THE EFFECTS OF STRETCHING SHOULDER MUSCULATURE ON THROWING VELOCITY

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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Candidate for the degree of Master of Science
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If I didn’t have the help of the following people I don’t know what this thesis would have turned out to be. Thank you to the Avella School District School Board members, my wonderful AD Darren Shaffer, Jane Gabler, Jim Morris, Jim Matelik, Jason Fogg, Dave Niekum, Curt Reddinger, and of course my athletes. A special thanks goes out to Jane and Curt for letting me use the gym and interrupt your classes.

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Introduction

It is common practice to stretch prior to exercise in order to prevent injury. However, it has been found that stretching has the potential to decrease power in the lower extremity. This project will examine if stretching has a similar effect on power production in the upper extremity as measured by throwing velocity.

Throwing a baseball is a total-body mechanism that places extraordinary stresses on the shoulder. For a baseball to travel 90 MPH, the hand must be traveling that fast at the time of release. Glenohumeral and scapulothoracic motion, in conjunction with movement of the pelvis and trunk, increases the distance through which the accelerating force may be applied to the ball. At the shoulder, this is achieved through excessive horizontal extension (approximately 30°) and external rotation (160-180°) during the cocking phase.¹

There are four components occurring transitionally from external to internal rotation that lead to the ball being released. These forces lead to maximum velocity. First the shoulder is explosively internally rotated. Ball release occurs between 40° and 60° of external rotation. Then as the shoulder is internally rotated, the elbow
flexes from 90° to approximately 120°. The elbow rapidly extends to a position of 25° of flexion 30-40 milliseconds before ball release. Third, 20 milliseconds before ball release, wrist flexion begins from a position of extension and ends in a neutral position. At this time the ball is released. The wrist does not flex beyond neutral until the ball is actually released. A common misconception is that “snapping” the wrist, or forcefully flexing it, increases throwing velocity. The majority of the speed in a fast over arm throw comes from the forearm, not the wrist.² Finally, radioulnar pronation begins 10 milliseconds before ball release, with the forearm pronated to approximately 90° at release.³

There are several muscle groups contributing to this forceful movement. In the early cocking phase the serratus anterior and trapezius are recruited to protract and rotate the scapula upward to position the glenoid.³ The supraspinatus provides fine adjustments to the humeral head while the middle deltoid provides most of the force for abduction. The supraspinatus also stabilizes the humeral head, thereby helping to protect the glenoid. The opposing influence of the serratus anterior, trapezius, rhomboids, and levator scapulae on scapular protracting, permit smooth external rotation of the humerus during the late cocking
The actions of the pectoralis major and minor, latissimus dorsi, biceps brachii and subscapularis also add anterior and posterior stability to the glenohumeral joint and shoulder girdle.\textsuperscript{3}

The major muscles that contribute to the observed forces of the acceleration phase are the powerful adductors/internal rotators of the shoulder, namely the pectoralis major and latissimus dorsi.\textsuperscript{3,4} The subscapularis guides the humeral head in the glenoid and prevents the subluxation of humeral head during explosive internal rotation.\textsuperscript{3,4} The teres minor limits the humeral head from posterior translation by allowing movement in the capsule when the shoulder is at maximum external rotation and extension, which can occur when the shoulder is cocked. In this study stretching of the latissimus dorsi and pectoralis major will be performed due to their roles as primary accelerators at the GH joint.

There are several factors which can effect throwing velocity including an athlete’s specificity of training, body size, how skilled one is, and angle of arm abduction during the acceleration phase.\textsuperscript{2,5-7} The closer the movement pattern and velocity of the training exercise is to the actual sporting movement, the greater the transference of training gains to athletic performance. Also, body size
has a strong positive effect on throwing velocity, while gender does not. Gender only matters when expressed as mass or height, which could be due to differences in muscle bulk. Ball speed is dependent on the skill of the thrower. The variability in ball speed in skilled throwers is due to variability in arm speed.

The goals of stretching before exercise are to increase flexibility and the muscle-tendon length. The increase of flexibility may enhance athletic performance and decrease the risk of injury during exercise. There are several types of stretching that produce increases in muscle and joint flexibility by different mechanisms. Static stretching is the most commonly used with the least associated risk of injury. This form of stretching is only effective in increasing static flexibility and does not affect dynamic flexibility as measured by active and passive stiffness. Ballistic stretching uses a bouncing motion. During this type of stretch the muscle is stretched at a fast rate then rebounded back repetitively. There is no evidence supporting that ballistic stretching is potentially more harmful than static stretching.

Proprioceptive neuromuscular facilitation (PNF) uses combinations of eccentric and passive stretching. Slow-
reversal-hold, contract relax, and hold-relax are the different variations of PNF. They all include the combination of alternating contracting and relaxing the agonist and antagonist muscles. When compared to static and ballistic stretching, all PNF techniques had improved range of motion more than the other two.\textsuperscript{8}

It has been found that there is a decrease in force output after stretching in the lower extremity.\textsuperscript{9-11} No research articles on force output and stretching could be found for the upper extremity. In one study on the lower extremity, after three different stretches of the knee and hip extensors, counter movement jump heights were significantly decreased.\textsuperscript{9} Fowles et al found similar results. They reported a 20\% decrease in power five minutes after stretching, which was accompanied by a 13\% decrease in activation as measured by the interpolated twitch technique (ITT) and a non-significant decrease in electromyographic activity (EMG).\textsuperscript{9}

It is still common practice to stretch prior to exercise, including overhand throwing. One may ask why, since it has been documented that, at least in the lower extremity, force output can be reduced after stretching. Also previous researchers have not examined power in the upper extremity or used high school aged athletes.
This study will attempt to fill in these gaps. The purpose of this study is to attempt to answer the following research questions:

1) Will stretching the internal rotators of the shoulder decrease throwing velocity?

2) Will stretching the internal rotators of the shoulder increase the active range of motion of internal rotation following throwing?

3) Will stretching the internal rotators of the shoulder increase the active range of motion of external rotation following throwing?
METHODS

The purpose of this study was to examine if it is necessary to stretch the posterior shoulder musculature to increase throwing velocity. The following will be discussed: Research Design, Subjects, Preliminary Research, Instruments, Procedures, Hypothesis, and Data Analysis.

Research Design

A quasi-experimental within subject design was used for this study. The independent variable was the condition. The dependent variables were throwing velocity, active range of motion (AROM) for internal rotation (IR) and external rotation (ER). There were two conditions with the subjects. Each subject was measured under each condition and served as their own control group.

The variable that was controlled was the stretching of the baseball and softball players. A strength of this study was that each subject will serve as their own control group so it was not necessary to have three separate groups. Some limitations of this study were that it was done on
high school students that are baseball and softball athletes and there were only two meetings.

**Subjects**

The subjects (N=13) were high school softball and baseball athletes from Avella High School. Subjects with a minor shoulder injury with in the past year were excluded from the study. The National Athletic Trainers’ Association (NATA) defines a minor injury as forcing loss of participation for less than one week, moderate injuries span 8-21 days, and anything beyond 21 days is severe.\(^{12}\) Athletes were not limited by the position that they play. Other demographic information that was obtained was year in high school, age, position(s) played, and throwing arm. Informed consent (Appendix C1) was obtained by the parents of the volunteers, and an ascent form (Appendix C2) from the volunteers themselves.

**Preliminary Research**

The purpose of preliminary research was to familiarize the researcher with the instruments that will be used, and determine the time frame necessary for testing each
subject. It also helped to familiarize the researcher with the stretching protocol that was used on each subject along with using the STALKER Sport cordless radar gun (Appendix C3). Preliminary subjects included baseball athletes from Washington and Jefferson College.

Instruments

The following instruments were used for the study: a subject demographic sheet (Appendix C4), a STALKER Sport radar gun to measure throwing velocity, and a static stretching routine of the latissimus dorsi and pectoralis major muscles (Appendix C5). The demographic sheet included year in school, throwing arm, if there had been an injury to the throwing arm in the last year, and positions played.

The number that appears on the radar gun was the subjects throwing velocity. A STALKER Sport radar gun was utilized. This is accurate within ±0.1 MPH.

Stretching Protocol

To stretch the latissimus dorsi the subject was supine on a treatment table with the hips and knees flexed, and the feet and low back flat on the table. The researcher
stood on the same side of the table as the subjects’
dominant side. The subject flexed the humerus while the
researcher held the scapula to prevent excessive abduction.
Traction was also be applied to the humerus while
stretching it overhead. This was a static stretch held
for 30 seconds.

To stretch the pectoralis major the subject was supine
on a treatment table. They placed their hands behind their
head as to do the test for a tight pectoralis major. The
researcher stood at their head and gently pushed on their
elbows to stretch the pectoralis major. This will be a
static stretch held for 30 seconds. If their arms hit the
table or they could not feel a stretch, a foam roller was
put underneath them so they could feel the stretch.

Procedures

The following steps were taken for this study:
approval from the Avella School District School Board
(Appendix C6), and approval to do the study by the
California University of Pennsylvania Internal Review Board
(Appendix C7). Once the study was approved there was a team
meeting at the beginning of a pre season practice,
informing them of the study. Interested volunteers
received consent forms at the end of the meeting. Details of the study were given along with informed consent for the parents and ascent from the student athletes. At this time a demonstration was done of the stretching that was performed and athletes scheduled meeting times. Approximately two days later, the study began. When the athlete was scheduled to meet with the researcher the consent form was turned in and they picked a number out of a hat determining what condition they would be in during the first session. Condition 1 was the stretching group and Condition 2 the control. Six athletes were in condition 1 on the first meeting. The session began with a warm that was the same for both conditions. This was the normal warm up performed by the team. There was a three minute run around the gym and any stretching that they felt necessary. There was not a set protocol for this round of stretching. They tossed a ball with a partner while kneeling. Gradually they stood and moved farther apart from one another while starting to throw harder.

Once they had completed warming up AROM for IR and ER were assessed using a goniometer. Individuals in Condition 1 were then stretched. After being stretched their throwing velocity was measured. They threw as hard as they could at a target 50 ft away 10 times. They were instructed
that they could do a crow hop if they felt necessary, but
there were not permitted to cross the line on the floor.
They were not allowed to rest for more than 30 seconds in
between each throw. AROM for IR and ER were reassessed
after throwing. After AROM had been assessed the second
time, participants were offered a bag of ice to help deter
any unwanted soreness.

The same protocol was followed for condition 2 with
the exception of being stretched. Approximately 7 days
later they came back for their second meeting, at which
time they switched groups.

Hypotheses

The following hypotheses are based on the review of
the literature and the intuition of the researcher.
1) Stretching the latissimus dorsi and pectoralis major
muscles of the shoulder will decrease throwing velocity.
2) There will be an increase in AROM of IR after
stretching the shoulder.
3) There will be an increase in AROM of ER after
stretching the shoulder.
Data Analysis

A dependent t test was used to determine the effect in conditions (stretch/no stretch), and the dependent variables AROM and velocity. An alpha level of ($P \leq 0.05$) was used to determine significance. SPSS 12.0 was used for this analysis.
RESULTS

Demographics

For this study thirteen high school aged softball and baseball athletes were tested. Of the thirteen athletes, nine were girls and four were boys. No one had sustained an injury to their throwing arm in the last year that prevented them from participating for five or more days. All thirteen also threw with their right hand. Eight were outfielders, two played first base, one played second base, one played third base, and one played catcher.

Hypotheses Testing

Three hypotheses were tested and results calculated. All hypotheses were tested using an alpha level of .05.

Hypothesis 1: Stretching the latissimus dorsi and pectoralis major muscles of the shoulder will decrease throwing velocity.

Means were calculated for velocity under each condition. Table 1 shows the mean throwing velocity under each condition. A dependent t test was calculated to
compare maximum velocity when stretching to maximum velocity without stretching.

Table 1. Means of Throwing Velocity Under Each Condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males W/Stretch</td>
<td>63.75 ± 2.63</td>
</tr>
<tr>
<td>Males W/out Stretch</td>
<td>60.75 ± 3.10</td>
</tr>
<tr>
<td>Females W/Stretch</td>
<td>42.89 ± 4.89</td>
</tr>
<tr>
<td>Females W/out Stretch</td>
<td>43.89 ± 5.44</td>
</tr>
</tbody>
</table>

Conclusion: The mean of velocity when stretching was 49.30 ± 10.87, and the mean of velocity without stretching was 49.08 ± 9.36. There was no significance between conditions ($t_{12} = .261, P = .799$). Table 2 shows the dependent t test for maximum velocity with and without stretching.

Table 2. Dependent t Test for Maximum Velocity With and Without Stretching

<table>
<thead>
<tr>
<th>Mean Difference</th>
<th>SD</th>
<th>Standard Error Mean</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Vel w/stretch-</td>
<td>.23</td>
<td>3.19</td>
<td>.89</td>
<td>.26</td>
<td>12</td>
</tr>
<tr>
<td>Max Vel w/out stretch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hypothesis 2: There will be an increase in AROM of IR after stretching the shoulder.

Means were calculated for post test IR averages with stretching to the mean post test IR averages with out stretching. Table 3 shows the difference in IR under each condition pre and post testing. A dependent t test was calculated to compare means of post test IR averages with stretching to the mean post test IR averages without stretching.

Table 3. Difference in IR Under Each Condition Pre and Post Testing

<table>
<thead>
<tr>
<th></th>
<th>Stretch</th>
<th>No Stretching</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre test</td>
<td>80.23</td>
<td>80.23</td>
<td>0</td>
</tr>
<tr>
<td>Post test</td>
<td>82.31</td>
<td>82.54</td>
<td>-0.23</td>
</tr>
</tbody>
</table>

Conclusion: The mean of post testing IR with stretching was 82.31 ± 11.22. The mean of post testing IR without stretching was 82.54 ± 8.68. There was not a significant difference in AROM of IR under either condition ($t_{12} = -.141, P = .890$). Table 4 shows the dependent t test for post test IR averages with and without stretching.
Table 4. Dependent t Test for Difference in IR With and Without Stretching

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Standard Error Mean</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post IR ave w/stretch-</td>
<td>-.23</td>
<td>5.90</td>
<td>1.64</td>
<td>-.14</td>
<td>12</td>
<td>.860</td>
</tr>
<tr>
<td>Post IR ave w/out stretch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hypothesis 3: There will be an increase in AROM of ER after stretching the shoulder.

Means were calculated for the post test ER averages with stretching and post test ER averages without stretching. Table 5 shows the difference in ER under each condition pre and post testing. A dependent t test was calculated to compare means of post test ER averages with stretching to the mean post test ER averages without stretching.

Table 5. Difference in ER Under Each Condition Pre and Post Testing

<table>
<thead>
<tr>
<th></th>
<th>Stretch</th>
<th>No Stretching</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre test</td>
<td>94.92</td>
<td>95.85</td>
<td>-0.93</td>
</tr>
<tr>
<td>Post test</td>
<td>95.62</td>
<td>98.08</td>
<td>-2.46</td>
</tr>
</tbody>
</table>

Conclusion: The mean of post testing ER with stretching was 95.62 ± 7.59. The mean of post testing ER
without stretching was 98.08 ± 9.56. There was not a significant difference in AROM of ER after stretching the shoulder \((t_{12} = -2.08, P = .060)\). Table 6 shows the dependent t test for post test ER averages with and without stretching.

Table 6. Dependent t Test for Post Test ER averages With and Without Stretching

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Standard Error</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post ER ave w/stretch</td>
<td>-2.46</td>
<td>4.27</td>
<td>1.19</td>
<td>-2.10</td>
<td>12</td>
<td>.060</td>
</tr>
<tr>
<td>Post ER ave w/out stretch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional Findings

In addition to the hypothesis testing the researcher also examined the relationships between demographic data and throwing velocity. A 2x2 ANOVA repeated measures was used to determine if gender and stretching condition had an effect on throwing velocity. The means for throwing velocity by gender and condition can be found in Table 7. Table 8 shows the results of the ANOVA examining the effect of gender and condition on velocity. The ANOVA revealed an interaction between stretching condition and gender with
boys throwing faster following stretching and girls throwing slower following stretching.

Table 7. Average Velocities by Gender and Stretching Condition.

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>W/Stretch</td>
<td>63.8</td>
<td>42.9</td>
</tr>
<tr>
<td>W/out Stretching</td>
<td>60.8</td>
<td>43.9</td>
</tr>
<tr>
<td>All Trials</td>
<td>62.3</td>
<td>43.4</td>
</tr>
</tbody>
</table>

Table 8. ANOVA Results Demonstrating the Effect of Gender and Stretching Condition on Velocity.

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stretching Condition</td>
<td>1</td>
<td>1.56</td>
<td>.237</td>
</tr>
<tr>
<td>Stretching Condition and Gender Error (throwing velocity)</td>
<td>11</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>6.245</td>
<td>.030</td>
</tr>
</tbody>
</table>

An independent t test was computed to compare overall throwing velocities regardless of stretching condition by gender. The mean velocities for each gender can be found at the bottom of Table 7. The results of the independent t test can be found in Table 9. There was a significant difference between genders with males having a higher throwing velocity than females ($t_{10.9} = 9.31, P < .001$).
Table 9. Independent t Test for Effect of Gender on Throwing Velocity.

<table>
<thead>
<tr>
<th>Mean</th>
<th>Standard Error Mean</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throwing velocity difference</td>
<td>18.9</td>
<td>2.03</td>
<td>9.31</td>
<td>10.9</td>
</tr>
</tbody>
</table>
DISCUSSION

To discuss the results of this study the following sections are presented: (1) Discussion of Results, (2) Conclusion, and (3) Recommendations.

Discussion of Results

Upon investigation of the stretching of pectoralis major and latissimus dorsi on maximum velocity and AROM of IR and ER, it was found that stretching had no significant effect on either maximum velocity or IR and ER AROM.

The findings of this study did not support the hypothesis that stretching would decrease throwing velocity. The research also rejected the hypotheses that stretching pectoralis major and latissimus dorsi would increase IR AROM as well as ER AROM.

There have not been any studies dealing with upper extremity stretching and its effects on throwing velocity. There have, however, been studies dealing with lower extremity stretching and vertical jump height. The difference in research outcomes between the upper and lower extremities could be due the stability of the joints, and size of the muscles involved. As the muscle size
increases, for example the quadriceps femoris to the supraspinatus, so does the GTO and muscle spindle count.\textsuperscript{15}

A static stretch of the pectoralis major and latissimus dorsi was used. Even though Behm,\textsuperscript{9} Fowles,\textsuperscript{10} and Marek\textsuperscript{11} used static stretching for the lower extremity, PNF has been found to increase ROM more than static and ballistic stretching.\textsuperscript{14} The present study did not find a significant increase in ROM after stretching. Perhaps the outcome would have been different had this type of stretching been used. If ROM was increased an effect on throwing velocity would be more likely.

The findings in this study could be limited to the use of only thirteen high school, in season athletes, whereas other studies dealing with stretching and its relationship to power had more subjects and different populations. Another limitation could be the type of stretching used. Because high school athletes are not familiar with PNF stretching it was easier to use static stretching.

The girls had some very poor throwing mechanics. Some did not use their whole body when they threw. The muscles that were being stretched may not have been used when they threw.
Conclusion

The findings of this study suggest that stretching does not affect throwing velocity nor does it significantly affect the AROM for IR or ER. Gender did affect throwing velocity under both conditions with males demonstrating higher throwing velocities than females. This could be due to the less skilled throwing mechanics of the girls.

Recommendations

As for stretching preventively, athletic trainers should keep on doing what they are doing. This study shows there is not an effect on throwing velocity, therefore, the outfielder catching the ball will be able to make the play at home if they are stretched. In other words, there will still be power behind the throw and the ball will make it to where it needs to go.

As for future studies, it is suggested to perform the trials out of season to limit the impact of practice. Another suggestion would be to utilize the same methods with different skill levels and see if the results are similar. A position specific study, comparing outfielders
to infielders, may also have a different outcome. As previously mentioned, high school students do not quite understand PNF stretching, therefore one might try that type of stretching and get a different outcome.
REFERENCES


11. Marek SM et al. Acute effects of static and


APPENDICES
APPENDIX A

Review of the Literature
The purpose of this literature review is to present information on the effects of stretching the shoulder musculature and throwing velocity. Many sports involve overhead throwing, which can cause laxity in the joint capsule. If athletic trainers can help prevent excess joint laxity and possible injury to the area, then pitchers would be able to pitch more innings, and possibly the following day. This literature review will discuss: 1) Functional Physiology of the Shoulder 2) Principles of Stretching 3) and Throwing Velocity.

Functional Anatomy of the Shoulder

The glenohumeral joint is the most mobile joint in the body with the highest rate of dislocation.\textsuperscript{1,2} The shoulder complex is comprised of the proximal humerus, the clavicle and scapula and their connection to each other; the clavicle attaching to the sternum and the scapula to the rib cage. This joint allows for 180° of rotation in the upper extremity in three different planes.\textsuperscript{1} Due to the amount of motion allowed, passive stability is significantly decreased. Numerous muscles must work
together both statically and dynamically to stabilize the joint.²

The dynamic stabilizers of the glenohumeral joint (GH) are the rotator cuff muscles because of the location of their scapular origins and insertions on the humerus.³ The rotator cuff is composed of four muscles: the supraspinatus, infraspinatus, teres minor, and subscapularis.²⁻⁴ These muscles play an essential role in maintaining the humeral head in a centralized position within the glenoid fossa, especially for overhead throwing athletes.⁴⁻⁵ They limit anterior translation of the proximal end of the humerus. The external rotators of the shoulder, or decelerators in throwing, are the supraspinatus, infraspinatus, and teres minor.⁴

The subscapularis guides the humeral head in the glenoid and prevents subluxation of the humeral head during explosive internal rotation. The teres minor limits the humeral head from translating posteriorly by allowing movement in the capsule when the shoulder is at maximum external rotation. This posterior movement can occur when the shoulder is cocked.⁶

Throwing a baseball is a total-body mechanism that places extraordinary stresses on the shoulder. For a baseball to travel 90 MPH, the hand must be traveling that
fast at the time of release. Glenohumeral and scapulothoracic motion, in conjunction with movement of the pelvis and trunk, increases the distance through which the accelerating force may be applied to the ball. At the shoulder, this is achieved through excessive horizontal extension (approximately 30°) and external rotation (160-180°) during the cocking phase.4

There are four components occurring transitionally from external to internal rotation that lead to the ball being released. These forces lead to maximum velocity. First the shoulder is explosively internally rotated. Ball release occurs between 40° and 60° of external rotation. Then as the shoulder is internally rotated, the elbow flexes from 90° to approximately 120°. The elbow rapidly extends to a position of 25° of flexion 30-40 milliseconds before ball release. Third, 20 milliseconds before ball release, wrist flexion begins from a position of extension and ends in a neutral position. At this time the ball is released. The wrist does not flex beyond neutral until the ball is actually released. A common misconception is that “snapping” the wrist, or forcefully flexing it, increases throwing velocity. The majority of the speed in a fast over arm throw comes from the forearm, not the wrist.7 Finally, radioulnar pronation begins 10 milliseconds before
ball release, with the forearm pronated to approximately 90° at release.  

The two muscles that are commonly weak and atrophied in pitchers are the supraspinatus and infraspinatus. This can lead to chronic discomfort and impingement. When the supraspinatus, pectoralis major, and latissimus dorsi eccentrically contract they protect the anterior joint structures that become stressed when the humerus is externally rotated. Any weakness or fatigue of these muscles will decrease their ability to protect the anterior joint structures, allowing the anterior capsule to stretch further which could possibly lead to shoulder pathology.  

The deltoid muscle is the prime mover for GH abduction. The anterior deltoid along with pectoralis major is the prime mover for GH flexion.  When the deltoid contracts to abduct the humerus, the humeral head translates superiorly. A small proportion of force causes the humerus to abduct. If left unopposed, the superior translatory force of the deltoid would cause the humeral head to impact the coracoacromial arch before much abduction had even occurred. Despite the inferior force from the subacromial arch hitting the humeral head, rotation could continue against the leverage of the arch; but pain from impinged structures would prevent much more
movement. The inferior translatory pull of gravity cannot offset the pull of the middle deltoid, because the resultant force of the deltoid must exceed that of gravity before any rotation can occur. The deltoid’s line of force pulls the humeral head upwards toward the subacromial surface during abduction.

In this way the rotator cuff offsets the pull of the deltoid muscle. It has been shown that abduction without the infraspinatus, teres minor, and subscapularis resulted in a substantial superior shift of the humerus in cadavers. The teres minor and infraspinatus also contribute to abduction by laterally rotating the humerus enough to prevent the greater tubercle from impacting the acromion. The actions of the deltoid along, with the actions of the infraspinatus, teres minor, and subscapularis form a force couple which allows for the divergent pulls of the combined forces to create a pure rotation. In the case of the humerus, the divergent pulls create an almost perfect spinning of the humeral head around a fixed axis of rotation. This force couple helps prevent subacromial impingement in a normally functioning shoulder. If the rotator cuff muscles fatigue before the larger deltoid fatigues or if there is an imbalance in torque production
between the rotator cuff and the deltoid, subacromial impingement can occur.\textsuperscript{12}

**Shoulder Proprioception**

During movement, proprioceptive sense varies at different points in the range of motion.\textsuperscript{9} Proprioceptors within the capsulotendonous junction, and muscles act through reflex arcs to supply cortical feedback on shoulder position. They also contribute to the motor programming required for precision movements and muscle reflex.\textsuperscript{9} In this way, proprioceptive sense plays an important role in providing and maintaining the dynamic stability of shoulder joint as well as muscular coordination during ballistic movements.\textsuperscript{9}

There is an abundance of muscle spindles and Golgi tendon organs (GTO) within the muscles and tendons; both of which are responsive to stretch tension. Muscle spindles predominate in the belly of the muscle. They are found in greater number in muscles that control precise movements than in postural muscles. A sensory nerve is located in the center of the spindle. When the spindle is stretched, the sensory nerve sends an impulse to the central nervous system (CNS), which then activates the motor neurons that innervate the muscle, causing contraction. Muscle spindles
are responsive to both length (tonic response) and the rate of change in length (phasic response). Each spindle has a type Ia afferent neuron that has a characteristic ending known as the annulosprial ending. The annulosprial (AS) ending is sensitive to the velocity of changes in fiber length, but only when the change is occurring. It is also sensitive to length responses, however there is a sharp decline in frequency of impulse.¹⁰

When GTO’s are stretched they send a signal to the CNS to cause the muscle to relax. They consist of a mass of nerve endings which are enclosed within a connective tissue capsule and embedded in muscle tendon. When muscles are contracted the tension in the tendon increases and the GTO’s are stretched and activated. They are less sensitive to stretch than muscle spindles and require a stronger stretch to be activated.

When the stress is greater than the GTO stretch threshold, the reflex contraction that is due to spindle stimulation is overridden and the muscle relaxes. The GTO is constantly providing information about the degree of tension on each segment of a muscle. This is a protective mechanism that lets the body know when the tension is extreme. The inhibitory effect can be great enough to cause a whole muscle contraction.¹⁰
It is important for pitchers to know where their arm is in space, it is just as important for them to stretch prior to playing in a game.

Principles of Stretching

Stretching is usually performed before an exercise in an attempt to enhance performance and reduce the risk of injury. The goal of stretching before exercise is to increase the muscle-tendon length and flexibility. The increase of flexibility may help to enhance athletic performance and decrease the risk of injury from exercise.13

Muscle contraction and passive stretching are the two ways that muscle-tendon units can be lengthened. The biomechanical properties, range of motion, and visoelastic properties of the muscle-tendon unit of muscle are all affected by stretching. Most research has failed to show changes in muscle properties such as active or passive stiffness as it relates to range of motion. The resulting increase is thought to be the influence of increasing stretch tolerance and pain threshold.13

There are several phenomena that occur to the visoelastic properties when external load is applied. When
tissues are held at a constant length, the force at that length gradually declines and is described as the “stress relaxation” response. When they are held at a constant force, the tissue deformation continues until a new length is reached. This is called creep. Creep may be one explanation for the immediate increase in range of motion after static stretching. Hysteresis is the area between the loading and unloading curves. It represents the energy lost as heat due to internal damping. Several studies have looked at the effects of stretching on stress-relaxation, creep, and hysteresis, however, none of them has demonstrated the relationship of these phenomena to the rate of muscle injury or performance.¹³

The muscle’s tendon is the major resistance to the final range of motion of the musculotendinous unit. Passive stiffness refers to the passive resistance of the muscle-tendon unit in a relaxed state when external forces are applied. Active stiffness is when there is resistance of the contracted muscle to transiently deform when external forces are briefly applied, and can be measured by the damped oscillation technique. The oscillation of the contracted muscle after application of external force results from the viscoelasticity of muscle and the level of muscle activation. Passive and active stiffness provide
more information on the muscle-tendon unit behavior during movement than range of motion alone.\textsuperscript{13}

Even though each technique of stretching is expected to increase muscle and joint flexibility, they all produce increases by different mechanisms. Static stretching is the most widely used technique, and has the least associated injury risk.\textsuperscript{13,14} While it is believed to be the safest technique when compared with other stretching techniques, static stretching is effective in increasing static flexibility only and does not affect dynamic flexibility as measured by passive and/or active stiffness.\textsuperscript{14} It does affect the visoelastic properties by reducing stress relaxation. The reduction of stress relaxation is an acute adaptation of the parallel elastic component to lower the imposed load across the myotendinous junction where injury usually occurs. There is no clear evidence that static stretching reduces the rate of injury.\textsuperscript{13}

The effects of stretching on muscle properties depend on various factors which include the stretching technique used, the time to stretch, the holding duration, time to rest, and the time gap between intervention and measurement.\textsuperscript{13} Ballistic stretching is a technique using a rhythmic bouncing motion.\textsuperscript{11} This type of stretching is
likely to increase flexibility through a neurological mechanism. The stretched muscle is moved passively to the end range by an external force or agonist muscle.\textsuperscript{13}

However, the bouncing motion of ballistic stretching has been suggested as more harmful than other stretching techniques.\textsuperscript{13} During ballistic stretching, the muscle is stretched at a fast rate then rebounded back repetitively. This results in greater tension and more absorbed energy within the muscle-tendon unit. The muscle is not allowed enough time to reduce tension (stress relaxation) or increase length (creep).\textsuperscript{13} Scientific evidence does not support the view that ballistic stretching is potentially more harmful than static stretching, however. Stretching at 60 bounces per minute, and 17 stretches per set for three sets, resulted in less severe muscle soreness than with holding a static stretch for 60 seconds with the same intensity and duration.\textsuperscript{12} Despite this evidence, a slow static stretch before exercising is still most often used.\textsuperscript{5,13}

Proprioceptive neuromuscular facilitation (PNF) is a complicated stretching technique with a combination of shortening contraction and passive stretching.\textsuperscript{9} There are several techniques including slow-reversal-hold, contract relax, and hold-relax. They all include the combination of
alternating contracting and relaxing the agonist and antagonist muscles. PNF techniques use a brief isometric contraction of the muscle to be stretched prior to be statically stretched. The GTO is facilitated causing an autogenic inhibition in that muscle to allow for elongation. When compared to static and ballistic stretching Sady et al (in Nelson) found that performing a PNF technique had improved range of motion more than the other two.

Overhead Throwing Velocity

Most throwers have significant laxity of the glenohumeral joint, which in turn allows for excessive range of motion. This hypermobility has been referred to as “throwers laxity.” They have excessive external rotation, where as their internal rotation is limited to 90° of abduction. Left-handed players have approximately seven degrees more of external rotation and 12° more total motion when compared to with right handed throwers. These findings were significant at the \( P<0.01 \) level. Some clinicians report that the excessive laxity that is exhibited is the result of repetitive throwing, referring to this as “acquired laxity.” Others have
documented that the overhead thrower exhibits a congenital laxity. Bigliani et al (in Wilk)\textsuperscript{8} looked at the laxity in 72 professional baseball pitchers and 76 position players. They found a high degree of inferior glenohumeral joint laxity. Sixty-one percent of pitchers and 47% of position players had a positive sulcus sign in their throwing shoulder. They also found that of the positive sulcus signs in the dominant shoulder, 89% of pitchers and 100% of position players had a positive sulcus sign in their nondominant shoulder as well.\textsuperscript{8}

Not only is the dominant side lax but there is a muscle imbalance. The internal rotators of the throwing shoulder are significantly stronger; whereas the external rotators are weaker than the non-throwing arm. This could be a precursor to injury. It has been suggested that an implementation of a preseason strengthening program may be beneficial in preventing injuries and improving performance.\textsuperscript{16}

The velocity at which someone can throw has a lot to do with their specificity of training. The closer the movement pattern and velocity of the training exercise is to the actual sporting movement, the greater the transference of training gains to athletic performance.\textsuperscript{17} Take baseball pitchers for example, throwing with over- and
underweight balls during practice is more specific than doing a bench press in the weight room.\textsuperscript{18} According to Schmidtleicher et al (in van der Tillar)\textsuperscript{18} general resistance training with a six to twelve repetition maximum had a positive influence on throwing velocity. They attributed this to the size principle of motor recruitment, meaning that only heavy load training ensures the recruitment of fast twitch motor units. Low loads do not overload the muscle enough to induce this adaptation. This is also true for training with an underweight ball. This is due to neural adaptation, such as higher nerve activity, synchronization of motor units, and higher firing frequency. These neural adaptations can provide a carryover effect when applied to lower velocity scenarios, i.e. throwing with regular balls. Conversely, training with overweight balls does not have a carryover effect to an increase in throwing velocity with a regular ball.\textsuperscript{18}

Not only does a training regimen have an influence on throwing velocity but so does body size. Body size has a strong positive effect on throwing velocity. However, there is not a significant difference between genders. When throwing velocity appeared to be affected by gender it was when size was expressed by mass or height. This could be due to differences in muscle bulk.\textsuperscript{19}
It has also been found that skilled throwers throw faster than non skilled throwers. When skilled throwers throw fast, variability in ball speed is due to variability in arm speed. A characteristic of skilled throwers is that they show relatively low variability in the timing of ball release. The relation between timing of ball release and ball speed is dependent on the skill of the thrower. It is a misconception that the wrist snap increases throwing velocity. The hand is in line with the forearm and has only gone through a small fraction of its range of motion. Recent evidence indicates that the whip-like effects at the wrist that result from forearm angular deceleration are damped in fast throws by co-activation of wrist flexor and extensor muscle activity. Hirashima et al (in Jegede)⁷ argue that the wrist joint is not suited either kinematically or dynamically to generate large enough flexion velocities that would make a major contribution to fast ball speeds. This suggests that the majority of the speed in a fast overarm throw is from forearm motion rather than wrist snapping.⁷

Another recommendation for improving throwing velocity is that the shoulder should be abducted to 90° during the final arm acceleration phase. If the trunk rotates with the instantaneous axis of rotation being synchronized with
or parallel to the longitudinal axis of the trunk at the instant the ball is released, the 90° rule leads to the longest moment arm, resulting in the fastest velocity for the hand and the ball. The angular velocity of the trunk about the longitudinal axis can peak at 1220°/s during the arm cocking phase. It can then gradually decrease but still be considerably high at the instant of ball release (580°/s). From this it can be expected that ball velocity is maximized at shoulder abduction angle of 90° or greater.20

This angle is also recommended to prevent injuries of the throwing arm. An angle of less than 90° puts additional stress on the throwing elbow and shoulder during pitching. This is due to the peak varus torque of the throwing elbow appearing to be near the maximum capacity of the ulnar collateral ligament to sustain torque.20

Summary

Due to the amount of mobility of the glenohumeral joint it is the most commonly dislocated joint.1,2 A number of muscles must work together to stabilize it both statically and dynamically.2 The rotator cuff muscles
maintain the humeral head in a centralized position within the glenoid fossa, especially for the overhead throwing athlete.\textsuperscript{2-5} They also limit the amount of anterior translation of the proximal humerus.\textsuperscript{4}

Not only is it important to have the appropriate muscle balance in the shoulder, it is important to have good proprioception. Propioceptors within the capsulotendonous junction, and muscles act through reflex arcs to supply feedback on shoulder positioning.\textsuperscript{9} Muscle spindles and Golgi tendon organs are responsive to stretch tension. Muscle spindles are predominate in the muscle belly and GTO’s are enclosed within a connective tissue capsule and embedded in muscle tendon.\textsuperscript{10} Stretching is just as important as knowing where one is in space.

The goal of stretching before exercise is to increase flexibility and the muscle-tendon length. The increase of flexibility may help enhance athletic performance and decrease the risk of injury from exercise.\textsuperscript{13}

There are several phenomena that occur when an external load is applied. The “stress relaxation” response occurs when tissues are held at a constant length and the force at that length gradually declines. When tissues are held at a constant length and tissue deformation continues until a new length is reached, it is called creep. This could
be one explanation for the immediate increase in range of motion after static stretching. Hysteresis is the area between the loading and unloading curves and represents the energy lost as heat due to internal damping.\textsuperscript{13}

There are several types of stretching that all produce increases in muscle and joint flexibility by different mechanisms. Static stretching is the most commonly used with the least associated risk of injury. This form of stretching is only effective in increasing static flexibility and does not affect dynamic flexibility.\textsuperscript{13} Ballistic stretching uses a bouncing motion. When doing this type of stretching the muscle is stretched at a fast rate then rebounded back repetitively. There is not any evidence stating that ballistic stretching is potentially more harmful than static stretching.\textsuperscript{13} Proprioceptive neuromuscular facilitation (PNF) uses a complicated combination of shortening contraction and passive stretching. Slow-reversal-hold, contract relax, and hold-relax are the different techniques; they all include the combination of alternating contracting and relaxing the agonist and antagonist muscles. When compared to static and ballistic stretching it has been found that performing a PNF technique had improved range of motion more than the other two.\textsuperscript{13}
It may not be wise to use a PNF technique on an overhand throwing athlete because of the significant increase in range of motion that it creates. Most throwers have significant laxity which allows for excessive range of motion. This excess hypermobility has been referred to as “throwers laxity.” It has been reported that the excessive laxity is a result of repetitive throwing, this being referred to as “acquired laxity.” To go along with the laxity of the dominant shoulder is muscle imbalance. The internal rotators are significantly stronger, and the external rotators are weaker; this could be a precursor to injury.

There are many factors which can affect throwing velocity which include their specificity of training, body size, how skilled one is, and angle of arm abduction during the acceleration phase. The closer the movement pattern and velocity of the training exercise is the actual sporting movement, the greater the transference of training gains to athletic performance. Body size has a strong positive effect on throwing velocity, however gender does not. Gender only affects throwing velocity when expressed by mass or height; this could be due to differences in muscle bulk.
Since it is recommended to stretch prior to exercise, and overhand throwing athletes have excess laxity one must ask if it is necessary for them to stretch their throwing arm prior to practicing.
APPENDIX B

The Problem
Statement of the Problem

Many sports involve overhead throwing, which can cause laxity in the joint capsule. As athletic trainers', if we can help prevent excess joint laxity and possible injury to the shoulder area, then pitchers, for example, would be able to pitch more innings, and possibly pitch the following day. The purpose of this study is to determine if an increase in shoulder flexibility has an effect on throwing velocity.

Definitions of Terms

The following are definitions of operational terms for understanding the study:

1) Active Stiffness – when there is resistance of the contracted muscle to transiently deform when external forces are briefly applied.

2) Ballistic Stretching – a stretching technique using a rhythmic bouncing motion.

3) Creep – this occurs when tissues are held at a constant length; the force at that length gradually declines and a new length is formed.

4) Crow hop – a shuffling side step before a throw\textsuperscript{24}

5) Eccentric Contraction – a lengthening muscle Contraction\textsuperscript{10}
6) Force Couple – when two or more muscles simultaneously produce force in different linear directions; the torques of these muscles act in the same rotary direction.

7) Hysteresis – the amount of relaxation or variation in the load-deformation relationship, that takes place within a single cycle of loading and unloading.\textsuperscript{21}

8) Passive Stiffness – the passive resistance of the muscle-tendon unit in a relaxed state when external forces are applied.

9) Proprioception – a neuromuscular position sense that orients individuals as to body or body part position in relation to space or other objects.\textsuperscript{21}

10) Proprioceptive neuromuscular facilitation (PNF) – Activation of either agonist of antagonistic muscle prior to the application of stretch.\textsuperscript{21}

**Basic Assumptions**

The following are basic assumptions of the study:

1) The subject sample is representative of the population of baseball and softball athletes at the Single A High School level.

2) The subjects will give their best effort when throwing.
3) The radar gun will be properly calibrated and is an accurate and valid measure of velocity.

Limitations of the Study

Some limitations of this study include:

1) A sample of convenience on high school athletes.
2) Lack of participation from the selected population.
3) External validity may be reduced because of the chosen sample.

Significance of the Study

This study will see if there is significance between stretching a softball or baseball player’s shoulder and the velocity they have behind their throw.

From what has been observed, the people who do the most throwing in a game like their shoulder to feel “loose” as much as possible. For example, softball players may get stretched prior to warm-up, again after warm-up, and at least three times during the game. The question is, does all this stretching improve or impede the velocity in her throw? Will that ball make it to second base in time to pick off the girl trying to steal? This study will help athletic trainers decide how much stretching is really needed, and which athletes should get stretched.
APPENDIX C

Additional Methods
APPENDIX C1

Informed Consent
Informed-Consent Form

Deanne Stipcak, a Graduate Assistant Athletic Training Student at California University of Pennsylvania, has requested my child’s participation in a research study. The title of the research is The Effects of Stretching Shoulder Musculature on Throwing Velocity. I have been informed that the purpose of the research is to determine if stretching muscles of the shoulder has an effect on throwing velocity.

Your child’s participation will include warming up and throwing 10 times as hard as they can over the distance of 50 feet, two different times. One time they will be stretched, by the researcher, prior to throwing. The other time they will not be stretched by the researcher prior to throwing. There will be approximately one week in between sessions. Each session should last no longer than 20 minutes.

The stretching that will be included will be a static stretch of the pectoralis major and latissimus dorsi muscles. Each stretch will be done one time and held for 30 seconds.

I understand there are foreseeable risks or discomforts to my child if I agree to let them participate in the study. The possible risks and/or discomforts include being sore from throwing or getting stretched more than they are used to. If soreness occurs it should not be more than the normal exertion that a high school athlete could endure, and should subside within three to four days.

I understand that in case of injury or continued, unexplained muscle or joint soreness the athlete will be referred to their family physician as the standard protocol for any injury.

There are no feasible alternative procedures available for this study.

I understand that the possible benefits of my child’s participation in the research will be to help determine if stretching certain muscles of the shoulder effects throwing velocity. In this case, the amount of pre-competition stretching may be reexamined.
I understand that the results of the research study may be published, but that my child’s name or identity will not be revealed. In order to maintain confidentiality of my records, Deanne Stipcak will maintain all documents indefinitely in a secure location in which only the student researcher and research advisor can access.

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

I have been informed that any questions I have concerning the research study or my child’s participation in it, before or after my consent, will be answered by Deanne Stipcak, sti3155@cup.edu, 403 Green St California, PA 15419, 724.388.6067 and Dr. Tom West, west_t@cup.edu, 250 University Ave California, PA 15419, 724.809.1321.

I understand that written responses may be used in quotations for publication but my child’s 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 allow my child to assume the risks involved, and understand that I or my child may withdraw consent and discontinue participation at any time without penalty or loss of benefit.

Parent
signature _____________________________ Date _______________

Student
signature _____________________________ 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 parent and 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

Child Assent Form
Child Assent Form

I, ___________________________, understand that my parents have given permission for me to participate in a study concerning stretching my shoulder and my throwing velocity (how fast I can throw) under the direction of Deanne Stipcak.

I have been informed that I will warm-up and have my shoulder stretched. I will then be asked to throw either a base or softball, depending on my sport, as hard as I can for 10 trials.

It has been explained to me that some foreseeable risks might include shoulder muscle joint soreness upon my involvement in this study. I will be offered a bag of ice when I am done throwing. If I become sore from the testing I am to report it to Deanne the day I notice it. If soreness lasts longer than 4 days, I will be referred to my family physician for further medical care.

My involvement in this project is voluntary, and I have been told that I may withdraw from participation in this study at any time without penalty and loss of benefit to myself.

Student’s Signature _____________________________ Date ___________
APPENDIX C3

STALKER Sport Radar Gun
Specifications

STALKER Sport

PERFORMANCE SPECIFICATIONS

Speed Range 5 - 250 MPH, 8 - 400 KPH
Accuracy + / - 0.1 MPH
Target Acquisition Time 0.045 Seconds (Ball Modes)
Sample Rate 25 Speed Updates per Second
Max. Clocking Distances
- Passenger Car 4000 Feet
- Snowmobiles 1500 Feet
- Watercraft 1000 Feet
- Baseballs 200 Feet

MICROWAVE SPECIFICATIONS

Operating Frequency 24.150 GHz (K Band)
Polarization Circular Polarization
3 dB Beamwidth 11 Degrees Nominal
Microwave Source Gunn-Effect Diode
Receive Type Schottky Barrier Mixer Diode
Power Output 15 Milliwatts Nominal

The STALKER SPORT complies with Part 15 and Part 90.101 of the FCC rules. FCC ID #BDUCM1003.

GENERAL SPECIFICATIONS

Product Type Stationary-Doppler Radar
Display Type Backlight Liquid Crystal
Operating Temperatures -20°F to +120°F
Storage Temperatures -40°F to +140°F

ELECTRICAL SPECIFICATIONS

Battery Handle 7.5 VDC, 1.5 Ah, Ni-Cad
Corded Handle Input 13.8 VDC (9.0 - 16.0 VDC)
Current Requirements Transmitting - 0.66 Amps
Standby - 0.20 Amps
Sleep Mode - 0.04 Amps

PHYSICAL SPECIFICATIONS

Weight (Battery Handle) 2.5 Pounds
Weight (Corded Handle) 2.2 Pounds
Dimensions 9.25" H x 3.5" W x 10.2" L
Housing Material High Impact Polycarbonate

WARRANTY

On Radar Gun 2 Years, Parts and Labor
On Batteries 90 Days Replacement

SERIAL COMMUNICATIONS PROTOCOL

A Display Handle or Corded Interface Handle is required for data communications to speed display boards, computers, and other electronic devices. The data connector is on the bottom of these handles. The display handle requires that the radar gun be powered through the data connector. The corded interface handle includes a cigarette lighter plug for powering the radar gun.

Connector on Handle 3 Pin Switchcraft TA3ML
Mating Connector Switchcraft TA3FL
Pin Order Pin 1 - Data
Pin 2 - 12 VDC Power
Pin 3 - Ground
Data Type TTL Format
+5V for Logic High
- G for Logic Low
BAUD Rate 1200 BAUD
Data Format 8 Data Bits
No Parity
2 Stop Bits

Data is sent in packets of four ASCII characters followed by a carriage return. A new data word is sent every time the speed changes (up to 23 samples per second) and/or every 1/3 of a second if the speed remains the same.

Example for 59.8 MPH (Vehicle Mode with Tenths Units)
Data Byte 1, ASCII 0
Data Byte 2, ASCII 5
Data Byte 3, ASCII 9
Data Byte 4, ASCII 8
Data Byte 5, ASCII CR

Example for 105 MPH (Ball Mode with Whole Units)
Data Byte 1, ASCII 1
Data Byte 2, ASCII 0
Data Byte 3, ASCII 5
Data Byte 4, ASCII : (Colon)
Data Byte 5, ASCII CR

Peak Mode - If Peak Hold is ON, the speed information transmitted will be only the peak speeds. With Peak Hold OFF, the data will be based on the continuously updated speed information.
APPENDIX C4

Student Demographic Sheet and Score Sheet
No____

Demographic Information

1. Gender: Male   Female

2. Grade: 9   10   11   12

3. Which arm is your dominant arm? Right   Left

4. Injury to throwing arm in last year? Yes   No

5. What positions do you play? List in order of most frequently played to least played _____________________
   ____________________________________________________
# Score Sheet

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Stretch</th>
<th>No Stretch</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Internal Rotation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre External Rotation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Throw 1</td>
<td></td>
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<td></td>
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<tr>
<td>Throw 2</td>
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<tr>
<td>Throw 3</td>
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<td></td>
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<tr>
<td>Throw 4</td>
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<td></td>
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<tr>
<td>Throw 5</td>
<td></td>
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<td></td>
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<tr>
<td>Throw 6</td>
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<tr>
<td>Throw 7</td>
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<tr>
<td>Throw 8</td>
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<td></td>
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<tr>
<td>Throw 9</td>
<td></td>
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<tr>
<td>Throw 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max Velocity Throw #</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post Internal Rotation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post External Rotation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C5

Stretching Protocol
To stretch the latissimus dorsi the subject will lay supine on a treatment table with the hips and knees flexed, and the feet and low back flat on the table. The researcher will stand on the same side of the table as the subjects’ dominant side. The subject will flex the humerus while the researcher will hold the scapula to prevent excessive abduction. Traction will also be applied to the humerus while stretching it overhead. This will be a static stretch held for 30 seconds.

To stretch the pectoralis major the subject will be lying supine on a treatment table. They will place their hands behind their head as to do the test for a tight pectoralis major. The researcher will be standing at their head and will gently push on their elbows to stretch the pectoralis major. This will be a static stretch held for 30 seconds. If their arms hit the table or they cannot feel a stretch, they will lie on a foam roller.
APPENDIX C6

Letter to the Avella High School Board
To: Whom It May Concern

From: Deanne Stipcak
403 Green St
California, PA 15419

RE: Thesis approval

Date: October 12, 2005

My name is Deanne Stipcak. I am the Graduate Assistant Athletic Training Student from California University of Pennsylvania. For me to complete my degree I am required to do a thesis. My thesis is entitled, “The Effects of Stretching Posterior Shoulder Musculature on Throwing Velocity.” Because I travel a great distance everyday, I would like to request the use of the baseball and softball athletes at Avella High School.

After informed consent and ascent have been collected, I will only need to meet with each student twice. The first time they meet with me they will fill out a demographic sheet containing the following information: year in school (ie; freshman, sophomore, etc), position played (ie; catcher, first base etc), and dominant side/hand. During the first meeting they will also throw for me to measure their throwing velocity on a “cold shoulder,” meaning warming it up but not stretching it. The second time they see me they will do the same warm up then I will stretch the posterior musculature of the shoulder and then they will throw for me.

I look forward to your approval of this important educational project as part of my degree.

Sincerely,

Deanne Stipcak
Ms. Deanne Stipcak  
California University of Pennsylvania  
250 University Avenue  
California, PA  15419-1394

RE: Thesis Approval

Dear Ms. Stipcak,

The Avella Area School Board approved for you to complete your thesis entitled “The Effects of Stretching Posterior Shoulder Musculature on Throwing Velocity” with the baseball and softball athletes in our school district.

If you have any questions, please do not hesitate to call.

Sincerely,

Wayde Killmeyer
Superintendent
APPENDIX C7

Institutional Review Board
California University of Pennsylvania

PROTOCOL for Research Involving Human Subjects

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)

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Project Title  The Effects of Stretching Shoulder Musculature on Throwing Velocity

Researcher/Project Director  Deanne Stincak

Phone # ( 724) 388.6067  E-mail Address  sti3155@cup.edu

Faculty Sponsor (if required)  Dr. Tom West

Department  Health Science and Sport Studies

Project Dates  Fall 2005  to  April 2006

Sponsoring Agent (if applicable)

Project to be Conducted at  Avella High School

Project Purpose:  ☒ Thesis  ☐ Research  ☐ Class Project  ☐ Other

Keep a copy of this form for your records.

Required IRB Training

The training requirement can be satisfied by completing the online training session at 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  

---
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.

   In this study we will examine the effects of stretching shoulder muscles on throwing velocity. The study will be performed on high school baseball and softball athletes. The study will be announced to these two groups at a team meeting at the beginning of practice, informing them of the study. Interested volunteers will receive consent forms at the end of the meeting. Details of the study will be given along with informed consent for the parents and ascent from the student athletes. The expected number of volunteers is 30 high school aged baseball and softball players. At a second meeting a demonstration will be done of the stretching that will be performed and consent and ascent forms will be collected and subjects will be randomly assigned to a testing order.

   The subjects will be randomly assigned to groups by picking a number out of a hat. The warm-up will be the same for both conditions and will be the warm up that the team typically performs prior to practice. Once they have completed warming up, active range of motion for glenohumeral joint internal and external rotation will be assessed using a goniometer. Individuals in condition 1 will then get stretched (the stretching protocol can be found on page 53). After being stretched their throwing velocity will be measured. They will throw as hard as they can towards a target 50 ft away 10 times. They will have a 30 second rest before throwing again. Active range of motion for internal and external rotation will be reassessed after throwing. After AROM has been assessed the second time, participants will be offered a bag of ice to help prevent any unwanted soreness.

   When individuals in Condition 2 they will follow the same testing procedures EXCEPT they will stand quietly for 70 seconds, to match the time that it would take to stretch them if they were in Condition 1. They will then do their 10 measured throws, throwing at a target 50 ft away. Approximately 7-10 days will separate testing sessions.

   A dependent T test will be used to determine the difference in conditions (stretch/no stretch), and AROM. An alpha level of \( P \leq 0.05 \) will be used to determine significance. SPSS 12.0 will be used to for this analysis.

   The following hypothesis will be tested:
1) Stretching the latissimus dorsi and pectoralis major muscles of the shoulder will decrease throwing velocity.
2) There will be an increase in AROM of IR after stretching the shoulder.
3) There will be an increase in AROM of ER after stretching the shoulder.

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.

   All subjects will be informed of the risks involved as stated in the informed consent. They will all perform the same warm up. All subjects will have up-to-date physicals, as required by the school, before participating. The risk of injury due to maximal throwing is no greater than the risk associated with participation in their sport. The only foreseeable risk is muscle/joint soreness. The researcher is certified in first aid and CPR, should care beyond this level of skill be needed, the participant will be referred to their family physician or an ambulance will be summoned.

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.

   All baseball and softball athletes at the high school will be allowed to participate with several exceptions. Athletes that have sustained an injury to their throwing shoulder with in the past year. The National Athletic Training Association (NATA) defines a minor injury as forcing loss of participation for less than one week, moderate injuries span 8-21 days, and anything beyond 21 days is severe. No punishment of any kind will be given by either the researcher or the coach if they do not wish to participate or finish the study.

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.
Prior to the beginning of the study the researcher will hold an informational meeting describing the study and showing them what stretches will be done. At this time the informed consent and ascent form will be distributed. Students will not be permitted to participate without both forms being signed and turned in.

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.

All information will be kept in a secure location at the residence of the researcher. Only the researcher will access to the records, and if need be the research advisor will see them.

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

______________________________  ________________________________
Project Director’s Signature    Department Chairperson’s Signature

Student or Class Research

______________________________  ________________________________
Student Researcher’s Signature  Department Chairperson’s Signature

Supervising Faculty Member’s Signature if required

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

Date 3/1/06
REFERENCES


ABSTRACT

TITLE: The Effects of Stretching Shoulder Musculature On Throwing Velocity

RESEARCHER: Deanne Stipcak

ADVISOR: Dr. Thomas F. West

DATE: May 2006

RESEARCH TYPE: Masters Thesis

PURPOSE: The purpose of this study was to examine the effects of stretching shoulder musculature on throwing velocity and AROM of IR and ER.

Problem: Certified Athletic Trainers preventively stretch athletes before practices and competitions. This study will investigate if this practice affects performance.

METHOD: A quasi-experimental within subject design was used. Each subject served as their own control group. Condition 1 served as the stretching group, condition 2 as the non stretching group. AROM of IR and ER was measured before and after throwing velocity was measured. When doing condition 1 AROM of IR and ER was measured before getting stretched.

FINDINGS: Stretching of the pectoralis major and latissimus dorsi did not have an affect on throwing velocity, AROM of IR or ER.

CONCLUSION: Preventative stretching does not hinder performance therefore it is okay to continue to practice.