2007

The Effect of High Velocity Sport Specific Training on Throwing Velocity

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THE EFFECT OF HIGH VELOCITY SPORT SPECIFIC TRAINING ON THROWING VELOCITY

by

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University of North Dakota, 2005

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A Scholarly Project
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Doctor of Physical Therapy

Grand Forks, North Dakota
May, 2007
This Scholarly Project, submitted by Christopher Albrecht, Mandy Caspers, and Jennifer Hammond in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy form the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and thereby approved.

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title The Effect of High Velocity Sport Specific Training on Throwing Velocity

Department Physical Therapy

Degree Doctor of Physical Therapy

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Signature(s)  

Date  12/1/14/06

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ACKNOWLEDGMENTS

We would first and foremost like to say thank you to our families for their endless support and encouragement. Without you we wouldn’t be who we are today. Thank you to the University of North Dakota Physical Therapy faculty and staff for their time and effort in making our years in the program memorable while helping to prepare us to excel in our field. Specifically we would like to thank our advisor Mark Romanick, PT, PhD, ATC in helping us develop this project.

To Renee Mabey, PT, PhD, thank you for all your time in assisting us in the compilation of our statistical data.

To the University of North Dakota baseball coach, Kelvin Ziegler as well as Beverly Hopman, we greatly appreciate allowing us the use of baseball equipment and the Hyslop facility.

Thank you to the University of North Dakota Police Department for use of the radar gun.

We greatly appreciate everyone’s assistance throughout this project.
ABSTRACT

Previous studies have shown strength training programs to be effective in improving throwing velocity. The aim of this study was to determine whether there was a significant training effect, as measured by an increase in throwing velocity, among subjects who had been instructed to perform proprioceptive neuromuscular facilitation (PNF) techniques of the dominant upper extremity at a slow and controlled speed, subjects who had been instructed to perform PNF techniques of the dominant upper extremity at a sport specific speed, and a control group. A total of 28 male and female subjects, between the ages of 21 and 30 participated in the study. Each subject’s throwing velocity was tested on two separate occasions with a radar gun to determine if increases in throwing velocity had occurred. Subjects underwent a six-week training protocol between velocity trials, during which time they performed PNF techniques using elastic band as a means of resistance. Training intensity was self monitored using the BORG Rate of Perceived Exertion (RPE) scale. The results of our study suggested that PNF strengthening can increase a person’s throwing velocity over a 6-week training program. While the gains in throwing velocity were not significant, increases did occur in both training groups. These results do not support training at a sport specific speed as being any more beneficial than training at a slow and controlled speed, as measured by no significant differences in throwing velocities between the two training groups.
CHAPTER 1
LITERATURE REVIEW

Throwing is an essential fundamental skill that all baseball players must possess. Specifically, the ability to throw a baseball with high velocity and accuracy is critical to the success of not only pitchers, but all position players that take the field. Training regimes that emphasize increasing a player’s throwing velocity are of utmost importance to coaches, trainers, and all professionals working in the field of sports medicine, in order to optimize the success of the player and team. To date there lacks a general consensus among these professionals as to which types of exercises and training programs will produce the largest gains in throwing velocity.

Throwing a baseball at a high velocity requires that an athlete produce a large amount of force over an extremely short period of time. In their review of the literature on the effects of resistance training on throwing velocity, DeRenne et al concluded that gains in throwing velocity can be expected by implementing a resistance training program. Clements et al also made mention of the fact that throwing velocity can be increased by augmenting the strength of the throwing musculature of the upper extremity. Furthermore, it is worthy to note that the ability to generate a large amount of muscular power is one of the main elements in the ability to throw a baseball at high velocities. Therefore, a resistance training program that focuses on gaining muscular power should improve the throwing velocity of an athlete.
Resistance training programs are classified according to three categories. Depending on the biomechanics of the specific exercise and its effects on the body's neuromuscular system these programs are known as general, special, or specific. General resistance training aims at increasing an athlete's overall muscular strength. Exercises that make use of free weights and pulley systems are categorized under this type of resistance training.

Newton et al. were able to demonstrate significant increases in throwing velocity in a study involving 24 college baseball players. Each athlete trained 2 times per week for a total of 8 weeks, isotonic exercises consisting of the barbell bench press and the barbell pullover. During the first 4 weeks of training each athlete performed 3 sets of their 8 to 10 repetition maximum (RM). The final 4 weeks of training consisted of 3 sets of each athlete's 6 to 10 RM. Athletes assigned to this upper body weight training program were shown to have a 4.1% increase in throwing velocity. Studies by Bagonzi and Swangard also showed significant increases in throwing velocity by using an upper body isotonic resistance training program.

Muscular power is achieved by performing exercises that are categorized under special resistance training programs. Ballistic resistance training is one type of training that falls under this category. Ballistic resistance training incorporates performing an explosive movement against resistance at the fastest possible speed. There are currently differing opinions amongst exercise professionals as to whether light or heavy loads should be used during ballistic training. Some researchers have recommended loads as light as 30% of the 1RM, where others have recommended loads as high as 80% to 90% of the 1RM. Nevertheless, the goal of a special resistance training program is to turn
muscular strength into muscular power. Jacobs makes mention of the fact that when designing a resistance exercise program, one must consider the velocity of the throwing motion. Burke et al recommended that when training for sports that involve throwing, it would be of benefit to perform exercises at a speed that approaches that of the actual athletic event itself.

McEvoy et al concluded that ballistic resistance training can indeed increase a person's throwing velocity. In this study 18 baseball players were assigned to either a ballistic weight training group or a control group. Athletes in the ballistic resistance training group performed 3 sets of explosive bench press throws and squat jumps at 30% to 50% of their 1RM. Athletes assigned to the control group did not engage in any form of resistance training; however, they were able to participate in regular baseball training drills such as batting and throwing practice identical to those in the ballistic training group. Athletes in the ballistic resistance training group trained 3 times a week every 2 weeks for a total of 10 weeks. Following the 10 weeks of training a significant increase in throwing velocity was found in the ballistic resistance training group, while the control group had no changes in throwing velocity.

Resistance training programs that consist of specific exercises are following the principle of specificity. In specific resistance training the exercises that are performed are consistent with the movement of the sport for which the athlete is training. In other words the program must be sport specific. If a resistance training program is to be sport specific, it is essential that the resistance exercises match the biomechanical properties of the sport movement targeted. An example of an exercise that incorporates
this principle is performing the throwing motion against the resistance of elastic tubing or a wall pulley system.²

Sullivan³ was able to demonstrate increases in throwing velocity in a study that utilized 58 healthy subjects. Training protocol consisted of performing 3 sets of 10 repetitions of the throwing motion, utilizing a wall pulley as a means of resistance. Following six weeks of training subjects in the group performing the wall pulley exercise were found to have a significant increase in throwing velocity over those in the control group. Railey⁴ found similar results in his study using 30 collegiate baseball players. In this particular study subjects simulated the throwing motion against the resistance of a wall pulley system. The athletes trained 4 times per week for a total of 7 weeks. Following training a significant increase in throwing velocity was again found in the training group as compared to the control group. These increases in throwing velocity were found despite the fact that the wall pulley resistance was never increased during the course of the study.

The overhand throwing motion is made up of a series of complex phases that are governed by the kinetic chain principle.¹⁵ In a motion such as throwing, energy and momentum are transferred through different body parts in a specific order. The energy and momentum that have been developed reach a maximum at the final body segment. The kinetic chain for the overhand throwing motion begins in the legs and progresses to the hips. From here the energy and momentum are transferred to the trunk, upper arm, forearm, hand, and lastly to the ball. It would be of importance to note here that according to DeRenne et al.,² when a ball is thrown in an overhead motion, 46.9% of the
ball’s velocity comes from a person’s stride and body rotation. The other 53.1% of the velocity comes from the athlete’s arm.\textsuperscript{2}

The overhand throw consists of six phases including: windup, stride, arm cocking, arm acceleration, arm deceleration, and follow through.\textsuperscript{14-16} The muscular activity and power that are generated in an overhand throw are minimal throughout the windup phase.\textsuperscript{15} During the stride phase the lead leg moves toward the target as both arms abduct. External rotation and horizontal abduction occur at the throwing shoulder and the elbow assumes a flexed position. The wrist and finger musculature are also very active during this phase, causing the wrist and fingers to extend. The arm cocking phase is characterized by maximal shoulder external rotation along with shoulder abduction. The wrist and fingers remain extended, and toward the end of this phase, the elbow begins to extend. The most explosive part of the throw occurs immediately following maximum external rotation of the shoulder and up until the moment the ball is released. Rightly so, this is termed the arm acceleration phase. As this phase continues, the throwing shoulder internally rotates, the elbow continues to extend, and the wrist assumes a neutral position. With the arm deceleration phase the shoulder reaches a position of maximum internal rotation while the arm horizontally adducts across the athlete’s body. The forearm is also pronated at the end of this phase. Throughout the follow through phase the arm continues to horizontally adduct across the body as the wrist and fingers flex. The importance of the lower extremities in the throwing motion cannot be underestimated. In their study on ground-reaction forces in baseball pitching MacWilliams et al\textsuperscript{17} concluded that a powerful leg drive correlates to an increase in wrist velocity, thus increasing the athlete’s throwing velocity.
Proprioceptive neuromuscular facilitation (PNF) techniques are centered on the idea that their movements, which are diagonal in pattern, are functionally based.18 Hence, resistance exercises that incorporate PNF patterns are following the training principle of specificity. Specifically, it is the upper extremity PNF D2 extension pattern that most closely simulates the overhand throwing motion.

To date there have been a limited number of studies conducted to determine what kind of resistance training program will produce the largest gains in overhand throwing velocity. The aim of this particular study was to determine whether there was a significant training effect, as measured by an increase in throwing velocity, among subjects who had been instructed to perform PNF techniques of the dominant upper extremity in a slow and controlled movement, subjects who had been instructed to perform PNF techniques of the dominant upper extremity in a ballistic manner, and subjects assigned to a control group. This study will attempt to answer two important questions: First and foremost, will a resistance training program that consists of PNF D2 extension (principle of specificity) produce gains in throwing velocity? Secondly, will there be a significant difference between the PNF resistance program that utilizes ballistic movement (special training) and the PNF resistance program that incorporates slow and controlled movements?

Allred et al19 conducted a study to determine whether there was a significant difference, as measured by throwing velocity, between those who performed PNF resistance exercises and those who performed straight plane resistance exercises for the dominant upper extremity. Forty-two male and female college students, who were not currently involved in college athletics, participated in the 8-week study. Subjects in both
exercise groups utilized elastic tubing as resistance and completed 3 sets of 15 repetitions. Subjects were instructed to maintain a rate of perceived exertion (RPE) of 16 and to progressively increase their resistive load by shortening the elastic tubing or by using a second piece of elastic tubing when the RPE of 16 was no longer being met. Both the PNF and straight plane resistance exercise groups were shown to have a significant increase in their throwing velocity as compared to the control group. Although the gains in throwing velocity between the PNF and straight plane group were shown to be statistically insignificant, the PNF group did show a larger gain in throwing velocity (+1.36 mph) as compared to the straight plane group (+.87 mph).

A related study was conducted by Edwards on the effects of PNF and isotonic weight exercises of the upper extremity on throwing velocity. The six-week training program utilized 20 collegiate baseball pitchers. The PNF training regimen consisted of performing 15 repetitions 3 times per week of 2 patterns against the manual resistance of someone trained in the PNF technique. Subjects in the isotonic weight exercise group performed 3 sets of 10 repetitions of 7 dumbbell shoulder exercises. The isotonic weight exercises were all performed in a straight plane of movement. Following the six weeks of training the PNF exercise group was shown to have a statistically significant increase in throwing velocity (p<.019). Surprisingly, a decrease in throwing velocity was found in the isotonic weight exercise group.

A similar study conducted by Shenk also revealed no changes in throwing velocity in a group of males who were instructed in a progressive isotonic weight resistance training program. However, in this same study a significant increase in throwing velocity (1.9 mph) was found in the group instructed to perform exercises using
surgical tubing. For subjects exercising with surgical tubing, progressive resistance was achieved by increasing the tension of the tubing and increasing the number of sets and repetitions performed. Thirty-four college males participated in the study. Participants in both groups exercised 3 times per week for a total of 8 weeks. Another fascinating finding of this study was the fact that an increase in throwing velocity occurred, despite the fact that no significant changes in strength gains were obtained in either exercise training group.

It is of no surprise that males, on average, throw balls at higher velocities than females. According to the results of a study conducted by Van den Tillar and Ettema\textsuperscript{22} no significant difference in throwing velocity between males and females were found when body size was expressed as fat-free body mass (FFM). Therefore it is reasonable to conclude that most differences in throwing velocity between men and women can be accounted for by FFM.

To summarize, more research is currently needed to help determine appropriate upper extremity resistance exercise programs that have the ability to increase an individual’s throwing velocity. Much of the research to date has continued to focus on upper extremity isotonic resistance exercises and their ability to increase throwing velocity. To our knowledge, few studies, if any, have attempted to combine ballistic movement with sport specific resistance exercises. It is our firm belief that our study will assist those professionals who seek to establish an effective resistance training program that will increase one’s overhand throwing velocity.
CHAPTER 2

METHODS

Subjects

Thirty subjects from the University of North Dakota student population ages 21-30 volunteered to participate in this study. Each participant was randomly assigned to one of three exercise groups: control, diagonal pattern at slow and controlled speed (SCS), and diagonal pattern at sport-specific speed (SSS). Males and females between the ages of 18 and 30 years old who were able to demonstrate an overhand throw in a safe and proper manner were included in the study population. Subjects were excluded from the study if they fell outside the specified age range; were currently participating in collegiate level baseball, softball, or tennis; were determined unfit for exercise based on our general health questionnaire (Appendix I); or were experiencing current shoulder dysfunction that interfered with the ability to throw. In order to participate in our study, all subjects were required to read and sign the provided consent form (Appendix II). At least one of the principal investigators was on hand to address any questions or concerns participants may have had at that time. The subject consent form also included information on participation in softball, collegiate level sports, and other workout activities. All research and procedures were approved by the Institutional Review Board (IRB) and Research Development and Compliance (D&C) through the University of North Dakota. All subjects were determined to be healthy and fit based on the PAR-Q
(Physical Activity Readiness Questionnaire), implying that it was safe for them to participate in the study. According to Thomas,\textsuperscript{23} the PAR-Q is a “safe preliminary screening of candidates for exercise testing and prescription.”

Out of 30 possible subjects, 28 were included for data analysis. One subject was excluded due to technical difficulties with the radar gun. One subject failed to return to the final velocity testing. The group consisted of equal distributions of males and females. The age range of our subject population was 21 to 30 years old. The mean age of this group was 23.6 years of age.

Results of pretesting questionnaire: 96.4% had throwing experience prior to testing; 60.7% were currently playing or planning to play summer softball; 82.1% were involved in a weight training program at the time this study was conducted (Table 1). Subjects were not required to alter any participation in daily weight training or softball activities in order to participate in this study.

Testing Procedures:

Research was conducted in a local gymnasium. Proper permission for use of the facility was obtained from facility officials prior to use. To determine throwing velocity, the same Doppler radar gun was obtained from the UND Police Department on two separate occasions. A Falcon\textsuperscript{®} HR-12 radar gun (Kustom Signals, Lenexa, KS) was used for the study.

Equipment for testing included: a protective net, a handheld Doppler radar gun and AC adapter, 3 standard-sized baseballs with a weight of 5.25 ounces each, and a chair at standard height. The radar gun was located at a distance of 25 ft from the subjects’
throwing point. At a height of 4 ft 9 in from the floor, the radar gun was located behind a protective net.

<table>
<thead>
<tr>
<th>Table 1. Participant Demographics</th>
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<tbody>
<tr>
<td>Control</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
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<tr>
<td>Throwing Experience</td>
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<tr>
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<tr>
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<tr>
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<tr>
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<tr>
<td>No</td>
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<tr>
<td>Currently Exercising</td>
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<tr>
<td>Yes</td>
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<tr>
<td>No</td>
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</table>

Validation of the radar gun and throwing distance were determined prior to experimental testing through multiple researcher throwing trials. A 50 Hz tuning fork was used to calibrate the accuracy of speed as specified in the manufacturer’s instructions. This was performed prior to subject testing. The Doppler radar gun is used to measure the linear velocity of a moving object. In our study, this object was a standard-sized baseball. The Doppler Principle states that the frequency of a radar signal will be higher after bouncing off an oncoming object. When the object is moving in the opposite direction of the observer, the signal will be lower than its original frequency. This change in frequency is used to determine the object’s velocity.24 The difference
between the transmitted signal and the received signal is detected by the radar gun in order to calculate speed accuracy within +/- 1.0 MPH.

Velocity Testing:

Subjects were required to undergo a short warm up consisting of throwing into a mat at submaximal effort before having their initial throwing velocity measured. All participants were given identical instructions on proper throwing technique in accordance with our study, regardless of exercise group. This technique was limited to only a single step prior to throwing, and a traditional pitching “wind up” was excluded. Subjects were asked to go directly into the arm cocking phase as previously described. Subjects were instructed to perform all test throws with maximal effort. They were allowed three consecutive throws with the top two scores being averaged for data analysis. If throwing velocity went undetected by radar, subjects were allowed an extra throw.

Exercise Protocol:

Subjects were required to attend an educational session in which they were instructed to carry out the exercises correctly in a manner that exposes them to the least amount of potential risk for injury. These exercises are described in the Appendix IV entitled Personal Exercise Protocol. The educational session included group assignment, demonstration, and explanation of exercise program guidelines including frequency, duration, and exertion level. Subjects were provided with written and verbal instruction on proper use and placement of elastic exercise band (Can-Do elastic ribbon Fabrication Enterprises Inc, White Plains, NY) and the Borg Rate of Perceived
Exertion Scale (RPE). Subjects were randomly assigned into three groups and were then sent home and asked to self administer the specified exercise program for six weeks. At the completion of this six week period, the subjects were asked to return for a final measure of throwing velocity.

For resistance training, subjects were provided with Can-Do exercise band™ for at home use for completion of the exercise protocol. Exercise band was chosen as a means of resistance due to its accessibility, low cost, and its effectiveness in demonstrating strength gains. Can-Do elastic ribbon™ is available in a variety of colors in accordance with resistance level. Darker-colored ribbon is used for higher resistance activities. Because our subject population was healthy and without shoulder pathology, black ribbon was chosen to ensure adequate resistance for strength gains. According to Hughes et al, black elastic tubing very closely resembles a 5 to 10 pound load and has been shown as an appropriate method to increase strength for people of all ages.

All subjects performing exercises were also provided with the Borg Rate of Perceived Exertion scale (RPE) Appendix V. This scale was used to gauge participant exercise intensity. A level of 16 was chosen to provide patients with maximal strength gains in accordance to research. Using this scale ensures that subjects will consistently perform at the same intensity level. Subjects were instructed to remain at this level. When subjects were no longer able to maintain this intensity with their current exercise band, they were instructed to double the band or to shorten the length to increase resistance. If exercise band was misplaced or damaged, a replacement was available upon request.
A critical component of any resistance training program is determining the appropriate resistance load. When one is using weights as the source of the resistance a certain percentage of a person’s 1RM is most often used. A 1RM is difficult to assess using elastic tubing as the source of resistance. Thus it is imperative that an alternate method be used to determine an appropriate load of force. In a study conducted by Lagally et al.\(^27\) it was determined that RPE using the Borg scale can be utilized as a method of both prescribing and monitoring the intensity of an individual’s resistance exercise program. In the study overall body and active muscle RPE was measured after performing 15 repetitions at 30% of the 1RM and 5 repetitions at 90% of the 1RM after the completion of each of the seven different resistance exercises. The load was not altered with the change in intensity of the exercise. It was also determined that active muscle RPE was greater than overall body RPE.

Test retest reliability for using the Borg RPE scale during resistance exercise was established in a study conducted by Legally and Costigan.\(^28\) Following 1 repetition of the leg extension exercise active muscle RPE was measured at 40%, 50%, 60%, 70%, 80% and 90% of the 1RM in two separate sessions. A significant increase in RPE occurred in both sessions as the intensity of the resistance exercise increased.

Buckworth et al.\(^29\) sought to determine if an individual’s exercise stage of change would influence their measured RPE scores. Subjects were divided into three groups based on their exercise histories, and a graded maximal exercise test was performed. RPE was measured at 50%, 60%, 70%, and 80% of each subject’s VO\(_{2\text{max}}\). The authors of this study went on to conclude that an individual’s exercise history did not seem to affect the ability to accurately measure RPE. Individuals in the preparation, action, and
maintenance exercise stages were found to report comparable RPE scores at varying exercise intensities.

It is also of importance to note that RPE ratings obtained from male and females engaged in similar resistance exercises appear to be alike. Pincivero et al measured knee flexor torque at varying levels of each subject’s maximal voluntary contraction. Although males generated a greater amount of knee flexor torque, similar RPE scores were recorded for both males and females at similar exercise intensities.

Motions in all anatomical planes can be combined into one smooth and consistent diagonal movement, through PNF. Subjects were given an exercise protocol consisting of the PNF D2 extension pattern using Can Do elastic ribbon for resistance. The changeover from D2 flexion to D2 extension approximates an overhand throwing mechanism. Traditionally, training has been achieved through a series of resistive exercises in straight anatomical planes. These traditional exercises are much more time consuming and do not replicate an actual throwing motion. As the PNF D2 extension pattern begins, the shoulder is placed in a position of abduction and external rotation. The elbow is flexed, the forearm is supinated and the wrist and fingers are in an extended position. As the pattern continues the shoulder becomes adducted and internally rotated, the elbow assumes an extended position, while the forearm is pronated and the wrist and fingers are flexed. Subjects were instructed to pull the band down and across the body, letting the thumb lead the movement. Arm circles were also included in the exercise protocol as a method of warm-up prior to exercise.
The control group consisted of 9 individuals. These subjects were required to attend the general education session as well as for initial and final velocity testing. These subjects were not given an exercise protocol.

SCS group consisted of 10 individuals. Subjects were instructed to pull the band down and across the body with focus on performing the exercise protocol in a slow, smooth, and controlled movement, taking no less than 20 seconds to perform 10 repetitions.

SSS group consisted of 9 individuals who were instructed in PNF exercises at a sport-specific speed. Subjects were instructed to pull the band down and across the body with maximal speed as if trying to throw a baseball as fast as possible with control upon return to starting position.

All exercise protocols were prescribed at 3 sets of 10 repetitions to be completed 4 times per week for a six-week period. Exercise sessions were to be spaced throughout the course of each week.

The means of the initial and final velocities were compared and analyzed to determine the change in throwing velocity for each subject. Exercise group allotment was used as the independent variable. Changes in velocity measures were used as the dependent variable. These variables were used to determine whether there was a significant change in throwing velocity based upon exercise group. A Mixed Model Analysis of Variance (ANOVA) was used to determine significance. A significant level of .05 was used to gain statistical power for the hypotheses. Descriptive and inferential statistics were computed using SPSS for Windows, version 11.5 (SPSS Inc, Headquarters, Chicago, Illinois).
CHAPTER 3
RESULTS

Data analysis was conducted through the use of a repeated measures design. A Mixed-model Analysis of Variance (ANOVA) was used to determine significance. A significance of .05 was used to gain statistical power for the hypotheses. Twenty-eight subjects were included for final data analysis.

A 2 (Time) x 3 (Group) mixed-model ANOVA revealed that the main effect for group was $F(2,25)=0.190$, $p=0.828$; Eta-squared$=0.015$, power$=0.076$. Thus there was no significant difference. No significant main effect for time was obtained $F(1,25)=3.345$, $p=0.079$; Eta-squared$=0.118$, power$=0.420$. There was no significant interaction between time and group; $F(2, 25)=3.195$, $p=0.058$; Eta-squared$=0.204$, power$=0.558$. See Table 2.

The control group demonstrated a mean decrease in throwing velocity of 0.722 mph from initial to final measurement. The SCS group demonstrated an increase in the mean throwing velocity of 1.400 mph. The mean throwing velocity in the SSS group increased by 1.556 mph from initial to final measurements (Table 3). There was also no significant difference between the control group and the exercise groups. Although both the SCS and SSS groups showed increases in velocity, these increases were not found to be significant ($p>.05$).
Table 2. Tests of Subjects Effects.

<table>
<thead>
<tr>
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<th>F</th>
<th>Sig.</th>
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<td>Main Effect (Time)</td>
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<td>0.118</td>
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<td>Interaction (Time x Group)</td>
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<tr>
<td>Main Effect</td>
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<td>0.828</td>
<td>0.015</td>
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Table 3. Initial and Final Throwing Velocity results (in mph)

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<th></th>
<th>Initial Velocity</th>
<th>Final Velocity</th>
<th>Difference</th>
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<td>45.000</td>
<td>- 0.722</td>
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<td>SCS</td>
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<tr>
<td>SSS</td>
<td>49.056</td>
<td>50.611</td>
<td>+ 1.556</td>
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Table 4. Descriptive Statistics

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<td>Control</td>
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<td>Final Measure</td>
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<tr>
<td>Control</td>
<td>45.000</td>
<td>15.646</td>
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<tr>
<td>SCS</td>
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<td>15.571</td>
<td>10</td>
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<td>15.696</td>
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CHAPTER 4

DISCUSSION

This study demonstrated that PNF strengthening can increase a person’s throwing velocity over a 6-week training program. While the gains in throwing velocity were not significant, the fact that the subjects in the two exercise groups showed an increase in throwing velocity and subjects in the control group showed a decrease in throwing velocity cannot be ignored. Both the SCS and the SSS group demonstrated increases in velocity measures by 1.4 mph and 1.56 mph, respectively, as the control group decreased by 0.72 mph.

A major limitation of this study dealt with statistical power, which was found to be low throughout the study. This could be due to the study’s small sample size, variability, and the differences between groups. "Power is the probability that [a] test will correctly detect a real treatment effect." The strength of the power value is dependent on the sample size; therefore larger samples tend to produce higher power values.

The variability between initial and final velocity trials also influenced the statistical power. This was widespread as shown by the use of standard deviation (SD). In this study SD was found to be relatively large among all groups and therefore could have been due to a training effect rather than a general strengthening effect. In order to
increase our statistical power the SD would have needed to be lower to accurately represent a larger global population.

The study utilized elastic band as a means of resistance training. Although elastic band has many benefits, it may not be an ideal form of resistance to demonstrate strength gains due to the changing resistance. As the subject pulls the tubing down and across the body, the angle of motion changes, causing inconsistent amounts of resistance throughout the motion. Therefore increases in throwing velocity may not be as likely to occur.

Another limitation was the duration of the training program. This study took place over a six-week period. Edwards demonstrated significance in throwing velocity using a PNF program over a six week period. Many other training programs have found increases in throwing velocity by using an 8-week training protocol. Bagonzi did not show significant increases in throwing velocity until the 16th to 18th week of training. This demonstrates that although six-weeks of training has been show to be beneficial in increasing one's throwing velocity, the subjects in our study may have benefited from a longer training protocol.

Compliance may have been a limitation in this study due to the fact that subjects were asked to self administer the training protocol. Although continuous monitoring would have been ideal, it is not realistic due to lack of resources, time, and supervision on the part of the participants as well as the researchers. A workout log could have been implemented as a method of increasing subject compliance to the training protocol; however it still relies on self report. As researchers, this written documentation would have been beneficial as it is a measurable form of subject compliance. Future researchers
may want to consider using a written exercise log, along with a follow-up visit to improve understanding of training protocols and therefore improve subject compliance.

A compliance questionnaire was administered to the experimental groups post final velocity testing. Sixteen of the 19 participants completed this questionnaire. Twelve of the 16 reported at least 50% or greater compliance with the assigned exercise protocol. Although this data was also self reported, we as the researchers were not aware of subject’s answers regarding compliance until each form had been completed and placed in a sealed envelope. This information was provided anonymously, to enhance the honesty of subjects.

Standardization of the throwing motion was attempted by limiting the amount of body rotation of each subject’s throw. This may have altered the overall throwing mechanics of subjects thus leading to decreased throwing velocity. As previously recorded, 46.9% of a ball’s velocity is due to a person’s stride and body rotation. Training programs that combine strengthening the trunk and lower extremity, as well as the upper extremity may be more likely to demonstrate greater gains in throwing velocity.

A high percentage of the study’s subject population was actively participating in an exercise program or a summer softball league during the study. Due to this, increases in throwing velocity potential may have been limited as subjects were not asked to discontinue any current exercise programs in order to participate in our study.

This study utilized healthy subjects. Future studies should consider using extended training protocols as well as various populations including athletes, patients
requiring shoulder rehabilitation, and a variety of age groups when examining the effects of different training speeds and its effects on throwing velocity.
CHAPTER 5
CONCLUSION

The results of our study demonstrated that PNF strengthening can increase a person's throwing velocity over a 6-week training program. While the gains in throwing velocity were not significant, increases did occur in both training groups. At this time it does not appear that training at a sport specific speed is any more beneficial than training at a slow and controlled speed, as measured by no significant differences in throwing velocities between the two groups. Future investigators should consider using extended training protocols as well as various populations including athletes and shoulder rehabilitation patients when examining the effects of different training speeds and its effects on throwing velocity. More research is necessary to examine the effects of sport specific speed on throwing velocity.
APPENDICES
APPENDIX A
Throwing Velocity Scholarly Project Participation Questionnaire

Participant ID________________________
Age:______________ Gender: M / F

General Health Questionnaire
Yes / No 1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
Yes / No 2. Do you feel pain in your chest when you do physical activity?
Yes / No 3. In the past month, have you had chest pain when you were not doing physical activity?
Yes / No 4. Do you lose your balance because to dizziness or do you ever lose consciousness?
Yes / No 5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
Yes / No 6. Is your doctor currently prescribing drugs (ex-water pills) for your blood pressure or heart condition?
Yes / No 7. Do you know of any other reason why you should not do physical activity?

Activity Level
Yes / No 8. Do you have any experience throwing a baseball or softball?
Yes / No 9. Are you currently participating in any collegiate sporting activities?
Yes / No 10. Are you currently playing summer softball or baseball or planning on playing in the next few weeks?
Yes / No 11. Are you currently participating in a workout program?
   If yes, how many times per week? ________________

Some of the above questions were adapted from the PAR-Q (Physical Activity Readiness Questionnaire) from the Canadian Society of Exercise Physiology.
APPENDIX B

Consent to Participate in Research

A Study on the Effects of Sport Specific Training on Throwing Speed

You are invited to voluntarily participate in a scholarly research project conducted by students of the UND Physical Therapy Program (Chris Albrecht, Mandy Caspers, and Jennifer Hammond) under the direction of physical therapy professor Dr. Mark Romanick. This study will compare the effectiveness of different styles of training on throwing speed. These findings will help to determine the most efficient strength training method for the shoulder musculature and its effect on throwing speed. Results will help to provide valuable information to the fields of Sports Medicine, Athletic Training, and Physical Therapy and to the clinical practice within these fields.

All volunteers must meet the following inclusion criteria: male or female between the ages of 18-30, must be able to demonstrate an overhand throw in a safe and proper manner, no current shoulder problems that will affect your ability to throw, and general health status cleared for exercise through the provided questionnaire.

Part I: You will be required to attend a short educational session (30 minutes-1 hour) which will review this study and its components and discuss proper exercise protocol. At this time you will be required to fill out a general health questionnaire regarding your health status and activity level. Exercises will be instructed in a manner that exposes you to the least amount of potential risk of injury, including a proper warm-up of light throwing. Any questions can be answered by the principle researchers at this time. Participants will be provided with a copy of this consent form as well as a copy of the prescribed exercise program and rate of perceived exertion scale. This scale is used to measure how hard you are working. This program will be followed for six weeks.

Part II: Your throwing speed will be assessed based on three throws. The best two throws will be averaged to determine your maximum throwing speed. Throwing speed will be measured using a radar gun. You will be required to participate in a warm up consisting of lightly throwing a baseball to prevent shoulder injury from occurring.

Part III: You will be asked to follow an assigned six week exercise program for the shoulder. This program involves using theraband as a method of resistance training. Theraband, an elastic resistance material, will be provided to all participants at the initial educational session or as needed throughout the study. You will work at a constant level of perceived exertion and at a designated speed. You will be randomly assigned to an exercise program consisting of diagonal movement patterns performed at either a slower speed or a more rapid training speed or no exercise. You will be shown how to properly perform these exercises as well as how to increase the resistance to keep the rate of perceived exertion constant throughout the program. You will be asked to rate your exertion level and maintain this level throughout your six week training period. This exercise program will be self administered and unsupervised; however the principle investigators will be available to you if questions or concerns arise, if additional instruction is needed, or to report injury or problems.
Part IV: After 6 weeks of following the provided exercise program you will be asked to return to re-measure your maximum throwing speed in the same manner as previously described in Part II. This data will then be compared to initial measurements and the final results of the study will be calculated. Following completion of our study, results will be available to all participants by contacting the UND Physical Therapy Department.

Although there is risk of injury involved with any exercise program, the risk is minimal if proper exercise procedure and warm up is followed. As a participant you stand to receive a greater understanding of exercise as well as possible strength and throwing speed gains. There is no cost to you to participate in this study.

The results of this study will remain confidential and your data will be identifiable only by a randomly assigned number known only to the principle investigators. These results will be kept in a locked file cabinet in the University of North Dakota Physical Therapy Department for three years following the completion of this study. After that period of time, all records will be shredded and completely destroyed. Only the researchers, advisors, and IRB procedure auditors will have access to this data.

As a voluntary participant you are free to withdraw from this study at this time or any time for any reason. No penalties or loss of benefits will result from refusal to participate in this study. If during any portion of this study you experience pain, discomfort, fatigue, or any other symptom affecting your health, please contact one of the researchers immediately. In the unlikely event that participation in this study results in physical injury or medical injury including first aid, emergency treatment, or any other follow up care, the investigators and advisors, along with the University of North Dakota are not responsible for any such injury or treatment. If injury occurs please contact UND Student Health Services at (701)777-4500 or Altru Hospital at (701)780-5000 or other preferred medical provider. These resources will be available as they are to the general public. All payment for such treatment will be provided by you and your insurance if applicable.

Please contact any of the investigators with questions, concerns, or if additional instruction is needed concerning this study. If you have lost or broken your theraband tubing, or feel you cannot maintain your expected exertion level with your current theraband, or feel you need a new one for any reason, please contact Jennifer Hammond at 701-640-2172 or email at jhammond@medicine.nodak.edu with any concerns or questions. Dr Mark Romanick is available at (701)777-2831. Thank you for your participation.

I have read and fully understand all terms as stated above and what has been presented to me. I willingly agree to participate in this study as it has been explained to me by the researchers.

<table>
<thead>
<tr>
<th>Participant Signature</th>
<th>Date</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Witness Signature</th>
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APPENDIX 'C

Directions on how to use the BORG Rate of Perceived Exertion Scale

- The following scale is used to determine the level of difficulty when completing a task. The effort is based on fatigue and how hard it is to accomplish a task.
- Perform your exercises using the following scale to rate how hard you are working. You should try to maintain a 16 (85% of your effort is required to complete the task).
- If you feel that the exercises are becoming too easy, adjust the resistance by moving closer to the fixed end of the theraband or by tying the theraband into a loop, doubling the resistance.

15 Point Scale

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<tr>
<th>Number</th>
<th>Effort Level</th>
<th>Description</th>
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<tbody>
<tr>
<td>6</td>
<td>20% effort</td>
<td>Very, very light (Rest)</td>
</tr>
<tr>
<td>7</td>
<td>30% effort</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>40% effort</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>50% effort</td>
<td>Very light (gentle walking)</td>
</tr>
<tr>
<td>10</td>
<td>55% effort</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>60% effort</td>
<td>Fairly light</td>
</tr>
<tr>
<td>12</td>
<td>65% effort</td>
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<td>13</td>
<td>70% effort</td>
<td>Moderately hard - steady pace (Feel tired but can continue)</td>
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<td>14</td>
<td>75% effort</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>80% effort</td>
<td>Hard (Becomes difficult to accomplish the exercises)</td>
</tr>
<tr>
<td>16</td>
<td>85% effort</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>90% effort</td>
<td>Very hard (strenuous and fatiguing, can perform 10-15 reps before resting)</td>
</tr>
<tr>
<td>18</td>
<td>95% effort</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>100% effort</td>
<td>Very, very hard (Can perform only 2-3 reps before resting)</td>
</tr>
<tr>
<td>20</td>
<td>Exhaustion</td>
<td>(Cannot complete exercise or able to perform only one repetition)</td>
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APPENDIX D

In a SLOW, SMOOTH, AND CONTROLLED movement lift your arms up and forward toward the ceiling and around your head performing a complete arm circle.

Repeat 15 times.

Now perform the arm circles in the opposite direction. Begin by moving your arms backwards and around your head completing a full arm circle.

Repeat 15 times.

You are now ready to begin the band exercise.

Stand with your arm up and out to the side. Hold a rubber exercise band.

Pull the band down and across your body letting your thumb lead the movement.

*REMEMBER: Focus on performing this exercise in a SLOW, SMOOTH, AND CONTROLLED movement. It should take you no less than 20 seconds to perform 10 repetitions.

Perform 3 sets of 10 repetitions. Allow yourself a 30 second break between sets.

Maintain your RPE of 16 through the 3 sets. (refer to Borg Scale handout)

PERFORM 4 TIMES PER WEEK SPACING YOUR EXERCISE SESSIONS OVER THE COURSE OF THE WEEK.

PLEASE FOLLOW THESE DIRECTIONS EXACTLY AS THEY ARE WRITTEN FOR 6 WEEKS, AT WHICH TIME YOUR THROWING SPEED WILL BE RETESTED
APPENDIX E

In a SLOW, SMOOTH, AND CONTROLLED movement lift your arms up and forward toward the ceiling and around your head performing a complete arm circle.

Repeat 15 times.

Now perform the arm circles in the opposite direction. Begin by moving your arms backwards and around your head completing a full arm circle.

Repeat 15 times.

You are now ready to begin the band exercise.

Stand with your arm up and out to the side. Hold a rubber exercise band.

Pull the band down and across your body letting your thumb lead the movement.

*REMEMBER: Pull the band down and across your body as FAST AS YOU CAN AS IF YOU WERE TRYING TO THROW A BASEBALL AS FAST AS POSSIBLE. Let your arm slowly return to the starting position.

Perform 3 sets of 10 repetitions. Allow yourself a 30 second break between sets.

Maintain your RPE of 16 through the 3 sets. (refer to Borg Scale handout)

PERFORM 4 TIMES PER WEEK SPACING YOUR EXERCISE SESSIONS OVER THE COURSE OF THE WEEK.

PLEASE FOLLOW THESE DIRECTIONS EXACTLY AS THEY ARE WRITTEN FOR 6 WEEKS, AT WHICH TIME YOUR THROWING SPEED WILL BE RETESTED.
REFERENCES


