A Comparison Study of Cervical Range of Motion Between Unilateral Breathers and Bilateral Breathers in Collegiate Swimmers during Freestyle Swimming

Nadine K.M. Takai

University of North Dakota

Follow this and additional works at: https://commons.und.edu/pt-grad

Part of the Physical Therapy Commons

Recommended Citation


https://commons.und.edu/pt-grad/436

This Scholarly Project is brought to you for free and open access by the Department of Physical Therapy at UND Scholarly Commons. It has been accepted for inclusion in Physical Therapy Scholarly Projects by an authorized administrator of UND Scholarly Commons. For more information, please contact zeinab.yousif@library.und.edu.
A COMPARISON STUDY OF CERVICAL RANGE OF MOTION
BETWEEN UNILATERAL BREATHERS AND BILATERAL BREATHERS
IN COLLEGIATE SWIMMERS DURING FREESTYLE SWIMMING.

by

Nadine Kathie Miyoko Takai
Bachelor of Science in Education
Northwestern University, 1992
Bachelor of Science in Physical Therapy
University of North Dakota, 1995

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
1996
This Independent Study, submitted by Nadine KM Takai in partial fulfillment of the requirements for the Degree of Master Physical Therapy for 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.

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title  A comparison study of cervical range of motion between unilateral breathers and bilateral breathers in collegiate swimmers during freestyle swimming.

Department  Physical Therapy

Degree  Master of Physical Therapy

In presenting this Independent Study Report in partial fulfillment of the requirements for graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in her absence, by the Chairperson of the department. It is understood that any copying or publication or other use of this Independent Study Report or part thereof for financial gain shall not be allowed without my permission. It is also understood that due recognition shall be given to me and the University of North Dakota in any scholarly use which may be made of any material in my Independent Study Report.

Signature  [Signature]
Nadine KM Takai

Date  Dec. 7th, 1995
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST of FIGURE</td>
<td>v</td>
</tr>
<tr>
<td>LIST of TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>vii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>viii</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I LITERATURE REVIEW</td>
<td></td>
</tr>
<tr>
<td>Breathing Styles</td>
<td>3</td>
</tr>
<tr>
<td>Purpose of this study</td>
<td>8</td>
</tr>
<tr>
<td>II METHODOLOGY</td>
<td></td>
</tr>
<tr>
<td>Subjects</td>
<td>9</td>
</tr>
<tr>
<td>Tester</td>
<td>9</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>10</td>
</tr>
<tr>
<td>Procedure</td>
<td>12</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>15</td>
</tr>
<tr>
<td>III RESULTS</td>
<td></td>
</tr>
<tr>
<td>Subject's Demographics</td>
<td>16</td>
</tr>
<tr>
<td>Results between Breathing Styles</td>
<td>16</td>
</tr>
<tr>
<td>Results by Gender</td>
<td>18</td>
</tr>
<tr>
<td>Results by Age</td>
<td>18</td>
</tr>
<tr>
<td>IV DISCUSSION</td>
<td></td>
</tr>
<tr>
<td>The Results</td>
<td>21</td>
</tr>
<tr>
<td>Further Studies</td>
<td>23</td>
</tr>
<tr>
<td>V CONCLUSION</td>
<td>24</td>
</tr>
<tr>
<td>APPENDIX</td>
<td></td>
</tr>
<tr>
<td>A Subject's Questionnaire</td>
<td>25</td>
</tr>
<tr>
<td>B Data Collection Sheet</td>
<td>26</td>
</tr>
<tr>
<td>C Information and Consent Form</td>
<td>27</td>
</tr>
<tr>
<td>D IRB Form and Approval</td>
<td>28</td>
</tr>
<tr>
<td>E Testing Procedure</td>
<td>33</td>
</tr>
<tr>
<td>F Permission to reprint</td>
<td>35</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>36</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sequence of freestyle swimming</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>CROM device placement on subject's head</td>
<td>11</td>
</tr>
<tr>
<td>3.</td>
<td>CROM device with magnetic yoke</td>
<td>13</td>
</tr>
</tbody>
</table>
**LIST OF TABLES**

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Normative data on cervical rotation using the CROM device</td>
<td>6</td>
</tr>
<tr>
<td>2. Comparison of cervical rotation based on breathing style</td>
<td>17</td>
</tr>
<tr>
<td>3. Comparison of cervical rotation by gender</td>
<td>19</td>
</tr>
<tr>
<td>4. Comparison of cervical rotation by age</td>
<td>20</td>
</tr>
</tbody>
</table>
ACKNOWLEDGMENT

I would sincerely like to thank the faculty at the University of North Dakota-Physical Therapy Program. I am sincerely grateful to my advisor, Sue Jeno, for her guidance, encouragement, time and effort in assisting me with my independent study project. I also want to thank, Renee Mabey, for her statistical knowledge. In addition, I want to thank my fellow classmates, especially Nancy Fiest and Chandel Dietz for their assistance.

I would also like to thank the North Dakota Varsity swim team and their coach, Mike Stromberg, for their participation in my study.

My dearest appreciation to Ronnie Day, my fiancée, for his never ending love, encouragement and support over these years. Also, a special thanks to my parents, Erik and Naomi, my siblings, K. Mark, Ross, and Nikki, and my future in-laws for their love and support.
ABSTRACT

The purpose of this study was to determine if there is a difference in cervical rotation between unilateral breathers and bilateral breathers for freestyle swimmers. The sample consisted of 44 (23 males, 21 females) University of North Dakota Varsity swim team members. Among the swimmers there were 19 bilateral breathers, 21 right unilateral, and 4 left unilateral breathers. The CROM device was the tool used to measure cervical rotation. An ANOVA analysis showed no significant difference in right rotation (p=.6585) and total rotation (p=.0693) for any breathing style, however a significant difference existed for left rotation (p=.0078) between bilateral and right unilateral breathers. The female swimmers showed significantly more cervical rotation than their male counterparts (p<.01). There was no significant difference based on age (p>.5). Bilateral breathers showed a significant difference between right rotation and left rotation (p=.011), however right unilateral breathers showed no significance (p=.583). Even though left unilateral breathers showed a seven degree increase in left rotation when compared to right rotation, significance could not be established due to the small sample size. Therefore, asymmetrical cervical rotation in swimmers may not necessarily indicate a pathological finding and is important to take into consideration when determining a rehabilitation
program for a swimmer with upper quadrant pathology. Additional research is needed to compare swimmers' varying swimming styles with range of motion measurements.
Imagine swimming 8,000 yards per day, five times per week, and 10 months per year. Murphy\textsuperscript{1} claimed that, on average, swimmers take six to ten strokes per length (25 yards). A bilateral breather breathes every third stroke, which results in at least 64,000 breaths per day; 320,000 breaths per week; 1,280,000 breaths per month. The repetitive cervical rotation that occurs during the breathing phase of freestyle swimming may cause repetitive injuries and overuse syndromes to the cervical spine.

According to Beach et al\textsuperscript{2}, freestyle is performed 80\% of the time for all swimmers regardless of their specialty. Freestyle is performed in the prone position (Figure 1). The swimmer starts with both arms and legs extended. To propel through the water, an alternating armstroke pattern is used in combination with a flutter kick. To breathe, the swimmer must turn his/her head to clear the water.

According to Councilman\textsuperscript{3}, the swimmer rolls on the longitudinal axis of his or her body to breath. Councilman claims that the body should roll $40^\circ$ plus or minus $5^\circ$. This body roll facilitates breathing by decreasing the amount of cervical rotation needed to take a breath. Councilman emphasized that the
Figure 1. -Sequence of Freestyle swimming.
Reprinted/Adapted by permission from Allyn and Bacon
swimmer should achieve the position to take a breath by rotating his or her neck on the body's longitudinal axis and without extending or sidebending the head. Based on this finding, this study will only compare cervical rotation of swimmers based on their breathing style.

There are two main types of breathing styles in freestyle swimming:

1) bilateral breathing, in which the swimmer breathes on both sides and
2) unilateral breathing, in which the swimmer breathes only on one side.

Bilateral breathing or alternate breathing consists of the swimmer breathing on one side, taking three arm strokes, and breathing to the other side. Many authors cite that alternate breathing has many advantages. The advantages of breathing bilaterally encourages the swimmer to be more symmetrical with his or her stroke. In addition, some authors state that decreasing the number of breaths taken may improve pulmonary capacity (hypoxic breathing training). As a competitive swimmer, bilateral breathing facilitates visualization of opponents on both sides. Maglisho states that the only argument against bilateral breathing is that the swimmer takes fewer breaths per lap which will result in an overall decrease of oxygen intake throughout a race. Decreased total oxygen intake may lead to earlier fatigue.

Unilateral breathers, take a breath every even numbered stroke, breathing to the same side each time. Many authors believe that unilateral breathing contributes to asymmetries that can lead to pathological conditions. These pathological conditions can be associated with muscle imbalances in the
Murphy states that there is inconsistent data on correlating breathing style to shoulder pathology. In his clinical experience, he has seen fewer impingement problems with bilateral breathers than with unilateral breathers.

During an intensive literature search on cervical range of motion specific to swimming, only one article on this topic was located. Guth's study compared cervical range of motion in 14-17 year old male swimmers (n=40) to normal adolescent males (n=40). This study consisted of eighty subjects, subdivided into four categories based on age. Guth determined in her research that there was a significant increase (p=.002) in rotation of the cervical spine in adolescent male swimmers versus normal males. She also found that the unilateral breathers in her sample showed significant increase in range of motion toward their breathing side. While Guth described cervical rotation in swimmers without pathology, an article by H.A. Ross, D.O. considered a treatment for swimmers with cervical pathology.

Dr. Ross coined the term “swimmer’s neck”. He suggested that swimmers with any neck pathology should use a mask and snorkle to breathe while swimming to decrease cervical movement. He stated that the head should be maintained in a neutral position without any cervical rotation, thereby reducing any repeatative trauma to the cervical spine. However, he did not address cervical range of motion specifically.
Range of motion is a common diagnostic tool used today by physical therapists to assess pathology. The most common guidelines for range of motion norms used today are those developed by the American Medical Association (AMA) and American Association of Orthopedic Surgeons (AAOS). These normative guidelines do not specify the measurement tool nor the sample's gender and age group. The AMA guideline for cervical rotation is 80°, whereas the AAOS guideline for cervical rotation is 60°.

There have been many studies measuring cervical range of motion in normal subjects versus subjects with a pathology from various age groups. Youdas et al established norms for cervical range of motion using the CROM device. The testers measured the differences in cervical range of motion between gender and ages. Their study consisted of 337 subjects ranging from eleven years old to ninety-seven years old. The normative data for cervical rotation is depicted in Table 1. They found that females tended to have more cervical rotation than their male counterparts of the same age. For right rotation and left rotation, the males had 4° and 20° less motion, respectively. They also concluded that throughout our life span, cervical range of motion decreases approximately 3°-5°.

Kuhlman did a similar study to Youdas et al, comparing gender and age with cervical range of motion. In this study, a gravity goniometer was the measuring device. The purpose of this study was to establish normative values for cervical range of motion between elderly subjects (n=42) and compare it with
Table 1. Normative data on cervical rotation using the CROM device

<table>
<thead>
<tr>
<th>Author</th>
<th>Right Rotation</th>
<th>Left Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ROM*</td>
<td>SD</td>
</tr>
<tr>
<td>Rheault, et al\textsuperscript{18}</td>
<td>61.7</td>
<td>11.8</td>
</tr>
<tr>
<td>Capuano-Pucci, et al\textsuperscript{15}</td>
<td>70.8</td>
<td>5.3</td>
</tr>
<tr>
<td>Youdas, et al\textsuperscript{17}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-19 yrs.-male</td>
<td>74.1</td>
<td>7.6</td>
</tr>
<tr>
<td>11-19 yrs.-female</td>
<td>74.9</td>
<td>9.8</td>
</tr>
<tr>
<td>20-29 yrs.-male</td>
<td>69.9</td>
<td>6.0</td>
</tr>
<tr>
<td>20-29 yrs.-female</td>
<td>74.6</td>
<td>5.9</td>
</tr>
<tr>
<td>30-39 yrs.-male</td>
<td>67.1</td>
<td>7.4</td>
</tr>
<tr>
<td>30-39 yrs.-female</td>
<td>71.7</td>
<td>5.7</td>
</tr>
<tr>
<td>40-49 yrs.-male</td>
<td>64.6</td>
<td>9.6</td>
</tr>
<tr>
<td>40-49 yrs.-female</td>
<td>70.2</td>
<td>6.6</td>
</tr>
<tr>
<td>50-59 yrs.-male</td>
<td>61.0</td>
<td>7.7</td>
</tr>
<tr>
<td>50-59 yrs.-female</td>
<td>61.2</td>
<td>8.6</td>
</tr>
<tr>
<td>60-69 yrs.-male</td>
<td>53.6</td>
<td>7.4</td>
</tr>
<tr>
<td>60-69 yrs.-female</td>
<td>65.2</td>
<td>9.7</td>
</tr>
<tr>
<td>70-79 yrs.-male</td>
<td>50.0</td>
<td>10.2</td>
</tr>
<tr>
<td>70-79 yrs.-female</td>
<td>53.4</td>
<td>8.8</td>
</tr>
<tr>
<td>80-89 yrs.-male</td>
<td>46.4</td>
<td>8.2</td>
</tr>
<tr>
<td>80-89 yrs.-female</td>
<td>52.6</td>
<td>10.5</td>
</tr>
<tr>
<td>90-97 yrs.-male</td>
<td>44.2</td>
<td>14.3</td>
</tr>
<tr>
<td>90-97 yrs.-female</td>
<td>51.8</td>
<td>8.7</td>
</tr>
</tbody>
</table>

*ROM in degrees
young adults (n=31). The elderly females (70-90 years old) had 73.7° rotation to the right and 74.6° rotation to the left, and their male counterparts had 71.4° right rotation and 70.1° left rotation. In comparison, the young females (20-30 years old) had 95.8° cervical rotation right and 95.3° cervical rotation left. The young adult males (20-30 years old) had 90.3° and 90.4° cervical rotation to the right and left respectively. He concluded that cervical range of motion was significantly less (p<.001) in the elderly population in all planes and that females had more range of motion than males. The two studies mentioned above indicate that range of motion measurements will differ for individuals based on their gender and their age.

The results in the preceding studies show inconsistencies in the normative data between the measuring devices used to measure cervical range of motion. This makes it difficult to determine if the patient has excessive or limited range of motion. Youdas et al\textsuperscript{15} did a comparison study on the reliability between the CROM device, Universal Goniometer, and visual estimation for cervical range of motion. They concluded that the CROM device (ICC>.80) was the most reliable in measuring cervical range of motion when compared to the other two tools (ICC<.80) for both intratester and intertester reliability.

When determining if a patient has limited cervical range of motion, these studies should be taken into consideration. If the therapist uses the CROM device as a mean of measurement, he or she should use the norms established with the CROM. Table 1 compares collected data for cervical rotation from
various studies which utilized the CROM device.\textsuperscript{14,16,17} The CROM device will be used as the primary means of measurement in this study.

More research is required to determine the effects of breathing style and the consequences of repetitive motion on the cervical spine. This study is designed to help establish data on swimmer's cervical range of motion for rotation. The purpose of this study is to determine if there is a difference in cervical rotation between unilateral and bilateral breathers during freestyle swimming.
CHAPTER 2

METHODS

Subjects:

The sample consisted of the University of North Dakota swim team members. There were forty-four subjects (23 males and 21 females), who participated in this study. The average age was 19.8 years with a standard deviation of 1.4 years. The subject participation criteria consisted of being over eighteen years old and having no history of cervical pathology. For this study, cervical pathology was defined as any neck injury that required medical attention. An approved informed consent form was signed by all subjects prior to the experiment. Approval for this research project was given by the University of North Dakota Institutional Review Board under project number IRB-9504-257 (Appendix D).

Tester:

A University of North Dakota Physical Therapy graduate student was the only tester involved in data collection. One observer was present during the research to ensure that the gravity dials of the CROM device remained at zero. The tester’s previous experience using the CROM was minimal. The tester was instructed in the use of the CROM during an evaluation class at the University of

9
North Dakota-Physical Therapy School. Prior to data collection, the tester reviewed the video on the CROM (Performance Attainment Associates, 958 Lydia Drive, Roseville, MN, 55113)\textsuperscript{20}. In addition, the tester had utilized the CROM on approximately four patients during her clinical affiliation.

A study by Capuano, et al\textsuperscript{14} showed that intratester reliability for rotation was high (above .85) with the exception of one tester, who showed a moderate reliability (.62) for right rotation. Whereas a study by Youdas, et al\textsuperscript{15} showed that intratester reliability for the CROM was consistently high for all testers. (.90 for left rotation and .93 for right.)

To ensure proper technique, intrarater reliability was performed with five junior physical therapy students serving as subject models. This tester's intratester reliability results demonstrated high or very reliable correlation ($a = .8993$).\textsuperscript{21,23,25}

**Instrumentation:**

The CROM device is made out of a light durable plastic. It fits on the subject's head similar to wearing eyeglasses. The nose piece fits on the bridge of the subject's nose and the bows fit over the subject's ears. A Velcro strap secures the CROM snugly to the subject's head. In addition, a magnetic yoke is applied around the subject's neck (Figure 2). Since the CROM uses a compass goniometer to measure rotation, the magnetic yoke enhances the magnetic field to give a more accurate reading. The CROM has two other gravity dials. One dial is in the frontal plane, which is used to measure lateral flexion and the other
Figure 2.-CROM device placement on subject's head
dial is in the sagittal plane, which is used to measure flexion and extension (Figure 3).

To test the accuracy of the CROM, Youdas et al.\textsuperscript{16} used a rotatary table that measured the CROM to the nearest degree. Their results showed a range from -2 to 2 degrees between three different testers. This verifies the static validity of the CROM. In order to prove that the CROM is valid for measuring actual cervical rotation, further studies must be done to accurately compare vertebral motion with measurements of the CROM. There have been no studies to date which measure actual vertebral cervical rotation in comparison to measurements taken with the CROM device.

**Procedure:**

Fifteen minute appointment times were established for data collection for each subject. The volunteers were randomly assigned to an appointment time. Prior to testing, each subject signed an informed consent form and filled out a questionnaire (Appendix A & C). Each subject was assigned a sequential "subject number" to maintain confidentiality. Questionnaires were kept separate form the data collection form (Appendix B) and were not reviewed until after data collection was compete. This was done to limit tester bias. Prior to data collection, the subject was asked to remove all jewelry and/or bulky clothing which might interfere with the experiment (i.e. eyeglasses, hair pieces, sweatshirts). The subjects were then taken to the testing area, where a verbal
Figure 3.- CROM device with magnetic yoke
explanation of the procedure and the measuring device was given by the tester (Appendix E).

In the testing area, the subjects sat in a standard metal-frame straight-back chair with their feet flat on the floor and their arms relaxed at their sides. Instructions were given to face the front and to keep their head and eyes fixed straight ahead. The magnetic yoke was applied around the subject's neck with the arrow pointing north. The CROM was placed securely on the subjects' head.

Each subject was given one trial rotation to the right and one trial rotation to the left. Verbal instructions were to "turn your head to the right as far as you can without tilting your head." The verbal instructions also stated that the shoulders should remain in contact with the back of the chair and not move; even though the CROM procedure manual stated that rotating the trunk will not affect the cervical measurement, and rotating the shoulders would only affect trunk rotation. A horizontal line was set-up on the walls of the testing area to assist the subjects with maintaining a neutral head position. This line also assisted in visual tracking. The subject was told to stop and wait at terminal rotation until the tester gave a verbal cue to return to the front.

All three dials were monitored for the zero position by the observer before each rotation. Zeroing of the gravity dials verified that the subject achieved a neutral alignment in the starting position. The gravity dials remained at zero throughout the testing procedure to ensure no lateral bending and flexion occurred at the cervical spine. Readings were taken from the magnetic dial.
Each subject performed three active physiological cervical rotations to the right and three active rotations to the left. The measurements were taken and recorded for all six rotation positions. After these measurements were obtained, the test was complete. At that time, the CROM and yoke were removed and the subject was thanked for their participation.

Data Analysis:

The mean value of the three trials for each rotational direction was calculated using a standard calculator and rounded to the nearest tenth. Computer software spssx\textsuperscript{22} was utilized to calculate the remaining statistical data. Frequency variables were calculated from the data obtained though the questionnaires. An ANOVA was utilized to determine if a significant difference existed in cervical rotation between bilateral breathers and right and left unilateral breathers. Post-hoc Tukey and Scheffe tests were performed to check for a significance between two treatment conditions based on breathing style.\textsuperscript{24} This test reduced the chance for a Type I error to occur. A p value of <.05 was considered to be significant.
CHAPTER 3

RESULTS

Demographics of the subjects were obtained from the questionnaire. Frequency variables were computed using the spssx program. There were a total of 44 swimmers, who participated in this study. The mean age was 19.8 years with a standard deviation of 1.4 years. There were 23 males and 21 females. The swimmers were asked to report the number of years they participated in competitive swimming, the number of breathes per 25 yards freestyle, and to indicate if they had experienced any shoulder injury and to state which shoulder or shoulders were involved. In addition, all subjects had to be free of cervical pathology. The mean years of swimming was ten years with a standard deviation of 3.2 years. The average number of breathes per length (25 yards) was seven breaths with a standard deviation of 2.4 breaths. Out of 44 swimmers, 30 reported no previous shoulder injury that required medical attention. However, ten swimmers had shoulder injuries to both shoulders, two swimmers reported right shoulder injuries; and two reported injuries to the left shoulder.

The results of the cervical rotation between breathing styles is summarized in Table 2. Table 2 shows the mean values of total rotation, right
Table 2: Comparison of cervical rotation based on breathing style

<table>
<thead>
<tr>
<th>Breathing Style</th>
<th>n</th>
<th>Right Rotation</th>
<th>SD</th>
<th>Left Rotation</th>
<th>SD</th>
<th>Total Rotation</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral Breather</td>
<td>19</td>
<td>70.7</td>
<td>10</td>
<td>75.5</td>
<td>9</td>
<td>146.2</td>
<td>17</td>
</tr>
<tr>
<td>Unilateral-Right</td>
<td>21</td>
<td>68.4</td>
<td>7</td>
<td>67.6</td>
<td>8</td>
<td>136.0</td>
<td>13</td>
</tr>
<tr>
<td>Unilateral-Left</td>
<td>4</td>
<td>70.5</td>
<td>6</td>
<td>77.2</td>
<td>9</td>
<td>147.6</td>
<td>13</td>
</tr>
<tr>
<td>Group</td>
<td>44</td>
<td>69.8</td>
<td>8</td>
<td>71.6</td>
<td>9</td>
<td>141.5</td>
<td>15</td>
</tr>
</tbody>
</table>

*ROM is in degrees
cervical rotation, and left cervical rotation between the types of breathing styles, bilateral versus unilateral breathers. Based on an ANOVA-oneway, there was no significant difference between the breathing styles for total rotation (F=2.8515, p=.0693) or for right rotation (F=.4221, p=.6585) for any breathing style. The overall total cervical range of motion for rotation between breathers revealed that right unilateral breathers had the least total range of motion. A significant difference in range of motion at p<.01 level was found for left rotation (F=5.4754, p=.0078) between right unilateral breathers and bilateral breathers. The right unilateral breathers had the least amount of left cervical rotation, whereas the left unilateral breathers had the most. Significance could not be established between the left unilateral breathers and right unilateral breathers due to the small sample size (n=4).

In addition, an ANOVA-oneway was computed to determine if a difference existed between genders and ages. The female subjects had significantly more cervical range of motion to the right, to the left, and total rotation (Table 3). However, no significant difference was found when comparing the age of the subjects. The age range was from 18 years old to 23 years old. Table 4 shows the mean value of right and left cervical rotation for each age group.
Table 3. Comparison of cervical rotation by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>n</th>
<th>Right Rotation</th>
<th>Left Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mean*</td>
<td>SD</td>
</tr>
<tr>
<td>Males</td>
<td>23</td>
<td>66.12</td>
<td>6.57</td>
</tr>
<tr>
<td>Females</td>
<td>21</td>
<td>73.40</td>
<td>7.52</td>
</tr>
<tr>
<td>Group</td>
<td>44</td>
<td>69.60</td>
<td>7.87</td>
</tr>
</tbody>
</table>

*ROM in degree
Table 4. Comparison of cervical rotation by age

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>n</th>
<th>Right Rotation</th>
<th>Left Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mean*</td>
<td>SD</td>
</tr>
<tr>
<td>18</td>
<td>12</td>
<td>70.85</td>
<td>2.37</td>
</tr>
<tr>
<td>19</td>
<td>6</td>
<td>67.23</td>
<td>3.54</td>
</tr>
<tr>
<td>20</td>
<td>13</td>
<td>70.46</td>
<td>8.73</td>
</tr>
<tr>
<td>21</td>
<td>7</td>
<td>68.29</td>
<td>4.67</td>
</tr>
<tr>
<td>22</td>
<td>5</td>
<td>67.60</td>
<td>9.38</td>
</tr>
<tr>
<td>23</td>
<td>1</td>
<td>76.70</td>
<td>0.00</td>
</tr>
<tr>
<td>group</td>
<td>44</td>
<td>69.60</td>
<td>7.87</td>
</tr>
</tbody>
</table>

*ROM in degrees
CHAPTER 4
DISCUSSION

This study compared cervical rotation between breathing styles of swimmers, their ages and their gender. The CROM device was chosen as the measuring tool because many studies have proven the CROM to be very reliable in measuring cervical rotation.15-19

This study’s findings on the effect of breathing style in cervical range of motion did not concur with Guth’s study.9 Guth compared cervical rotation between 14-17 year old male non-swimmers and 14-17 year old male swimmers, and in addition did a comparison analysis between cervical rotation of the swimmers and their breathing styles. In her study, a significant increase was found in cervical rotation when compared to that of nonswimmers. In addition, Guth found a significant increase in cervical rotation to the specific breathing side of the swimmer.

The results of this study showed a trend toward an increase in cervical range of motion in left unilateral breathers toward their breathing side. However, a significant difference could not be established due to the small sample size (n=4). The results showed that left unilateral breathers had seven degrees more left cervical rotation than right cervical rotation. In addition, left unilateral
breathers had the most left cervical rotation when compared to right unilateral breathers and bilateral breathers.

It was interesting to note that the right unilateral breathers had the least amount of cervical rotation for both right and left rotation. Councilman\textsuperscript{3} states that increasing body roll decreases the amount of cervical rotation, which is required during the breathing phase of freestyle swimming. However, there is no analysis available in the literature of swimming styles that can support these results.

For bilateral breathers, it could be theorized that the cervical rotation right and left would be equal. This was not found to be true in this study. The bilateral breathers had four degrees more left rotation than right rotation, which was found to be significant. This finding contradicts many studies that support bilateral breathing to promote more symmetrical motion.\textsuperscript{3-8}

Further analysis of the results revealed that age was not a factor influencing the results. The age range was 18 years to 23 years. Based on an ANOVA, there was no significant difference between 18 through 23 year old subjects. Based on Youdas et al\textsuperscript{16} study, the normative data for cervical rotation for this age range was approximately 71 degrees for left rotation and 72 degrees for right rotation. The results of this study were comparable, the subjects averaged 72 degrees for left and 70 degrees for right rotation (Table 3).

Gender was found to be an influencing factor in cervical range of motion. For both right and left rotation, the results showed that females had
seven degrees more rotation than their male counterparts (Table 4). This data correlates with many studies that have found females to have more range of motion than males.\textsuperscript{16,18,25}

The sample in this study consisted of UND varsity swim team members. The self-reported background data varied greatly and contained many inconsistencies. These inconsistencies occurred between swimming experience, daily yardage, and breaths per length, all which could have influenced the results in this study.

Further studies should be done to compare these collegiate swimmers to other collegiate swimmers in a NCAA Division II schools in order to increase the sample size. To get normative data, data can be collected on collegiate non-swimmers and a comparison can be made to the swimmer's sample. Comparing age can be another avenue for further research, comparing age-group swimmers (under 18 years old) with master (over 30 years old) swimmers. The use of cinematography can assist in analyzing body rolls between breathing styles and comparing it to cervical rotation, to determine if swimming style is a factor in cervical range of motion. Increasing the sample size of left unilateral breathers will help determine any significance in the results. Using the data from this study, a repeated measures test could be done to compare preseason and postseason measurements. This will help determine if training has an affect on the results.
CHAPTER 5

CONCLUSION

The results of this study did not conclusively verify that the repeated cervical motion that occurs during the breathing phase of swimming may cause an increase in cervical rotation, especially toward their breathing side. Bilateral breathers showed a significant difference between right rotation and left rotation. Right unilateral breathers did not show a significant increase of cervical rotation to their breathing side. Left unilateral breathers showed a seven degree increase to their breathing side, however significance could not be established due to the small sample size. This trend suggests that the asymmetries between left and right cervical rotation for swimmers may be “normal” or expected, dependent on their breathing style.

Therefore, factors that must be taken into considerations when measuring cervical range of motion include age, gender, and the type of device used. In addition, the therapist must recognize any activities the patient may be involved in, for example swimming, prior to determining if excessive or limited range of motion is pathological or attributed to their activities.
Appendix A

Subject's Questionnaire

Name: ___________________________  Code Number: ________
Age: ______
Sex: ______
Height: ______
Weight: ______

Hand Dominance: ______

Type of freestyle breather: (please mark appropriately)

  Bilateral breather ______

  Unilateral breather-Right ______

  Unilateral breather-Left ______

How many years have you been competitively swimming? ______

How months do you swim per year? ______

What is your approximate daily yardage? ______

How many breathes per length (25 yards) do you breathe? ______

Any previous incident of shoulder pathology? Yes ________ No ________
(pathology is defined as any shoulder problem requiring medical attention)

If yes, which shoulder: Right ________ Left ________ Both ________

Thank You for participating in this study.
Appendix B

Cervical Range of Motion Data:
Subject’s Code Number: ________

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C
INFORMATION AND CONSENT FORM

TITLE: A Comparison Study of Cervical Range of Motion Between Unilateral Breathers and Bilateral Breathers in Collegiate Swimmers during Freestyle Swimming.

You are being invited to participate in a study conducted by Nadine KM Takai, a student in the Masters of Physical Therapy Program at the University of North Dakota. The purpose of this study is to determine if there is a difference in your neck motion based on your type of breathing style during freestyle swimming. Only subjects without a history of neck pathology will be asked to participate in this study. Pathology is defined as any neck injury that required medical attention.

I anticipate that the experimental session will last about one hour total. You will be asked to report to the Hyslop Swimming Pool at the University of North Dakota at an assigned time. You will be asked to complete a questionnaire. Then you will be instructed on the process of performing cervical rotation. I will be measuring the amount of movement that will occur at your neck.

Any information that is obtained through this study that can identify you will be kept confidential and will be disclosed only with your permission.

Your decision whether or not to participate will not prejudice your future relations with the Physical Therapy Department of the University of North Dakota. If you decide to participate, you are free to discontinue participation at any time without prejudice.

There is always some degree of risk involved when participating in an experimental procedure. However, the investigator in this study feels that the risk of injury or discomfort is minimal.

The investigator involved is available to answer any questions that you have concerning this study. In addition, you are encouraged to ask any questions concerning this study that you may have in the future. Questions may be asked by calling Nadine KM Takai at 777-2831. A copy of this consent form is available to all participants in this study.

In the event that this research activity results in physical injury, medical treatment will be available, including first aid, emergency treatment, and follow-up care as it is to a member of the general public in similar circumstances. Payment for such treatment must be provided by you and your third party payor, 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 PARTICIPATE IN THE RESEARCH PROJECT.

Participant’s Signature Date

Witness Signature (not the scientist) Date
Appendix D

EXQUISITE REVIEW REQUESTED UNDER ITEM ___ (NUMBER[S]) OF HHS REGULATIONS
EXEMPT REVIEW REQUESTED UNDER ITEM ___ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA
HUMAN SUBJECTS REVIEW FORM
FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED
PROJECTS INVOLVING HUMAN SUBJECTS

PRINCIPAL INVESTIGATOR: Nadine KM Takai TELEPHONE: 777-2831 DATE: 4-19-95

ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: P.O. Box 9637, University of North Dakota


PROJECT TITLE: A Comparison Study of Cervical Range of Motion between Unilateral Breathers and Bilateral Breathers in Collegiate Swimmers during Freestyle Swimming

FUNDING AGENCIES (IF APPLICABLE): ________________________________ DISSERTATION OR
TYPE OF PROJECT: __ NEW PROJECT __ CONTINUATION __ RENEWAL __ THESIS RESEARCH __ STUDENT RESEARCH PROJECT
__ CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER: Sue Jeno MA, PT

PROPOSED PROJECT: __ INVOlVES NEW DRUGS (IND) __ INVOlVES NON-APPROVED USE OF DRUG __ INSTITUTION

IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATIONS, PLEASE INDICATE THE CLASSIFICATION(S):
__ MINORS (<18 YEARS) __ PREGNANT WOMEN __ MENTALLY DISABLED __ FETUSES __ MENTALLY RETARDED
__ PRISONERS __ ABORTUSES __ UND STUDENTS (>18 YEARS)

IF YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE ___

1. ABSTRACT: (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.

Most competitive swimmers spend at least half of their practice time performing freestyle. Repeated cervical rotation occurs during the breathing phase in freestyle swimming. A swimmer has the option to breathe unilaterally (to one-side) or bilaterally (to both sides). Unilateral breathers breathe on one side either to their left or to their right, every two (2) arm strokes. Bilateral breathers breathe to the right and then to the left alternating every 3 arm strokes.

The purpose of this study is to determine if there is a difference in cervical range of motion between unilateral breathers and bilateral breathers during freestyle swimming. The results of this study will establish research data on swimmer's cervical range of motion. This information is valuable when designing a rehabilitation program for swimmers with upper quadrant pathology and is directly applicable to clinical practice. Currently, little research has been done to investigate swimmer's neck mobility. Because this research is specific to swimmers, it is necessary to use human subjects.
SUBJECTS:
The sample will consist of 60 University of North Dakota Varsity Men's and Women's Swimming Team members, ages 18-25 years, with no history of cervical pathology. The subjects will be voluntarily recruited.

INSTRUMENT:
The CROM (cervical range of motion) device will be used to measure cervical rotation. The CROM is placed on the subject's head, aligned on the bridge of their nose and ears, and fastened to the back of their head with a velcro strap. A magnetic plane meter measures rotational movement in combination with a magnetic yoke placed on the subject's shoulder. The magnetic yoke consists of two magnetic poles pointing north.

The reliability of the CROM was tested by Rheault, et al. Their results showed that there was no significant difference between testers (intertester) and sessions (intratester), \(p=0.01\).

METHOD:
Upon signing the consent form, verbal instructions will be given concerning the purpose and the procedure of the experiment. Then, the subjects will be given a demographic questionnaire (See Appendix A). Upon completion of the questionnaire, the subjects will be directed to a testing area.

Prior to entering the testing area, the subjects will be asked to remove all jewelry and clothing that might interfere with the experiment. The testing area will consist of a straight back chair. A horizontal line will be placed on the wall in front, to the left, and to the right of the subject, the line will be used for the purpose of tracking. The subjects will be instructed to follow this line when performing cervical rotation.

The subject will be positioned in the straight chair facing 90 degrees to magnetic north, with feet flat on the floor, arms relaxed at their sides, and eyes fixed straight ahead. At that time, the CROM device will be positioned on the bridge of their nose and over the ears of the subject, similar to applying eyeglasses. The instrument will be fastened to the subject’s head by the velcro strap attached to the device. In addition, a shoulder mounted magnetic yoke will be applied to assist with the compass goniometer needed for measuring cervical rotation.

The subject will be instructed by the tester on the active physiological cervical rotation. This will be followed by a warm up period. The warm up period will consist of each subject performing one (1) repetition of cervical rotation to the right and one (1) repetition of cervical rotation to the left. Data collection will consist of the measurements recorded of the subject's cervical rotation to the right for three (3) trials and then to the left for three (3) trials. The measurements will be recorded to the nearest degree. The recordings will be recorded on the pre-printed data form (see Appendix B).

3. BENEFITS: (Describe the benefits to the individual or society.)

The results on this study will establish research data on swimmer's cervical rotation. It will assist physical therapist in determining sport-specific rehabilitation and protocol for swimmers. Currently, little research has been done to investigate the cervical spine and its implications for injury and rehabilitation. Therefore, this research will add to the understanding of swimmer's neck based on cervical rotation measurements.

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.)

The risk to the subjects in this experiment will be minimal. The CROM device is an assessment tool used routinely in the physical therapy clinics for measuring cervical range of motion. The subjects will perform movements that are normal to the cervical spine. Therefore, this experiment should not cause any neck discomfort.

The data will be collected in a confidential manner, and the collected data will be kept confidential. The subjects will be assigned a code number and names withheld to ensure strict confidentiality.
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.

The consent forms will be kept by Sue Jeno in the Department of Physical Therapy, Medical Science North, Room 151, for a period of two (2) years. A copy of the consent form is attached. (See Appendix C).

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  
Box 8138, University Station  
Grand Forks, North Dakota 58202

On campus, mail to: Office of Research & Program Development, Box 134, or drop it off at Room 101 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:**

<table>
<thead>
<tr>
<th>Position</th>
<th>DATE:</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>Project Director or Student Adviser</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training or Center Grant Director</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Revised 8/1992)
UNIVERSITY OF NORTH DAKOTA'S
INSTITUTIONAL REVIEW BOARD

DATE: April 19, 1995
PROJECT NUMBER: IRB-9504-257

NAME: Nadine KM Takai
DEPARTMENT/COLLEGE: Physical Therapy

PROJECT TITLE: A Comparison Study of Cervical Range of Motion Between Unilateral
and Bilateral Breathers in Collegiate Swimmers During Freestyle Swimming

The above referenced project was reviewed by a designated member for the University's
Institutional Review Board on 4/21/95 and the following action was taken:

☐ Project approved. EXPEDITED REVIEW NO. 3
Next scheduled review is on April 1996.

☐ Project approved. EXEMPT CATEGORY NO. ______. No periodic review scheduled
unless so stated in REMARKS SECTION.

☐ Project approved PENDING receipt of corrections/additions in ORPD and approval by
the IRB. This study may NOT be started UNTIL IRB approval has been received. (See
REMARKS SECTION for further information.)

☐ Project approval deferred. This study may not be started until IRB approval has
been received. (See REMARKS SECTION for further information.)

☐ Project denied.
(See REMARKS SECTION for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the
research project must be reported immediately to the IRB Chairman or ORPD.

cc: Sue Jeno, Adviser
Dean, Medical School

Signature of Chairman/or designated IRB Member: ____________ Date: 4/21/95
UND's Institutional Review Board

If the proposed project (clinical medical) is to be part of a research activity funded
by a Federal Agency, a special assurance statement or a completed 596 Form may be
required. Contact ORPD to obtain the required documents.
Appendix E

Testing Procedure:

- "Thank You for participating in my research project."
- "This is a consent form which you must read, then sign and date."
- "If you have any questions during the experiment, don't hesitate to ask."
- "Here is a questionnaire, please complete the entire form to the best of your knowledge. All data collected during this experiment will remain confidential."
- After completing the questionnaire, the subjects will be asked to remove all jewelry and clothing that might interfere with the experiment.
- The subjects will be taken to the testing area.
- "Please sit up straight in this chair. Your feet must be flat on the floor. Your arms must be relaxed to your side. Your eyes must be fixed straight ahead."
- Application of the magnetic yoke and CROM.
- Subjects given a verbal description of the yoke and CROM.
- "This is a magnetic yoke that is placed around your neck to enhance magnetic north, because I will be using a compass to measure your motions. This is the CROM. It is made out of a light durable plastic. This is the nose piece that fit on the bridge of your nose. This is the ear piece that fits over your ears. You wear it like wearing glasses. The Velcro straps are used to fit the CROM snugly to your head."
"You'll be asked to complete one trial to the right and one trial to the left."

Now turn your head to the right as far as you can without tilting your head and moving your shoulders. You may use the horizontal line as a guide to help keep your head leveled.

"Now, turn your head to the right as far as you can go, and stop. Now, you may return to the front. Now turn your head to the left as far as you can go, and stop. Return to the front."

"Now the test will begin. You will have three trials to the right. After each trial, measurements will be taken and the dials re-zero. Then, you will have three trials to the left."

"We need to zero all the dials before we start."

TEST-Record Measurements

"The experiment has now ended, do you have any questions."

"THANK YOU for participating in my experiment."
November 8, 1995

Dear Madura Takai,

Allyn & Bacon grants permission for you to reprint/adapt 61-65 from THE SCIENCE OF SWIMMING by author, Counselman, J. E. for use in your dissertation or research project.

This is a nonexclusive permission for one time use in your graduate report or research project in the English language and in all copies to meet your degree requirements. New permission is required if your thesis is to be published at a later date. This permission does not extend to any material appearing in our publication with credit to another source. Permission to use such material must be obtained from the original copyright holder. Please refer to the credit lines for the appropriate sources.

Please include the following credit line on the first page where our material begins:

From author, title. Copyright date. Reprinted/Adapted by permission from Allyn and Bacon.

Thank you for your interest in our publication.

Sincerely,

Bonnie Tower
Permissions Editor
REFERENCE


37


22. Currier DP. Elements of research in physical therapy, Baltimore: Williams & Wilkins, 1990.

