THROWING MECHANICS: SHOULDER MUSCLE FORCE PRODUCTION AND SHOULDER JOINT RANGE OF MOTION BEFORE AND AFTER FATIGUE

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by

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Submitted in Partial Fulfillment of the Requirements for the
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CHAPTER 1

INTRODUCTION

Musculoskeletal fatigue has been a subject of studies over the years. Ellenbecker and Roetert (1999) defined fatigue in multiple, different ways. These authors define it from the participant's point of view as a "pain" or "discomfort" while performing an action or a need to exert more energy to perform the same task over time (Ellenbecker & Roetert, 1999). Not only can the participant feel fatigue set in, but the muscle will display symptoms of experiencing fatigue.

Neuromuscular fatigue results from multiple metabolic processes that lead to a decline in muscle tension. Muscle fibers stimulated at high frequencies exhibit a decrease in tension due to progressively failing action potentials (Allen, Lee, & Westerblad, 1989). Allen, Lee and Westerblad (1989) found that when fatigue is occurring, failure of action potentials causes a lack of intracellular calcium, preventing muscle fiber contraction. Neyroud, Maffiuletti, Kayser and Place (2011) found similar results in a study involving isometric contractions of the muscles surrounding the knee. Muscular contraction did not occur because of a lack of calcium binding to the cell (Neyroud, et al., 2011). Whilst this was found to occur in the knee extensors, the possibility of fatigue can appear in any muscle throughout the body, including the shoulder muscles.

Anatomy of the Shoulder

The shoulder joint is considered to be a ball-and-socket joint. The head of the humerus is known as the "ball" which sits in the glenoid labrum of the shoulder. This labrum is known to be the "socket" portion of the joint (Peat, 1986). The shoulder joint works with the shoulder girdle to produce movements of the upper extremity. The shoulder girdle is comprised of three joint articulations. These articulations include the sternoclavicular articulation, acromioclavicular articulation and the glenohumeral articulation. Multiple ligaments in the shoulder complex hold the joint articulations together. According to Terry and Chopp (2000), these ligaments are known as “static stabilizers.” Along with the ligaments or “static stabilizers”, multiple muscles are also responsible for holding the shoulder complex together (Terry & Chopp, 2000). Terry and Chopp classify the musculature of the shoulder as being “dynamic stabilizers” due to their functional role. Nerves branching from the brachial plexus innervate the shoulder girdle and its musculature (Peat, 1986). These anatomical structures make up the shoulder girdle, which provides proper movement in multiple directions on both sides of the upper body.

The musculature of the shoulder can be divided into anterior and posterior groups based on their anatomical location. Starkey, Brown and Ryan (2008) classify the following muscles to be on the anterior side of the shoulder girdle: pectoralis major, pectoralis minor, coracobrachialis, anterior deltoid, middle deltoid, and the biceps brachii muscle. The posterior muscles of the shoulder girdle include: rotator cuff muscles (supraspinatus, infraspinatus, subscapularis and teres minor), teres major, rhomboid major, rhomboid minor, levator scapulae, trapezius muscles (upper, middle and lower), latissimus dorsi, posterior deltoid and the long head of the triceps brachii muscle (Starkey, Brown & Ryan, 2008). These muscles provide the strength and range of motion during movements of the girdle. Shoulder anatomy, strength differences and how it contributes to injury in overhead athletes will be explored in this literature review.

The shoulder girdle has the capability of performing fourteen different movements. The movements specifically performed at the glenohumeral joint include: flexion, extension, horizontal abduction, horizontal adduction, abduction, adduction, lateral (external) rotation and medial (internal) rotation (Biel, 2010). The sternoclavicular joint and acromioclavicular joints coordinate to perform these specific movements: elevation, depression, adduction (retraction), abduction (protraction), upward rotation and downward rotation (Biel, 2010). Multiple muscles work together to perform each of these movements. Multiple muscles also work together to counteract the movement being performed.

Purpose of the Study

Fatigue commonly occurs in the shoulder muscles, most noticeably in overhead movements in athletes. Fatigue can have an effect on athletes' performances as it sets in. Twist and Eston (2005) completed a study to determine the effect muscle damage from exercise and fatigue can have on performance requiring high intensity exercise. The study utilized plyometric training in the protocol. The results of the study found that there was a decrease in the peak power output once the muscle damage had occurred leading to fatigue (Twist & Eston, 2005). The purpose of this study is to determine if fatigue of the shoulder joint muscles has an effect on torque output during simulated throwing motions. A possible clinical application to increasing strength and endurance to prevent fatigue is desired. Two hypotheses were formulated for this study. The first was that there will be a decrease in torque output from pre-test to post-test. The second hypothesis was that differing angular velocities will lead to differing decreases in torque output.

CHAPTER 2

LITERATURE REVIEW

Effect of Neuromuscular Fatigue on Musculature Output

Fatigue develops with any type of training. It has consistently been found to occur in studies utilizing high intensity training protocols. Regardless of the specific movement, fatigue develops with strenuous activity of any kind. Hostrup and Bangsbo (2017) performed a study requiring participants to perform speed endurance exercises. These authors noted that intense exercise requires large amounts of force output. Any occurrence of fatigue would cause this output to increase at a rate that is higher than originally produced for the activity (Hostrup & Bangsbo, 2017). Similar to the previous study mentioned, high intensity exercise of the upper extremity can lead to fatigue with high performance. Pearcey, et al. (2016) completed a study utilizing an arm bicycle to perform intense exercise, sprints. The results of this study showed a decrease in the force output by the participants as each sprint was performed. The decrease in force output was found to be greater in the earlier sprints rather than the later repetitions (Pearcey, et al., 2016). The high intensity exercises performed in these studies caused a decrease in the production of force as the activity continued.

Fatigue affects the muscle physiology which may lead to specific symptoms in the body. Contessa, Adams and De Luca (2009) studied the effect on the motor unit when fatigue has set in. The participants in this study performed isometric knee extension. There was a noticeable decrease in the production of force toward the end of the measurements, as compared to the beginning contractions. Along with the noted decrease, there was an inconsistency found in the force output per consecutive repetition. As the repetitions were performed, the force output varied (Contessa, Adams, & De Luca, 2009). The variation in force production between each repetition caused an increase in the number of motor units utilized. Motor units were added throughout the repetitions as the force output decreased. The more the output of the force decreased, the higher the number of motor units that were added to the movement (Contessa, Adams, & De Luca, 2009). This recruitment of new motor units while exercising is important in being able to complete activity once fatigue has set in.

Motor unit recruitment is crucial to being able to continue performing once fatigue sets in. Because the shoulder consists of multiple muscles, recruitment of motor units is important. Jensen, Pilegaard, and Sjogaard (2000) completed a study focusing on motor unit recruitment during shoulder abduction. The participants in this study held an isometric contraction in shoulder abduction. The results of this study found that as the time while holding the contraction increased so did the number of motor units being recruited (Jensen, Pilegaard, & Sjogaard, 2000). The increase in motor unit recruitment is vital for an athlete's performance as fatigue begins to set in.

Isokinetic Dynamometer Testing Fatigue

Isokinetic dynamometers have been utilized frequently to test fatigue in the upper extremity. Ellenbecker and Roetert's (1999) study is one of many that have used isokinetic dynamometer testing to examine fatigue of the muscle. Ellenbecker and Roetert (1999) compared the amount of fatigue the internal shoulder rotators experienced in comparison to the external rotators of young tennis players. In this study, there was a larger amount of fatigue in the internal rotators, while being tested in shoulder abduction in the supine position, in comparison to the external rotators (Ellenbecker & Roetert, 1999). Similar to Ellenbecker and Roetert (1999), Batalha, Raimundo, Tomas-Caus, Fernandes, Marinho and de Silva (2012) utilized the isokinetic dynamometer to study fatigue in swimmers along with balance and strength. Batalha et al. (2012) tested internal rotation and external rotation in the shoulder at 90^o of abduction. The participants completed two protocols at two different angular velocities between the dominant and non-dominant arm (Batalha, et al., (2012). As shown by the studies mentioned above, Ellenbecker and Davies (2000) reported on the capability of the isokinetic dynamometer to determine fatigue. The amount of work produced by the participant can be compared amongst the repetitions performed. The comparison of the data can demonstrate any possible fatigue that has set in (Ellenbecker & Davies, 2000). The isokinetic dynamometer has been used to test fatigue of musculature for quite some time.

Isokinetic dynamometers have been used to test fatigue on the lower extremity, as well. Kaminski et al. (2000) utilized an isokinetic dynamometer to test the rectus femoris muscle under fatigue. The fatigue protocol focused on testing peak torque before and after fatigue while performing concentric and eccentric contractions (Kaminski, et al., 2000). In 2008, Greig also tested level of fatigue in the knee flexors and extensors in male soccer players utilizing an isokinetic dynamometer. Greig (2008) tested the participants following treadmills protocols. Greig (2008) studied the knee flexor and extensor peak torque through concentric and eccentric contractions. In this study, he found a decrease in force production by the hamstrings when working eccentrically through the range of motion (Greig, 2008). In 1989, Gray and Chandler utilized an isokinetic dynamometer to test the level of fatigue in the rectus femoris muscle. Knee flexion and extension repetitions were performed in the seated position at 180^o/s. Gray and Chandler (1989) compared the differences in the amount experienced between eccentric and concentric contractions. The results showed higher torque productivity when performing eccentric contraction when compared to concentric contraction (Gray and Chandler, 1989). The isokinetic dynamometer has been used repeatedly to test specificities of fatigue in musculature in the upper and lower extremities.

CHAPTER 3

METHODS

Participants

Fifteen (N = 15, 6 males, 9 females) participants volunteered for this research project. The female participants were members of a National Collegiate Athletic Association (NCAA) Division I softball team. The male participants were members of a NCAA Division I baseball team. These participants were asked to participate because they have experience playing a sport that requires throwing.

Procedures

The participants performed all activities in the biomechanics lab in 132 Davies Hall. Each participant signed the informed consent, and filled out a medical questionnaire form, before completing any other aspects of the project. Exclusion criteria for the participants included pregnancy, having shoulder surgery on the throwing arm within the past twelve months or having any current injury holding the athlete out from participation in any sport. When it was determined that the participant would be included, he or she received a number to label them for confidentiality purposes. It was also noted whether the participant was a female (1) or male (2).

After the determination of participation was complete, the participant began the warm-up. The warm-up consisted of walking at a moderate pace on the treadmill for 5-10 minutes. After the walking was completed, each participant completed ten arm circles forward and ten arm circles backward. The participant then completed three shoulder stretches on the wall in different directions. Each stretch was held for fifteen seconds and completed three times in each direction. Once the stretches were completed, the participant began the data collection process.

A Biodex system 3 dynamometer (Shirley, NY) was used for these procedures. The participants were secured while lying supine on the fully reclined Biodex chair to minimize movement of the body. A force actuator with an attachment arm secured to its axis was used to record force and movement data during each participant's arm movements. The participant had his or her shoulder joint aligned with the axis of the actuator. The participant held the distal hand-grip of the attachment arm during the procedures. Velcro strips secured the participant's arm to the attachment arm. The measurements being taken consisted of flexion and extension at the shoulder joint. Flexion of the shoulder was measured with the arm in anatomical position and raised to 180 degrees of shoulder flexion. Extension of the shoulder was measured with the shoulder starting in 180 degrees from the anatomical position and lowered to anatomical position.

The pre-test measurement was taken at the very beginning of the data collection process. It consisted of nine total repetitions. Three repetitions were completed at three different angular velocities in blocked order: 45, 90, and 120 °/s. After the pre-test measurements were taken, the participant moved from flexion to extension and extension to flexion in the full range of motion of the shoulder forty times. The end of each direction of motion was established using the dynamometer. For shoulder flexion, the participant began with his or her arm in anatomical position. The participant ended the shoulder flexion at 180 degrees from anatomical position. For shoulder extension, the participant began at 180 degrees from anatomical position. The participant completed the shoulder extension movement when he or she reached anatomical position. Each participant completed four sets of ten repetitions with one minute of rest between each set. The angular velocity was set for these four forty repetitions at 180 °/s. Once the last minute of rest had passed, post-test measurements of shoulder flexion and extension were performed, similar to the pre-test measures. Once data collection was complete, each participant completed the three stretches on the wall again. Each stretch was held for fifteen seconds for a total of three times in each direction. After completing the stretches, the participant was finished and allowed to leave the laboratory.

Data Analysis

The torque data were extracted from the Biodex system 3 computer and analyzed using custom software. Initially, the torque data were processed at 2 Hz using a fourth-order zero-lag Butterworth filter to smooth the data. Next, the constant velocity portions of the movement were isolated to ensure only the forces at the given velocities were analyzed to minimize effects due to positive and negative accelerations.

The torque data were analyzed using the Statistical Package for the Social Sciences (SPSS). The average and peak torques of each repetition were calculated utilizing Microsoft Excel. The means at each pre and post measurement velocity, as well as within the fatigue protocol blocks, were analyzed using SPSS through the repeated measures format. This repeated measures test analyzed the possible change in force output by the participant from pre-test to post-test. A 2x3 repeated measures ANOVA was run between pre-test to post-test (2) while analyzing angular velocities (3). The measure was run on the first two repetitions for each angular velocity. The angular velocities analyzed were 45 ^{o}/s, 90 ^{o}/s and 120 ^{o}/s. The fatigue protocol was measured utilizing a 4x10 repeated measures ANOVA between the four blocks of ten repetitions. A one-way repeated measures ANOVA was run as a post-hoc analysis for similar angular velocities from pre-test to post-test. A Tukey post-hoc analyses was utilized to test any interaction effects. The data were analyzed linearly with a level of significance value of < 0.05.

CHAPTER 4

RESULTS

Pre-post Average Torque

The means and standard deviations were taken of the average torque output and the peak force output during the pre-test and post-test trials. The means and standard deviations of the average torque output by gender per pre-test and post-test trials can be found in Table 1. The total mean average torque outputs during the pre and post-tests at 45 °/s were 30.57 ± 11.6 Nm and 25.41 ± 9.4 Nm, respectively. The total mean average torque output during the pre and post-tests at 90 °/s were 22.11 ± 10.3 Nm and 21.81 ± 6.0 Nm, respectively. The total mean average torque outputs during the pre and post-tests at 120 °/s were 21.87 ± 9.2 Nm and 18.98 ± 4.8 Nm, respectively. There were no significant differences between pre and post measures within angular velocities. A significant pre-post x velocities interaction effect was present between the 90^o/s versus 120^o/s velocities ($F2,26 = 5.037$, $p < 0.04$). A significant main effect was reported between 45^o/s and 120^o/s velocities ($F2,13 = 20.403$, $p < 0.01$)

Pre-post Peak Torque

The means and standard deviations of the participants of the peak torque output by gender per pre-test and post-test trials can be found in Table 2. The total mean peak torque output during the pre and post-tests at 45 °/s were 43.01 ± 12.7 Nm and 39.49 ± 12.4 Nm, respectively. The total mean peak torque output during the pre and post-tests at 90 °/s were 34.44 ± 12.9 Nm and 33.96 ± 9.0 Nm, respectively. The total mean peak torque output during the pre and post-test at 120 °/s was found to be 34.23 ± 13.8 Nm and 31.25 ± 8.6 Nm, respectively. No significant interaction effects within peak torque from pre-tests to post-tests were reported.

Fatigue – Average Torque

The means and standard deviations of the participants of the average force output by gender per fatigue block can be found in Table 3. A significant sex difference was present ($F_{1,12} = 5.217$, $p < 0.04$). Each fatigue block consisted of ten repetitions. The total mean of the first, second, third, and fourth fatigue block were 16.42 ± 3.6 Nm, 16.67 ± 4.4 Nm, 15.88 ± 3.9 Nm, and 14.98 ± 3.4 Nm, respectively. A significant difference was present between block 2 and block 4 ($F_{3,10} = 3.335$, $p < 0.04$).

Fatigue – Peak Torque

The means and standard deviations of the participants of the peak force output by gender per fatigue block can be found in Table 4. The mean of the first, second, third, and fourth fatigue blocks were 28.51 ± 10.2 Nm, 28.89 ± 11.8 Nm, 27.98 ± 11.2 Nm, and 26.81 ± 9.4 Nm, respectively. No significant interaction effects were reported. No significant main effects were reported. There was a significant sex difference present ($F_{1,12} = 5.749$, $p < 0.04$)

TABLE 1. Means and standard deviations of the average torque measured in Nm during the pre-tests and post-tests at differing angular velocities (°/s).

		PRE 45*	PRE 90	PRE 120*	POST 45*	POST 90	POST 120*
MALES	Mean	38.67†	25.40†	26.89†	29.92†	25.80†	21.61†
	SD	11.4	14.8	11.6	12.6	5.1	4.7
FEMALES	Mean	25.17	19.93	18.52	22.41	19.14	17.23
	SD	8.2	5.2	5.2	5.0	5.0	4.1

* Indicates a significant difference between velocities ($p < 0.05$)
† Indicates a significant difference between sexes ($p < 0.05$)

TABLE 2. Means and standard deviations of the peak torque measured in Nm during the pre-tests and post-tests at differing angular velocities (°/s).

		PRE 45	PRE 90	PRE 120	POST 45	POST 90	POST 120
MALES	Mean	49.71	36.16	40.79	43.76	37.95	36.06
	SD	13.2	17.9	17.9	17.6	10.6	9.5
FEMALES	Mean	38.54	33.28	29.85	36.64	31.31	28.04
	SD	10.5	8.5	8.1	6.3	6.7	6.4

TABLE 3. Means and standard deviations of the average torque measured in Nm during the fatigue tests at 180°/s.

		FT (1)	FT (2)*	FT (3)	FT (4)*
MALES	Mean	19.07†	20.89†	19.60†	18.27†
	SD	8.2	8.2	8.2	5.7
FEMALES	Mean	13.12	12.44	12.15	11.70
	SD	5.1	4.8	4.1	3.9

* Indicates a significant difference between blocks ($p < 0.05$)
† Indicates a significant difference between sexes ($p < 0.05$)

TABLE 4. Means and standard deviations of the peak torque measured in Nm during the fatigue tests at 180°/s.

		FT (1)	FT (2)	FT (3)	FT (4)
MALES	Mean	33.61†	35.67†	36.01†	34.30†
	SD	9.0	12.1	11.8	8.4
FEMALES	Mean	25.10	24.38	22.60	21.80
	SD	9.5	9.2	6.8	6.2

† Indicated a significant difference between sexes ($p < 0.05$)

CHAPTER 5

DISCUSSION

This study examined the effect fatigue has on shoulder muscle force output during controlled (isokinetic) flexion and extension. The results of this study support the null hypotheses. There was a decrease in peak torque from pre-test to post-test for each angular velocity. However, due to the standard deviation size, the result was not significant ($p > 0.05$). Similar to the study by Pearcey, et al. (2016), the results of the average torque produced show that there was a decrease in force between 45^o/s and 120^o/s for males and females. These results are also similar to the results of the study by Contessa, Adam and De Luca (2009). The amount of force output varied based on the angular velocity at which the test was performed. The results showed this variation between each angular velocity throughout the pre-tests and post-tests for males and females.

Post-hoc analyses were run utilizing one-way repeated measures ANOVAs. Tukey post-hoc analyses were used to study interaction effects. There were significant interaction effects within average torque from pre-tests to post-tests, present in the 90^o/s versus 120^o/s condition. The significant interaction effects were found due to the change in the angular velocities as the torque output was being measured. Fatigue had set in by the post-test measurement causing the significant difference. There was a significant main effect within average torque from pre-tests to post-tests, present in the 45^o/sec versus 120^o/sec condition. Due to fatigue setting in, the force output was lower during the post-test than the pre-test. There were two significant effects within the average fatigue protocol. A significant main effect was seen between specific blocks in the fatigue protocol. This main effect was found in the third block and due to the fact that fatigue had already begun to set in. A significant effect was found within subjects when the fatigue protocol was analyzed due to males generally being able to produce a greater force than females.

Effect of Fatigue on the Musculature

A decrease was noticed among the average torque and peak torque results from pre-test to post-test, however, it was not significant. Due to the differing force outputs between the participants, there was a large variation from the mean. This caused a large standard deviation, therefore, insignificant results. In order to eliminate this effect, all participants should be tested beforehand and participants with similar force outputs should be chosen. Similar to previous studies in the past, the decline in production of the force followed multiple repetitions of flexion and extension. Gray and Chandler (1989) found this same trend amongst the volunteers that participated in the study. The decline in torque was noted through flexion and extension (Gray & Chandler, 1989). The decrease in force output amongst the flexors and extensors occurred in other studies utilizing the isokinetic dynamometer as well. Kotzamanidis (2004) completed a study testing the effect of fatigue on knee flexors and extensors. The results of this study also showed a decrease in the amount of torque production from pre-fatigue to post-fatigue (Kotzamanidis, 2004). While studies differ in the amount of exercise done during the procedure to produce fatigue, a consistent finding of decrease in force production has been noted. As mentioned earlier, this decrease in force production relates to the lack of calcium binding to the cell (Allen, Lee, & Westerblad, 1989). If the calcium is not released in the cell, contraction cannot occur, causing fatigue (Allen, Lee, & Westerblad, 1989). Another explanation could be, as Green (1997) found, due to higher ATP utilization than ATP production causing accumulation of harmful by-products such as hydrogen ions and inorganic phosphates, which disturb actomyosin cycling. Another possibility could be depletion of glycogen, the primary fuel source for the cell (Green, 1997).

Male versus Female

With standard deviation and significance taken into consideration, the peak and average torques produced by males and females, in comparison, were not conclusive. This finding was consistent among all angular velocities throughout pre-tests and post-tests. While the comparison of males to females does not alter the accuracy of the hypothesis, it is interesting to note this information. These differences may occur due to males generally having a higher density of musculature; therefore, more muscle fibers can produce a greater force. Along with this, an assumption can be made that males generally have longer arms than females due to the fact that, on average, males are taller than females. This can possibly lead to a greater production of torque by the male sex. Because of this assumption, the length of the attachment arm was modified for each individual.

Practical Applications

The results of this study can be very beneficial to the training of softball and baseball players. Noting the number of repetitions per trial along with the total repetitions can be helpful when formulating a throwing program. Coaches should take into consideration the fatigue experienced over 40 repetitions in order to prevent muscle damage and injury as a result of fatigue. The results of the fatigue protocol indicate that a beneficial strengthening program for the athlete would include resting, stretching between strengthening exercises. For females, the results of the fatigue protocol show a decrease in torque output. With this being said, it would be beneficial to incorporate rest into the workout while completing it. For males, the torque output throughout the fatigue protocol fluctuates from block to block. Even though there is not a steady decrease throughout the fatigue protocol, rest would still benefit the males in order to allow for more motor unit recruitment time and ATP production. It would be beneficial to create a training program for the athletes to prevent injury. It is also important to note the differences amongst different angular velocities. These data show that varying velocities can affect the musculature force output in distinctive ways. The angular velocities can influence the speed at which the athlete makes the throws during the throwing program. The results of this study can help create a practice plan for softball and baseball teams that alternates exercises for throwers after 40 repetitions in order to alleviate fatigue throughout activity.

Future Research

If this study were to be completed again, a recommendation would be to increase the number of participants. Another suggestion would be to have the same number of participants for each sex in order to have more consistency. The last suggestion would be to run the fatigue trials at a higher angular velocity than 180^{o}/sec, followed by the post-test trials again. This could potentially give more support to the findings of the experiment and increase its validity.

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APPENDICES

APPENDIX I:

Cover Letter

Dear Possible Future Participants,

I am a graduate student in the Department of Kinesiology, which is a part of the College of Education and Human Services. Along with being a graduate student, I am the certified athletic trainer for the Southern Illinois University softball team. Earning my Master's Degree requires the completion of a research project. The research project I will be conducting involves the amount of force produced by the shoulder joint through specific ranges of motion. Choosing to participate in this study will require the use of the shoulder joint on your dominant side. You will be required to move through flexion and extension repetitively for a specific number of repetitions. Through this, the amount of force you produce will be measured and later examined. Participation in this study will only require one session lasting about one hour. Being a current athlete on the Southern Illinois University softball or baseball team without an injury requiring surgery within the past twelve months makes you the perfect candidate for the data collection of this research project. You can choose to reject to participate in this study, as participation in this study is voluntary. Your certified athletic trainer, granting you permission to become a participant in this study if you so choose, has reviewed your past and current medical history. If you choose to participate in this study, you will be given a number to be identified through.

As mentioned above, I am the certified athletic trainer for the softball team here at SIU. However, participation in this study is completely voluntary and not required for any person to participate in. Choosing whether or not to participate in this study will not affect your eligibility or position on the team here at SIU.

If you have any questions about the requirement of the research or possible participation, please contact

Adrianne Bosworth ATC, LAT

Graduate Assistant Athletic Trainer

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"This project has been reviewed and approved by the SIUC Human Subjects Committee. Questions concerning your rights as a participant in this research may be addressed to the Committee Chairperson, Office of Sponsored Projects Administration, Southern Illinois University, Carbondale, IL 62901-4709. Phone (618) 453-4533. E-mail siuhsc@siu.edu"

APPENDIX II:

Consent Form

I am a graduate student in the Department of Kinesiology, which is a part of the College of Education and Human Services. Earning my Master's Degree requires the completion of a research project. The research project I will be conducting involves the amount of force produced by the shoulder joint through specific ranges of motion. Choosing to participate in this study will require the use of the shoulder joint on your dominant side. You will be required to move through flexion and extension repetitively for a specific number of repetitions. Through this, the amount of force you produce will be measured and later examined. Participation in this study will only require one session lasting about one hour. Being a current athlete on the Southern Illinois University softball or baseball team without an injury requiring surgery within the past twelve months makes you the perfect candidate for the data collection of this research project. You can choose to reject to participate in this study, as participation in this study is voluntary. Your certified athletic trainer, granting you permission to become a participant in this study if you so choose, has reviewed your past and current medical history. If you choose to participate in this study, you will be given a number to be identified through.

Possible fatigue and minimal soreness may arise due to your participation in this research project. It should not affect your activities of daily living or ability to participate in team activities or practice.

The Department of Health and Human Services requires that you be advised as to the availability of medical treatment if a physical injury should result from research procedures. The researchers do not have funds specifically dedicated to compensate you for any adverse effects that you may experience by participating in this research. Nevertheless, you retain all your legal rights to seek compensation in the event of injury or other adverse event. If you are a registered student at SIUC, you are eligible to receive medical treatment at SIUC Student Health Center. If you are not a registered student at the university, immediate medical treatment is available at usual and customary fees at Memorial Hospital of Carbondale. In the event you believe you have suffered any injury as a result of participating in the research program, please contact the Chairperson of the Human Subjects Committee, who will review the matter with you. Phone (618) 453-4533.

A medical questionnaire must be completed before participation in this research project. Your answers on this questionnaire may cause you to be removed from the data collection.

I am the certified athletic trainer for the softball team here at SIU. Choosing whether or not to participate in this study will not affect your eligibility or position on the team here at SIU.

If you have any questions about the requirement of the research or possible participation, please contact

Adrianne Bosworth ATC, LAT

Graduate Assistant Athletic Trainer

Principal Investigator

1490 Douglas Drive

Cell: (225) 252-7896

Michael Olson Ph. D.

Associate Professor – Department of Kinesiology

Principal Investigator

121 Davies Hall

(618) 536-2244

_____ I have read the material above, and any questions I asked have been answered to my satisfaction. I understand a copy of this form will be made available to me for the relevant information and phone numbers. I realize that I may withdraw without prejudice at any time.

Signature Date

____ ___________________

This project has been reviewed and approved by the SIUC Human Subjects Committee. Questions concerning your rights as a participant in this research may be addressed to the Committee Chairperson, Office of Sponsored Projects Administration, Southern Illinois University, Carbondale, IL 62901-4709. Phone (618) 453-4533. E-mail siuhsc@siu.edu

APPENDIX III:

Questionnaire

MEDICAL HISTORY FOR RESEARCH PROJECT   Today's Date:_____/_____/_____

Personal Information:

Age:_____ Date of Birth: _____/_____/_____ Sex:______ Code #: ______

Individual to be contacted in case of an emergency **(local contact)**:

____

Relationship to you: _____________________________

Telephone No: ________________

Do you have medical alert identification? _________ YES _______NO

If YES, where is it located and what is it for?

____

Current Medications (include ALL medications)

Name of Drug:	Dosage:
___________________	_________________
___________________	_________________
___________________	_________________
___________________	_________________

Hospitalizations:

Please list the last three (3) times you have been to see a physician, been hospitalized or had surgery.

When Why (surgery, etc.)

_____________ ____________________

_____________ ____________________

_____________ ____________________

Family History:

Have any members of your immediate family had, or currently have, any of the following?

	Heart Disease	Pulmonary Disease	Stroke	Diabetes	Sudden Death
Mother	______	______	______	______	_____________
Father	______	______	______	______	_____________
Sisters	______	______	______	______	_____________
Aunts/Uncles	______	______	______	______	_____________
Grandparents	______	______	______	______	_____________
Don’t know	______	______	______	______	_____________

Have you ever had shoulder or elbow juoint pain? YES NO

If YES, what was the duration of the pain: less than 1 week, less than 1 month, between 2-6 months, between 6-12 months, over 1 year

When was your last incidence of back pain and how long did it last? _________________

Personal Medical History:

Do you have any known allergies? ______ YES ______NO

If YES, please explain:________________________

Do you use tobacco products? ______YES ______NO

If YES, please describe product used (cigarettes, pipe, dip, etc.)

How often per day (packs, bowls, etc.)_________

How long you have been a tobacco user (years): __________

What is your resting blood pressure? ______________

Please check the following disease conditions that you have had or currently have:

____ High blood pressure ____ Aneurysm ____ Abnormal chest X-ray

____ Anemia chstrl. ____ Asthma ____High blood press.

____ Diabetes ____ Emphysema ___ Angina pectoris

____ Jaundice ____ Bronchitis ____ Heart attack

____ Hepatitis ____ Thyroid problems ____ Heart surgery

____ Hernia ____ Heart failure ____ Phlebitis

____ Cancer ____ Heart murmur ____ Gout

____ Epilepsy or seizures ____ High blood triglycerides

____ Infectious mononucleosis ____ Kidney stones

____ Stroke/transient ischemia attacks ____ Rheumatic fever

____ Osteoporosis ____ Arteriosclerosis

Please provide dates and explanation to any of the above which you checked:

____

Have you experienced, or do you currently experience any of the following on a recurring basis?

____Shortness of breath ____ Dizziness, lightheadedness, fainting

____ Daily coughing ____Discomfort in the chest, jaw, neck or arms ____ Rapid heart rate

____ Joint soreness

____Joint swelling ____Slurring or loss of speech

____ Blurring of vision ____Unusually nervous or anxious

____ Sudden numbness or tingling

____Loss of feeling in an extremity

____Skipped heart beats or palpitations

If YES to any of the above, please explain:

____

Orthopedic/Musculoskeletal Injuries:

Please check the following disease or conditions which you had or currently have

____ Stiff or painful muscles ____ Muscle weakness

____ Head injury ____ Swollen joints

____ Amputation ____ Shoulder injury

____ Painful feet ____ Fractures or dislocations

____ Ankle injury ____ Severe muscle strain

____ Tennis elbow ____ Whiplash or neck

____ Limited range of motion ____ Torn ligaments injury in any joint ____ Pinched nerve

____ Slipped disc

____ Bursitis ____ "Trick" knee/knee injury

____ curvature of spine

Do any of the above limit your ability to exercise? _____ YES _____NO

If YES to any of the above, please explain: ___________________________

APPENDIX IV:

Human Subjects Committee Approval

SIUC HSC FORM A

REQUEST FOR APPROVAL TO CONDUCT RESEARCH ACTIVITIES INVOLVING HUMAN SUBJECTS

Project Title
Throwing Mechanics: Force Production and Range of Motion of the Shoulder Before and After Fatigue

CERTIFICATION STATEMENT

By making this application, I certify that I have read and understand the University's policies and procedures governing research activities involving human subjects. I agree to comply with the letter and spirit of those policies. I acknowledge my obligation to:

1. Accept responsibility for the research described, including work by students under my direction.
2. Obtain written approval from the Human Subjects Committee of any changes from the originally approved protocol **BEFORE** implementing those changes.
3. Retain signed consent forms in a secure location separate from the data for at least **three** years after the completion of the research.
4. Immediately report any adverse effects of the study on the subjects to the Chairperson of the Human Subjects Committee, SIUC, Carbondale, Illinois - 618-453-4533 and to the Director of the Office of Sponsored Projects Administration, SIUC. Phone 618-453-4540. E-mail: **siuhsc@siu.edu**

Adrianne Bosworth 10/3/16

Researcher(s) or Project Director(s) Date
Please print or type name below signature.

RESEARCH ADVISOR/PROJECT DIRECTOR'S ASSURANCE: My signature on this application certifies that the student is knowledgeable about the regulations and policies governing research with human subjects and that I have thoroughly reviewed the student's protocol for compliance with university policy. I am aware of my obligations stated on Form A and will be available to supervise the research. When on sabbatical leave or vacation, I will arrange for an alternate faculty sponsor to assume responsibility during my absence. I will advise the Human Subjects Committee by letter of such arrangements.

9/22/16

Researcher's Advisor or Faculty Sponsor (required for all student projects) Date
Please print or type name below signature.

The request submitted by the above-named researcher(s) was approved by the SIUC Human Subjects Committee.

This approval is valid for one year from the review date for non-exempt research. Unless the protocol is approved as exempt, researchers must request an extension to continue the research after that date. This approval form must be included in all Master's theses/research papers and Doctoral dissertations involving human subjects that are submitted to the Graduate School.

11/1/16

Interim Chairperson, Southern Illinois University Human Subjects Committee Date

VITA

Graduate School

Southern Illinois University

Adrianne Bosworth

Adrianne.bosworth@gmail.com

Louisiana State University, Baton Rouge, Louisiana

Bachelor of Science, Athletic Training, May 2015

Research Paper Title:

Throwing Mechanics: Shoulder Muscle Force Production and Shoulder Joint Range of Motion Before and After Fatigue

Major Professor: Olson, Michael (Ph.D)