UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

HIP AND KNEE POSITIONS DURING THE CURLING DELIVERY

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science

Ellanora F. Kraemer

College of Science and Health
Human Performance

July, 2009
HIP RANGE OF MOTION IN THE SPORT OF CURLING: DELIVERY

July 2009

By Ellanora F. Kraemer

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree:

Master of Science in Human Performance

The candidate has completed the oral defense of the thesis.

Mark N. Gibson
Thesis Committee Chairperson

Ellen Wright
Thesis Committee Member

Glenn Wright
Thesis Committee Member

Vijendra K. Agrawal
Director, University of Graduate Studies
The primary purpose of this study was to determine the relationships between trunk, thigh, hip and knee measurements from the forward slide phase of the curling delivery. The second purpose of this study was to determine the relationship between hip goniometric measurements and hip measurements from the forward slide phase of the curling delivery. The third purpose of this study was to establish normative range of motion data for the trunk, thigh, hip and knee during the forward slide phase of the curling delivery. Sixty junior-level curlers (30 females, 30 males) aged 13-21 participated in active hip extension goniometric measurements and motion analysis of hip and knee positions during the curling delivery. A strong relationship was found between absolute trunk and relative hip measurements from the curling delivery. A fair relationship was found between absolute thigh and relative hip measurements from the curling delivery, along with absolute hip and relative knee measurements from the curling delivery. Gender differences were found for the absolute trunk and relative hip measurements from the curling delivery. No relationship was found between relative hip extension goniometric measurements and hip measurements from the curling delivery. Absolute trunk extension measurements from the curling delivery were 37.2° and 27.5° for female and male subjects. Absolute thigh measurements and relative knee measurements from the curling delivery were 33° and 31° for both genders. Relative hip measurements from the curling delivery were -3.9° and 5.7° for female and male subjects.
I am grateful to everyone who helped me complete my thesis, especially Mark Gibson, my thesis chair, for your time and guidance. Also, thank you to Dr. Tom Kernozek for your patience and expertise. Great thanks to Dr. Glenn Wright, committee member and advisor, for guiding me through the Human Performance Graduate Program.

Thank you to USA Curling for lending me the equipment to perform this study. To all the individuals at the Junior National Championships in Devil’s Lake, ND who participated in the study, my sincere appreciation. A special thanks to Lynita Delaney, for your endless ideas, and for bringing me into the world of competitive curling.

To Shellie, my greatest appreciation, for your unconditional support and constant encouragement. To Kim and Ann, thank you for your patience and persistence in working with me. Thank you all for believing in me and giving me hope.

Lastly and more importantly, I would like to thank God for giving me the strength to overcome the obstacles and adversities that were placed in my path prior to me considering college, in my pursuit of a bachelor’s degree, and in my pursuit of a master’s degree. I would not be the person who I am, and the person I hope to be, without Him watching over me.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vii</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td>2</td>
</tr>
<tr>
<td>Hypothesis of the Study</td>
<td>2</td>
</tr>
<tr>
<td>Definitions of Terms</td>
<td>2</td>
</tr>
<tr>
<td>METHODOLOGY</td>
<td>4</td>
</tr>
<tr>
<td>Introduction</td>
<td>4</td>
</tr>
<tr>
<td>Selection of Participants</td>
<td>4</td>
</tr>
<tr>
<td>Test Procedures</td>
<td>5</td>
</tr>
<tr>
<td>Statistical Analysis</td>
<td>8</td>
</tr>
<tr>
<td>RESULTS</td>
<td>8</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>13</td>
</tr>
<tr>
<td>CONCLUSIONS</td>
<td>17</td>
</tr>
<tr>
<td>Future Considerations</td>
<td>18</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>19</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>21</td>
</tr>
<tr>
<td>Review of Literature</td>
<td>21</td>
</tr>
<tr>
<td>Informed Consent</td>
<td>38</td>
</tr>
<tr>
<td>TABLE</td>
<td>PAGE</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>1. Descriptive statistics for absolute trunk extension measurements from the forward slide phase of the curling delivery</td>
<td>9</td>
</tr>
<tr>
<td>2. Descriptive statistics for absolute thigh extension measurements from the forward slide phase of the curling delivery</td>
<td>10</td>
</tr>
<tr>
<td>3. Descriptive statistics for relative hip measurements from the forward slide phase of the curling delivery</td>
<td>11</td>
</tr>
<tr>
<td>4. Descriptive statistics for relative knee measurements from the forward slide phase of the curling delivery</td>
<td>12</td>
</tr>
<tr>
<td>5. Descriptive statistics for hip extension goniometric measurements with the knee at full extension and at 90° flexion</td>
<td>13</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. An example of angular measurements for the absolute trunk, absolute thigh, and relative hip from analysis of the curling delivery</td>
<td>7</td>
</tr>
<tr>
<td>2. The relationship between absolute trunk extension and relative hip extension measurements from the forward slide phase of the curling delivery</td>
<td>9</td>
</tr>
<tr>
<td>3. The relationship between absolute thigh extension and relative hip extension measurements from the forward slide phase of the curling delivery</td>
<td>10</td>
</tr>
<tr>
<td>4. The relationship between absolute thigh extension and relative knee flexion measurements from the forward slide phase of the curling delivery</td>
<td>11</td>
</tr>
<tr>
<td>5. The relationship between relative knee flexion and relative hip extension measurements from the forward slide phase of the curling delivery</td>
<td>12</td>
</tr>
<tr>
<td>6. Set-up for the curling delivery</td>
<td>26</td>
</tr>
<tr>
<td>7. Drawback of the curling delivery</td>
<td>27</td>
</tr>
<tr>
<td>8. Forward slide of the curling delivery</td>
<td>29</td>
</tr>
<tr>
<td>9. Release of the rock</td>
<td>30</td>
</tr>
</tbody>
</table>
INTRODUCTION

Background

Curling is a growing sport in the United States, and became an official Olympic sport in 1988 after being a demonstration sport in previous Olympic years (USA Curling, 2008). Curling is played at several different levels, including the most competitive level - the World Championships and Olympic Games. The sport also has recreational leagues, competitive leagues, local, state, regional and national tournaments. The developmental level, known as Junior Curling in the United States, has become popular and competitive over the past few years. Junior curlers must be under the age of 21 years, and are eligible to compete at local, state, regional, national, and world championships. Most junior curlers learn how to curl from certified curling coaches (USA Curling, 2008).

Curling requires two technical skills, stone delivery and sweeping (Special Olympics British Columbia, 2008; USA Curling Coaching Manual, 1999; Watson, 1950). The sport of curling requires balance, strength, flexibility, coordination, muscular endurance, and power (Behm, 2007; USA Curling Elite Coaches Cadre, 2008). Many different delivery techniques have been taught as the sport has developed. In order to be successful in the sport of curling, highly competitive curlers must be proficient and consistent in their curling delivery. The most common curling delivery technique is the “no-backswing delivery” (CurlTech, 2008).
The majority of literature related to curling is comprised of coaching and teaching manuals, books, and magazines. The review of literature in this study demonstrates the lack of scientific evidence for the curling delivery. This study will examine the forward slide phase of the curling delivery and provide normative range of motion data for the trunk, hip and knee. This will contribute to the literature and aid those coaching the no-back swing curling delivery.

**Purpose of the Study**

The primary purpose of this study was to determine the relationships between trunk, thigh, hip and knee measurements from the forward slide phase of the curling delivery. The second purpose of this study was to determine the relationship between hip goniometric measurements and hip measurements from the forward slide phase of the curling delivery. The third purpose of this study was to establish normative range of motion data for the trunk, thigh, hip and knee during the forward slide phase of the curling delivery.

**Hypotheses of the Study**

There will be relationships between trunk, thigh, hip and knee measurements from the forward slide phase of the curling delivery.

There will be a relationship between hip extension goniometric measurements and hip extension measurements from the forward slide phase of the curling delivery.

**Definitions of Terms**

*Backswing Delivery* - pendulum motion in which the curler lifts the stone off the ice as the body draws back prior to sliding forward on the ice (CurlTech, 2008).

*Delivery* - action of throwing the curling stone (CurlTech, 2008).
Draw-weight - the momentum required for a stone to reach the house or circles at the opposite end of the ice sheet (Watson, 1950).

Drawback and Step - the curler draws the rock back and lifts up the hips, followed by taking a step back on the sliding foot while shifting body weight to the sliding foot (USA Curling, 2008).

Flat-foot delivery - the front, sliding foot, remains flat on the ice during the entire movement of delivery (CurlTech, 2008).

Follow-through - stay in the delivery position after releasing the rock, watching the rock travel down the ice (CurlTech, 2008).

Forward Press - the foot is in the hack with body weight on the hack foot, and the curler moves the rock forward 4-5 inches, while keeping the lower body still (USA Curling, 2008).

Forward Slide - the curler pushes out of the hack with the hack foot, transferring all of the weight from the hack foot to the sliding foot (USA Curling, 2008).

Hack - object the curler pushes off from during delivery, similar to starting blocks for track sprints (CurlTech, 2008).

House - the rings or circles to which the stones are played (Watson, 1950).

Line of delivery - an imaginary line through the center of the rock to the broom held at the opposite end of the ice sheet (USA Curling, 2008).

No-lift delivery - the curling rock remains on the ice during the entire movement of the delivery (CurlTech, 2008).

Set-up - the starting point of delivery with the foot in the hack (CurlTech, 2008).
Slider - ¼ inch thick Teflon on the bottom of the curling shoe that allows the curler to slide or move forward on the ice without lifting the foot off the ice (Curling Canada, 2008).

Sliding Device - also known as the “stabilizer” or “crutch”; allows curler to maintain a more upright and balanced delivery (CurlTech, 2008).

Take-out weight - the momentum required for a stone to contact and remove another stone out of the area of play (Curling Canada, 2008).

Toe-tuck delivery - the toes of the front, sliding foot, are in contact with the ice during the delivery (CurlTech, 2008).

METHODOLOGY

Introduction

The primary purpose of this study was to determine the relationships between trunk, thigh, hip and knee measurements from the forward slide phase of the curling delivery. The second purpose of this study was to determine the relationship between hip goniometric measurements and hip measurements from the forward slide phase of the curling delivery. The third purpose of this study was to establish normative range of motion data for the trunk, thigh, hip and knee during the forward slide phase of the curling delivery. The methods and procedures of this study are divided into the following sections: selection of participants; test procedures; and statistical analysis.

Selection of Participants

The subjects for this study consisted of sixty (30 males and 30 females) apparently healthy junior-level curlers. The subjects were recruited at the Junior National Championships in North Dakota in February, 2009. All of the participants had three or
more years of curling experience and were between the ages of 13-21 years. Subjects were excluded from the study if they had any current lower body injuries. Subjects were also excluded if they had a “tuck” delivery or backswing delivery. Right-handed (n = 55) and left-handed (n = 5) subjects were included in the study. Prior to the beginning of the study, subjects over 18 years of age read and signed an informed consent form describing their involvement in the study (see Appendix B). Subjects under 18 years of age were required to obtain permission from a parent or guardian (see Appendix B). After permission was granted, the subject and parent/guardian read and signed an informed consent form describing their involvement in the study. This research protocol was examined and approved by the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects. Permission was also granted from USA Curling, the governing body for the sport of curling in the United States.

**Test Procedures**

All of the testing took place at the Junior National Curling Championships in Devil’s Lake, North Dakota on February 6-10, 2009. The primary investigator conducted all of the testing. The investigator established intra-rater reliability of goniometer hip measurements for the dominant leg prior to conducting the study. The investigator collected data with a test-retest pilot study on eight subjects. Active hip extension with the knee in full extension was measured. Active hip extension with the knee at ninety degrees of flexion was also measured. The investigator was blinded to the numerical values on the goniometer and a colleague recorded the data. Reliability for the investigator was calculated with an intra-class correlation coefficient. The intra-rater reliability was .95 for goniometer measurement of hip extension with the knee in full
extension. The intra-rater reliability was .96 for goniometer measurements of hip extension with the knee at ninety degrees of flexion.

A universal goniometer was used to measure active hip extension of the subject’s curling delivery trail leg. The right hip was measured on subjects with a right-handed curling delivery. The left hip was measured on subjects with a left-handed curling delivery. The subject lay prone on the evaluation table and was instructed to keep the pelvis on the table and lift the leg straight toward the ceiling. The subject was first instructed to perform hip extension with the involved knee in full extension. The subject then was asked to perform hip extension with the knee at ninety degrees of flexion. The subject was given a practice trial to ensure understanding of the testing procedure. Identical procedures were used for each subject. The fulcrum of the goniometer was placed over the greater trochanter of the femur. The stationary arm was placed along the midline of the torso, and the movement arm was along the long axis of the femur with the lateral epicondyle as the distal reference point. Goniometer measurement methods were taken from Starkey & Ryan, 2002.

Each subject’s draw-weight curling delivery was videotaped from the lateral view with a Sony High Definition Handycam 9 camcorder (HDR-HC9, Sony Electronics, San Diego, CA). The video camera was placed in the same plane of the curling delivery. Videotaping took place during team practices prior to the start of the Junior National Championships. Identical procedures were used for videotaping each subject. The subjects were allowed to warm-up prior to videotaping. The subjects were not told the purpose of the videotaping to minimize the risk of subjects modifying their normal curling delivery.
The curling delivery videos were uploaded into Dartfish TeamPro 5.0 (Dartfish, Alpharetta, GA). Video was taken at the rate of 60 frames per second. Angular measurements were taken from the video frame at which the toes of the back leg crossed the center of the innermost circle on the sheet of ice, also known as the midpoint of the forward slide phase. The relative knee angle was measured at the center of the knee joint, the lateral malleolus and the greater trochanter of the femur. An example of this measurement (152.6°) is shown in Figure 1. The absolute trunk angle was measured at the greater trochanter of the femur and the acromion process of the scapula. The stationary arm for absolute trunk and absolute thigh angles was set to the right horizontal plane (x-axis). An example of the absolute trunk angle (47.9°) is shown in Figure 1. The absolute thigh angle was measured at the greater trochanter of the femur and the center of the knee joint. An example of the absolute thigh angle (32.0°) is shown in Figure 1. The relative angle of the hip was then determined by subtracting the absolute trunk angle value from the absolute thigh angle.

Figure 1. An example of angular measurements for the absolute trunk, absolute thigh, and relative hip from analysis of the curling delivery.
The investigator established intra-rater reliability for angular measurements from analysis of the curling delivery. The investigator conducted a test-retest study on eight subjects (4 male, 4 female) from the study. Absolute trunk, absolute thigh, and relative knee angles were measured. Reliability was calculated with an intra-class correlation coefficient. The intra-rater reliability was .99 for absolute trunk, absolute thigh, and relative knee measurements from the forward slide phase of the curling delivery.

**Statistical Analysis**

The relationships between absolute trunk, absolute thigh, relative hip and relative knee measurements from the forward slide phase of the curling delivery were calculated with Pearson product-moment correlations. Gender relationships for each variable were calculated with an independent t-test \( p < .05 \). The relationships between hip extension goniometric measurements and hip extension measurements from the curling delivery were calculated with Pearson product-moment correlations. The SPSS 16.0 statistical package (SPSS, Inc., Chicago, IL) was used to analyze the data.

**RESULTS**

Descriptive statistics for absolute trunk extension motion analysis measurements from the forward slide phase of the curling delivery between subject groups are shown in Table 1. The independent t-test for absolute trunk extension measurements from the curling delivery revealed a significant difference \( p=.0 \) between male and female subjects. There was no relationship between absolute trunk and absolute thigh measurements \( .1 \) from the curling delivery. There was also no relationship between absolute trunk and relative knee measurements \( -.1 \) from the curling delivery. A strong
relationship \((r=-.8; \ p<.05)\) was found between absolute trunk extension and relative hip extension measurements from the curling delivery. See Figure 2.

Table 1. Descriptive statistics for absolute trunk extension measurements from the forward slide phase of the curling delivery. Positive values indicate the trunk was extended and negative values indicate the trunk was flexed relative to the x-axis.

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>30</td>
<td>37.2</td>
<td>11.0</td>
<td>20.1 – 57.3</td>
</tr>
<tr>
<td>Male</td>
<td>30</td>
<td>27.5</td>
<td>8.8</td>
<td>7.4 – 49.3</td>
</tr>
</tbody>
</table>

Figure 2. The relationship between absolute trunk extension and relative hip extension measurements from the forward slide phase of the curling delivery.

Descriptive statistics for absolute thigh extension measurements from the forward slide phase of the curling delivery are shown in Table 2. The independent t-test for absolute thigh extension from the curling delivery revealed no significant difference \((p=.9)\) between genders. A relationship was found between absolute thigh measurements and relative hip measurements \((.5; \ p<.05)\) from the curling delivery. See Figure 3. A
strong relationship was found between absolute thigh measurements and relative knee measurements (.95; p<.05) from the curling delivery. See Figure 4.

Table 2. Descriptive statistics for absolute thigh extension measurements from the forward slide phase of the curling delivery. Positive values indicate the thigh was extended and negative values indicate the thigh was flexed relative to the x-axis.

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>30</td>
<td>33.3</td>
<td>8.2</td>
<td>17.4 – 54.6</td>
</tr>
<tr>
<td>Male</td>
<td>30</td>
<td>33.2</td>
<td>7.1</td>
<td>16.2 – 42.9</td>
</tr>
</tbody>
</table>

Figure 3. The relationship between absolute thigh extension and relative hip extension measurements from the forward slide phase of the curling delivery.
Descriptive statistics for relative hip measurements from the forward slide phase of the curling delivery are shown in Table 3. The independent t-test revealed a significant difference ($p=0.0$) between genders for relative hip extension measurements from the curling delivery. Descriptive statistics for relative knee flexion measurements from the forward slide phase of the curling delivery are shown in Table 4. The independent t-test revealed no significant difference ($p=0.9$) between genders for knee flexion measurements from the curling delivery. A relationship was found between relative knee measurements and relative hip measurements ($-0.5; p<0.05$) from the curling delivery. See Figure 5.

Table 3. Descriptive statistics for relative hip measurements from the forward slide phase of the curling delivery. Positive values indicate hip extension and negative values indicate hip flexion relative to the anatomical neutral position.

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>30</td>
<td>-3.9</td>
<td>12.8</td>
<td>-31.1 - 18.6</td>
</tr>
<tr>
<td>Male</td>
<td>30</td>
<td>5.7</td>
<td>11.3</td>
<td>-13.2 - 33.4</td>
</tr>
</tbody>
</table>
Table 4. Descriptive statistics for relative knee measurements from the forward slide phase of the curling delivery. Zero degrees was full knee extension and positive values indicated knee flexion.

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>30</td>
<td>30.1</td>
<td>8.5</td>
<td>13.4 – 54.6</td>
</tr>
<tr>
<td>Male</td>
<td>30</td>
<td>30.3</td>
<td>8.1</td>
<td>12.9 – 44.0</td>
</tr>
</tbody>
</table>

Figure 5. The relationship between relative knee flexion and relative hip extension measurements from the forward slide phase of the curling delivery.

Descriptive statistics for maximum hip extension goniometric measurements are shown in Table 5. No significant difference was found between genders for hip extension goniometric measurements with the knee at 90° flexion (p=.1) or with the knee at full extension (p=.8). No relationship was found between hip extension goniometric measurements and hip measurements from the forward slide phase of the curling delivery (p<.05).
Table 5. Descriptive statistics for hip extension goniometric measurements with the knee at full extension and at 90° flexion. Zero degrees was anatomical position. Negative values indicate hip extension and positive values indicate hip flexion.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Knee Extension</td>
<td>Female</td>
<td>30</td>
<td>-17.5</td>
<td>5.6</td>
<td>-25.0 - 5.0</td>
</tr>
<tr>
<td>Full Knee Extension</td>
<td>Male</td>
<td>30</td>
<td>-17.1</td>
<td>5.9</td>
<td>-29.0 - 6.0</td>
</tr>
<tr>
<td>90° Knee Flexion</td>
<td>Female</td>
<td>30</td>
<td>-13.7</td>
<td>5.8</td>
<td>-24.0 - 2.0</td>
</tr>
<tr>
<td>90° Knee Flexion</td>
<td>Male</td>
<td>30</td>
<td>-11.1</td>
<td>6.5</td>
<td>-29.0 - 6.0</td>
</tr>
</tbody>
</table>

DISCUSSION

The primary purpose of this study was to determine the relationships between trunk, thigh, hip and knee measurements from the forward slide phase of the curling delivery. The second purpose of this study was to determine the relationship between hip goniometric measurements and hip measurements from the forward slide phase of the curling delivery. The third purpose of this study was to establish normative range of motion data for the trunk, thigh, hip and knee during the forward slide phase of the curling.

Many of the results from this study were expected, except the difference between male and female subjects on hip extension measurements from the forward slide phase of the curling delivery. The female subject group had significantly greater hip extension measurements from the curling delivery than the male subject group. There was also a significant relationship between genders for these measurements ($r=-.8; p<.05$). This contrasted the goniometric measurements of hip extension, which were not significantly different between male and female subjects. Female curlers used 22% of their
goniometric hip extension during the curling delivery. Male curlers used 11% of their goniometric hip extension during the curling delivery. There was no relationship between genders for the goniometric measurements. The difference between measurements from the curling delivery and goniometric measurements was directly due to the absolute trunk angle measurements from the curling delivery. The absolute trunk angle was measured relative to the horizontal plane. The trunk angle of the female curlers was 9° higher than the male curlers, creating a more upright trunk posture.

B. Tschirhart (personal communication, April 29, 2009) and Tschirhart et al. (2008) stated that an upright trunk posture provided a greater perspective of the entire area in which the rock must travel. However, some have disagreed with this theory and thought a more forward-leaning trunk posture was better (B. Tschirhart, personal communication, April 29, 2009; L. Delaney, personal communication, April 27, 2009; Tschirhart, et al., 2008). This lower position enabled the athlete to have a better perspective for the line of delivery of the curling stone. This better perspective may be due to the curler viewing the target (broom at opposite end of ice) in the same line of sight as the curling stone.

Tschirhart et al., (2008) believed the curler’s body should approximate an equilateral triangle during the delivery, with each side at a 60° angle. The three sides of the triangle included: a) a line down the center of the trunk; b) a line along the arm holding the rock; and c) a line along the thigh of the sliding leg. The thigh of the sliding leg should be parallel to the ice surface to prevent excessive knee flexion.
This research study looked at one side of the Tschirhart et al. (2008) triangle, the absolute trunk angle relative to horizontal plane. None of the curlers in this study had the recommended 60° angle. Two of the curlers (1 male and 1 female) had a 45° trunk angle and only seven curlers (1 male and 6 females) were between 46-57°. Fifty one curlers (28 males and 23 females), or 85% of the subjects were below 45° absolute trunk angle, indicating a more forward leaning trunk posture. These values contrasted the equilateral triangle theory, and are more congruent with B. Tschirhart. He recommended curlers use a 45° trunk angle during the delivery (personal communication, April 29, 2009).

Although Tschirhart et al. (2008) recommended the 60° absolute trunk angle, they also stated a lower trunk angle required more extension of the hip and ankle. The lower angle, in combination with the stretch reflex, may have produced greater power and acceleration during the delivery than an upright trunk posture. The stretch reflex was activated when the curler draws the hips and the stone backward. This action pre-stretched the muscle, leading to a reflex contraction of the muscle when the curler moved forward. Although the lower trunk angle and stretch reflex have had many benefits, they also decreased the curler’s body control during the delivery. The curler’s power may have been directed off-target if the body was positioned incorrectly or the sliding foot moved too quickly.

In contrast to the differences in absolute trunk angle and hip extension measurements from the curling delivery, the knee flexion measurements from the curling delivery did not differ between groups. The hip extension measurements from the curling delivery were related to the knee flexion measurements for both the female and male subject groups. This means as hip extension increased the amount of knee flexion
decreased. The male subject group had a stronger relationship than the female subject group. Although not addressed in this study, recreational and older curlers may have a stronger relationship between hip extension and knee flexion, based on direct observations of the curling delivery.

The results of this study established normative values for hip extension, trunk flexion, and knee flexion for the curling delivery for junior-level curlers. Female curlers were in four degrees of hip extension, and male curlers were in six degrees of hip flexion during one frame of the curling delivery. Average values for trunk extension were 37° and 28° for females and males, respectively. Average values for knee flexion were 30° for both genders. The difference between genders for trunk extension measurements from the curling delivery was not due to a lack of flexibility in male subjects, because both genders had similar hip extension goniometric measurements (-17°). These differences may have been due to different coaching philosophies regarding trunk posture during the forward slide phase of the curling delivery. Future research may confirm this theory.

Gajdosik and Bohannon (1987) reviewed several studies on the reliability and validity of goniometric measurements used in physical therapy. They found greater reliability with intratester measurements than intertester measurements. Active ROM measurements were also more reliable than passive ROM measurements. Goniometers are generally considered valid measurement tools, even though small errors may occur in the construction of goniometers (Gajdosik and Bohannon, 1987). The goniometric measurements in the current study were done by one investigator and utilized active range of motion measurements to increase the reliability of the measurements. The intra-
rater reliability for this study was .95 for active hip extension goniometric measurements. Goniometer measurements for active hip extension averaged -17° for both genders with the knee extended, and -13° and -11° for females and males with the knee flexed to ninety degrees. The information found in this study supports the non-scientific coaching and teaching literature and has created a foundation for future studies.

CONCLUSIONS

The primary purpose of this study was to determine the relationships between trunk, thigh, hip and knee measurements from the forward slide phase of the curling delivery. A strong relationship was found between absolute trunk and relative hip measurements from the curling delivery. A fair relationship was found between absolute thigh and relative hip measurements from the curling delivery, along with relative knee and relative hip measurements from the curling delivery. The significant difference between genders for relative hip extension measurements during the curling delivery was directly due to the significant differences in absolute trunk extension measurements from the curling delivery. The second purpose of this study was to determine the relationship between hip goniometric measurements and hip measurements from the forward slide phase of the curling delivery. No relationship was found between these two variables.

The third purpose of this study was to establish normative range of motion data for the trunk, thigh, hip and knee during the forward slide phase of the curling delivery. Absolute trunk angles from the curling delivery were 37.2° and 27.5° for females and males. Absolute thigh angles from the curling delivery were 33.0° for both genders. Relative hip measurements from the curling delivery were -3.9° and 5.7° degrees for the females and males. Relative knee flexion measurements from the curling delivery were
31° for both genders. The results of this study found no significant differences between groups on knee measurements from the curling delivery or hip goniometric measurements. The results of this study presented scientific data to support the delivery techniques found in coaching and teaching manuals, books and magazines. Furthermore, this study has provided groundwork for future studies on the sport of curling.

Future Considerations

This study provided normative data on the curling delivery sixty Junior National Championship qualifiers. The data were taken from one video frame of the forward slide phase of the curling delivery. A future study with a smaller subject pool and more trials may improve the reliability of this study. Another option would be to examine a more diverse subject pool, comparing different ages and competitive levels. Also, more sensitive equipment (greater frame rate), skin-tight clothing, and marker placement at each anatomical location will improve the accuracy of the study. The development of a 3-D portable analysis system would allow researchers to look at multiple planes of view and multiple phases of the curling delivery, and may provide greater insight into improving the delivery technique. The relationships between the curling delivery technique and shooting percentage, body stability, and force output of the body cannot yet be controlled. The development of methods to research these topics will provide further advancement of the delivery.
REFERENCES


APPENDIX A

REVIEW OF LITERATURE
REVIEW OF LITERATURE

Introduction

This literature review provides an overview of the sport of curling. Specific areas of focus are: (a) history of the sport of curling and the curling delivery; (b) modern curling delivery technique; and (c) basic analysis of the curling delivery. This literature review also provides information on the validity, reliability, and normative values for goniometric instrumentation.

The Sport of Curling

History of Sport of Curling and the Curling Delivery

The sport of curling was developed in Scotland in the sixteenth century (USA Curling, 2008). Farmers in Scotland developed the game on frozen marshes. They used stones that were naturally smoothed by the rivers and streams. Scottish immigrants brought the game of curling first to Canada and then to the United States in the early 1800’s. Curling developed in Europe during the twentieth century. Standardized twenty-kilogram curling rocks and rubber hacks were introduced to the game of curling during the early twentieth century. The speed of the ice was quite slow in the early and mid-twentieth century, and the game was based on take-outs. Indoor ice rinks, purified water and the curling ice scraper were introduced in the 1980’s. The quality of the ice improved dramatically and the speed of the ice quickened. This resulted in the development of a draw-type game instead of the original take-out game, leading to changes in the curling delivery technique, which will be discussed later in the literature review.
The standard curling game lasts ten ends, with each team member delivering two rocks per end, alternating with the opposing team (CurlTech, 2007). Each team has four players (positions), named the lead, second, vice skip, and skip. The lead delivers his or her rocks first, followed by the second, vice skip and skip. The skip determines the strategy of the game and selects the shots for each team member. The skip also holds the broom at the opposite end of the ice as the target. One person delivers the rock and the other two players sweep the stone’s path as necessary. The sweepers are in the best position to judge the speed of the rock and the skip is in the best position to determine the line of the rock. Each rock delivered must have accurate aim, weight (velocity), and the correct handle or turn (clockwise or counterclockwise). The score for each end is determined after both teams deliver their team’s eight stones. The twelve foot circle at each end of the curling rink is the “house” or the scoring area. The team with the stone closest to the center of the house receives one point for each stone closer than the opposing team. Each sheet of ice is sixteen feet wide and 150 feet long.

The stone rotates and follows a curvilinear path as it proceeds down the ice (CurlTech, 2007). The amount of curl is based on the surface temperature of the ice and speed of the rock. Curlers can increase the temperature of the ice by sweeping in front of the rock. This action decreases friction between the stone and ice, allowing the stone to curl less and slide farther (up to 15 feet farther). Sweeping also clears the ice of frost and debris that may slow the stone down or change its course.

The original curling delivery was quite simple. Curlers wore rubber overshoes to increase friction and prevent them from falling on the ice (Watson, 1950). The curler gained a “foot-hold” on the ice, swung the stone backward in the air and then pushed the
stone forward (CurlTech, 2007; Watson, 1950). A major Canadian curling influence, Ken Watson (1950), introduced the curling “slide” in the 1940’s by removing the rubber overshoe from his non-hack foot to allow the foot to slide on the ice. Watson discovered the curler could more accurately control the rock weight and direction by sliding out of the hack as the rock was released. The “toe-tuck” delivery developed soon after, which reduced friction on the slow ice surface and allowed the curler to get closer to the ice.

Both the toe-tuck delivery and flat-foot delivery continued into the 1970’s. Some curlers preferred the stability of the flat-foot slide in comparison to the toe-tuck delivery.

Another change in the curling delivery is from the lift delivery to the no-lift, flat-foot delivery. Some individuals still use the lift delivery, bringing the rock off the ice as the body moves back prior to the forward slide. The lift delivery increases the opportunity for mistakes as the rock usually slides forward across the centerline of the body. The lift delivery also causes small chips in the ice when the rock contacts the ice.

**Modern Curling Delivery Technique**

The modern curling delivery technique is the no-lift, flat foot delivery. The two goals of the curling delivery are to throw the rock on the line of delivery and to throw the rock with a fluid motion to encourage consistent weight control (CurlTech, 2007). Right-handed individuals usually deliver the rock with the right hand while holding the broom in the left hand, and vice versa for left-handed individuals. The broom is tucked under the arm-pit and is used for balance if necessary. The curling hack is similar to starting blocks for track sprinters, except the two unmovable foot-holds are parallel and are at a decreased angle than starting blocks. Right-handed curlers place the right-foot in the left-
side of the hack. Curlers may use the broom during the delivery or a sliding device, to increase the base of support during the delivery.

CurlTech, Hot Shots Curling, Tschirhart, and USA Curling (2007; 11/9/08; 2006; website accessed 3/31/09) teach the no-lift, flat-foot delivery. They emphasize balance of the body over the sliding foot, not favoring either the broom side or the rock side of the body. This allows the body to slide more upright and straighter, leading to a straight line of delivery. CurlTech (2007) also emphasizes four key power generators in the delivery. These are weight shift, body drop, leg drive, and arm extension.

The CurlTech delivery is composed of six steps: (1) set-up, shot planning and mental preparation; (2) the forward press; (3) the drawback and step; (4) the forward slide; (5) the release; and (6) the follow-through (2007). The curling delivery is slightly different for Tschirhart (2006). He defines four positions for the delivery (1) hack position; (2) park position; (3) bottomed out; and (4) pose position. Hot Shots Curling (accessed 11/9/08) divides the delivery into three phases (1) pull back; (2) forward slide; and (3) release of the rock. The USA Curling delivery technique includes three movements (1) press; (2) drawback; and (3) forward slide (accessed 03/31/09). The stages are explained below.

Step one of the CurlTech delivery starts with cleaning the bottom of the rock and the ice area under the rock to remove any debris that may alter the course of the rock (2007). The curler places the ball of the foot against the back of the hack and points the toe toward the skip’s broom at the opposite end of the ice. Body weight is mainly on the hack foot and the curler squats down into the hack. Next, the curler places the sliding foot flat on the ice, ahead of the hack foot to the left of the hack, pointing the knee of the hack
foot directly at the skip’s broom. See Figure 5. The shoulders and hips should be square to the skip’s broom. The curler holds the broom ahead of the sliding foot with the pad of the broom facing upward, and maintains this position throughout the delivery. The curler positions the rock under the right shoulder with a small degree of elbow flexion. The curler takes a few seconds to mentally prepare for the shot and then moves onto step two of the delivery.

Figure 6. Set-up for the curling delivery.

Step two of the CurlTech delivery is the forward press (2007). The curler moves the rock forward 4-5 inches. The knee may drop slightly during the forward press, but the lower body should remain relatively still. The curler maintains slight elbow flexion of the right arm. Tschirhart (2006) combines step one and two of the CurlTech delivery into one position, the hack position. This is the first movement of the USA Curling delivery (accessed 03/31/09).

Step three of the CurlTech delivery is the drawback and step movement (2007). See Figure 6. This starts power generation for the delivery. The body moves back as the hips rise. The sliding foot slides back 2-4 inches behind the hack as most of the body
weight shifts to the sliding foot. The sliding foot should remain directly in line with the position from step one. Weight shift onto the sliding foot allows power to develop for the curling delivery. This is the point at which most of the delivery power is generated. The sliding foot stays behind the hack until the rock is 2-3 feet in front of the hack. The sliding foot then moves forward, causing the body to drop slightly toward the ice. The body follows the rock, moving toward a forward lunge position while keeping the rock in front of the body. The combination of moving the sliding foot forward and body drop produces power. The sliding foot should not cross over the center of the body, as this may cause the body to drift toward the right.

Figure 7. Drawback of the curling delivery.

Tschirhart (2006) describes CurlTech’s phase three as the park position. The curler moves the stone straight back toward the hack and then straight forward in the same line. The sliding foot stays about an inch to the side of the hack as it slides backward and forward. The curler does not stop the motion between the back and forward movement unless the curler is going to perform a full take-out shot. USA Curling (03/31/09) labels this phase as the drawback movement. In contrast to the CurlTech
delivery, USA Curling recommends body weight to be evenly distributed on both feet during the drawback phase.

Hot Shots Curling assumes the curler completes phases one and two of the CurlTech delivery prior to starting the actual curling delivery. The first phase of the Hot Shots Curling delivery is the pull back phase (11/9/08). This phase is similar to CurlTech’s phase three and Tschirhart’s phase two. The hips rise up as the stone is pulled straight back towards the hack foot. The sliding foot moves straight back and body weight is transferred to the sliding foot, as the curler pauses prior to the next phase. The hips and shoulders should remain square to the line of delivery, which is an imaginary line from the hack to the skip’s broom.

The next phase of the delivery is the forward slide, in which the curler pushes out of the hack. See Figure 7. This is Tschirhart’s and USA Curling’s step three, CurlTech’s step four, and Hot Shots Curling phase two of the delivery (2006, accessed 03/31/09, 2007; 11/9/08). The curler pushes out of the hack with enough leg drive to balance the weight shift and body drop. According to CurlTech (2007), leg drive is 30% of the total delivery power. Weight shift, body drop and arm extension are the other 70% delivery power. Too much leg drive may cause a pushing-type of slide rather than a fluid forward slide. Body weight transfers completely to the sliding foot during this step. The sliding foot should be centered under the chest and turned out to about 45° to increase the base of support. The broom or sliding device can be used for balance, but downward pressure should not be on the broom or the rock. The hack foot trails directly behind the body along the line of delivery. The shoulders are square to the line of delivery and the
throwing arm is slightly bent. The broom stays ahead of the sliding foot to keep the shoulders square toward the skip's broom.

Figure 8. Forward slide of the curling delivery.

Step five of the CurlTech delivery is the release of the rock (2007). See Figure 8. Hot Shots Curling (11/9/08) names this phase the release of the rock. The curler is sliding forward on the ice with arm holding the rock elbow slightly flexed and the wrist held high. The curler slowly rotates the rock to the twelve o'clock position as the arm straightens and then the fingers release the rock. This allows the rock to continue rotating after the release, allowing the rock to stay along the line of delivery. The rock rotates 2-2 1/2 times from the point of release to the stopping point at the opposite end of the sheet. The rock will move off the line of delivery and cause the person to miss the shot if the rock is moved laterally during the delivery or the athlete raises the arm while turning the rock.
Step six of the CurlTech delivery is the follow-through (2007). The curler remains in the sliding position after letting go of the rock to watch the rock slide down the ice. The curler does not rest the knee or hand on the ice, as this will melt and damage the ice. Tschirhart (2006) combines CurlTech’s step five and six into the pose position. This occurs when the athlete lets go of the rock and maintains the same body position for a few seconds.

The curling delivery changes slightly for different weights or speeds of the rock (CurlTech, 2007). Ice conditions are different in every club and several different weights are required during a curling game. Heavier shots or heavier ice is considered “slow” and requires greater weight shift to the sliding foot behind the hack and more powerful forward leg drive. Three main “weights” occur in general during the curling game; front of the house, in the house, and through the house.
Basic Analysis of the Curling Delivery

Very few researchers have analyzed the biomechanics of the curling delivery. Dr. Bill Sands (2007) conducted an unpublished study on EMG activation and the curling delivery in Olympic-level curlers. He found EMG activity increased when the curler performed a take-out delivery in comparison to the draw-weight delivery. He found that most of the increased EMG activation came from the upper body muscles (biceps brachii, lateral triceps, and anterior deltoid) rather than the lower body (gastrocnemius, vastus lateralis, gluteus maximus, and biceps femoris). Dr. Sands also found the athletes used two different methods of pushing out of the hack. Some of the curlers had a “burst” of EMG activation at the beginning of delivery, whereas other curlers had sustained drive from the leg on the hack.

An article by Tschirhart, Comartin, and Gazdewich (2008) discusses the differences in the backswing and no-backswing delivery. According to Tschirhart et al., (2008) the stretch reflex forms the basis of the backswing delivery. This reflex is activated when the curler draws the hips and the stone backward. This action pre-stretches the muscle, leading to a reflex contraction of the muscle when the curler slides forward. The problem with activating the stretch reflex is less control over the delivery and ability to correct the slide. The energy may be directed off-target if the body is positioned incorrectly or the sliding foot moves too quickly. According to Tschirhart et al., (2008) the stretch reflex in the backswing delivery is more powerful than the newly developed no-backswing delivery. The development of the no-lift delivery has lead to the development of the no-backswing delivery. The authors state that the no-backswing delivery starts right from the hack. The athlete does not slide back prior to the forward
slide, but instead uses hip extension to push out of the hack. Take-out shots require
greater maximal force production in a shorter period of time than the draw-weight or
guard-weight delivery. According to Tschirhart et al., (2008) the no-backswing delivery
looks similar to a sprinter running out of the starting blocks, as the curler leans forward to
maximize triple extension (hip, knee and ankle) and power.

Tschirhart et al. (2008) provides a basic analysis of the delivery in his article. The
starting posture is upright and the knee flexion angle of the drive leg is less than the
sliding knee. The quadriceps stabilize the height of the body during the draw-weight
delivery. According to Tschirhart et al., (2008) the gluteus maximus is the prime mover
for the hack leg and hip extension the primary motion. Knee extension of the hack leg
naturally occurs as the hip extends.

According to Tschirhart et al., (2008) the curler’s body should make an equilateral
triangle during the delivery. The three sides of the triangle include a line down the back,
which must be straight, a line along the arm holding the rock, and a line along the thigh
of the sliding leg. The thigh of the sliding leg should be parallel to the ice surface,
preventing excessive knee flexion. The goal is to prevent the development of anterior
knee pain.

Tschirhart et al. (2008) address delivery-specific flexibility in their article. In
general, female curlers have too much flexibility and not enough strength in the hips and
drop into the delivery position rather than controlling the motion. This “drop” is most
commonly visible at the curler’s head when it abruptly moves downward, rather than
smoothly transitioning inferiorly. USA Curling (1999) also emphasizes delivery-specific
flexibility for many reasons. Adequate flexibility allows the curler to have a smooth delivery. It also contributes to optimum performance and reducing the risk of injury.

**Goniometer Instrumentation**

**Validity and Reliability of Goniometer Measurements**

Gajdosik and Bohannon (1987) reviewed several studies on the reliability and validity of goniometric measurements used in physical therapy. They focused on how reliability is affected by testing procedures, including active versus passive range of motion measurements. The authors found that standardized testing procedures minimized the amount of inaccurate measurements. They also found that some of the reliability was related to changes in range-of-motion (ROM) from repeated trials. Active ROM measurements were much more reliable than passive ROM measurements, possibly because it was hard to standardize the amount of force applied to the limb in passive ROM testing. Gajdosik and Bohannon’s review (1987) also looked at the variability and reliability of intertester and intratester measurements and instrumentation. Their review found greater variability with intertester measurements than intratester measurements. Many studies also showed higher intertester reliability for upper body goniometric measurements than lower body measurements.

Goniometers were generally considered valid measurement tools, even though small errors may occur in the construction of goniometers (Gajdosik & Bohannon, 1987). One limitation of goniometric measurements is the axes of motion are not fixed, because other motions may occur within the joints. Gajdosik and Bohannon (1987) accept this limitation and “are confident that the ROM measured closely approximated movement around a central point.”
Normative Values for Hip Extension Goniometer Measurements


Summary

The sport of curling and the curling delivery have changed dramatically over the past two hundred years. The modern curling delivery technique has improved the curler’s balance, stability, power and accuracy. Curling coaches have attempted to analyze the curling delivery by dividing it into steps or phases. These coaches do not have scientific data to support their analyses, but have developed the delivery technique through direct observations. This study quantifies range of motion variables for the curling delivery trail leg and compares it to goniometric measurements. Active range of motion goniometric measurements have been considered valid and reliable when variables, such as the number of investigators and type of range of motion measurement (active or passive), are
controlled. Further research must be done on the biomechanics of the curling delivery to advance the sport of curling in the United States and throughout the world.
REFERENCES


APPENDIX B

INFORMED CONSENT
INFORMED CONSENT

Research Consent Form
University of Wisconsin – La Crosse
1725 State Street, La Crosse, WI 54601
PI: Ellanora Kraemer

TITLE: Hip and Knee Positions during the Curling Delivery.

*Why have you been asked to participate in this research?*

You are being asked to take part in this research study because you have qualified for the U.S. Junior National Curling Championships. Participation in this study is completely voluntary.

The primary purpose of this study is to determine the relationships between trunk, thigh, hip and knee measurements from the forward slide phase of the curling delivery.

*What will happen during the study?*

For this study, we are asking you to allow us to measure hip extension of your trailing leg for the curling delivery. You are asked to wear loose-fitting pants during the measurement of hip range of motion. Informed consent will be obtained first, followed by range of motion measurements. The investigator will videotape your curling delivery during your prescribed practice time. Please inform the investigator if you have any injuries or medical conditions that may limit your participation in this study.

*How many people will be in this study and how long will this study last?*

This research study may involve about 75 subjects. While this study may span one to three months, your actual participation time will be less than one hour. Curlers will be tested in Devils Lake, North Dakota at the U.S. National Championships.

*What are the possible risks and discomforts of the study?*

Risks and discomforts with participation are minimal. The investigator and data collector is trained in CPR and First Aid. The risk of serious of life-threatening complications, for healthy individuals, is near zero. The risk of having flexibility measured is muscle soreness. The risk of demonstrating the curling delivery is injury from falling on the ice. The tests will be terminated if injuries or complications occur.

*How will you benefit by being a part of the study?*

You may benefit from learning the relationship between hip flexibility and the curling delivery.
Who will have access to your information if you participate in the study?

The principal investigator and thesis committee will have access to information obtained in the study. All efforts will be made to maintain confidentiality, but it cannot be guaranteed. The results of this study may be presented at scientific meetings or in scientific publications; however, subject identities will not be disclosed.

Do you have to participate in this study?

Participation in this study is completely voluntary. Refusing to participate or discontinuing participation at any time will involve no penalty.

What are the costs and payments for taking part in this study?

There are no additional costs to you to take part in this research study. You will not be paid in this study.

What happens if you get sick or hurt as a result of the study?

In the unlikely event that any injury or illness occurs as a result of this research, the Board of Regents of the University of Wisconsin System, and the University of Wisconsin-La Crosse, their officers, agents and employees, do not automatically provide reimbursement for medical care or other compensation. Payment for treatment of any injury or illness must be provided by you or your third-party payor, such as your health insurer or Medicare. If any injury or illness occurs in the course of research, or for more information, please notify the investigator in charge. I have been informed that I am not waiving any rights that I may have for injury resulting from negligence of any person or the institution.

Who can you call if you get sick, injured, or want more information about this study?

We have attempted to write this consent form as clearly as possible for your understanding. Feel free to ask as many questions as you wish about this consent form, the procedures, and any information you do not understand. Study personnel will explain all the procedures that you will be asked to follow.

For more information about this research study or to report injury or side effects, you may contact the student, Ellanora Kraemer, or the study advisor Mark Gibson, Faculty Member, Department of Exercise and Sport Science, UW-L (608-785-8190). Questions regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects (irb@uwlaux.edu).
Informed Assent Form
(Required for Age 12 through 17)

Child/Adolescent’s Understanding:
Have all your questions regarding how the research study might affect you been answered? Yes / No (Circle one)

If you want to be part of the study, please sign your name. If you do not want to be part of the study, then do not sign your name. You can say no to being in the study, and you will not be disliked or treated differently.

_________________________  ______________________
Child/Adolescent’s Signature  Date of Signature

Printed Name of Subject

Parent’s/Court-Appointed Guardian’s Understanding:
Have all your questions about how the research study is going to affect your child and/or yourself been answered? Yes/No (Circle one)

I believe my child is fully informed and is willing to participate in this study.

_________________________  ______________________
Parent’s/Court-Appointed Guardian’s Signature  Date of Signature

Investigator:

I have discussed this study and the possible risks and benefits of the study with the child, and I believe he/she is fully informed and is willing to participate in this study.

_________________________  ______________________
Investigator’s Signature  Date of Presentation

What does signing this form mean?

A signature indicates that:
• You or your child have read the above.
• You or your child have freely decided to take part in the research study described above.
• The studies general purposes, details of involvement and possible risks and discomforts have been explained to you and your child.
You will receive a signed copy of this consent/authorization form, if requested.

Signature of Subject

(If 18 or older and able to give informed consent.)

Printed Name of Subject

............OR.............

Signature of Parent (if subject is less than 18) ....OR....
Health Care Agent as Designated by Power of Attorney
For Health Care (if participant is 18 or older) ......OR.....
Court-Appointed Guardian (Circle appropriate title)
Reason subject was unable to give informed consent:

Printed Name of the Above Signature

Signature of Investigator

Printed Name of Investigator