The Relationship Among Posture, Shoulder Range of Motion, and Intensity of Pain in Female Collegiate Swimmers

A THESIS

Submitted to the Faculty of the School of Graduate Studies and Research of California University of Pennsylvania in partial fulfillment of the requirements for the degree of Master of Science

by

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California, Pennsylvania
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CALIFORNIA, PA

THESIS APPROVAL

Graduate Athletic Training Education

We hereby approve the Thesis of

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I would like to take this opportunity to thank the many people in my life who have guided me along this long road to becoming an athletic trainer. First, I would like to thank God for giving me the strength and power to achieve any goal that I set my mind to.

I would like to thank my advisor Dr. Joni Roh for supporting me and encouraging me all throughout my years here at Cal U. Without your motivation I would not be where I am today, thanks for being a part of my life. Also, I would like to thank my other committee members Dr. Rebecca Hess and Mrs. Ellen West for your knowledge and input to help make this product a success.

I would also like to give a special thanks to the Cal U women’s swimming team, without you girls my thesis would be nothing! A special thanks also goes to my classmates for making my last year here at Cal U so memorable. I’ll never forget you guys, I had a blast! Good luck to your future endeavors.

Next, I would like to thank my family for pushing me to be the best and never letting me settle for just average. Love you guys: Mom, Dad, and Casey.

Lastly, I would especially like to thank my boyfriend Riely for just being there through the hard times writing this thesis and loving me no matter what mood I’m in. You have been my rock and the person I looked to when I needed to vent, Love You. I am dedicating this thesis to my puppy Dozer, who has recently passed away. Thank you for giving me companionship when I was lonely and teaching me responsibility, selflessness, and most of all how to be a great Mom.
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Swimming has become a fast growing sport for cardiovascular and musculoskeletal fitness.\textsuperscript{1} Throughout the United States, over 120 million people are turning to swimming as their favorite form of recreation.\textsuperscript{1} Of these participants, more than 165,000 are age-group swimmers registered with United States Swimming, Inc., and almost 19,000 swimmers 25 years of age or older are registered with United States Masters Swimmers.\textsuperscript{2} This highly popular sport seems like fun, but what people are unaware of is that repetitive shoulder pain is the most common musculoskeletal complaint among competitive swimmers. The shoulder cannot tolerate repetitive overhead activities which can put a tremendous amount of strain on the associated structures and result in pain.\textsuperscript{1}

The shoulder joint is the most mobile joint in the body; therefore, it is structurally insecure.\textsuperscript{1} The wide range of motion of the shoulder is necessary for different swimming techniques, however what the joint achieves in range of motion, it sacrifices in instability.\textsuperscript{2} When instability is sacrificed, connective structures such as muscles, ligaments, and tendons become stressed throughout the range of motion. Early detection of anatomical
imbalances, especially in posture, may prevent further complications in an athlete’s career.

Ideal posture is a composite of all the joints of the body at any given moment. Good posture is also defined as a situation when the center of gravity of each segment is placed vertically above the segment below. For example, the “neutral” position of the pelvis is conducive to good alignment of the abdomen and trunk, and that of the extremities below.

Kendall et al explains that evaluating and treating postural problems requires an understanding of basic principles relating to alignment, joints, and muscles. A common observed postural condition related to swimmers is sway-back due to the classic posture signs: the head is forward with the cervical spine slightly extended, thoracic spine has an increase in flexion with a posterior displacement of the upper trunk, lumbar spine is in flexion (flattening) of the lower lumbar area, pelvis is in posterior tilt, and the hip and knee joints are in hyperextension. Lastly, the ankle joints remain in neutral due to knee joint hyperextension usually resulting in plantar flexion of the ankle, but that does not occur here because of anterior deviation of the pelvis and thigh. Faulty posture can adversely affect the position of the
shoulder joint, and malalignment of this joint can predispose one to injury and chronic pain.\textsuperscript{3-5}

Overuse is agreed to be the main factor in the development of shoulder pain, and may be accompanied by a second insult such as strength imbalance, fatigue, improper technique, and flexibility.\textsuperscript{6-8} If ignored, these symptoms may progress to more significant injuries, so it is imperative that coaches become aware of these common causes of shoulder pathologies.

The most frequent shoulder pathologies seen in competitive swimmers are glenohumeral impingement, biceps tendonitis, and shoulder instability.\textsuperscript{1,2,9,10} Bak\textsuperscript{11} reported clinical observations found positive impingement signs in 39 of 49 painful shoulders, but painful shoulders also exhibited excessive (grade 2 or more) anterior or inferior glenohumeral translation.

Warner et al\textsuperscript{12} evaluated three groups of subjects; 15 asymptomatic volunteers, 28 patients with glenohumeral instability, and 10 patients with impingement syndrome. The instability group, which included 69\% with microtrauma and 75\% with an injury incurred during overhead sports, showed significantly larger humeral head translation during the drawer test than the asymptomatic volunteers. Also, 68\% had impingement signs.
Athletes and coaches alike should be aware of the high incidence of shoulder pathologies, and thus take the steps needed to keep the problem under control. By understanding the basic anatomy, causes, and common injuries of the shoulder complex athletes can attack the causal factors of pain before they begin.

The most important factor in treating the painful swimmer’s shoulder is prevention. Decreasing or eliminating the amount of internal rotation and adduction types of exercises and continuing to emphasize external rotation and abductor strength is recommended. The incidence of shoulder pain in competitive swimming ranges from 40-80%, respectively. While research has addressed posture and shoulder range of motion, the literature is limited in demonstrating any type of relationship between these factors and pain in competitive swimmers. The purpose of this study was to determine whether a correlation exists between posture, excessive or limited range of motion, and shoulder pain in female collegiate swimmers.
METHODS

Research Design

A descriptive correlational design was used to measure posture, shoulder joint range of motion, and the intensity of shoulder pain. Each athlete was measured for altered posture, shoulder internal/external rotation and flexion, and shoulder pain. The duration of measuring took approximately 25 minutes per athlete. The athletes were measured at the end of their competitive season. Results were limited to Division II female swimmers. Also, the correlational design did not allow for cause and effect among variables.

Subjects

Subjects were volunteers from the California University of Pennsylvania NCAA Division II women’s swim team (n=14). Participation was voluntary, and participants had to be cleared by the University’s Student Health Service at preseason to deem the athlete healthy and free of injury. Any athlete who has received surgery to the shoulder within the last year was eliminated due to the limited range of motion and pain associated with recovery.
Prior to the study, informed consent was administered to the athletes and worded in lay terms to educate athletes about the risks and procedures (Appendix C1). By signing the consent form each subject indicated that their participation was completely voluntary and that all results would remain confidential. Demographic information was obtained directly after the informed consent. This was read and completed by the subject (Appendix C2). The questions included were age, year in school, number of consecutive years they had competed in swimming, current daily yardage, current practices per day, months per year of training, handedness, type of stroke they swim, type of swimmer, and any current medication being taken. A photographic release form was completed by each subject so that the researcher could use the data for further analysis (Appendix C3).

Preliminary Research

The purpose of preliminary research was to familiarize the researcher with the instruments and procedures that were used in testing posture, range of motion, and pain; it also helped determine an appropriate time frame for testing each athlete. Trials with the posture analysis, goniometer, and Swimmer’s Shoulder Pain Scale allowed the
researcher to become proficient with the equipment to ensure accurate measurements. Two volunteer subjects were chosen to participate in the research but were not used in the study.

Instruments

The following measures were used for the study: the Watson-MacDonncha Posture Analysis (WMPA) measured ankle varus and valgus, knee interspace, knee hyperflexion and hyperextension, lordosis, kyphosis, scoliosis S and C, rounded shoulders, scapular winging/abduction, shoulder symmetry, and forward head (Appendix C4); shoulder range of motion using a goniometer measured internal rotation, external rotation, and flexion (Appendix C5); and the Swimmer’s Shoulder Pain Scale which measured current shoulder pain in each subject (Appendix C6). Data obtained by these measurements were recorded on a SPSS® data collection sheet (Appendix C7).

Posture Analysis

The Watson-MacDonncha Posture Analysis (WMPA) was used for the assessment of posture. The WMPA is a valid and reliable method of assessing posture.\textsuperscript{14} The results of the
second retest indicated that the qualitative posture scale has high intra-rater reliability. Watson\textsuperscript{14} reported an intra-rater and inter-rater reliability ranging from 0.90-0.95. The intra-rater of 0.95 was found using similar procedures. The inter-rater of 0.90 was found using repeated assessments that were identical to the original assessments for all ten aspects of posture.

A Sony Cyber-shot 4.1 mega pixel digital camera was used to photograph the subject’s posture. The researcher used Microsoft Office Picture Manager for the digital pictures on the computer. Microsoft Office Picture Manager allows for enlarged pictures so that the pictures can be printed onto eight inch by eleven inch sheets. The ten aspects were evaluated to measure the composite posture score: ankle varus and valgus, knee interspace, knee hyperflexion and hyperextension, lordosis, kyphosis, scoliosis “S” and “C”, rounded shoulders, shoulder symmetry, shoulder abducted winged scapula, and forward head.

A platform 20 cm high, 60 cm long, and 40 cm wide was used for taking the subject’s picture at different angles. Adhesive reflective dots were placed on specific landmarks that were measured by two plumb-lines suspending from the
ceiling, to the right side and left of the platform, 120 cm from either side of the box.

Using the two methods of qualitative and quantitative measuring creates one score for each of the ten aspects. Subjects could receive a score from 10-50 points, with higher scores representing better posture. The scale has been broken down into three categories of postural deviation. Each category was assigned a score of 5, 3, or 1. A score of 5 corresponded to good body mechanics that range from no deviation to a level just above that of the next category. A score of 3 corresponds to a moderate deviation, and a score of 1 corresponds to a marked deviation.

Goniometry

Bovens and associates\textsuperscript{15}, in a study of the variability and reliability of nine joint motions throughout the body, used a universal goniometer to examine active external rotation range of motion of the shoulder complex with the arm at the side. Three physician testers and eight healthy subjects (five males and three females) aged 30 ± 6 years participated in the study. All volunteers were university personnel and familiar with the purpose of the study. Intratester reliability coefficients for lateral rotation
of the shoulder ranged from 0.76 to 0.83, whereas intertester reliability coefficient was 0.63. Mean intratester standard deviations for the measurements taken on each subjects ranged from 5.0° to 6.6°, whereas the mean intertester standard deviation was 7.4°. The measurement of external rotation range of motion of the shoulder was more reliable than range of motion measurements of the forearm and wrist. Boone et al\textsuperscript{16} additionally reported that the intertester reliability was higher for upper extremity motions ($r = 0.86$) than for lower extremity motions ($r = 0.58$).

The subject was measured in a supine position with the arm at the edge of the table and knees flexed to maintain proper alignment of the spine. This method of measuring glenohumeral motion required the subject to move their arm into each motion actively. Normal ranges of motion for each position were: internal rotation, 80°-90°; external rotation, 90°-100°; and flexion, 170°-180°.\textsuperscript{17,18} Each subject was scored according to degree of motion and how much it differentiated from the norm as either excessive (increased from the normal range) or limited (decreased from the normal range) range of motion.
Swimmer’s Shoulder Pain Scale

The subjects completed a Swimmer’s Shoulder Pain Scale adapted from Greipp\textsuperscript{19} to measure shoulder pain.\textsuperscript{13} (Appendix C6) The scale is a valid way of questioning specific pain in swimmer’s shoulder,\textsuperscript{13} although no reliability coefficient has been reported for the use of this scale.\textsuperscript{13,19} The pain questions range from 0-6, with zero corresponding with no pain and six corresponding with severe shoulder pain, lasting 12 hours a day making it almost impossible to practice hard.

Procedures

The researcher applied for and received approval from the Institutional Review Board of California University of Pennsylvania to perform the study (Appendix C8). After preliminary testing was completed, the volunteers were contacted via email about their participation in the study. All interested participants read and signed the necessary paperwork such as informed consent, demographics, and a photographic release form at the initial meeting. Then the subjects were asked to fill out the Swimmer’s Shoulder Pain Scale to reveal an accurate reflection of the athlete’s current shoulder pain after practice. The subjects
identified their intensity of pain, ranging from 0-6.
Lastly, the subjects were given a time to come in for the
analysis portion of the study. Since the measuring took
approximately 25 minutes, the volunteers were measured
within a one week time frame with at least four volunteers
per day.

The posture analysis was assessed using the following
standardized procedures. A grid was placed over the top of
the photographs taken of the subjects using transparency
paper that has been recommended to line up with one of the
two plumb lines next to the subject. Another transparency
was used with circle diameters for determining the degrees
of lordosis and kyphosis. A protractor and a ruler were
also used when measuring the desired angles through the
reflective dots on the landmarks.

The first stage of the WMPA procedure was
photographing the subject in four different positions. A
diagram was drafted for the standing position of the
participant (Appendix C9). The subjects were asked to wear
their swimming suits so that anatomical landmarks and
posture was easy to assess.

There were three colored lines taped on the top of the
platform. Red was vertical, blue horizontal, and yellow was
set at a 45° angle from the left back corner to the front
right corner of the box from the camera’s view. The first line was red and used for anterior and posterior pictures. The second line was blue for the left lateral view. The third line was yellow for the posterior left lateral oblique picture. The next picture was the red line again, however, the subject was facing away from the camera for a posterior view. The last picture was the subject holding their subject number. Oral directions were given during the WMPA (Appendix C10).²⁰

The following landmarks were marked on the subjects using adhesive reflective dots (Appendix C11).²⁰ The patellar notch and the greater trochanter were marked on the left side. The axis of the glenohumeral joint and the auricle pinna on the ear were also marked on the left side. On the anterior surface, both the clavicle heads, both anterior superior iliac spines, tibial tuberosities, and the horizontal and vertical center of the patella were marked. On the posterior surface, the vertebrae prominens C7, T3, T6, T9, and T12 along the thoracic spine, L3 and L5 in the lumbar spine, and the most prominent point of the sacrum were marked. The horizontal and vertical centers of both calcaneous were marked as well. The subjects were asked to stand upright standing straight ahead with their chin parallel to the ground and to fully extend elbows and
knees for all four photographs. The digital camera was placed 10ft from the front of the platform. The height of the center of the camera lens was 120cm from the floor. The previous methods were the procedures suggested for WMPA.\textsuperscript{14}

Shoulder range of motion including internal rotation, external rotation, and flexion were measured three times for consistency with a universal goniometer. Measuring internal rotation required positioning the subject supine, with the arm being tested in 90° of shoulder abduction. The forearm was placed perpendicular to the supporting surface and in 0° of supination and pronation so that the palm of the hand faced toward the feet. The full length of the humerus rested on the examining table. The elbow was not supported by the examining table. A pad was placed under the humerus so that the humerus was level with the acromion process. Goniometer alignment was placed as follows: center the fulcrum of the goniometer over the olecranon process, align the stationary arm so that it is either perpendicular to or parallel with the floor, and align the moving arm with the ulna using the olecranon process and ulnar styloid for reference. Testing motion was performed by medially rotating the shoulder moving the forearm anteriorly, bringing the palm of the hand toward
the floor. The shoulder was maintained in 90° of abduction and the elbow in 90° of flexion during the motion. The end range of motion occurred when resistance to further motion was felt and attempts to overcome the resistance caused an anterior tilt or protraction of the scapula.21

External rotation required positioning the subject supine, with the arm being tested in 90° of shoulder abduction. The forearm was placed perpendicular to the supporting surface and in 0° of supination and pronation so that the palm of the hand faced toward the feet. The full length of the humerus rested on the examining table. The elbow was not supported by the examining table. A pad was placed under the humerus so that the humerus was level with the acromion process. Goniometer alignment was placed as follows: center the fulcrum of the goniometer over the olecranon process, align the stationary arm so that it is either perpendicular to or parallel with the floor, and align the moving arm with the ulna using the olecranon process and ulnar styloid for reference. Testing motion was performed by rotating the shoulder laterally moving the forearm posteriorly, bringing the dorsal surface of the palm of the hand toward the floor. The shoulder was maintained in 90° of abduction and the elbow at 90° of flexion during the motion. The end range of motion
occurred when resistance to further motion was felt and attempts to overcome the resistance caused a posterior tilt or retraction of the scapula.\textsuperscript{21}

Shoulder flexion required the subject be supine, with the knees flexed to obtain neutral pelvis. The shoulder was positioned in 0° of abduction, adduction, and rotation. The elbow was placed in extension so that tension of the long head of the triceps muscle did not limit the motion. The forearm was positioned in 0° of supination and pronation so that the palm of the hand faced toward the body. Goniometer alignment was placed as follows: center the fulcrum of the goniometer over the lateral aspect of the greater tuberacle, align the stationary arm parallel to the midaxillary line of the thorax, and align the distal arm with the lateral midline of the humerus. The testing motion was performed by flexing the shoulder lifting the humerus off the examination table, bringing the hand up over the subject’s head. The extremity was maintained in neutral abduction and adduction during the motion. The end of the glenohumeral flexion range of motion occurred when resistance to further motion was felt and attempts to overcome the resistance caused upward rotation, posterior tilt, or elevation of the scapula.\textsuperscript{21} Any questions from the
subjects regarding the study were answered throughout the data collection process.

Hypothesis

The following hypothesis was based on a review of the research:

There will be a significant relationship among posture, swimmer’s shoulder range of motion, and intensity of pain.

Data Analysis

An α level of ≤ 0.05 was used in this data analysis. A Pearson Product Moment Correlation was used to determine the relationship among posture scores, swimmer’s shoulder degree of motion, and intensity of pain.
RESULTS

Demographic Data

The participants (n = 14) in this study were from California University of Pennsylvania women’s swimming team. All swimmers were right hand dominant and on average began their competitive swimming career at the age of eight. The age range of the swimmers who participated was 18 to 22 (20.0 ± 1.04). The amount of daily yardage ranged from 4000-9000 (5821.4 ± 1338.9). Practices per week ranged from five to 11 (7.3 ± 1.4). Months per year ranged from six to 10 (7.9 ± 1.4).

A majority (43%) of the participants were represented by the sophomore class followed by the junior class at (36%), and the freshman class at (21%). See Table 1. Over 64% of the participants swam 5-6000 yards per day. See Table 2. Refer to Table 3 to view time spent swimming.

Table 1. Frequency of Class Rank

<table>
<thead>
<tr>
<th>Class</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>3</td>
<td>21.4</td>
</tr>
<tr>
<td>Sophomore</td>
<td>6</td>
<td>42.9</td>
</tr>
<tr>
<td>Junior</td>
<td>5</td>
<td>35.7</td>
</tr>
</tbody>
</table>
Table 2. Class Rank and Number of Yards per Day

<table>
<thead>
<tr>
<th>Class rank</th>
<th>&lt;5000 yards (n = 3)</th>
<th>5-6000 yards (n = 9)</th>
<th>&gt;6000 yards (n = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Junior</td>
<td>4500</td>
<td>5500 (500)</td>
<td>8000</td>
</tr>
<tr>
<td>Sophomore</td>
<td>4000</td>
<td>5625 (479)</td>
<td>9000</td>
</tr>
<tr>
<td>Freshman</td>
<td>-</td>
<td>6000</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 3. Time Spent Swimming (n = 14)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td>Consecutive Years</td>
<td>12.64</td>
<td>2.307</td>
</tr>
<tr>
<td>Practices Per Week</td>
<td>7.29</td>
<td>1.437</td>
</tr>
<tr>
<td>Months Per Year</td>
<td>7.93</td>
<td>1.385</td>
</tr>
</tbody>
</table>

Table 4 reports that 43% of the subjects were sprinters, 29% competed in sprinting and distance events, and 14% were either middle distance or distance. Two of 14 subjects reported that they were taking medication for pain caused by tendonitis of both knees in one swimmer and the right knee of the other. These two swimmers only swam distance.

Table 4. Frequency Table for Type of Swimmer

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprinter</td>
<td>6</td>
<td>42.9</td>
</tr>
<tr>
<td>Middle Distance</td>
<td>2</td>
<td>14.3</td>
</tr>
<tr>
<td>Distance</td>
<td>2</td>
<td>14.3</td>
</tr>
<tr>
<td>Sprint/Dist</td>
<td>4</td>
<td>28.6</td>
</tr>
</tbody>
</table>

Fourteen subjects completed the entire study; two subjects were unable to schedule times for the WMPA posture.
analysis and range of motion testing, therefore they were excluded from the study. Posture scores using the WMPA analysis ranged from 10-50 with a higher number indicating a good posture. Specific to the 14 subjects, the range of posture scores were 30-44 with the average posture scoring (36.3 ± 4.0). Figure 1 shows an example of a good posture score (44) and Figure 2 shows an example of a poor posture score (30).

Figure 1. Good Posture Score Using WMPA Analysis
A metric grid transparency was used to measure the subject’s posture to help determine an appropriate score. The photographs were placed under the grid and aligned with one of the two plumb lines visible on the photograph. For the purpose of measuring kyphosis and lordosis, circles of an appropriate diameter were fitted to the spinal curvature apparent on the qualitative scale. See Figures 1 and 2 and
Appendix C4. Table 5 shows means of posture scores according to year.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>39.33</td>
<td>3</td>
<td>4.163</td>
</tr>
<tr>
<td>Sophomore</td>
<td>35.33</td>
<td>6</td>
<td>4.676</td>
</tr>
<tr>
<td>Junior</td>
<td>35.60</td>
<td>5</td>
<td>2.608</td>
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</tbody>
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Table 6 represents means and standard deviations of the average range of motions for flexion, internal rotation and external rotation.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
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<tbody>
<tr>
<td>Internal Rotation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>84.02</td>
<td>15.241</td>
</tr>
<tr>
<td>Left</td>
<td>87.40</td>
<td>13.840</td>
</tr>
<tr>
<td>External Rotation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>93.57</td>
<td>10.354</td>
</tr>
<tr>
<td>Left</td>
<td>90.02</td>
<td>10.092</td>
</tr>
<tr>
<td>Flexion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>184.43</td>
<td>18.020</td>
</tr>
<tr>
<td>Left</td>
<td>183.98</td>
<td>17.488</td>
</tr>
</tbody>
</table>
Hypothesis Testing

The level of significance for the hypothesis testing was set at the .05 alpha level.

Hypothesis: There will be a significant relationship among posture, swimmer’s shoulder range of motion, and intensity of pain.

A Pearson Product Moment Correlation was calculated examining the relationship among the posture scores, average ranges of motion, and pain intensity scores. No significance was found. See Table 7.
Table 7. Pearson Product Moment Correlation Among Posture Score, Shoulder Range of Motion, and Pain Scores.

<table>
<thead>
<tr>
<th></th>
<th>Right IR</th>
<th>Left IR</th>
<th>Right ER</th>
<th>Left ER</th>
<th>Right Flexion</th>
<th>Left Flexion</th>
<th>Total Posture</th>
<th>Shoulder Pain</th>
<th>Consec Years</th>
<th>Practice Per Week</th>
</tr>
</thead>
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† Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Additional Findings

Although there were no correlations between posture, shoulder range of motion, and intensity of pain, a significant negative correlation did exist between consecutive years and posture ($r_{14} = -.623, P = .017$). Thus, indicating the more consecutive years the swimmers swam, the more posture deviations were present.

Several tests were completed in addition to hypothesis testing. The data used in these tests were from the individual posture analysis categories, range of motion, total posture score, and some categories from demographics.

Specific to posture, a Pearson’s Correlation was used to examine the correlation between the 10 aspects of posture, shoulder range of motions, total posture score, and demographics. A significant moderate positive correlation was found to exist between kyphosis and right internal rotation ($r_{14} = .599, P = .023$) and kyphosis and left internal rotation ($r_{14} = .535, P = .049$). There was also a significant moderate positive correlation between kyphosis and right flexion ($r_{14} = .747, P = .002$) and kyphosis and left flexion ($r_{14} = .668, P = .009$). See Table 8.
Table 8. Pearson Correlation of Kyphosis and Right and Left Internal Rotation

<table>
<thead>
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<th>Variables</th>
<th>n</th>
<th>r</th>
<th>P</th>
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<tbody>
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<td>Kyphosis*</td>
<td>14</td>
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<td>Right IR</td>
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<tr>
<td>Left Flexion</td>
<td></td>
<td>.668</td>
<td>.009</td>
</tr>
</tbody>
</table>

†P < .01
*P < .05

Additionally, total posture scores and rounded shoulders had a moderately positive significance ($r_{14} = .541$, $P < .046$).

Also, mean and standard deviation for rounded shoulders according to stroke indicate that less rounded shoulders coincide with the freestyle, breaststroke, and a combination of freestyle, backstroke, and butterfly. However, freestyle combined with butterfly, and the combination of freestyle, breaststroke, and butterfly indicate more rounded shoulders. See Table 9.

Table 9. Mean and Standard Deviation for Rounded Shoulders According to Stroke

<table>
<thead>
<tr>
<th>Stroke</th>
<th>(n)</th>
<th>Rounded Shoulder Score</th>
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</thead>
<tbody>
<tr>
<td>Freestyle</td>
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<td>5</td>
</tr>
<tr>
<td>Breaststroke</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Freestyle/Backstroke/Butterfly</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Backstroke</td>
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<td>4.3(1.2)</td>
</tr>
<tr>
<td>All strokes</td>
<td>2</td>
<td>4(1.4)</td>
</tr>
<tr>
<td>Freestyle/Butterfly</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Freestyle/Breaststroke/Butterfly</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
A significant correlation was also found when comparing the various shoulder range of motions. Right and left arms for all ranges of motion had a strong positive correlation. For example, right and left flexion had a strong positive significance ($r_{14} = .945, P = .000$), right and left internal rotation had a strong positive significance ($r_{14} = .742, P = .002$), and right and left external rotation had a moderately positive significance ($r_{14} = .595, P = .025$). Right flexion had a strong positive correlation with right internal rotation ($r_{14} = .754, P = .002$) and left flexion was correlated with left internal rotation ($r_{14} = .826, P = .000$). The findings indicate that left and right ranges of motion were similar and related to one another in the shoulder girdle, specifically between flexion and internal rotation. Lastly, average pain scores were reported to be relatively low ($1.64 \pm 1.55$) among this group of female athletes.
DISCUSSION

Discussion of Results

The purpose of this study was to identify a significant relationship among posture, swimmer’s shoulder range of motion, and intensity of pain among California University of Pennsylvania women’s swimming team. The findings of this study did not support the hypothesis that there would be a significant correlation among posture scores, shoulder range of motion, or pain scores.

There have not been any reported studies concerning these specific variables; however, research has been conducted on shoulder flexibility, strength, and endurance to shoulder pain in competitive swimmers. Yet, discrepancies regarding flexibility and its role among shoulder injuries are found in the literature. In addition to hypothesis testing, analyses were performed on the 10 aspects of posture, shoulder range of motions, total posture score, and demographics. A comparison among the average ranges of motion in right flexion, left flexion, right internal rotation, left internal rotation, right external rotation, and left external rotation showed no significant means and deviations from the standard degrees of motion. Also, the
average pain scores were relatively low on a scale from 0-6 indicating moderate levels of pain. This data is impressive because pain is relevant to swimmers shoulders due to overuse and repetitive motion.\textsuperscript{2,13} One may argue that swimming 4000-9000 yards a day is repetitive, yet pain reported as minimal.

Another additional finding included the relationship among swimmer’s year in school and posture scores. It was found that the freshman had better posture scores than the upperclassman. This is remarkable because it is known that the upperclassman have had previous training in Pilates and core stabilization as part of their dry land workouts. This should have made their posture scores higher, in addition the fact that more time was spent in the pool. Pilates and core stabilization has been used to correct posture deviations, yet for this sample, the researcher did not find that to be true.\textsuperscript{20}

Range of motion was correlated positively with kyphosis. Meaning if kyphotic curvature was less deviated, then greater range of motion was present in internal rotation and flexion bilaterally.

Mean and standard deviation scores for rounded shoulders according to stroke indicated that less rounded
shoulders coincide with the freestyle, breaststroke, and a combination of the freestyle, backstroke, and butterfly. Although, swimmers who swam combined strokes such as the freestyle and butterfly; and the freestyle, breaststroke, and butterfly had more rounding of the shoulders or a more deviated posture.

It has been noted that the butterfly is closely related to the freestyle, except that both the arm and leg actions are performed by both sides simultaneously.\textsuperscript{22} Thus, if an evaluation is due to tight pectoral musculature and weak back musculature they will be found in both strokes because the same muscles are used.

Overall, in both strokes the serratus anterior and subscapularis maintained a high level of activation throughout the stroke, making these muscles highly susceptible to fatigue and vulnerable to injury.\textsuperscript{22-23} The serratus anterior abducts the shoulder girdle and the subscapularis internally rotates the shoulder joint. If both of these muscles are tight due to excessive motion that could possibly cause the shoulders to be rounded.

Possibly, latissimus dorsi could be the main dysfunction in swimmers having rounded shoulders due to overuse and being over-stretched. The main functions of latissimus dorsi are to upwardly rotate and adduct the
scapula. Also weak stabilizers and an unstable pectoral girdle may also cause rounded shoulders when the serratus anterior is being over activated. However, specific muscle activity was not examined in this study. Whenever the swimmers were combining the freestyle, breaststroke, butterfly, latissimus dorsi may have become overused and overstretched during these events thereby having a more rounded shoulder posture.
Conclusion

The results of the Pearson Product Moment Correlation analysis of posture, shoulder range of motion, and intensity of pain showed no significant correlation, indicating a relatively homogenous group of female athletes. The data collected showed range of motion analysis to be within normal limits, pain to be relatively minimal, and posture scores to have minimal posture deviations.

This is important to the athletic trainer because the influence of dry land/water protocol regimented by the coach may result in moderate overall posture, range of motion, and a minimal amount of pain. Although, the older swimmers exhibited more postural deviations, there was not statistical support to indicate that neither pain nor range of motion was related. Therefore, the range of motion was within normal limits and the reported pain was minimal even after following a 4-day conference meet. Possibly the specific training of this particular team had a positive effect on the variables examined.
Possible future studies could include evaluating male swimmers or swimmers at other institutions where Pilates and core stabilization training are not performed. Investigate differences between coaches who train and concentrate on techniques verses those coaches who do not focus on technique. Also, perhaps the most important potential research study should be to examine reliability and validity of a universal pain scale.
REFERENCES


APPENDIX A

Review of the Literature
Competitive swimming is a recreational sport that involves 120 million participants yearly; coincidently the most common musculoskeletal complaint in swimmers is shoulder pain. Though the specific cause of pain is unknown, many factors such as overuse, repetitive stress, and improper stroke mechanics seem to be the main focuses. Biomechanical research suggests that significant changes in muscle activity and strength, particularly of the shoulder rotators and scapular stabilizers, play an important role in the development of shoulder problems in the overhead athlete. The purpose of this literature review is to determine why muscle imbalances and improper stroke mechanics can lead to the intensity of shoulder pain. The following topics will be reviewed: (1) Muscle Imbalances in the Shoulder Complex, (2) Swimming Stroke Mechanics, (3) Interfering Shoulder Pain in the Swimmer, and (4) Summary.

Muscle Imbalances in the Shoulder Complex

Research shows that over 60% of swimmers begin their training at age 8 or under, but the average age of referral for initial complaints of the shoulder is 18 years; the time that the athlete is actively involved in high school or early collegiate competition.¹ Due to delayed recognition
of the initial injury, proper training methods could not be
instilled during the early years of competition which in
turn could account for many muscular and anatomical
problems.

Anatomy of the Shoulder

The shoulder, or glenohumeral joint is the most mobile
joint in the body; therefore, it is structurally insecure.\(^1\)
The shoulder joint consists of the articulation between the
shallow, concave glenoid cavity of the scapula and the
convex surface of the humeral head; only a small part is in
contact with the glenoid cavity at any instant.\(^2\) The
shoulder girdle joints also includes articulations with the
thorax and the distal aspect of the clavicle and provide
more range of motion to shoulder movements.\(^2\)

The upper extremity is suspended from the chest by
eight bilateral articulations in all: the sternoclavicular
joint medially, the scapulothoracic posteriorly, and the
acromioclavicular and glenohumeral joints laterally. The
actions of each of these eight joints are dependent and
directly related to one another. With all the joints
working together simultaneously, it allows the shoulder
complex to obtain a range of motion of 180° in abduction.
A two-to-one ratio occurs between the shoulder joint and
shoulder girdle; for every 3° of abduction, the
glenohumeral joint is abducted 2° and the scapulothoracic
articulation is abducted 1°. The wide range of motion of
the shoulder is necessary for different swimming
techniques, however what the joint achieves in range of
motion it sacrifices in instability. When instability is
sacrificed connecting structures such as muscles and
tendons become stressed throughout the range of motion.

The muscles of the shoulder complex can be divided
into three distinctive groups. The scapulohumeral group
consists of the rotator cuff muscles supraspinatus
(adduction), infraspinatus (external rotation), teres minor
(external rotation), subscapularis (internal rotation). As
well as, the deltoid (flexion, abduction, extension,
internal rotation and external rotation), teres major
(internal rotation), and coracobraclialis (flexion and
internal rotation). The rotator cuff muscles provided
dynamic stability to the shoulder joint by holding the
humeral head within the glenoid, allowing the more powerful
muscles around the shoulder to be active above the shoulder
level.

The axioscapular group which is made up of the
trapezius (scapular elevation, adduction, and depression),
serratus anterior (scapular abduction), rhomboids (scapular
elevation and adduction), levator scapula (scapular elevation), and pectoralis minor (scapular depression and tilting). The purpose of these muscles are to act on the scapula moving it upward, downward, elevate it, and depress it while providing more range of motion, and/or stability to the entire shoulder complex. The axiohumeral group is made up of the pectoralis major (internal rotation, adduction, and flexion), and the latissimus dorsi (internal rotation and extension). These muscles are primarily used in most of the swimming strokes for strength and power.

The shoulder joint is minimally stabilized by surrounding ligaments and muscles. The glenohumeral articular capsule and associated ligaments consist of the coracohumeral ligament, three glenohumeral ligaments, and the coracoacromial ligament. Early detection of anatomical imbalances, especially in posture may prevent further complications in an athlete’s career.

Posture

Ideal posture is a composite of all the joints of the body at any given moment. Posture may also be described in terms of muscles balance or imbalance. Good posture is also defined as a situation when the center of gravity of
each segment is placed vertically above the segment below. The skeletal alignment for a posture assessment is as follows: the spine has normal curvature, the lower extremity bones (lateral malleolus, fibular head, greater trochanter, acromioclavicular joint, and tempromandibular joint) are in ideal structure for weight bearing, the pelvis is in “neutral” position, the chest and upper back are in a position that favors proper function of the respiratory system, and the head is erect in a well-balanced position that minimizes stress on the neck musculature.

Kendall et al explains that evaluating and treating postural problems requires an understanding of basic principles relating to alignment, joints, and muscles. The “neutral” position of the pelvis is conducive to good alignment of the abdomen and trunk, and that of the extremities below. Neutral position of the pelvis is defined as the anterior superior iliac spines are in the same horizontal plane with the symphysis pubis. Neutral position of the spine is when the thorax and shoulder girdle are in a position that favors optimal function of the respiratory organs.

A plumb line can be used in a standing position to view posture. Plumb lines provide an absolute vertical
line for measuring deviations. The point in line with which a plumb line is suspended must be a standard fixed point. Since the only fixed point in the standing posture is at the base where the feet are in contact with the floor, the point of reference must be at the base. A movable point is not acceptable as a standard. The position of the head is not stationary and using the lobe of the ear as a point in line with which to suspend a plumb line is not appropriate.\textsuperscript{6,7}

The plumb line test is used to determine whether the points of reference of the individual being tested are in the same alignment as are the corresponding points in the standard posture. The deviations of the points of reference from the plumb line reveal which part of the subject’s alignment is faulty.\textsuperscript{6,7}

The optimal alignment of the shoulder is a line of reference passing directly through the shoulder joint. In good alignment the scapulae lie flat against the upper back, approximately between the second and seventh thoracic vertebrae, and about four inches apart. Faulty positions of the scapulae adversely affect the position of the shoulder joint, and malalignment of this joint can predispose to injury and chronic pain.\textsuperscript{6}
Many postural abnormalities exist including lordosis, flat back, kyphosis, sway back, and forward head. The most common postural abnormality occurring in swimmers is the sway back posture. Usually the head is forward with the cervical spine slightly extended. The thoracic spine has an increase in flexion with a posterior displacement of the upper trunk. The lumbar spine is in flexion (flattening) of the lower lumbar area. The pelvis is in posterior tilt and the hip and knee joints are in hyperextension. Lastly, the ankle joints remain in neutral due to knee joint hyperextension usually resulting in plantar flexion of the ankle, but that does not occur here because of anterior deviation of the pelvis and thigh. Posture is one portion of a long list of causes for muscular imbalances which in turn can lead to injuries if not corrected in a timely manner.

Causes of Injury

It has been estimated that the average collegiate swimmer performs more than one million strokes annually with each arm. It is no wonder that this repetition or overuse is generally agreed to be the major factor in the development of shoulder pain, and that because not all
swimmers develop shoulder pain, the overuse must be combined with a second insult.⁸

Kennedy and Hawkins⁹ first described the condition of swimmer’s shoulder, not as a diagnosis but, instead, as a collection of symptoms that are consistent among competitive swimmers resemble those of tendonitis of the rotator cuff and biceps tendon, impingement syndrome, and instability. Several variables that could trigger the symptoms include strength imbalance, fatigue, improper technique, and flexibility.¹⁰

Swimming focuses on adduction and internal rotation of the shoulder during the propulsive phases of the different strokes.⁵ Muscles such as latissimus dorsi, pectoralis major and minor, subscapularis, and teres major have generally greater strength and produce more torque during the propulsive phase in swimming.⁸ Although, when external rotators such as teres minor and infraspinatus are compared to the opposing group there seems to be significant muscular imbalances, not because swimmers have underdeveloped external rotators but due to the extreme developmental imbalance.⁸

One of the main functions of the rotator cuff musculature is to depress the humeral head in order to minimize the degree of subacromial impingement while
overheard movement is occurring. If the muscles will no longer work together efficiently, the humeral head will not remain depressed as needed, and the problem of imbalance will assist in causing impingement.\textsuperscript{5,8}

Muscle fatigue is another major component in the cause of injuries. Most forward propulsion in swimming is generated by the arms, and as discussed above, swimmers have increased strength in adduction and internal rotation.\textsuperscript{8} Performance in swimming, however, depends on both maximal ability to propel the body through the water and on the sustained maximal ability to do so. Endurance increases swimming performance that is why athletes can sometimes spend 20 to 30 hours a week in the pool.\textsuperscript{8}

Muscle fatigue has also been linked to the onset of swimmer’s shoulder as a result of improper technique or a disruption in glenohumeral and scapulothoracic motions.\textsuperscript{10} A common technical mistake made by a swimmer is dropping the elbows during the recovery phase of the stroke. This results in an increase in external rotation, placing unnecessary stress on the static stabilizers (ligaments and capsule) while fatiguing the dynamic stabilizers (rotator cuff, biceps, scapular musculature) of the glenohumeral joint.\textsuperscript{10} As the season progresses, exercises with an
emphasis on endurance should be slowly introduced into a
functional training program.\textsuperscript{10}

In addition to functional training, flexibility is
necessary for season progression since it permits maximal
stroke efficiency and coordination. However, caution should
be implemented, as not to overstretch the anterior capsule
of the shoulder.\textsuperscript{11} The effectiveness of proper warm-up
should not be ignored, although swimmers should adhere to
the idea that mobility must strike a balance with
stability.\textsuperscript{11} Greipp et al\textsuperscript{12} were able to predict swimmer’s
shoulder with 90\% accuracy based on their preseason
measurement of shoulder flexibility and found a significant
correlation between anterior shoulder inflexibility and
shoulder pain. Several other research studies, however,
have not been able to identify a correlation between
flexibility and shoulder pain.\textsuperscript{13,14} The difference between
the studies are sample size and various pathologies.

Competitive swimmers like other highly motivated
athletes, have deaf ears to the suggestion of rest, which
can help heal microtremora. If ignored these symptoms may
progress to more significant injuries, so it is imperative
that coaches become aware of these common causes of
shoulder pathologies.
Shoulder Pathologies

Between the humerus and the acromion process (tip of the shoulder) bones, lie the tendons of the rotator cuff, and the bursa that protects these tendons. Normally, these tendons slide effortlessly within this space. In some people this space becomes too narrow for normal motion, and the tendons and bursa become inflamed. Inflammation leads to thickening of the tendons and bursa, and contributes to the loss of space in this location. Eventually, this space becomes too narrow to accommodate the tendons and the bursa, and every time these structures move between the bones they are pinched, causing impingement.\textsuperscript{1,2,5}

Subacromial impingement has received the most attention and is often implicated as the sole cause of swimmers shoulder. The pathology of impingement involves repetitive microtrauma to a relative avascular region of the supraspinatus tendon on the anterior edge of its insertion on the greater trochanter of the humerus. Without a functionally effective supraspinatus to depress the head of the humerus against the glenoid, the traction supplied by the deltoid pulls the humeral head proximally, further decreasing the subacromial space in advanced disease.\textsuperscript{1}

Impingement is graded into three stages. Stage 1 is the beginning stage of the tendonitis, causing some edema,
hemorrhage, and the beginning of the inflammatory process. Stage 2 involves thickening and fibrosis of the soft tissue structures. Stage 3 involves advanced conditions of shoulder impingement, such as rotator cuff tears, biceps tendon ruptures, and bony changes under the acromion process.\textsuperscript{2,5}

Isolated biceps lesions rarely occur in swimmers, more often they are associated with rotator cuff impingement listed above. When present, the site of the inflammation is most commonly the long head of the biceps tendon as it runs in the bicipital groove. Repeated trauma may also further damage the transverse ligament as it slips back or forth upon completing a normal stroke.\textsuperscript{1}

Shoulder instability is another major pathology seen in swimmers. Instability may be difficult to diagnose because the symptoms of pain may be similar to those caused by impingement, tendonitis, and the two conditions can coexist.\textsuperscript{2} The athlete may have discomfort while carrying loads that pull downward on the inferior part of the capsule or with overhead arm movements such as in swimming.\textsuperscript{2} The basic lesion that contributes to shoulder instability is an enlarged joint capsule due to repetitive forceful stretching from the wide range of shoulder movement performed during swimming.\textsuperscript{2,15}
Examination of the shoulder should include stress on the glenohumeral joint in three directions—anteriory, posteriorly, and inferiorly. Fortunately for the swimming athlete, swimmers do not tend to have a high incidence of anterior joint instability, with the exception of backstrokers. The backstroke involves maximal abduction and external rotation of the shoulder, particularly during hand push-off as the backstroker initiates a flip turn. The acquired looseness of the anterior capsule is thought to be caused by repetitive stretching that the stroke involves and passive shoulder stretching exercises completed before practice.

Posterior joint instability is similarly found among swimmers and the general population. For example, Fowler and Webster reported 55% of swimmers tested were found to have posterior joint laxity, while 52% of the control group showed positive signs of instability. The position that puts swimmers at risk the most is forward flexion and internal rotation of the shoulder, a repeated action in all swimming strokes. Swimmers with significant posterior joint instability may actually dislocate or subluxate their shoulders during the swimming motion.

Athletes and coaches alike should be aware of the high incidence of shoulder pathologies, and thus take the steps
needed to keep the problem under control. By understanding the basic anatomy, causes, and common injuries of the shoulder complex, athletes can attack the causal factors of pain before they begin.

Swimming Stroke Mechanics

Swimming is an activity that relies on maximal propulsive force applied over an extreme range of motion of the upper extremity. Depending on the particular stroke, up to 90% of the propulsion is generated from the arm pull.\textsuperscript{1,2,5,18} Four major swimming patterns are used in competition, the crawl (freestyle), backstroke, breaststroke, and the butterfly stroke. Each has characteristic arm patterns but all use two phases of action, pull and recovery. Pull is the propulsive phase equivalent to acceleration in the throwing sports, but the action is sustained. Except for the breast stroke, the pull phase begins with hand entry into the water. The arm is positioned maximally overhead, then forcefully drawn down to the body. Sustained forceful depression is performed in a different way for each stroke.\textsuperscript{18}

Arm action for the freestyle and butterfly are similar with both beginning with humeral abduction and external
rotated. During the backstroke, hand entry begins with the arm hyperflexed and internally rotated. Lastly, the breaststroke begins with the arms overhead and internally rotated.\textsuperscript{1,2,18} During the recovery period there is rapid repositioning of the arm for the next pull through phase. The motions used at this time are equivalent to the cocking phase or overhead throwing. For all but the breaststroke this is primarily a midair activity.\textsuperscript{1,2,18}

For the freestyle and butterfly, “elbow lift” is the first visible sign of the recovery phase. This implies recovery begins with shoulder extended and semi-abducted while the arm is still internally rotated placing the glenohumeral joint in an unstable position. Following this out of water exit action, recovery continues with external rotation and full abduction to quickly reach the desired overhead position for the next pull-through phase. During the backstroke, recovery is rapid flexion to full overhead position. The breaststroke precedes this action with midline adduction.\textsuperscript{1,2,18}

Swimming Styles

The fastest, most popular, widely used stroke for training is the freestyle stroke. The cycle of the freestyle stroke is broken down in three phases: the entry
and first half of the pull, the end of the pull, and the recovery. During the entry and beginning of the pull phases the glenohumeral joint is in forward flexion, and the humerus is in abduction and internal rotation. During the end of the pull, the joint is extended and the humerus is in adduction and internal rotation. During the recovery period, the arm is in abduction and internal rotation, moving from extension to flexion above the water. Power for the freestyle stroke comes 80% from the pull and 20% from the kick.\(^5\)

The backstroke is considered the complement to the freestyle stroke in that the arm actions involve the same three phases. During the entry, the shoulder is abducted to 180° and the arm is externally rotated with a straight elbow. During the pull-through phase, the arm moves into abduction and internal rotation. During the recovery, the shoulder is flexed and moves above the water into the 180° abduction and external rotation position for the entry. Power comes 25% from the kick and 75% from the pull.\(^5\)

The butterfly stroke is performed with movements at the same time, unlike the other previous strokes listed. During the entry phase both shoulders are flexed, abducted, and internally rotated. During the pull-through phase the shoulders move into extension. During the recovery phase
the arms are brought above the water from extension to flexion while abducted and internally rotated, using a slightly bent elbow. The athlete's power comes from 30% from the kick and 70% from the pull when performing the butterfly.\textsuperscript{5}

The breaststroke has a 50/50 split from where the power is initiated, the kick and the pull, using bilateral motion like that of the butterfly. During the beginning of the pull phase, the shoulders are abducted, the arms are internally rotated, and are below the water surface. During the pull through phase, the arms move into adduction, remain internally rotated, and are always below the water surface. During the recovery, the arms return in a circular pattern, always under the water surface.\textsuperscript{5}

With the basic pattern of arm motion being the same for all four strokes, it is logical to assume the primary propulsive force in swimming is the musculature between the trunk and the arm, that is the pectoralis major and the latissimus dorsi. Simultaneous action by the teres major and pectoralis minor would add a third muscular chain.\textsuperscript{18}

Surface electromyography (EMG) recordings indicate that participation by the latissimus dorsi is poor, therefore, making the pectoralis major the dominant muscle. This may be less true for the backstroke due to a more
posterior arm pattern, as well as, strokes emphasizing internal rotation which might make latissimus dorsi a strong contributor in conjunction with teres major.\textsuperscript{16}

To excel at the sport of competitive swimming, mechanical efficiency is an important factor.\textsuperscript{19} The swimming technique that produces the greatest distance per stroke at the most efficient energy will produce the best results.\textsuperscript{17} Athletes who experience excessive joint ranges in the shoulder complex have been know to perform at higher levels.\textsuperscript{20}

\textbf{Range of Motion}

Full range of motion of the shoulder requires movement at the glenohumeral, sternoclavicular, acromioclavicular, and scapulothoracic joints. Two methods generally used to measure range of motion are active and passive. Although few studies directly compare the reliability of measuring active range of motion with that of passive range of motion, sufficient evidence is available to suggest passive range of motion is more difficult to measure reliably then active range of motion.\textsuperscript{21} Amis and Miller\textsuperscript{22} acknowledge this problem and have reported that passive movements are extremely difficult to reproduce due to the stretching of the soft tissues. The limits of motion
depend on the force applied to the limb, which must, carefully be controlled. The normal degrees of measurement in all the ranges are as follows: flexion, 180°; extension, 60°; abduction, 180°; adduction, not usually measured because it is the return to zero position from abduction; medial (internal) rotation, 70°; and lateral (external) rotation, 90°.23

Increased shoulder range of motion is advantageous in all the aquatic sports. By allowing the arm more forward elevation, a shoulder with increased range of motion allows the arm and body to achieve a 180° angle. This angle permits the body to be parallel to the surface, minimizing the forward axial surface area and reducing drag. An increased shoulder range of motion also allows for a greater stroke length, which correlates directly with swimming speed.8

Although important for better performance, increased shoulder range of motion is determined by the capsuloligamentous complex, which acts as a connector limiting motion, becoming tight only at the extremes of motion. A shoulder with increased range of motion has what is called capsuloligamentous laxity.8
Glenohumeral Joint Laxity

Laxity portrays the actual translation within a joint without influence of pain during passive motion.\textsuperscript{19} Extended laxity is a necessary feature of the soft tissue surrounding the shoulder for normal glenohumeral rotation. The degree of laxity differs in individuals; the most common opinion about the importance of gender in this area is that females have a larger amount of laxity than males. However, others claim that there are no differences between males and females.\textsuperscript{20} Athletes participating in sports involving repetitive overhead motion have shown signs of greater-than-normal laxity which will predispose the glenohumeral joint to episodes of instability.\textsuperscript{24}

The term hypermobile can describe excessive motion compared with normal ranges, and describes an angular movement. Joint hypermobility is a result from genetic variations with the result of excessive tissue stretch. Two types of hypermobility are described in the literature. The first is benign hypermobility syndrome which occurs in people whose joints are just like everyone else’s. The other has features that suggest that it may be part of an inherited connective tissue disorder.\textsuperscript{20}

Bak and Magnusson\textsuperscript{25} reported that there was a difference between competitive swimmers with and without
symptomatic shoulders concerning the degree of rotation, but concluded that these changes were not related to their symptoms. Competitive swimmers appear to need excessive mobility of their shoulder joints in order to perform an efficient swimming technique. There is a very subtle balance between excessive mobility and instability. On the one hand an excessive motion allows the athlete to perform more powerful swim strokes, but on the other hand this extensive motion might stretch those structures responsible for producing stability resulting in future instability.\textsuperscript{20}

Laxity that allows excessive joint translations resulting in instability may be a key factor in causing shoulder pain. If glenohumeral instability is the important variable, this would account for the fact that only certain athletes subjected to the same training program and work load suffer interfering shoulder pain.\textsuperscript{1}

Interfering Shoulder Pain in the Swimmer

Pain for swimmers may be elicited at different phases of the stroke. According to Fowler\textsuperscript{26}, who studied a group of competitive swimmer with reported shoulder pain, the onset of pain during the phases of the freestyle stroke varied. Pain was reported by 47.1\% of subjects during the
entry and first half of the pull phase; 14.3% reported pain during the end of the pull; 23.2% reported pain during the recovery; and 17.8% reported pain throughout the stroke. The greatest moment of pain during the backstroke tends to happen in the entry and the first half of the pull phase. The greatest moment of pain during the backstroke tends to happen in the entry and the first half of the pull phase.

The butterfly stroke produces the highest incidence of shoulder pain. Research by McMaster and Troup reported, a total of 1262 swimmers, levels ranging from youth to masters, were surveyed about pain while using the butterfly stroke. It was unanimous throughout the groups that performing the butterfly produced the greatest amount of pain when suffering from swimmer’s shoulder. The greatest degree of pain seems to occur during a major portion of the stroke—the late portion of the recovery through to the first half of the pull.

The breaststroke tends to produce the least incidence of shoulder pain. Breaststrokers tend to have pain initially during the freestyle stroke, then breaststroking movements are later affected because it relies less on upper body power than with any other stroke, therefore this stroke seems to be less of a causative factor in shoulder pain.
Injury Prevention

The most important factor in treating swimmer’s shoulder is prevention. After injury it is preferred to treat an injury by cutting training to one-half the previous level while emphasizing stretching, strengthening, anti-inflammatory medication, and fundamentals. Activity is increased as pain diminishes in an effort to minimize the detraining effect of an injury.\(^1,2,28\)

The best time to initiate preventative measures is when the athlete first takes to the water. Proper instruction in the development of stroke mechanics should be the goal of every swimming coach. Too much emphasis is placed upon performance times and too little emphasis on proper technique, which in the long run is the essential factor for continuing success.\(^1,2\)

One of the goals of prevention is to avoid dysfunction or imbalance of the rotator cuff and the scapular stabilizers.\(^16,25,27\) Rubber band and resistive weight training of the pectoralis major and latissimus dorsi may prevent injury, although controlled studies on this matter are lacking.\(^17\) Low resistance, high repetitive sport specific exercises simulating the swimming stroke should be employed.\(^1\) Also, it is believed that posterior capsular
stretching will be helpful in the treatment of impingement.\textsuperscript{28}

Today’s athlete should be able to perform to maximal potential without overtraining or mistraining. With further research into the mechanics of swimming injury, and continued advances in medical technology and techniques of prevention, it is hoped that swimmer’s shoulder will become less of a problem for the sports medicine practitioner and the swimming athlete alike.\textsuperscript{1}

**Functional Training**

Joint proprioception or kinesthesia in freestyle swimmers is an important aspect of functional training. In theory, retraining of proprioception should match the sport-specific stimulation of the joint and muscle receptors. Since swimming is an open chain activity, the exercises used should reflect this. Plyometrics are proposed to enhance power and explosiveness, but they may also help to improve synchrony of movement that is needed for the swimming stroke.\textsuperscript{30}

These exercises can be performed by gradually increasing the size of medicine balls. Various exercises can be utilized for swimmers, including chest, overhead, and side passes with medicine balls. Plyometric exercises
such as these should progress accordingly in speed, difficulty, repetitions, and weight.\textsuperscript{30}

The results of a study done by Swanik et al\textsuperscript{10} indicated that functional training reduces the incidence of injury in swimmers. Strength changes did occur over a 6-week period, further validating the need to constantly re-evaluate functional or dry-land training programs for strength and endurance development and deficits, as well as, to incorporate current demands of the sport throughout competitive and off-season programs. Furthermore, decreasing or eliminating the amount of internal and adduction types of exercises and continuing to emphasize external rotation and abductor strength is recommended.

Scovazzo et al\textsuperscript{31} found that competitive swimmers with painful shoulders recruit the rhomboid muscle more during the propulsive phase of the freestyle stroke compared with swimmers with pain-free shoulders. The mid scapular muscles are therefore long and strong. This may be why swimmers present with exquisite tenderness and spasms in the rhomboids. Swimmers try to stretch these muscles that are already lengthened. Instead, these muscles need to be trained to contract in a more shortened position. This will additionally help correct the forward shouldered posture to allow for increased subacromial space.\textsuperscript{31}
A case study was reported on a female swimmer who had been battling shoulder pain all throughout her competitive season. She developed posterior shoulder pain in addition to her anterior symptoms and over time the posterior pain had limited her swimming greatly.\textsuperscript{32}

Additionally, Pink et al\textsuperscript{33} and Scovazzo et al’s\textsuperscript{31} comparison of electromyographic firing patterns in swimmers with and without shoulder pain did however reveal significant differences between the two groups for certain muscles, including less serratus anterior and more rhomboid activity in the painful shoulder group than the normal group during pull through. At the exact time that the serratus anterior was dysfunctional and exhibiting abnormally low levels or activity, the rhomboids were exhibiting significantly more in the painful shoulders.\textsuperscript{31} Thus, the rhomboids were retracting and downwardly rotating while the serratus anterior should have been doing the opposite. Also, the rhomboids may have been substituting for a fatigued serratus anterior.\textsuperscript{31}

Although there is no way to confirm if these differences were a cause or a result in a loss of proximal stability, altering the normal scapulohumeral rhythm, and placing increased demands on the rotator cuff musculature and the biceps. This improper rhythm was believed to have
contributed to the problem by causing faulty stroke mechanics which the swimmer reported.

The athlete began treatment and only participated only in kicking workouts during practice. By the end of a few weeks she was competing again and even winning races. This just goes to show that hard work and determination pays off when an athlete is serious about getting back to functional activity.

Summary

The shoulder joint is the most mobile joint in the body; therefore, it is structurally insecure. The wide range of motion of the shoulder is necessary for different swimming techniques, however what the joint achieves in range of motion it sacrifices in instability. Early detection of anatomical imbalances, especially in posture may prevent further complications in an athlete’s career.

Ideal posture is a composite of all the joints of the body at any given moment. Kendall et al explains that evaluating and treating postural problems requires an understanding of basic principles relating to alignment, joints, and muscles. Faulty posture can adversely affect
the position of the shoulder joint, and malalignment of this joint can predispose to injury and chronic pain.\textsuperscript{6}

Overuse is agreed to be the main factor in the development of shoulder pain, because not all swimmers have this pain it is suggested that overuse is combined with a second insult.\textsuperscript{8} Several variables that could trigger the symptoms include strength imbalance, fatigue, improper technique, and flexibility.\textsuperscript{10} Shoulder pathologies that can stem from these causes are as follows impingement, biceps tendonitis, and instability. By understanding the basic anatomy, causes, and common injuries of the shoulder complex, athletes can attack the causal factors of pain before they begin.

Swimming is an activity that relies on maximal propulsive force applied over the extremities in motion of the upper extremity. Four major swimming patterns are used in competition, the crawl (freestyle), backstroke, breaststroke, and the butterfly stroke. Each has characteristic arm patterns but all use two phases of action, pull and recovery.

With the basic pattern of arm motion being the same for all four strokes, it is logical to assume the primary propulsive force in swimming is the musculature between the trunk and the arm, that is the pectoralis major and the
To excel at the sport of competitive swimming, mechanical efficiency is an important factor. The swimming technique that produces the greatest distance per stroke at the most efficient energy will produce the best results.

Athletes who experience excessive joint ranges in the shoulder complex have been known to perform at higher levels. A shoulder with increased range of motion has what is called capsuloligamentous laxity. Laxity portrays the actual translation within a joint without influence of pain during passive motion. Laxity that allows excessive joint translations resulting in instability may be a key factor in causing shoulder pain.

Shoulder pain has been found to occur in men and women, on the dominant and nondominant sides, during all parts of the stroke and all strokes, at all distances, and at all levels of training. The described pain varies from minor, nagging, pain occurring only with vigorous use of hand paddles to chronic debilitating pain lasting well past the end of practice. The pain varies in location about the shoulder, including anteriorly, anterolaterally, superiorly, posteriorly, and at the insertion of the deltoid.
The most important factor in treating the painful swimmer’s shoulder is prevention. After injury it is preferred to treat an injury by cutting training to one-half the previous level while emphasizing stretching, strengthening, anti-inflammatory medication, and fundamentals. Decreasing or eliminating the amount of internal rotation and adduction types of exercises and continuing to emphasize external rotation and abductor strength is recommended.\textsuperscript{1,2,28}

By understanding the key factors such as muscular imbalances, stroke mechanics, and the causes for pain a rational plan can be formulated for treating and preventing swimmer’s shoulder. There is no question that the consequences of shoulder problems are serious for the competitive swimmer, but it is hoped that management of this pain can be a unified approach to a successful career.
APPENDIX B

The Problem
Statement of the Problem

Shoulder pain is a common complaint of competitive swimmers. The term “swimmer’s shoulder” is typically used to describe any type of shoulder discomfort which can affect the swim season that may last 10-12 months a year. Research supports two common contributing factors associated with swimmer’s shoulder they include: flexibility and muscle imbalances between the internal and external rotators. However, literature is limited in demonstrating any type of correlation between these factors and shoulder pain. It is important for the athletic trainer to understand this problem so that a preventative measure can be applied. The purpose of this study was to determine whether a correlation exists between posture, excessive or limited range of motion, and shoulder pain.

Definition of Terms

The following terms have been defined using the appropriate references and will be applied throughout the study:

1. **Dynamic Stabilization** – the ability to maintain joint control due to unequal forces acting on the body.¹⁰
2. **Flat Back** — posture has lost the normal “S” shaped curvature of the spine in the sagittal plane. The thoracic and lumbar curvatures are decreased and the spine is relatively straight.\(^6\)

3. **Forward Head** — the anterior displacement of the head relative to the thorax.\(^6\)

4. **Hypermobility** — is described as excessive motion compared with normal ranges, and describes an angular movement.\(^23\)

5. **Impingement** — the narrowing of the subacromial space causing the tendons of the shoulder to become pinched between the bones.\(^1,2,5\)

6. **Instability** — is experienced by the athlete and presupposes an excessive mobility of the joint with effect on pain perception during active motion.\(^21\)

7. **Joint Laxity** — laxity portrays the actual translation within a joint without influence of pain during passive motion.\(^20\)

8. **Kyphosis** — is increased anterior concavity of the normal thoracic curve.\(^6\)

9. **Lordosis** — is increased posterior concavity of the lumbar and cervical curves.\(^6\)
10. **Neutral Position** - is defined as the anterior superior iliac spines are in the same horizontal plane with the symphysis pubis.\(^6\)

11. **Plumb Line** - provides an absolute vertical line for measuring deviations.\(^6\)

12. **Plyometrics** - are exercises proposed to enhance power and explosiveness.\(^29\)

13. **Posture** - is defined as a situation when the center of gravity of each segment is placed vertically above the segment below.\(^6\)

14. **Static Stabilization** - is the ability to balance all forces acting on the body, resulting in equilibrium.\(^10\)

15. **Subluxation** - involves the partial or complete disassociation of the joint’s articulating surface that may spontaneously return to their normal alignments.\(^26\)

16. **Surface Electromyography** - a technique in which electrodes are placed on the skin overlying a muscle to detect the electrical activity of the muscle.\(^17\)

17. **Sway Back** - is often referred to as a position of instability. With this posture the person relies on postural stability from their ligaments rather than that of muscular support.\(^6\)
18. **Torque** - or movement of force, is the turning effect of an eccentric force.

**Basic Assumptions**

The following were the basic assumptions of the study:

1. The Watson MacDonncha Posture Analysis and the Goniometer were valid and reliable tools for testing.

2. The Swimmer’s Shoulder Pain scale will show an accurate reflection of the swimmer’s pain when given after practice.

3. The Swimmer’s Shoulder Pain Scale is a valid tool although no reliability coefficient has been reported for the use of this scale.

**Limitations of the Study**

The following were possible limitations of the study:

1. The study’s results were limited to similar size Division II female swim programs.

2. A homogeneous sample (females only) were used.

**Significance of the Study**

Shoulder pain in competitive swimmers is demonstrated to be present at all levels of competition.¹⁶ There can be a variety of different problems associated with the shoulder
without specific reference to their cause, thus resulting in confusion and misinterpretation. Researchers have found that the primary cause of shoulder pain in swimmers is impingement of the rotator cuff, biceps tendon, subdeltoid bursa, and subacromial arch.\textsuperscript{14} The mechanism of injury is believed to be a result of repetitive stress, overuse, and improper stroke mechanics.\textsuperscript{14} Since 80\% of practices focus on the freestyle technique, of the four main strokes: freestyle, butterfly, breaststroke, and backstroke, it suggests that this particular method has a great impact on shoulder pain and injury.\textsuperscript{14}

Flexibility regarding pain and injury is controversial in much of the literature. Some authors suggest that a lack of shoulder flexibility in swimmers contributes to shoulder injury. On the other hand, one author discusses the influence of hyperflexibility in swimmers, which may cause a multitude of problems.\textsuperscript{14} Even though training techniques have greatly improved over the past 10 years, the incidence of shoulder pain in swimming has not declined.\textsuperscript{16}

Shoulder pain in the swimming athlete that interferes with effective training is serious and may result in decreased performance. To excel at the sport of competitive swimming, mechanical efficiency is an important
The swimming technique that produces the greatest distance per stroke at the most efficient energy use will produce the best result. Therefore, a significant mechanical factor that the athlete has to overcome is drag. Poor body mechanics may result in increased active drag and decreased swimming efficiency.

While many factors may attribute to pain and injury in competitive swimmers, this study will look at the connection between whether or not flexibility and/or posture play an important part in preventing these injuries. If athletic trainers can have their athletes perform certain stretches or corrective postural training prior to their practice then there may be less incidences of pain and injury.
APPENDIX C

Additional Methods
APPENDIX C1

Informed Consent
Informed-Consent Form

Jamie Lavis, who is a graduate athletic training student at California University of Pennsylvania, has requested my participation in a research study at this institution. The title of the research is *The Relationship Among Posture, Shoulder Range of Motion, and Intensity of Pain in Female Collegiate Swimmers*.

I have been informed that the purpose of the research is to determine whether a correlation exists between posture, excessive or limited range of motion, and intensity of pain. Students who are 18 years of age or older and members of the California University of Pennsylvania women’s swim team will be asked to participate on a voluntary basis.

My participation will involve being measured for a posture analysis, internal/external rotation and flexion of the shoulder joint, describing current pain on the Swimmer’s Shoulder Pain Scale, and completing a demographics form. The duration of gathering this information from the subjects will take approximately 30-40 minutes.

I understand that there are foreseeable risks or discomforts by participating in this study. Any possible risk and/or discomfort could include pain or joint subluxation; this would be controlled by the athlete using active range of motion. The researcher’s knowledge of proper execution, as well as using standard goniometric procedures, will minimize this risk. There are no risks and/or discomforts for measuring posture.

There are no feasible alternative procedures available for this study.

I understand that the possible benefits of my participation in the research are to contribute to the existing knowledge of swimmers shoulder and to help predict why in fact pain occurs. The field of athletic training will benefit from this research because it will help enhance injury prevention techniques and it may help determine an actual cause of the mechanism of injury.

I understand that the results of the research study may be published but my name or identity will not be revealed. In order to maintain confidentiality of my records, Jamie Lavis will maintain all documents in a secure location in which only the student researcher and research advisor can access. Any information gathered will correspond to a subject code so that the subject’s identity will never be exposed. The student researcher and the research advisor will be the only people who will be able to access this information. The documents will be locked in a secure office, so that confidentiality will remain evident.

I have been informed that I will not be compensated for my participation.

I have been informed that any questions I have concerning the research study or my participation in it, before or after my consent, will be answered by Jamie Lavis, lav8916@cup.edu, (814)244-9049; or Dr. Joni Roh, roh@cup.edu, (724) 938-4562.

I understand that written responses may be used in quotations for publication but my identity will remain anonymous.
I have read the above information. The nature, demands, risks, and benefits of the project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to me upon request.

Subject's signature__________________________________________ Date _______________

Other signature (if appropriate)________________________________ Date ________________

I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature.

I have provided the subject/participant a copy of this signed consent document if requested.

Investigator’s signature________________________________________ Date ________________

Approved by the California University of Pennsylvania IRB
APPENDIX C2

Demographics
Subject # _____

Demographics

1. Age ____
2. Year in School       Fr   Soph   Jr   Sr
3. Number of consecutive years in competitive swimming ______
4. Current daily yardage ______
5. Current practices per week ______
6. Months per year of training ______
7. Handedness: Right   Left
8. Type of stroke: (circle all that apply)
   Freestyle   Breaststroke
   Backstroke   Butterfly
9. Type of swimmer: Sprinter   Distance   Both
10. Are you currently taking medication for pain? 
    Yes   or   No
    If yes, for what specific type of injury or complaint? ______________________
APPENDIX C3

Photographic Release Form
Photographic Release Form
Watson MacDonncha Photographic Posture Analysis

Subject # __________
Date ____________

The researcher requests the use of photographic material for parts of her study and possibly future presentations. The material will be used for the research project as the researcher has described in the informed consent document that you have signed. These materials may be used for professional publications, professional conferences, websites, and pictorial exhibits related to the study.

The researcher also emphasizes that the appearance of these materials on certain media (websites, professional publications, news releases) may require the transfer of copyright of the images. This means that other individuals may use your image. Regarding the use of your likeness in photographs, tapes, or recordings, please check one of the following boxes:

I do ___
I do not____

Give unconditional permission for the investigator to utilize photographs of me.

________________________________ _____________
Signature      Date

Note: Even should you choose not to allow your image to be used, the researcher can still benefit from your inclusion as a research study participant.

Permission by Allison S. Mills¹⁹
APPENDIX C4

Assessment Criteria for Posture
Fig. 1.—Ankle posture. Fig. 2.—Knee interspace. Fig. 3.—Knee hyperextension/flexion. Fig. 4.—Lordosis. Fig. 5.—Kyphosis. Fig. 6.—Scoliosis "C".
Fig. 7—Scoliosis "S". Fig. 8—Round shoulders and abducted scapulae. Fig. 9—Shoulder symmetry. Fig. 10—Forward head. Fig. 11—Measurement of lordosis.
## Quantitative Scoring Scale

<table>
<thead>
<tr>
<th>Posture Aspect</th>
<th>Score of a 5</th>
<th>Score of a 3</th>
<th>Score of a 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ankle Valgus or Varus</td>
<td>&lt; 7 degrees</td>
<td>7-10 degrees</td>
<td>&gt; 10 degrees</td>
</tr>
<tr>
<td>2. Knee Interspace</td>
<td>Ankle together; medial epicondyles touching</td>
<td>1. Medial epicondyles touching; medial malleoli not touching 2. Medial malleoli are touching but there is 1-3mm between the medial epicondyles</td>
<td>1. Medial epicondyles are more than 4mm apart; medial malleoli are touching 2. Q angle is measured more than 15 for women and more than 12 degrees for males</td>
</tr>
<tr>
<td>3. Knee Hyperflexion or Hyperextension</td>
<td>A line can be drawn straight through the thigh and lower leg. No marked deviation</td>
<td>Moderate deviation from the midline either in extension or in flexion</td>
<td>Extreme deviation from the midline either in extension or in flexion</td>
</tr>
<tr>
<td>4. Lordosis</td>
<td>Circle with a diameter of 7cm</td>
<td>Circle with a diameter of 4.5cm</td>
<td>Circle with a diameter of 3cm</td>
</tr>
<tr>
<td>5. Kyphosis</td>
<td>Circle with a diameter of 9cm</td>
<td>Circle with a diameter of 7cm</td>
<td>Circle with a diameter of 6cm</td>
</tr>
<tr>
<td>6. Scoliosis</td>
<td>Vertical line drawn through vertebrae markers; no deviation</td>
<td>Moderate deviation; 1.5-3 degrees of the vertical line</td>
<td>Extreme deviation; greater than 3 degrees deviation from the vertical line</td>
</tr>
<tr>
<td>7. Shoulder; rounded</td>
<td>Shoulders are behind the upper chest</td>
<td>Shoulders are slightly forward of the upper chest</td>
<td>Shoulders are in front of the upper chest</td>
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<tr>
<td>8. Shoulder Symmetry</td>
<td>No difference in symmetry</td>
<td>Deviation greater than 1mm-2.5mm</td>
<td>Deviation greater than 2.5mm</td>
</tr>
<tr>
<td>9. Shoulder Abducted; Winged Scapulae</td>
<td>No deviation from a slight outline of the scapulae</td>
<td>Inferior angles and portions of the medial border are clearly visible</td>
<td>Inferior angles were protruding excessively and/or all the medial borders and scapular spines are visible</td>
</tr>
<tr>
<td>10. Forward Head Posture</td>
<td>Head protraction angle is less than 5 degrees</td>
<td>Head protraction angle is in between 5-10 degrees</td>
<td>Head protraction angle is greater than 10 degrees</td>
</tr>
</tbody>
</table>
APPENDIX C5

Goniometry
Universal Goniometer

Measuring Shoulder Flexion
APPENDIX C6

Swimmer’s Shoulder Pain Scale
Swimmer’s Shoulder Pain Scale

Please check the box that corresponds to your current shoulder pain level.

☐ No pain

☐ Occasional shoulder pain which lasts less than two hours. No problem.

☐ Shoulder pain lasting longer than 2 hours following swim practice.

☐ Shoulder pain experienced on forceful arm movements.

☐ Shoulder pain which is annoying for perhaps eight hours a day. Could have affected my practice abilities.

☐ Pain was very annoying. Almost certainly affected my ability to practice hard.

☐ Severe shoulder pain, lasting at least 12 hours a day (unless I used ice, medication, etc). Almost impossible to practice hard.
APPENDIX C7

Data Collection Sheet
<table>
<thead>
<tr>
<th>Subject #</th>
<th>Internal Rotation Right</th>
<th>Internal Rotation Left</th>
<th>External Rotation Right</th>
<th>External Rotation Left</th>
<th>Flexion Right</th>
<th>Flexion Left</th>
<th>Ankle Valgus/Varus</th>
<th>Knee Interspace</th>
<th>Knee Hyper-Ext/Ext</th>
<th>Lateralis</th>
<th>Kyphosis</th>
<th>Scoliosis</th>
<th>Rounded Shoulders</th>
<th>Shoulder Adducted</th>
<th>Shoulder Abduced</th>
<th>Forward Head</th>
<th>Pain Scale Scores</th>
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</table>
Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects

(Reference IRB Policies and Procedures for clarification)

---

**Project Title:** The Relationship Among Posture, Shoulder Range of Motion, and Intensity of Pain in Female Collegiate Swimmers.

**Researcher/Project Director:** Jamie L. Lavis

**Phone #** 814-244-9049  
**E-mail Address:** lav8916@cup.edu

**Faculty Sponsor (If required):** Dr. Joni Roh

**Department:** Health Science & Sports Studies

**Project Dates:** January 2007 to April 2007

**Sponsoring Agent (If applicable):**

**Project to be Conducted at:** California University of Pennsylvania – Hamer Hall

**Project Purpose:** ☑ Thesis  □ Research  □ Class Project  □ Other

---

**Required IRB Training**

The training requirement can be satisfied by completing the online training session at [http://cme.nci.nih.gov/](http://cme.nci.nih.gov/). A copy of your certification of training must be attached to this IRB Protocol. If you have completed the training at an earlier date and have already provided documentation to the California University of Pennsylvania Grants Office, please provide the following:

**Previous Project Title:**

**Date of Previous IRB Protocol:**

---

**Keep a copy of this form for your records.**
Please attach a typed, detailed summary of your project AND complete items 2 through 6.

1. Provide an overview of your project-proposal describing what you plan to do and how you will go about doing it. Include any hypothesis(s) or research questions that might be involved and explain how the information you gather will be analyzed. For a complete list of what should be included in your summary, please refer to Appendix B of the IRB Policies and Procedures Manual.

The purpose of this study is to determine whether a correlation exists between posture, excessive or limited range of shoulder motion, and shoulder pain. This study will measure posture using the Watson-MacDonncha posture analysis, internal/external range of motion and flexion using standard procedures for a goniometer, and pain using the Swimmer’s Shoulder Pain Scale. Subjects will consist of volunteers from the California University of Pennsylvania women’s swim team. Each subject will be measured once at a scheduled time before practice during a week period. The hypothesis is that there will be a relationship among swimmer’s shoulder degree of range of motion, posture score, and intensity of pain. The data will be analyzed using a Pearson Product Moment Correlation using an alpha level of <0.05 to determine significance.

2. Section 46.11 of the Federal Regulations state that research proposals involving human subjects must satisfy certain requirements before the IRB can grant approval. You should describe in detail how the following requirements will be satisfied. Be sure to address each area separately.

   a. How will you insure that any risks to subjects are minimized? If there are potential risks, describe what will be done to minimize these risks. If there are risks, describe why the risks to participants are reasonable in relation to the anticipated benefits.

Risk will be minimized by using the standard operating procedures for goniometry testing. Participants will place their shoulder in the proper position actively to ensure the full range of motion is reached to their specific tolerance. Risk of pain or subluxation is possible but with the researcher’s knowledge of proper execution this risk will be none to minimal. Any injuries that may occur during goniometry testing can be treated in the Athletic Training room at Hamer Hall provided by any certified athletic trainer or the graduate researcher, Jamie Lavis. The possible benefits from participating in this study include contributing to existing knowledge about the shoulder, enhancing injuries prevention techniques, and determining the cause of shoulder pain.

   b. How will you insure that the selection of subjects is equitable? Take into account your purpose(s). Be sure you address research problems involving vulnerable populations such as children, prisoners, pregnant women, mentally disabled persons, and economically or educationally disadvantaged persons. If this is an in-class project describe how you will minimize the possibility that students will feel coerced.

Sixteen California University of Pennsylvania swimmers will be asked to participate in the study involving the cause of shoulder pain. The study is limited to this select population due to the specifics of the research study. Each subject will have the opportunity to volunteer or not.
c. How will you obtain informed consent from each participant or the subject’s legally authorized representative and ensure that all consent forms are appropriately documented? Be sure to attach a copy of your consent form to the project summary.

Informed consent and a photographic release form will be read and signed by the subject prior to the study.

d. Show that the research plan makes provisions to monitor the data collected to insure the safety of all subjects. This includes the privacy of subjects’ responses and provisions for maintaining the security and confidentiality of the data.

Subjects will be asked after each test if they are experiencing pain, discomfort, or injury—privately. The goniometry measurements, posture analysis scores, and pain assessment as well as any other information obtained will be kept confidential in a locked office in which only the researcher and research advisor will have access to.

3. Check the appropriate box(es) that describe the subjects you plan to use.

- Adult volunteers
- CAL University Students
- Other Students
- Prisoners
- Pregnant Women
- Physically Handicapped People
- Mentally Disabled People
- Economically Disadvantaged People
- Educationally Disadvantaged People
- Fetuses or fetal material
- Children Under 18
- Neonates

4. Is remuneration involved in your project? □ Yes or □ No. If yes, Explain here.

5. Is this project part of a grant? □ Yes or □ No. If yes, provide the following information:
   - Title of the Grant Proposal
   - Name of the Funding Agency
   - Dates of the Project Period

6. Does your project involve the debriefing of those who participated? □ Yes or □ No
   If Yes, explain the debriefing process here.

7. If your project involves a questionnaire interview, ensure that it meets the requirements of Appendix ___ in the Policies and Procedures Manual.
Project Director’s Certification
Program Involving HUMAN SUBJECTS

The proposed investigation involves the use of human subjects and I am submitting the complete application form and project description to the Institutional Review Board for Research Involving Human Subjects.

I understand that Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects. If the Board grants approval of this application, I agree to:

1. Abide by any conditions or changes in the project required by the Board.
2. Report to the Board any change in the research plan that affects the method of using human subjects before such change is instituted.
3. Report to the Board any problems that arise in connection with the use of human subjects.
4. Seek advice of the Board whenever I believe such advice is necessary or would be helpful.
5. Secure the informed, written consent of all human subjects participating in the project.
6. Cooperate with the Board in its effort to provide a continuing review after investigations have been initiated.

I have reviewed the Federal and State regulations concerning the use of human subjects in research and training programs and the guidelines. I agree to abide by the regulations and guidelines aforementioned and will adhere to policies and procedures described in my application. I understand that changes to the research must be approved by the IRB before they are implemented.

Professional Research

<table>
<thead>
<tr>
<th>Project Director’s Signature</th>
<th>Department Chairperson’s Signature</th>
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</thead>
</table>

Student or Class Research

<table>
<thead>
<tr>
<th>Student Researcher’s Signature</th>
<th>Supervising Faculty Member’s Signature if required</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Department Chairperson’s Signature</td>
</tr>
</tbody>
</table>

**ACTION OF REVIEW BOARD (IRB use only)**

The Institutional Review Board for Research Involving Human Subjects has reviewed this application to ascertain whether or not the proposed project:

1. provides adequate safeguards of the rights and welfare of human subjects involved in the investigations;
2. uses appropriate methods to obtain informed, written consent;
3. indicates that the potential benefits of the investigation substantially outweigh the risk involved.
4. provides adequate debriefing of human participants.
5. provides adequate follow-up services to participants who may have incurred physical, mental, or emotional harm.

☑ Approved ☐ Disapproved

Chairperson, Institutional Review Board  01-31-07 Date
APPENDIX C9

Participant Positioning
Participant Positioning: Photography

Posture

Anterior View

Left Lateral View

Left Oblique View

Posterior View
APPENDIX C10

Oral Directions for Photography
Watson MacDonncha Posture Analysis

Oral Directions during Photography:

1. Please hold your arms relaxed and at your side with your thumbs pointing forward. If possible your heels will be touching with your feet parallel over the red line.

2. If your knees are pressing together and your heels are not touching, please place your knees slightly touching, leaving your ankles to be naturally comfortable.

3. If you are uncomfortable please bend your knees and lower you body to return to an original position.

4. PICTURE #1: Please stand upright staring straight ahead with chin parallel to the ground and fully extend the elbows and knees. (Anterior View)

5. PICTURE #2: Please turn 90 degrees to your right and place your feet together over the blue line. Stand upright staring straight ahead with your chin parallel to the ground and fully extend your elbows and knees. (Lateral View)

6. PICTURE #3: Please turn 45 degrees to your right again and place your feet parallel with the yellow line. Stand upright staring straight ahead with your chin parallel to the ground and fully extend your elbows and knees. (Oblique View)

7. PICTURE #4: Please turn 45 degrees to your right and place your feet parallel with the red line and face the back wall. Stand upright staring straight ahead with your chin parallel to the ground and fully extend your elbows and knees. (Posterior View)

8. PICTURE #5: Please turn around and hold up your subject number in front of your chest. Thanks!
APPENDIX C11

Anatomical Landmarks
ANATOMICAL LANDMARKS FOR PHOTOGRAPHY

#1 ANTERIOR VIEW: 10 pts total
- Clavicle heads
- AC & SC joints
- ASIS
- Center of the patellae
- Tibial tuberosities

#2 LEFT LATERAL VIEW: 4 pts total
- Ear: Pinna
- Axillary fold
- Greater trochanter
- Patellar notch

#3 POSTERIOR VIEW: 9 pts total
- C7
- T3
- T6
- T12
- L3
- L5
- Sacrum
- Center of calcaneous

23 markers total
10 Anterior
4 Left lateral
9 Posterior

Permission by Allison S. Mills
REFERENCES


33. Pink M, Perry J, Browne A, et al. The normal shoulder during freestyle swimming: an electromyographic and cinematographic analysis of
TITLE: THE RELATIONSHIP AMONG POSTURE, SHOULDER RANGE OF MOTION, AND INTENSITY OF PAIN IN FEMALE COLLEGIATE SWIMMERS

RESEARCHER: Jamie Lynne Lavis, ATC, PES, EMT

ADVISOR: Joni L. Roh, EdD, ATC

DATE: May 2007

RESEARCH TYPE: Master’s Thesis

PURPOSE: The purpose of this study was to determine whether a correlation existed between posture, excessive or limited range of motion, and shoulder pain.

PROBLEM: Literature is limited in demonstrating any type of correlation between posture, flexibility, and shoulder pain.

METHOD: 14 NCAA Division II female swimmers were used. The instruments included: a posture analysis, goniometer, and a pain scoring scale.

FINDINGS: No significant correlation was found between posture, pain, and shoulder range of motion, indicating a relatively homogenous group of female athletes.

CONCLUSION: The data collected showed range of motion analysis to be within normal limits, pain to be relatively minimal, and posture scores to have minimal posture deviations. Possibly the specific training of this particular team has had a positive effect on the variables examined. Future studies could include male swimmers or swimmers at other institutions where Pilates and core stabilization training are not performed.