?

Hypothesis

Null: There is equal or greater kinematic variance between arms in the overarm throwing motion of 2 to 3 year olds compared to 4 to 5 year olds; and equal or
greater kinematic variance between arms in the 4 to 5 year olds compared to the 6 to 7 year olds.

Alternate: There is less kinematic variance between arms in the overarm throwing motion of 2 to 3 year olds compared to 5 to 6 year olds; and less kinematic variance between arms in the 4 to 5 year olds compared to the 6 to 7 year olds.
CHAPTER II
LITERATURE REVIEW

The overarm throwing motion is complex, involving numerous joints of the body. Not only are the joints of the upper extremity utilized, but the trunk and lower extremity are also involved in the mature throwing pattern. Since this is a skilled motor activity, Wild\(^3\) proposes children proceed through different stages of motor development when learning to throw. The first stage occurs at 2-3 years of age, when the child throws by elevating the arm forwards over the shoulder and then extending the elbow in the direction of ball release. The child lacks trunk rotation, foot movement, and any signs of weight shifts. In the second stage, which occurs at 3 ½ to 5 years of age, the child starts to initiate trunk rotation first by rotating away from the target and then by rotating towards the target. The third stage, ages 5 to 6, is distinguishable from the second stage when the child steps with the same side foot and the throwing arm moves obliquely overhead in a circular trajectory. The fourth stage, considered as the mature throwing pattern, is characterized by a contralateral step with trunk rotation, upper arm swing, humeral medial rotation, elbow extension and forearm pronation. Studies\(^4\) have shown most children display the proficient-throwing pattern by the age of 6, while others\(^5\) state girls of this age show incomplete development and are delayed in its acquisition relative to boys. It is believed that the differences in acquisition are due to environmental conditions, such as lack of practice and encouragement, rather than biological factors.\(^5\)
Marques-Bruna and Grimshaw\textsuperscript{4,5} further delineated the throwing motion by classifying it as either 'static' or 'dynamic', 'arm-dominated' or 'sequentially-linked'. 'Static' throws are those in which the child stood still while throwing, in contrast to 'dynamic' throws, where the child moved forward. An 'arm-dominated' throw is similar to Wild's first stage, where the arm is elevated forward in front of the body and the elbow is extended in the sagittal plane. It is described as a pushing action and is divided into two phases. Phase 1 is the \textit{Push Up Phase} consisting of the movement from initiation to ball release. Phase 2 is the \textit{Follow Through Phase} consisting of the movement from ball release to completion.

A 'sequentially-linked' throw involves moving the arm backward over the shoulder and then propelling it forward in the direction of the throw.\textsuperscript{4,5} 'Sequentially-linked' throws are divided into three phases. The \textit{Back Swing Phase} consists of the movement from initiation to the point of maximal humeral lateral rotation. The \textit{Propulsion Phase} consists of the movement from maximal humeral lateral rotation to ball release. And finally, the \textit{Follow Through Phase} is the movement from ball release to completion. Research\textsuperscript{5} findings concluded that the throwing patterns ('static', 'dynamic', 'arm-dominated', and 'sequentially-linked') did not relate to a specific aged child. Research\textsuperscript{5} did reveal all arm-dominated throws were static throws, while most sequentially linked throws were dynamic throws.

In a skilled motor activity, such as throwing, most humans favor one hand over the other.\textsuperscript{2} This preferred, dominant, hand is usually distinguishable from its non-dominant counterpart by a more fluid and accurate motion. The dominant hand has become more effective in its execution of motor tasks due to the repetitive practice it has
received compared to the untrained hand. With practice, the timing of muscle responses, otherwise known as coordination, is improved. Hore et al. through kinematic analysis, concluded that throws made with the non-dominant arm were more variable in height and length than throws made with the dominant arm. This difference was due in part to increased variability in the rotations at proximal joints (shoulder, elbow, and wrist) in the non-dominant arm. However, it was revealed that the variability in distal joints (fingers), such as the onset of finger extension by the non-dominant hand, had a greater impact on the accuracy of the throwing motion. The study stated distal joints show more variability than proximal joints because they are controlled by the contralateral cerebral hemisphere, whereas proximal joints are controlled by both cerebral hemispheres.

The novice at motor skills, i.e. a young child, is often more variable or unpredictable in their outcomes compared to a skilled performer. Research has shown this variability may be due to the inability to effectively organize the appropriate motor units. As children mature and their neuromuscular system develops, they are better able to employ the proper muscles for specific motor tasks, such as throwing.

With age, children also start to express a preference for a single hand, otherwise known as lateralization. This can occur as early as 12 months. Curt et al. stated that handedness in 3 year olds is less lateralized than in 6 year olds, and Bruml indicated that by kindergarten a unimanual preference is well established. Before the effects of lateralization and differential training are distinguished, it is believed fewer differences occur between the two sides of the body. This was substantiated in a study where no training was given to either side of the body involving tapping of the great toe. The results concluded no significant differences were observed in the performance of the two
sides. However, when this same experiment was conducted using the index fingers, a significant difference was noted on the preferred side. This suggests that with age and experience, the differences between hands are more discernible.

Overall, the research conducted on the progression of overarm throwing in children has provided qualitative information. Few have clearly documented the three-dimensional kinematics of the overarm motion, providing quantitative data. Exceptions to this include the studies conducted by Marques-Bruna and Grimshaw.\textsuperscript{4,5} And even fewer studies have compared the throwing motion of one hand to another, especially in children below the ages of 7 or 8.\textsuperscript{9} It is therefore the purpose of this project to obtain kinematic data in order to explore the biomechanical differences in the overarm throwing techniques of children between the ages of 2 and 7, and also to provide possible correlation, if any, of those discrepancies to hand dominance.
CHAPTER III

METHODOLOGY

Subjects

Eleven children, three females and eight males, were divided into three groups according to their age (see tables 1 through 4). Participants in this study were a sample of convenience from children who have previously participated in pediatric activities for the University of North Dakota Physical Therapy department. Subject selection was based on the premise that each child had normal motor and cognitive function and was within the required age range of 2 to 7 years.

Table 1. Descriptive Statistics of Group 1 (Age 2 to 3)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age*</td>
<td>3.4</td>
<td>2.3 - 3.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Height</td>
<td>38.2</td>
<td>34.8 - 40.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Weight</td>
<td>34.4</td>
<td>31.5 - 40.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*Age in years, Height in inches, Weight in pounds
Table 2. Descriptive Statistics of Group 2 (Age 4 to 5)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>5.0</td>
<td>4.8 – 5.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Height</td>
<td>45.0</td>
<td>41 – 49</td>
<td>5.7</td>
</tr>
<tr>
<td>Weight</td>
<td>44.5</td>
<td>37 – 52</td>
<td>10.6</td>
</tr>
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</table>

Table 3. Descriptive Statistics of Group 3 (Age 6 to 7)

<table>
<thead>
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<th></th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>6.7</td>
<td>6.6 – 6.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Height</td>
<td>48.8</td>
<td>47 – 50.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Weight</td>
<td>60.1</td>
<td>53.8 – 66.5</td>
<td>9.0</td>
</tr>
</tbody>
</table>

Table 4. Gender Statistics of Groups

<table>
<thead>
<tr>
<th></th>
<th>Age 2 to 3</th>
<th>Age 4 to 5</th>
<th>Age 6 to 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Females</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

A parent of each subject completed a pediatric pre-screening questionnaire prior to participation in this study (see appendix B). The screening was designed to identify any motor or cognitive developmental delays, which would necessitate exclusion from the project. Two male subjects were disqualified from participation due to parental report
of previously diagnosed learning disabilities. The remaining nine children, three females and six males, were assessed as normally developing and therefore continued with involvement in the research project. The form also identified which hand each child preferred for skilled tasks, which was then classified as the subject’s ‘dominant’ hand.

Each subject and their parents were informed of the purpose, risks, and benefits of participation. A parent of each child then signed a consent form for participation approved by the Institutional Review Board of the University of North Dakota (see appendix C).

**Instrumentation**

The three cameras used to film the entire throwing activity were Peak High-Speed video 60/120 Hz cameras (Peak Performance Technologies, 7388 S. Revere Parkway, Suite 601, Englewood, CO 80112-9765). A camera frequency of 60 Hz was utilized during the trials, with a shutter speed of 1/250 of a second. The trials were taped on a JVC model BR-S378U video cassette recorder (JVC of America, 41 Slater Drive, Elmood Park, MF 07470). To synchronize the video information, the cameras were genlocked together and a time code was recorded on the video tapes using the SMPTE time code generator.

For appropriate calibration of the space that would be used to video tape the subjects, an eleven-point calibration frame was filmed prior to any subject testing. The frame designated a coordinate system to plot all points in space as (X,Y,Z).

After recording the subjects’ movements, the video tape was analyzed using the Peak Motus Software. A Sanyo model GVR-S955 (Sanyo, 1200 W. Artesia Boulevard, Campton, CA 90220) video cassette recorder was used to play back the tapes for the
purpose of digitization. According to previous research, the Peak 5 Motus System has shown high reliability and provides valid data on angular position and angular velocity.

It was first determined which trials were performed using the ‘dominant’ and the ‘non-dominant’ arms, as previously determined for each subject. During analyzation of the data, the throwing action of each subject was then categorized as either ‘dynamic’ or ‘static.’ A static throw is one in which the subject stands still while throwing, in contrast to a dynamic throw, where the subject moves forward or takes a step. Each subject’s throws were further classified as either ‘arm-dominated,’ which consists of a pushing action to propel the ball, or as ‘sequentially-linked,’ which is described as a mature throwing pattern that includes a wind-up, contra-lateral step, and follow through.

Procedure

Video taping of the subjects was carried out in the University of North Dakota Physical Therapy department. The subjects’ parents were allowed in the testing area at all times. Female subjects wore black, short sleeved leotards, and male subjects wore only dark colored athletic shorts. Twelve reflective markers were placed on each subject with adhesive tape to represent the joint centers of upper and lower extremities. The markers were placed bilaterally on the acromion, olecranon, midway between the ulnar and radial styloids of the dorsal wrist, the iliac crest, the lateral joint line of the tibia and femur, and on the lateral malleolus (see figure 1).

Two paper targets were attached to separate stands and were placed ten feet apart. The child was then asked to stand on an “X” midway between the targets. Each target was 11x16 inches, and was adjusted on the stand so the superior border of the target was at a height equal to the level of the child’s axillae. The targets were placed to allow for
Figure 1. Reflective marker placement.
maximal camera vantage point and also to elicit similar throwing efforts from the subjects (see figure 2).

![Figure 2. Camera placement and target area.](image)

Verbal and visual instructions of the desired overhand throwing task were given to each child. A period for practice throws with each hand was allowed until the child expressed verbal readiness for trials to begin. Once ready, the child completed three trials of an overarm throw aimed at one target with the same arm. The subject then turned 180 degrees and completed three trials with the other arm, aiming at the opposite target. Following completion of the trials, the markers were removed from the child’s body, and the child was given a piece of candy, with parental permission. This concluded the subject’s involvement in the study.
Data Analysis

Each trial was digitized from the initiation of movement until four fields after ball release. Movement initiation began at the arm in ‘arm-dominated’ throws and at the foot in ‘sequentially-linked’ throws. Five kinematic variables were then obtained in order to assess the normal progression of motor development of subjects. These variables included time of throw, speed of ball release, shoulder abduction before or at ball release, elbow angle at release, and type of throw. These variables were chosen for analysis based on previous research that used them as key factors in obtaining information regarding normal motor development in children.

The statistical data was computed to obtain means, ranges, and standard deviations for all variables. This then allowed for multi-variant comparisons across age groups, and right and left hands. The information gained was intended to show statistical trends reflecting the progression of motor development and enable comparison to the results of previous research.
CHAPTER IV
RESULTS

Qualitative Variables

Type of throw

In general, the type of throwing technique utilized by the subjects demonstrated a progression towards a mature throwing pattern with increasing age. Of the four classifications, ‘dynamic’ and ‘sequentially-linked’ throws are indicative of a more advanced throwing pattern. The use of ‘static’ and ‘arm-dominated’ throwing techniques are characteristic of an early and inefficient type of throw. Only one trial out of twenty performed in the youngest age group was a ‘dynamic’ type throw, meaning they stepped as they threw the ball. Furthermore, only five were classified as a ‘sequentially-linked’ type of arm motion. Four of the five ‘sequentially-linked’ throws were performed by one subject, but all of those trials were carried out in a less advanced, ‘static’ method.

Of the eight trials of the second age group (4 to 5 years), three were ‘dynamic’ and four were ‘sequentially-linked’ techniques. This was, however, demonstrated by only one subject in the group, a male. The other 4 to 5 year old, a female, utilized a ‘static’ and ‘arm-dominated’ throwing style for all of her four trials. In the oldest age group, half of the eight trials were classified as ‘dynamic’, while six of the attempts were performed in a ‘sequentially-linked’ throwing fashion. The table below outlines
the increasing percentage of each age group that demonstrated more advanced methods of throwing.

Table 5. Subjects Demonstrating a More Advanced Throwing Pattern

<table>
<thead>
<tr>
<th>Type of throw</th>
<th>Age 2-3</th>
<th>Age 4-5</th>
<th>Age 6-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>5%</td>
<td>37.5%</td>
<td>50%</td>
</tr>
<tr>
<td>Seq-linked</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
</tr>
</tbody>
</table>

Quantitative Variables

*Time of throw*

There was no clear pattern of increasing or decreasing time required to throw in correspondence with the three age groups. On average, the subjects in the second age group (4 to 5) required the shortest amount of time to complete their trials (mean = 0.77 sec with dominant arm; 0.635 sec with non-dominant arm). The shortest amount of time taken to complete any one trial for any subject was 0.12 seconds, a female in the 2 to 3 year age group, while the longest was 2.94 seconds, also a female in the youngest age group.

The 6 to 7 year-olds demonstrated the largest time difference between arms, taking 0.23 seconds longer to complete non-dominant arm throws than dominant arm throws. The 2 to 3 year-olds also took longer, on average, to throw with their non-dominant arm (mean = 0.20 sec), but the 4 to 5 year-olds, in contrast, took an average of 0.14 seconds longer to throw with their dominant arm. The tables below provide specific data on the three age groups in regard to throwing time.
Table 6. Group 1 (Age 2 to 3) Time of Throw in Seconds

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>1.0</td>
<td>0.1 – 2.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Non-dom</td>
<td>1.2</td>
<td>0.5 – 2.9</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Table 7. Group 2 (Age 4 to 5) Time of Throw in Seconds

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>0.8</td>
<td>0.5 – 0.9</td>
<td>0.2</td>
</tr>
<tr>
<td>Non-dom</td>
<td>0.6</td>
<td>0.6 – 0.7</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Table 8. Group 3 (Age 6 to 7) Time of Throw in Seconds

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>1.2</td>
<td>0.8 – 1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Non-dom</td>
<td>1.4</td>
<td>1.2 – 1.6</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Ball velocity at release

Evaluation of the ball velocity at release did demonstrate a strong trend for increasing speed with age. The mean average of the three age groups when throwing with the dominant hand were 3.862 m/s, 4.035 m/s, and 8.424 m/s, respectively. The oldest age group showed the most dramatic discrepancy in ball velocity between the dominant and non-dominant arms, with a mean difference of 2.675 m/s. In contrast, the youngest age group demonstrated only a 0.749 m/s difference between arms.

Table 9. Group 1 (Age 2 to 3) Velocity of Ball at Release in Meters/sec

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>3.9</td>
<td>2.9 – 5.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Non-dom</td>
<td>3.1</td>
<td>2.5 – 3.9</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Table 10. Group 2 (Age 4 to 5) Velocity of Ball at Release in Meters/sec

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>4.0</td>
<td>3.2 – 4.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Non-dom</td>
<td>3.7</td>
<td>3.4 – 4.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Table 11. Group 3 (Age 6 to 7) Velocity of Ball at Release in Meters/sec

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>8.4</td>
<td>5.8 – 11.4</td>
<td>2.9</td>
</tr>
<tr>
<td>Non-dom</td>
<td>5.7</td>
<td>3.7 – 7.6</td>
<td>1.7</td>
</tr>
</tbody>
</table>

**Maximum throwing shoulder abduction**

This variable is defined as the maximum abduction of the throwing-side shoulder before or at ball release for each trial. As with the ‘time of throw’ variable, the 4 to 5 year olds demonstrated the smallest amount of shoulder abduction before or at ball release (mean = 41.96° with dominant arm; 40.95° with non-dominant arm). The oldest age group has the most abduction with the dominant arm (mean = 60.77°). This age group also demonstrated the greatest amount of difference in shoulder abduction between the dominant and non-dominant arms (10.17°). The youngest children produced mean averages that fell in between those of the other two groups. As the tables outline below, there was not a definite progression of least to most mean values or difference between shoulder abduction in the youngest to oldest age groups.

Table 12. Group 1 (Age 2 to 3) Maximum Shoulder Abduction Before or at Ball Release

<table>
<thead>
<tr>
<th>arm</th>
<th>mean</th>
<th>range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>53°</td>
<td>20.3 – 89.0°</td>
<td>21.7°</td>
</tr>
<tr>
<td>Non-dom</td>
<td>62.5°</td>
<td>32.1 – 92.4°</td>
<td>22.3°</td>
</tr>
</tbody>
</table>
Table 13. Group 2 (Age 4 to 5) Maximum Shoulder Abduction Before or at Ball Release

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>42°</td>
<td>29.3 – 55.1°</td>
<td>10.5°</td>
</tr>
<tr>
<td>Non-dom</td>
<td>41°</td>
<td>36 – 42.8°</td>
<td>3.3°</td>
</tr>
</tbody>
</table>

Table 14. Group 3 (Age 6 to 7) Maximum Shoulder Abduction Before or at Ball Release

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>60.8°</td>
<td>50.0 – 75.3°</td>
<td>8.3°</td>
</tr>
<tr>
<td>Non-dom</td>
<td>70.9°</td>
<td>52.7 – 81.1°</td>
<td>7.9°</td>
</tr>
</tbody>
</table>

Elbow flexion

This variable was determined simply by observing the amount of elbow flexion in the throwing arm at ball release. The oldest age group demonstrated the least amount of elbow flexion with both arms, with an average of 90.54° when throwing with the dominant arm, compared to 97.83° on the non-dominant side. No child achieved less than 51.69° or more than 137.24° of elbow flexion at release. The middle age group demonstrated the greatest amount of variance between dominant and non-dominant arms, with an average of 8.58° difference. The 6 to 7 year olds showed less variance than the middle age group (7.29°), but more than the 2 to 3 year olds, who combined for an average of 4.66° of discrepancy between arms.

Table 15. Group 1 (Age 2 to 3) Elbow Flexion at Ball Release

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>98.49°</td>
<td>51.7 – 137.2°</td>
<td>34.1°</td>
</tr>
<tr>
<td>Non-dom</td>
<td>103.1°</td>
<td>64.6 – 136.2°</td>
<td>33.8°</td>
</tr>
</tbody>
</table>
Table 16. Group 2 (Age 4 to 5) Elbow Flexion at Ball Release

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>114.5°</td>
<td>83.3–128.9°</td>
<td>22.1°</td>
</tr>
<tr>
<td>Non-dom</td>
<td>105.9°</td>
<td>93.7–116.4°</td>
<td>9.8°</td>
</tr>
</tbody>
</table>

Table 17. Group 3 (Age 6 to 7) Elbow Flexion at Ball Release

<table>
<thead>
<tr>
<th>Arm</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>90.5°</td>
<td>74.4–99.7°</td>
<td>4.5°</td>
</tr>
<tr>
<td>Non-dom</td>
<td>97.8°</td>
<td>82.9–117.8°</td>
<td>11°</td>
</tr>
</tbody>
</table>

The following reports (figures 3 and 4) contain composite illustrations of stick man figures. All trials in each age group were averaged to obtain a representative throw. A line graph report (see figure 5) is also included, depicting the average elbow flexion for the subjects in each age group. The age group lines are plotted in an overlay fashion to enable comparison between 2-3 year-olds, 4-5 year-olds, and 6-7 year-olds.

Effects of Throwing Style on Quantitative Variables

Of the 36 trials, 9 subjects with 4 trial each, 15 throws were 'sequentially-linked' and 21 were 'arm-dominated.' We can get a different perspective on the results when looking at a summary of the quantitative variables as affected by the arm strategy used by the subjects. Children who utilized a 'sequentially-linked' type of throw demonstrated less elbow flexion at ball release (mean = 93.9°) than the subjects who used an 'arm-dominated' type of approach (mean = 106.8°). Using a 'sequentially-linked' arm motion also generally created greater velocity at ball release (mean = 5.35 m/s) compared to throwing with an arm-dominated style (mean = 3.67 m/s). 'Arm-dominated' throws took
Figure 3. Ensemble average of right arm throws across all age groups from initiation of movement to ball release. Viewed from the right side. Note the feet in the first two age groups remain relatively static, while the feet move with the throw in the oldest age group.
Figure 4. Ensemble average of left arm throws across all groups from initiation of movement to ball release. Viewed from the right side. Note the feet in the first two age groups remain relatively static, while the feet move with the throw in the oldest age group.
Figure 5. Ensemble average of right and left elbow flexion across all age groups. The angles shown are from initiation of movement to ball release (100%).
longer to complete (mean = 1.08 sec) when weighed against the 'sequentially-linked' trials, which lasted an average of .99 seconds from the initiation of movement to ball release. Finally, the maximum amount of shoulder abduction reached at or before ball release was an average of 15.2° greater in 'sequentially-linked' throws when compared with those the were 'arm-dominated.' Table 18 illustrates these results.

Table 18. Effects of Throwing Style on Quantitative Variables

<table>
<thead>
<tr>
<th>Throwing Style</th>
<th>Elbow Flexion</th>
<th>Ball Velocity</th>
<th>Time of Throw</th>
<th>Shoulder Abd</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL</td>
<td>93.9°</td>
<td>5.35 m/s</td>
<td>.99 sec</td>
<td>64.8°</td>
</tr>
<tr>
<td>AD</td>
<td>106.8°</td>
<td>3.67 m/s</td>
<td>1.08 sec</td>
<td>49.5°</td>
</tr>
</tbody>
</table>

SL= Sequentially-linked; AD= Arm-dominated; Abd= Abduction
CHAPTER V
DISCUSSION

Qualitative Variables

Type of throw

In a study conducted by Marques-Bruna and Grimshaw,⁵ they indicated that a particular throwing pattern did not correspond to a specific aged child. The results of this study support that conclusion, but indicate a tendency for younger children (3 to 4 year olds) to use a 'static', 'arm-dominated' throw, while older children (6 to 7 year olds) tend to use a 'dynamic', 'sequentially-linked' throw. It is postulated that younger children prefer a static position secondary to limited balance, and as balance increases so will the use of a dynamic throwing posture.⁵

Marques-Bruna and Grimshaw⁴,⁵ also indicated that girls are delayed in their acquisition of the throwing compared to boys. Boys display the proficient throwing pattern ('dynamic' and 'sequentially-linked') by 6 ½ years old, while girls of the same age display incomplete development of the overarm throwing motion. This study was able to substantiate this claim by observing the data recorded in the middle age group (4 to 5 year-olds). A male subject completed three 'dynamic' throws and four 'sequentially-linked' throws, while a female subject of the same age completed all of her throws in the less advanced 'static' and 'arm-dominated' method. This indicated the male was more
advanced in acquiring the adult throwing pattern. The researcher was unable to make
gender comparisons in the oldest age group because both subjects were males.

**Quantitative Variables**

*Time of throw*

The results of this study indicate that 'arm-dominated' throws take longer to
complete. This does not correspond with other research\textsuperscript{4,5} indicating 'sequentially-linked'
throws take longer. However, the previous research was conducted on very young
children, ages 30 months or younger, compared to the children in this study who were 7
years of age or younger. The results do show the variable nature of throwing in young
children. This was demonstrated by the youngest age group having both the fastest throw
of .12 seconds and the slowest throw of 2.94 seconds. The data does indicate the oldest
age group has the greatest differences in time of throw between arms, with the non-
dominant arm taking longer to complete.

*Ball velocity at release*

This study supports the findings of previous research\textsuperscript{5} that indicate 'sequentially-
linked' throws have an increase in velocity compared to 'arm-dominated throws'. This
study, along with others\textsuperscript{4,5}, report velocity increases with age, which is expected since
older children use the 'sequentially-linked' method of throwing. This trend was examined
in a combination of studies that showed ball velocity increased in males from 11.8 m/sec.
in kindergarten to 23.6 m/sec. in seventh grade to 34 m/sec. as an adult.\textsuperscript{12,13} It is believed
that the ability to involve the whole body in the throwing motion is an important
determinant of velocity of ball at release.\textsuperscript{5,14} The increase in velocity may also be due to
increases in body size, effects of practice, or general maturity with increases in nerve conduction velocity.\textsuperscript{5,6}

The results of this study also support the findings of Curt et al.\textsuperscript{10} that indicate handedness in 3 year olds is less lateralized than in 6 year olds. In this study, 2 to 3 year old children showed a decrease in lateralization as indicated by a lesser amount of differences in ball velocity between arms (.749 m/sec.). Six to seven year old children displayed the greatest difference in ball velocity between arms (2.675 m/sec) indicating more lateralization had occurred.

\textit{Maximum throwing shoulder abduction}

Previous kinematic analysis of the adult overarm throwing motion indicated that the arm achieves 90-110 degrees of abduction.\textsuperscript{14} This study concluded that arm abduction was greater in ‘sequentially-linked’ throws, but abduction was no better in dominant compared to non-dominant arms. Older children (6 to 7 year olds) did have the most abduction which is expected since they performed the greatest number of ‘sequentially-linked’ throws. Here again, the greatest differences noted between arms occurred in the oldest age group. However, the youngest age group showed more differences than the middle age group. This result was not expected and complicated the trend of increased lateralization with age.

\textit{Elbow flexion at ball release}

The results of this study indicated that the children in the oldest age group, who used 'sequentially-linked' throws 75\% of the time, had the least amount of elbow flexion. In other words, they had the greatest amount of elbow extension. This coincides with previous research\textsuperscript{4,5} that indicated elbow extension is greater in ‘sequentially-linked’
throws. Maximum elbow extension was reported in this study as not exceeding $128^0$ of extension. Marques-Bruna and Grimshaw$^5$ reported maximum elbow extension was no more than $163^0$ for any child. No child in either study achieved full elbow extension. This is thought to be due to the activation of a safety mechanism that prevents hyperextension of joints and subsequent damage. When making comparisions to the research conducted by Marques-Bruna and Grimshaw$^{4,5}$, it needs to be taken into consideration their subjects were at a younger age than the subjects in the present study.

**Limitation of the study**

There were several limitations in this study. First, there were a small number of subjects who participated in the project, and furthermore the subjects were unequally divided into age groups. This did not allow for formal analysis of variance to ascertain statistically significant differences. Therefore, only trends were reported in this project and generalizations should be made with caution. A recommendation for future studies would be to increase the sample size and have equal size age groups to allow for statistical analysis. Another limitation was many frames of data had to be manually digitized when completing the video analysis. This was due in part to the examiner's inability to control the lighting conditions resulting in increased skin reflection, especially on boys who were not wearing a shirt. Future studies should capture video in a dark room with subjects wearing tight fitting, black, long-sleeved shirts and pants. Yet, another limitation was the researchers had to visually determine the frame at which ball release occurred in order to obtain results on velocity and elbow flexion. The video quality made this a difficult task and compromised the results of this study. Future research should incorporate a hand switch for accurate documentation of ball release.
The subjects were also confined to a specific space when performing their throw, which may have contributed to restrictions in their movement or throwing motion. Utilizing a larger calibration frame may alleviate this problem.

Other recommendations for future research include having an equal number of male and female subjects in each age group to determine specific gender differences. Researchers may also benefit by including other variables such as the height of the ball at release, the angle of the ball at release, displacement of the hip midpoint, and the hip to shoulder separation angle. It would also be of interest to compare normally developing children to those who have developmental delays.

Conclusion

It is apparent that children utilize a variety of methods when completing an overarm throw. This study shows younger children tend to use a 'static' and 'arm-dominated' throw, while older children use a 'dynamic' and 'sequentially-linked' throw. Since formal statistical analysis was not performed, the examiner was unable to accept or reject the previously stated hypothesis. However, this study was able to examine the trends of each age group relating to the five variables (type of throw, time of throw, ball velocity, maximum shoulder abduction, and elbow flexion at release). The results of the variables both uphold and dispute the hypothesis. The oldest age group displayed the greatest amount of shoulder abduction, the least amount of elbow extension, and the greatest differences between dominant and non-dominant arms in all variables except elbow flexion. Ball velocity was also the greatest in the oldest age group. All of these results substantiated the researcher's hypothesis that kinematic variance will be more marked with the age. However, some results disputed the hypothesis. These include the
fact the middle age group had fewer differences between arms on the variables of time of throw, ball velocity, and shoulder abduction compared to the youngest age group. They also displayed the greatest variance between arms on one variable, maximum elbow flexion. It is the researcher’s belief the results of the 4-5 year-olds may be skewed because of limited subjects, one male and one female, resulting in an outlier. Based on these findings it is impossible to make the overall claim that increased kinematic variance is noted with an increase in age.

Clinical Implication

The results of this study can provide useful information regarding how the overarm throw is completed in normally developing children. Once a standard for 'normal' throwing has been established it can be helpful in treating children who are developmentally delayed. This information can be a reference for coaches, educators, physical therapists, and anyone who assesses motor control.
The purpose of this study is to explore the technical differences and effects of handedness in overhead throwing motion of children. Subjects will be divided into three groups of three, ages 2-3, 4-5, and 6-7 for analysis. Methods used will include a four camera Peak 5 video motion analysis system to record all angles while each child completes three trials of relaxed throwing and three trials aimed at a target for accuracy, using both right and left arms. Joint angles and velocities will be digitally analyzed using the Peak Motus software. This study necessitates the use of child subjects to accurately examine when hand dominance emerges and creates observable differences in the throwing motions between hands.
PLEASE NOTE: Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding).

2. PROTOCOL: (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

We are undertaking this research, a pilot study, to partially fulfill graduation requirements for the UND Physical Therapy program. Our hypothesis is that less deviations in overarm throwing technique will be noted bilaterally in young children (ages 2-3) compared to older children (ages 6-7) due to the lesser influence of handedness. Approximately nine children, male and female, will be divided into three groups of three according to their age. Age groups will be ages 2-3, 4-5, 6-7. There are no plans to add or replace subjects once the study is underway, therefore if subjects withdraw from the study it is possible the number will be less than 9. Subject selection will be based on the premise that the child has normal motor and cognitive functions and falls within the required age ranges. Diagnosed or suspected cognitive, physical, or motor delays, as assessed by the completion of a pediatric screening form, would result in exclusion from the study. Participants in this study will be a sample of convenience of children who have previously participated in pediatric activities in the physical therapy department. The principal investigators will contact the parents of the participants of the study by phone. Each child will be accompanied by his/her parent to a one time, one hour video taping session. There are no plans to replace or add participants after the study in underway. Prior to initiation of video taping, a parental consent form will be explained to each parent and the procedure will be discussed with both parent and child. A copy of the signed consent form will be left with the parent. It is stated in the parental consent form that participation is voluntary and their child is free to discontinue participation in the study at any time without prejudice. Each child, regardless of performance in the study, will receive a small reward, such as a small puzzle, coloring book, or piece of candy, with parental consent. No other form of compensation will be given. If they agree to allow their child to participate, a pediatric screening form will be completed (attached as appendix B).

The research will be carried out by the principal investigators in the UND Physical Therapy Department. Each subject will have adhesive reflective markers placed at the shoulder, elbow and wrist joints of both arms, which will assist in obtaining data regarding joint angles and velocities that will be digitally analyzed using Peak Motus software. Distance and accuracy of each trial will also be recorded by the investigators. Each child will be recorded using the Peak 5 video motion analysis system with four cameras in a controlled environment. A target will be placed at a distance and size appropriate for the child's age. If after 30 minutes the child is not willing to perform the desired tasks, participation will be discontinued. All data recorded in written, video, or computer disks form will be stored under lock and key in a file in Dr. Peg Mohr's office in the UND Physical Therapy Department for three years following the completion of the study. All video images, once digitized to stickman and graphical data, will be erased. Only the primary investigators will have access to the videos in human format.
3. BENEFITS: (Describe the benefits to the individual or society.)
This study will provide information regarding the emergence and effect of hand dominance in overarm throwing by young developing children. This information can be used by medical professionals to learn more about normal motor development in children. This study can also be used to build on in future studies using more normally developing pediatric subjects, subjects with developmental delays, or comparing children to adults in their overarm throwing techniques. Possible benefits to the child may include an introduction to a new motor skill and obtaining a treat. A benefit to both the child and the parents will include the experience of participating in a research project.

4. RISKS: (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject’s dignity and self-respect, as well as psycho-logical, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)
Possible risks include emotional disturbance if the child cannot complete the desired task. In such an instance, the child will be reunited with a parent and given reassurance and encouragement. Each child will be given a small reward, with parental permission, regardless of performance during the trials. There may also be risk of the child falling during the required activities, but an investigator will be in close proximity at all times to ensure the safety of the child. Methods to ensure confidentiality include storage of all written and computer data pertaining to the study under lock and key. Each child will be identified by a number and results reported will not contain reference to any child and no pictures of specific individuals will be used without specific parental permission. It is not anticipated that pictures of specific individuals will be used, but if for some reason the researchers want to use a picture (e.g., for a presentation), the parents will be contacted and permission in writing will be obtained. The parent will be allowed to preview the pictures prior to use. Each subject will be assigned a time slot so as to minimize interaction among subjects and throwing will be in a controlled, confined environment.

Although it is not anticipated, in the event that this research activity results in a physical injury, medical first aid and emergency treatment will be provided as it is to members of the general public in similar circumstances. The subject’s parents and their third party payment, if any, must provide payment for any such treatment.
5. CONSENT FORM: A copy of the CONSENT FORM to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no CONSENT FORM is to be used, document the procedures to be used to assure that infringement upon the subject’s rights will not occur.

Describe where signed consent forms will be kept and for what period of time.

All copies of the pediatric screenings and consent forms will be secured for a three year period following the completion of the study in the office of Dr. Peg Mohr, PT at the University of North Dakota, (701) 777-2831.

6. For FULL IRB REVIEW forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

Office of Research & Program Development
University of North Dakota
Grand Forks, North Dakota 58202-7134

On campus, mail to: Office of Research & Program Development, Box 7134, or drop it off at Room 105 Twamley Hall.

For EXEMPT or EXPEDITED REVIEW forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University’s policies and procedures governing the use of human subjects.

SIGNATURES:

Jacelyn D. Brederland 4-12-99
Principal Investigator

Kathleen J. Hajicek 11-12-99
Date

Peggy Mahn 11-12-99
Project Director or Student Adviser

Training or Center Grant Director

(Revised 3/1996)
APPENDIX B
Pediatric Screening

Date: __________
Child's name: __________ Birthdate: __________ Age: _______ Sex: M F
Parent’s Name: __________ Phone: __________

Does your child have trouble seeing? Y / N If yes, is it corrected with glasses contacts? __________

Does your child have hearing problems? Y / N If yes, is it corrected with hearing aids? __________

Does your child have any speech problems? ____________________________

Does your child have any physical abnormalities? Y / N If yes, please list__________________________

We would like to have information about some of the developmental milestones of your child. Indicate the age in months when your child first did each of the following (indicate that the child has not yet done it by writing “No;” if you do not remember, write “NR”) Please be as specific as possible in pinpointing the age.

Held head erect __________ Sat alone __________ Crawled __________

Pulled to stand __________ Stood alone __________

Walked without holding on to furniture __________

Ran with good control __________ Put on clothes __________

Is your child’s speech easy to understand by parents, peers, and other adults? __________

Is your child right or left-handed? __________

When did you first notice a hand preference? __________

Has your child ever been in special education? If so, when, where, and what kind? __________

Do you suspect or has your child ever been diagnosed with any cognitive, physical, or motor deficits? Y / N
If yes, what and when? __________

Do you suspect or has your child ever been diagnosed with any learning or attention difficulties? Y / N
If yes, what and when? __________

INFORMATION AND CONSENT FORM

TITLE: Three-dimensional kinematics of the overarm throwing motion in children ages two to seven.

Your child is being invited to participate in a study conducted by Katherine Hagen and Jacalyn Breidenbach, physical therapy students at the University of North Dakota. The purpose of this study is to explore the differences in overarm throwing techniques between dominant and non-dominant hands in children of differing ages. From the study, we hope to gain information that can be used by all medical professionals to learn more about motor development.

Your child will be videotaped while performing three overhead throws with each arm while aiming at a target for accuracy. Please do not be concerned if you feel your child may not be able to aim accurately at the target. It is not imperative that they hit the target as we are simply analyzing the differences in their techniques. All children will be given a small reward regardless of their performance, with your permission. Rewards may include such things as a small puzzle, coloring book, or candy.

The study will take approximately one hour of you and your child’s time. You will be asked to come to the Physical Therapy Department at the University of North Dakota at an assigned time. We ask that your child wear tight fitting, dark colored (black or navy) shorts and long sleeved shirt for the videotaping session. If your child is male and is comfortable being videotaped in only shorts, that is preferred. You will be asked to complete a questionnaire regarding your child’s development at some time before initiation of videotaping.

During the session, we will first record your child’s age, gender, height, and weight. Reflective markers will then be placed, with adhesive tape, to various bony landmarks on your child’s body. The reflective markers will allow the video to measure joint angles and the velocity of each throw. The procedure of the activity will be fully explained to you and your child, including verbal and visual instructions.

A brief period for practice throws will be allowed before recording with the video cameras. We will then record your child throwing with a three-camera video system. You will be allowed to remain in the room for all procedures. Once the data collected from the videotape is analyzed and converted into graphical information, the original tape containing your child’s pictures will be erased. Prior to that time, the tape will be stored in a locked cabinet accessible only to the investigators.

Although the process of physical performance testing always involves some degree of risk the investigators in this study feel that the risk of injury or discomfort is very minimal. If your child becomes upset for any reason, such as inability to complete the throws or hit the target, encouragement and comfort will be given to him/her. Again, you
will be allowed in the room during all procedures, if you desire. During the throwing activity, a researcher will be near your child at all times to ensure his/her safety. Neither your nor your child’s name will be used in any reports of the results of this study. Any information that is obtained in connection to this study and that can be identified with you or your child will remain confidential and will be disclosed only with your permission. A number known only by the investigators will identify the data associated with your child. The investigators or participant may withdraw from the experiment without prejudice at any time, for any reason, prior to completion of the videotaping. Neither you nor your child’s decision to not participate will affect your future relationship with the Physical Therapy Department or the University of North Dakota.

The investigators involved are available to answer any questions you have concerning this study now or in the future by calling Peg Mohr at (701) 777-2831 or Jacalyn Breidenbach at (701) 746-5769. A copy of this consent form will be provided to all participants in the study.

Although it is not anticipated, in the event that this research activity (which will be conducted in the Physical Therapy Department at the University of North Dakota) results in physical injury, medical treatment will be available, including first aid, emergency treatment and follow-up care, as it is to members of the general public in similar circumstances. Payment for any such treatment must b provided by you and your third party payment, if any.

ALL OF MY QUESTIONS HAVE BEEN ANSWERED AND I AM ENCOURAGED TO ASK ANY QUESTIONS THAT I MAY HAVE CONCERNING THIS STUDY IN THE FUTURE. MY SIGNATURE INDICATES THAT HAVING READ THE ABOVE INFORMATION, I HAVE DECIDED TO ALLOW MY CHILD(REN) TO PARTICIPATE IN THE RESEARCH PROJECT.

I have read all of the above information and willingly agree to allow my child to participate in this study explained to me by Katherine Hagen, SPT and Jacalyn Breidenbach, SPT.

__________________________________________
Child’s Name

__________________________________________
Parent’s Signature Date

__________________________________________
Witness (not the scientist) Date
REFERENCES


REFERENCES (CONT.)
