Isokinetic Ratios of Concentric and Eccentric Work Production of Internal and External Rotators in a Simulated Throwing Pattern

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University of North Dakota

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ISOKINETIC RATIOS OF CONCENTRIC AND ECCENTRIC
WORK PRODUCTION OF INTERNAL AND EXTERNAL ROTATORS
IN A SIMULATED THROWING PATTERN

by

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Bachelor of Arts in Japanese
University of Hawaii, 1993
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An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
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in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

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May
1996
This Independent Study, submitted by Deane M. Chinen in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title
Isokinetic Ratios of Concentric and Eccentric Work
Production of Internal and External Rotators in a Simulated Throwing Pattern

Department
Physical Therapy

Degree
Master of Physical Therapy

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Date Dec. 5th, 1995
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みんなさん、いろいろお世話にかかりまして、どうもありがとうございました。
(To everyone, thank you for all your support)
To my parents and my best friend, Derek Mayeshiro...
ABSTRACT

Shoulder internal and external rotators have been the focus of several isokinetic studies. However, an examination of muscular work in a functional pattern has not been investigated. Therefore, the purpose of this study was twofold: 1) to establish normative ratios of concentric to eccentric work of internal and external shoulder rotators respectively, and 2) to provide information on the balance of strength in shoulder rotators during a simulated throwing pattern.

Twenty-seven subjects without shoulder pathology were tested on the KIN-COM isokinetic dynamometer. The statistics for the whole group revealed 55% more concentric internal rotation work in relation to eccentric external work given the range of motions used.

This normative data may help to establish clinical goals in the rehabilitation of overhead athletes.
CHAPTER 1

INTRODUCTION

The shoulder complex is an intricate joint that allows more range of motion than any other joint mechanism. While maintaining flexibility and stability, the normal shoulder allows full arm mobility in all planes of motion. The integrity of the shoulder complex is usually not challenged by activities of daily living. However, the shoulder complex is highly challenged by the athlete who participates in activities requiring repetitive overhead motions. Athletes who engage in sports such as baseball, swimming, water polo, and tennis place unique stresses and demands upon the shoulder complex. These overhead sports often require excessive amounts of shoulder external rotation, anterior humeral head displacement, velocity, force, and repetition. Thus, in an attempt to maintain a balance between stability and mobility, the shoulder complex may develop muscle fatigue, eccentric overload, and disability. Subsequently, overhead athletes often present with symptoms of shoulder instability, impingement, and rotator cuff injury.

Numerous factors create intrinsic shoulder problems in overhead athletes. For example, a balance between shoulder external and internal rotation strength and range of motion is an important factor. The normal individual has approximately 90 degrees of both shoulder external and internal rotation. In contrast, the throwing athlete has been shown to have as much as 175 degrees of external rotation, with internal rotation limited to 75 degrees or less.
An imbalance in shoulder rotators can lead to posterior capsule tightness and cause increased anterior translation of the humeral head during shoulder elevation. Such abnormal biomechanics can then lead to subacromial impingement.\textsuperscript{2,8} Maintaining or restoring a balance between shoulder internal and external rotators may be a key element in the prevention or correction of faulty biomechanics.

The intent of this study was to establish normative work ratios of concentric internal rotation and eccentric external rotation for the throwing shoulder. The pattern of concentric internal rotation followed by eccentric external rotation closely resembles muscular contractions that occur during a baseball throw. Using a simulated throwing pattern on an isokinetic unit, the results from this study seek to provide information on ratios of work in a functional pattern of movement. Additionally, it is believed that concentric/eccentric baselines for the shoulder rotators will be a significant addition to the current literature. Normative data may also help to establish clinical goals in the rehabilitation of overhead athletes.
CHAPTER 2

LITERATURE REVIEW

The shoulder complex is composed of three primary bones: the humerus, the scapula, and the clavicle. Its main articulations include the sternoclavicular, glenohumeral, acromioclavicular joints, and one "functional" articulation between the thorax and the scapula, the scapulothoracic joint. The sternoclavicular joint is the only bony attachment between the entire shoulder complex and the body. Therefore, the shoulder relies heavily on muscular attachments and ligamentous structures within the scapulothoracic joint for stability.

There are four main stabilizing mechanisms in the shoulder: the scapular rotator muscles, the rotator cuff muscles, the ligaments, and the capsule. The serratus anterior, rhomboid major and minor, trapezius, and levator scapula muscles orient the scapula for proper positioning of the humerus under the coracoid process and into the glenoid fossa. Meanwhile, the supraspinatus, infraspinatus, teres minor, and subscapularis muscles work to secure the humeral head in the glenoid fossa to control humeral rotation. The shoulder joint's static stability stems from ligaments (anterior, inferior, and middle glenohumeral) and the glenohumeral capsule.

Shoulder instability develops as a result of overuse or overstretch of shoulder stabilizers. Repetition of high velocity motions such as throwing, can cause microtrauma to musculotendinous stabilizers. In the pitching athlete, scapular stabilizers must absorb large amounts of kinetic energy during the
deceleration/eccentric phase of a throw. Repeated trauma during eccentric motion leads to decreased or asynchronous firing of shoulder muscles and stretching of the static ligamentous stabilizers. These static restraints often fail during repeated abduction and external rotation, causing anterior instability. Additionally, as the humeral head rides anteriorly and superiorly in the coracoacromial arch, impingement and rotator cuff tears can occur.⁹ Thus, overhead athletes commonly present with subtle anterior subluxation and secondary impingement tendinitis or rotator cuff trauma.

According to Kerlan,⁰ the repeated motion of pitching is one of the most stressful activities in sports. The act of pitching has also been well researched through a breakdown and analysis of its main components. Pitching is a highly dynamic activity and can be divided into five phases (Fig 1): windup, early cocking, late cocking, acceleration, and deceleration/follow-through.¹¹ Electromyographic (EMG) studies demonstrate the actions of various muscles around the shoulder girdle during the pitching motion.¹²,¹³ During the windup phase, the upper extremity is flexed with both hands holding the ball. EMG studies by Jobe et al¹³ show minimal shoulder muscle activity during this stage. During the period of shoulder abduction and external rotation, the early cocking phase, significant peak activity is seen in the anterior, middle, and posterior deltoids when the arm is elevated to 90 degrees. During the late cocking phase, the supraspinatus, infraspinatus, and teres minor begin to fire. However, at the point of maximum external rotation and initial forward trunk rotation, the SIT muscles (supraspinatus, infraspinatus, and teres minor) become idle and the subscapularis fires to decelerate the shoulder's external rotation.¹³ Keating et al¹⁴ have shown that the subscapularis contributes 53% of the rotator cuff moment and acts as the most important muscle in stabilizing
Fig 1.—The five phases of pitching a baseball (from left to right): wind-up, early cocking, late cocking, acceleration, and follow-through. (Reprinted with permission from Glousman R, Jobe F, Tibone J, Moynes D, Antonelli D, Perry J. Dynamic electromyographic analysis of the throwing shoulder with glenohumeral instability. J Bone and J Surg 1988;70-A:221)
the humeral head at this stage. Additionally, the pectoralis major and latissimus dorsi muscles become active at this point of maximum external rotation.\textsuperscript{12} These muscles contract eccentrically to provide anterior stability to the glenohumeral joint.\textsuperscript{15} The serratus anterior controls movement at the scapulothoracic joint and provides a stable glenoid against which the humerus rotates during the late cocking phase and the following acceleration and deceleration phases.

During the acceleration phase of pitching, the arm moves from maximum abduction and external rotation at the shoulder to a position of internal rotation and adduction across the body at ball release. Activity is seen in the pectoralis major, serratus anterior, and latissimus dorsi during this phase.\textsuperscript{12,13} These muscles produce internal rotation of the shoulder in a concentric fashion. This phase of pitching shows relatively low muscle activity even though the arm accelerates through space.

The final stage of the pitching sequence is deceleration/follow-through.\textsuperscript{11} This stage shows the greatest amount of activity with all muscles firing intensely.\textsuperscript{13} It is presumed that the pectoralis major and latissimus dorsi muscles act as forceful internal rotators to assist the subscapularis in carrying the arm across the chest. Primarily, the subscapularis internally rotates the shoulder while the remaining rotator cuff muscles and the deltoid muscles work to decelerate the arm in space. In addition, leg and trunk muscles work to absorb momentum throughout the pitching process.\textsuperscript{10} A pitcher with good body mechanics and timing can prevent arm injuries with a smooth transfer of momentum from the throwing arm to the lower body.

Glousman and colleagues\textsuperscript{5} conducted an EMG study using skilled male throwing athletes with chronic anterior instability. Overall, this study revealed
variable muscle activity of most shoulder muscles except the deltoid. Muscle activity around the shoulder was sometimes inconsistent while other muscle activity was mildly increased or markedly decreased. Infraspinatus activity was inconsistent during the cocking and follow-through phases. The biceps and supraspinatus muscles showed increased activity in an attempt to compensate for laxity in anterior shoulder ligaments. Moreover, the shoulder internal rotators (pectoralis major, subscapularis, latissimus dorsi and serratus anterior) showed a decrease in activity during the late cocking phase. The authors of this study did not know whether the imbalance of muscles was the primary problem or a secondary complication. However, imbalance of shoulder rotators was considered an important factor in the subjects' anterior instability.

The shoulder is also stressed in other overhead sports such as swimming, water polo, and tennis. These sports are similar to baseball with respect to the need of increased shoulder range of external rotation. Nonetheless, significant differences exist due to the various requirements of these sports. Swimming requires overhead motion of the upper extremity. Much like the baseball throw, swimming utilizes shoulder propulsion and subjects the shoulder to considerable forces. However, the swimmer must also overcome resistance (drag) of the water on the body. Although the lower extremity is involved in propelling the body through water, there is general agreement that the arm is the main source of propulsion in all strokes except the butterfly. Each swimming stroke can be broken down into two main components: pull-through and recovery. The pull-through phase consists of shoulder adduction, internal rotation, and extension. The recovery phase is dominated by shoulder abduction, external rotation, and flexion. The recovery phase of swimming requires less external rotation than the throwing motion of a baseball pitch. Shoulder motion during
the swimming stroke occurs in a concentric fashion as the adductors and internal
rotators are more active than their antagonists (abductors and external rotators).
Overall torque ratios of swimmers are higher than their nonswimming
counterparts in most motions except external rotation.\textsuperscript{16} The torques generated
during swimming are not equal to the throwing motion. Additionally, there is a
strong demand for rapid repositioning of the arm to prepare for the next
stroke.\textsuperscript{11(p389)} The continuous repetition of arm movements predisposes the
swimmer to shoulder laxity. Muscle activity of the rotator cuff again attempts to
maintain stability while allowing arm mobility throughout stroke patterns.

In water polo the upper extremity throwing motion is similar to the phases
found in pitching. The water polo player must maintain an egg-beater kick in
order to maintain some semblance of a stable platform from which to
throw.\textsuperscript{11(p381)} Therefore, all momentum during the acceleration phase of the
throw must be generated from the egg-beater kick, body momentum, and arm
acceleration. In addition, Elliott\textsuperscript{17} suggests that water polo players with
excessive external rotation and limited internal rotation are at risk for shoulder
pain. During water polo, the majority of shoulder rotation occurs out of the
water. Complete internal rotation is often limited due to drag of the water upon
deceleration. The water polo swimming stroke also requires quick sprinting in
the water. Thus, the stroke rate is much faster with a decrease in stroke length
during water polo. Since water polo encompasses both swimming and throwing,
the water polo player is at significant risk for shoulder injury secondary to both
actions.

During the tennis overhand serve, the tennis racquet creates an
additional kinetic link in the overhead throw.\textsuperscript{11(p381)} Despite this kinetic link,
Leach\textsuperscript{18} discovered that much of the impact force is dissipated by the racquet's
strings. The overhead tennis serve can be broken down into phases similar to the pitch in baseball. Moreover, muscle activity patterns are comparable to those in pitching. The tennis player also may be at significant risk for shoulder injury secondary to the effects of overhead movements on shoulder ligaments and muscles.

EMG studies have been used to determine specific muscle activity during athletic activity patterns such as the baseball throw and tennis serve. Understanding muscle activity during these movements provides valuable information for effective sport regimens and rehabilitation of the athlete. As a complement to EMG research, isokinetic studies have been used to investigate muscle strength under fixed conditions.

Isokinetic units such as the KIN-COM dynamometer allow dynamic loading of a contracting muscle within a controlled and preset velocity and range of motion. Isokinetic exercise can be viewed as a series of isometric contractions as muscles work maximally throughout the range of motion. The dynamometer can be set at specific rates to allow muscles to produce maximal output relative to force, work, power, or to dynamic conditions of a particular functional activity. In addition, the aforementioned parameters can be measured using an isokinetic dynamometer. The isokinetic dynamometer has been used extensively in physical therapy clinics as a form of progressive strengthening after injury. Subsequently, several isokinetic studies have been used as guidelines for the use of the isokinetic dynamometer within the clinic. Numerous isokinetic studies have referred to velocity and speed interchangeably. Velocity is the more appropriate term to use when discussing direction and degrees of movement per second. However, for the purposes of
this study, velocity and speed will be used interchangeably to mean the same thing; a vector of degrees per second.

The shoulder internal and external rotator muscles have been examined by several isokinetic studies. Walmsley and Szybbo researched concentric values of torque for shoulder internal and external rotators at various positions (neutral, flexion to 90 degrees, abduction to 90 degrees) and variable speeds (60, 120, 180 degrees/second). This study showed that shoulder internal rotation torque values were significantly different between the neutral position (defined as 15 degrees of abduction) and the 90 degrees of shoulder abduction position. External rotation torque values were statistically different between the 90 degrees of flexion position and both the neutral and 90 degrees abducted positions. Speed did not have a statistically significant affect on concentric internal rotation but was significant for external rotation. The slower speed of 60 degrees/second produced higher torque values than 180 degrees/second for external rotation. The authors suggested increased range of speeds and/or insufficient number of subjects may have accounted for the difference in torque due to changes in speed which occurred only with external rotation. Torque values found secondary to positional differences were viewed as the result of altered muscle length/tension ratios.

Soderberg and Blaschak examined concentric shoulder internal and external rotation torque production in various positions with varying velocities. Rotator torque values were taken in six sitting positions: neutral shoulder motion, 45 degrees of abduction, 90 degrees of abduction, 45 degrees of flexion, 90 degrees of flexion, and 45 degrees of abduction and flexion. Torque was measured at three velocities: 60, 180, 300 degrees/second. Peak torques significantly decreased when testing velocity was increased. This finding
supports the use of velocity spectrums, progressing from high to low velocities, in the rehabilitation of shoulder patients when using an isokinetic unit.

Warner and colleagues\(^{22}\) examined flexibility, laxity, and strength of shoulder rotators in asymptomatic subjects and in subjects presenting with instability or impingement symptoms. Peak torque and total work for nondominant and dominant shoulders were calculated in a standing position at two speeds, 90 and 180 degrees/second, using the Biodex dynamometer. Evaluation of the shoulder rotators in normal subjects revealed 30% larger ratios of internal rotation peak torque/total work to external rotation peak torque/total work in the dominant shoulder when compared to the nondominant shoulder. External rotation strength was similar in both dominant and nondominant shoulders. Individuals with shoulder impingement on their dominant side demonstrated a significant difference in their internal rotation/external rotation ratios for peak torque and total work. The impingement group produced peak torque and total work ratios that were significantly higher than the normal group. This finding reveals an increase in internal rotation strength or, conversely, a decrease in external rotation strength. The authors believe that relative weakness of external rotators is an important aspect of shoulder impingement.

Other isokinetic studies have focused specifically on the overhead athlete. Perrin et al\(^{23}\) evaluated isokinetic variables in athletes (swimmers and pitchers) and nonathletes. Their study suggests that normal extremity dominance may affect muscle strength in athletes such as baseball players. Their findings are important for clinical applications. Therapeutic exercise that promotes bilateral equivalency of shoulder muscle strength may not be an appropriate goal for athletes who use their muscles in an asymmetrical pattern. The authors also suggest obtaining normative data for the athlete with regards to
torque acceleration energy, power, and work. Such information would be useful for the rehabilitation of athletes.

Chandler and associates\(^2^4\) evaluated shoulder strength, power, and endurance in twenty-four college tennis players. The subjects were tested for concentric shoulder internal and external rotation in a supine position with the arm abducted to 90 degrees on a Cybex isokinetic unit. Testing speeds of 60 and 300 degrees/second were used in this study. Subjects produced more torque in internal rotation at both speeds for both dominant and nondominant shoulders. Ratios of external and internal shoulder rotation for peak torque and average power were also calculated. Muscle imbalances found in the dominant shoulder were thought to be caused by weakness or lack of external rotation strength in relation to internal rotation strength. In addition, the nondominant arms revealed a more even balance between external and internal rotators at 300 degrees/second for both peak torque and average power. However, this study failed to test shoulder external rotators in their primary functional movement during the deceleration phase of tennis, the eccentric motion.

Wilk et al\(^2^5\) looked specifically at strength of internal and external rotators in baseball pitchers using the Biodex isokinetic unit. Subjects in this study performed concentric internal and external rotation at varying speeds for both the throwing and nonthrowing arms. The authors believed that the results of their study would be beneficial in establishing a muscle performance profile for the professional thrower. The difference in internal rotator torque was not statistically different between both arms. However, the external rotators of the nonthrowing arm demonstrated higher mean peak torque values at 180 degrees/second than the throwing arm at the same speed. Wilk and colleagues acknowledged that external rotators work eccentrically during the throw, and that
eccentric work is essential for symptom-free throwing. However, this study did not examine the strength of external rotators in an eccentric fashion.

Alderink and Kuck\textsuperscript{26} researched isokinetic shoulder strength of high school and college-aged pitchers. Their study examined agonist/antagonist ratios of strength in the shoulder muscles. External rotators were approximately two-thirds as strong as internal rotators when tested in a concentric fashion. Again, shoulder internal and external rotators were not tested in a pattern resembling the baseball throw. Researchers in this study also acknowledged the need for isokinetic testing of shoulder muscles in an eccentric mode.

Ellenbecker and colleagues\textsuperscript{27} examined concentric and eccentric strength training for the rotator cuff musculature of college varsity tennis players. During a six week training period, subjects underwent either isokinetic concentric training or isokinetic eccentric training. The concentric training group demonstrated eccentric gains. Eccentric training lead to significant concentric strength gains upon post-training tests. However, eccentric strength gains in the eccentric training group were not statistically significant. This study concluded that significant overflow and specificity of training power gains can occur, particularly at fast functional velocities, through concentric and eccentric isokinetic training.

Malerba et al\textsuperscript{28} examined reliability of isometric testing of shoulder external and internal rotators. Shoulder rotators were tested with subjects in a sitting position and the arm in the scapular plane. Using the Biodex isokinetic dynamometer, Malerba and colleagues discovered test-retest reliability was clinically acceptable for concentric testing but not for eccentric testing of shoulder rotators. The authors suggest that eccentric motion is a more complex task than concentric motion, and may have affected test scores.
A review of the literature suggests that normative ratios of shoulder muscle strength will benefit clinicians seeking to rehabilitate overhead athletes with shoulder pathology. Particularly, establishing baselines of work during concentric internal rotation and eccentric external rotation will provide data on shoulder strength in the pattern of shoulder muscle contraction during a throw. Since deceleration of the arm during throwing occurs eccentrically, normative data on external rotators in an eccentric mode will be a useful addition to the current literature on isokinetic studies. Therefore, the purpose of this study was twofold: 1) to establish normative ratios of concentric to eccentric work of internal and external shoulder rotators respectively, and 2) to provide information on the balance of strength in shoulder rotators during a simulated overhead activity.
CHAPTER 3

METHODOLOGY

Subjects

Twenty-seven subjects, ten males and seventeen females, between the ages of 20 and 36 (mean=25), were selected from a volunteer population of University of North Dakota students. The subjects had no history of shoulder problems or pathology. Objective orthopedic evaluative procedures were used to screen subjects and to rule out general anterior and posterior instability of the shoulder. All subjects were tested in supine for apprehension signs during extreme external and internal rotation with the arm abducted to 90 degrees and the elbow flexed to 90 degrees. A medical questionnaire was utilized to obtain the general health status of each individual. Volunteers accepted in this study were free of shoulder musculoskeletal problems and general neurological and cardiovascular problems.

Prior to the study, volunteers filled out an activity level questionnaire. A consent form approved by the University of North Dakota Institutional Review Board was signed by all participants in this study (Appendix). Each subject was tested for work during shoulder internal and external rotation in their dominant shoulder, the shoulder they would normally use to throw or pitch a ball. Descriptive information on the subjects in this study was also compiled (Table 1).
Table 1.—Descriptive Information on Subjects

<table>
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*RECREATIONAL ACTIVITY LEVEL

**LEGEND:**
1= Sedentary work and no recreational activity
2= Sedentary work and light recreational exertion
3= Sedentary work and intense recreational exertion
4= Moderate occupational and recreational exertion
5= Intensive occupational and recreational exertion
Instrumentation

All tests were conducted on the KIN-COM robotic dynamometer (Chattex Corporation, 101 Memorial Drive, P.O. Box 42887, Chattanooga, TN 37405). Some researchers have recommended calibration of the isokinetic unit every two weeks. Therefore, due to the importance of calibration, force and velocity calibrations were conducted prior to each day of isokinetic testing. The KIN-COM displayed variables such as average work, torque, power, and fatigue index. The work values were calculated internally by the KIN-COM system as the average of torque multiplied by the angular displacement over the set of repetitions. Control of the lever arm position and speed, as well as force exertion in the user are monitored through feedback loops in the KIN-COM unit. A strain gauge bridge is used to measure force. A bar-encoded shaft is also utilized to determine position and speed values. Farrell et al. affirm that the KIN-COM operating systems produce valid and reliable measurements of the lever arm and strain gauge systems. They concluded that use of the KIN-COM unit is acceptable for most clinical and research applications.

Procedure

All subjects were positioned uniformly for both the practice sessions and the test. The customized position placed the subjects seated with the testing arm in 85 degrees of abduction and 85-90 degrees of elbow flexion (Fig 2-4). This shoulder position was determined by adjusting the dynamometer head to zero degrees of rotation and 20 degrees of upward tilt. The seated position was chosen to simulate the functional throwing position while isolating shoulder musculature. This position allowed normal gravitational forces to act upon the upper extremity and trunk while providing glenohumeral joint stability.
Fig 2. — Seated custom testing position (maximum external rotation)
Fig 3. — Seated custom testing position (neutral external/internal rotation)
Fig 4. — Seated custom testing position (maximum internal rotation)
Prior to all isokinetic procedures, subjects independently stretched the anterior/posterior/inferior shoulder capsules of their dominant arm as a warm-up activity. Each stretch was done two times for 20-second static holds. General apparatus was set up according to the KIN-COM instruction manual. A large 360 degree goniometer, calibrated in one degree increments, was used to measure shoulder and elbow joint angles prior to practice and testing sessions. The humerus was aligned with the dynamometer's shaft axis to ensure joint motion alignment with the isokinetic unit. A sternal stabilizer and lap seat belt were also used during all procedures to better isolate the selected muscle groups. As a safety precaution the subjects were given a safety button to stop all procedures on the KIN-COM, if apprehension or difficulties occurred.

Concentric internal rotation was initiated at 100 degrees of external rotation and ended at 44 degrees of internal rotation (total range of motion=144 degrees). Eccentric external rotation testing started at eight degrees external rotation and concluded at 75 degrees of internal rotation (total range of motion=83 degrees). These ranges were found to be within the subjects' normal ranges of motion. Several trial sessions prior to actual testing were conducted to ensure testing speeds and positions that did not produce pain within the joint or cause potential harm to the shoulder. In a previous shoulder study, actual angular velocities during throwing have been shown to reach a mean maximum angular velocity of 6,940 degrees/second (+/-1080 degrees/second). Given the limitations of isokinetic unit velocities and considering safety of the subjects, the angular velocities of 250 and 200 degrees/second were considered representative of acceleration and deceleration components of a simulated throw. Arrigo and Wilk\textsuperscript{11(p356)} recommended testing velocities ranging from 90 to 450 degrees/second.
Each subject participated in two practice sessions within a one week period prior to isokinetic testing. The practice sessions increased subject familiarity with the isokinetic machine. Hageman et al.\textsuperscript{30} recommended establishing greater subject familiarity with procedures during isokinetic testing. Arrigo and Wilk\textsuperscript{11(p354)} also suggested allowing clients to undergo at least one isokinetic session prior to actual testing. Both practice sessions consisted of the following exercise protocol: two sets of six submaximal repetitions at 90, 120, and 200 degrees/second for concentric internal rotation and eccentric external rotation. Throughout the practice sessions, the subjects were consistently given 30 seconds of rest between sets. Subjects were also given 60 seconds of rest between the three speeds. For both the practice and testing sessions, subjects were asked to work only in concentric internal rotation and eccentric external rotation. Therefore the tester applied external force to the wrist pad to move the lever arm to the starting positions. This procedure was done to prevent muscle fatigue and provide a more fluid movement similar to a throwing motion. Additionally, all subjects were encouraged to observe the visual representation of the exercise in bar graph form on the KIN-COM monitor screen. The visual aid was used only during the practice sessions, as visual feedback can result in earlier fatigue and affect test results.\textsuperscript{11(p355)} Therefore, its use is not recommended during isokinetic testing.

Subjects were tested in random order, and at least one day of rest was allowed between the last practice session and the test. Following subject briefing on the testing procedure and the maximal effort required, a warm-up session was conducted on the KIN-COM dynamometer. All subjects were exercised in the following order: concentric warm-up, concentric test, eccentric warm-up, eccentric test. The warm-up sessions consisted of two sets of six
submaximal repetitions at 120 and 200 degrees/second for both concentric internal rotation and eccentric external rotation. The subjects also practiced one set of five repetitions at 250 degrees per second at submaximal effort just prior to the concentric internal rotation test for the purpose of increasing subject familiarity with the actual testing speed. During all warm-ups, 30-second rest periods were given between repetition sets and 60-second rest periods were given between speeds. The subjects were also given 60 seconds of rest between the warm-up sessions and the tests.

Subjects performed maximal effort repetitions for concentric internal rotation in two sets of five repetitions at 250 degrees/second with a one-minute rest between sets and were then given a five-minute rest period. After the eccentric warm-up, the eccentric test was conducted at maximal effort in two sets of five repetitions at 200 degrees/second with a one-minute rest between sets.

The subjects were provided with standard commands to assume the starting test position, to initiate testing, and to end testing. Due to recommendations offered by previous isokinetic testers, consistent and encouraging verbal commands to help facilitate maximal effort during the test were also used.11(p355)

**Data Analysis**

Arrigo and Wilk11(p360) suggest that peak torque measurements alone cannot determine a patient's complete status. Variables such as power, work, and time parameters should also be considered for effective muscular performance scores. Perrin et al23 also suggest that peak torque relationships may not always be consistent with peak torque acceleration energy, power, and work for all muscles groups, particularly for injured muscle groups. Peak torque
describes the amount of force generated at one moment during a particular movement. In contrast, work reveals the amount of force during the whole movement and may be a more appropriate measure of functional activity. Therefore, for each individual, the average work in concentric internal rotation and the average work in eccentric external rotation were taken for one repetition. Ratios of the two average work values were established. Data was compiled using Microsoft Works and SPSSX for IBM software and the computer output of the KIN-COM dynamometer. Average values and standard deviations for the group as a whole for both the concentric and eccentric tests were then calculated. These average values, in turn, were evaluated as normative ratios of concentric internal rotation and eccentric external rotation for the group as a whole. To account for possible strength differences between males and females, the average values and standard deviations calculated for men and women were also analyzed as two separate groups. A t-test for independent samples was conducted to evaluate differences between men and women for calculated work values of concentric internal rotation, eccentric external rotation, and for the ratio of concentric internal rotation to eccentric external rotation.
CHAPTER 4
RESULTS

Statistics for the group as a whole (Table 2) revealed 55% more concentric internal rotation work in relation to eccentric external rotation work (52.41/34.33) within the range of motion parameters used in this study. The average work ratio had a standard deviation of 0.34. Mean values for the separate components of concentric work and eccentric work revealed wide standard deviations demonstrating the variability among the subjects.

Values separated for men and women (Table 3) showed a slight difference in work ratios with males generating 57% more concentric work versus eccentric work (80.27/51.65). Women were found to produce 54% more concentric work in comparison to eccentric work (36.03/24.14). Figure 5 represents the components of work ratios for men and women in bar graph form. The standard deviations for the work ratios were 0.2 for men and 0.4 for women. A large variability was seen in the values for concentric work and eccentric work when evaluated as separate components. An analysis of variance using a t-test for independent samples (Table 4) revealed statistical significance at the 0.05 level between the work values of men and women for concentric and eccentric work. However, there was no statistical significance between men and women for the ratio of concentric internal rotation to eccentric external rotation.
Table 2.—Statistics for the Group as a Whole

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<th>VARIABLE</th>
<th>VELOCITY (degrees/second)</th>
<th>MEAN</th>
<th>SD</th>
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<tbody>
<tr>
<td>Concentric Internal Rotation (Ft-Ib)</td>
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<tr>
<td>Average Work for 1 repetition</td>
<td>250</td>
<td>52.41</td>
<td>27.23</td>
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<tr>
<td>Eccentric External Rotation (Ft-Ib)</td>
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<tr>
<td>Average Work for 1 repetition</td>
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<td>Concentric IR/Eccentric ER (Ft-Ib)</td>
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<tr>
<td>Average Work Ratio for 1 repetition</td>
<td>250/200</td>
<td>1.55</td>
<td>0.34</td>
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Table 3.—Statistics Separated for Men and Women

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<th>SD</th>
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<td>male subjects (n=10)</td>
<td>26.7</td>
<td>5.3</td>
<td>22-36</td>
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<tr>
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<tr>
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</tr>
<tr>
<td>Average Work for 1 repetition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>80.27</td>
<td>24.7</td>
<td>61.8-134.2</td>
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<tr>
<td>female</td>
<td>36.03</td>
<td>9.64</td>
<td>17.0-52.8</td>
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<tr>
<td>Eccentric External Rotation (Ft-lb)</td>
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</tr>
<tr>
<td>Average Work for 1 repetition</td>
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<td></td>
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<tr>
<td>male</td>
<td>51.65</td>
<td>15.52</td>
<td>25.0-61.7</td>
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<td>female</td>
<td>24.14</td>
<td>5.47</td>
<td>15.4-29.8</td>
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<tr>
<td>Concentric IR/Eccentric ER Ratio (Ft-lb)</td>
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<tr>
<td>Average Work Ratio for 1 repetition</td>
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<tr>
<td>male</td>
<td>1.57</td>
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<td>female</td>
<td>1.54</td>
<td>0.4</td>
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Table 4.—Comparison of Average Work and Work Ratio Between Men and Women (t-test for independent samples)

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<tr>
<td>men</td>
<td>10</td>
<td>80.27 +/- 24.7</td>
<td>5.44</td>
<td>10</td>
<td>&lt; 0.001</td>
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<tr>
<td>women</td>
<td>17</td>
<td>36.03 +/- 9.64</td>
<td></td>
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<tr>
<td>Eccentric External Rotation (Ft-lb)</td>
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<td></td>
<td></td>
<td></td>
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<td>Average Work for 1 repetition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>men</td>
<td>10</td>
<td>51.65 +/- 15.52</td>
<td>5.41</td>
<td>10</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>women</td>
<td>17</td>
<td>24.14 +/- 5.47</td>
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<td></td>
</tr>
<tr>
<td>Concentric IR/Eccentric ER Ratio (Ft-lb)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Average Work Ratio for 1 repetition</td>
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<td></td>
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<tr>
<td>men</td>
<td>10</td>
<td>1.57 +/- 0.2</td>
<td>0.23</td>
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<td>0.821</td>
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<tr>
<td>women</td>
<td>17</td>
<td>1.54 +/- 0.4</td>
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Fig 5. — Average work values of concentric internal rotation (CON IR) and eccentric external rotation (ECC ER) for men and women.
CHAPTER 5

DISCUSSION

The results of this study indicate an average work ratio of 1.55:1.00 for concentric internal rotation to eccentric external rotation. This demonstrates that individuals without shoulder pathology worked 55% more in concentric internal rotation than in eccentric external rotation given the range of motion parameters used in this study. A ratio of eccentric work to concentric work revealed a 34% deficit in eccentric external work in comparison to concentric internal rotation work.

Statistical analysis of the ratios viewed separately for men and women showed relatively similar ratios of 1.57 and 1.54, respectively. An analysis of variance using a t-test for independent samples revealed no statistical significance between the work ratio for men and women. The fact that men and women achieved similar ratios is notable. Apparently, larger work values in the male group did not affect the overall ratio of work for shoulder muscle groups. However, when the values of concentric internal rotation and eccentric external rotation were evaluated separately, a wide standard deviation was discovered. Variability between members within both the male group and female group was relatively high.

Overall, men showed greater work values for both concentric internal rotation and eccentric external rotation as compared to women. An analysis of variance for concentric internal rotation and eccentric external rotation between
the male and female groups showed statistical significance. Men demonstrated an average concentric work value 223% greater than female concentric work. Male eccentric work was greater than female eccentric work by 214%. The standard deviation in the male group was also higher than the female group. Difficulty in stabilizing male subjects secondary to increased chest muscle bulk and increased force generated (compared to the female group) may have affected the results. The results may suggest that testing of male subjects was not conducted under as much uniformity as during female group testing. Deviations in testing position, speed, and protocol have been known to significantly affect test results.\textsuperscript{11}(p359)

Work, the area under the entire torque curve for one repetition, was investigated in this study. Therefore, the range of motions for both the concentric and eccentric movements are highly important. Concentric internal rotation was calculated in an arc of 144 degrees of motion from external to internal rotation. Eccentric external rotation was determined in a course of 83 degrees of internal rotation. These specific ranges were chosen to simulate a throwing pattern of movement without compromising the safety of the subjects. However, because of the unique range of motions chosen, this study may be difficult to simulate within the clinic. Difficulties may arise for several reasons including: 1) patient limitation of external rotation and/or internal rotation, 2) patient intolerance to testing range of motion parameters without shoulder pain, 3) patient intolerance to testing speeds, particularly eccentric speed of 200 degrees per second. All of the subjects in this study tolerated the custom position, range of motion, and testing speeds without significant complaints of shoulder pain or injury. However, the subject population for this study was physical therapy students who were active exercisers. In addition, the majority
of subjects (74%) had previous experience playing recreational softball, a throwing sport.

Replication of this study for a population of overhead athletes involved in sports such as swimming, water polo, and tennis may not be beneficial. While these sports require overhead movements and excessive external rotation of the shoulder, factors divergent from throwing also exist. Resistance/drag of water and the application of the tennis racquet are just some factors that create unique circumstances to the aforementioned sports. These sports need to be tested in their separate functional patterns of movement in order for data to be meaningful.

Although this study may not be easily replicated with a sedentary population or with other overhead athletes, further research into ratios of work for shoulder rotator musculature in baseball players will be a useful adjunct. As baseball players often demonstrate excessive external rotation and limited internal rotation, the ratio of work concentrically and eccentrically may be different than the results found in this study.

The testing position utilized in this study was as follows: seated with sternal and lap belt stabilization and isolation of shoulder internal and external rotation to a sagittal plane of motion. Actual pitching motion allows for segmental mobility at joints other than the shoulder such as the elbow, spine, hip, knee, and ankle. Therefore, while this study attempted to simulate a throwing motion, normal body compensations were not allowed and may affect a baseball player's ability to tolerate the range of motions used in this study. The throwing athlete has been shown to have range of internal rotation limited to 75 degrees or less. Thus, range of motion parameters may need to be altered to accommodate the baseball player's shoulder internal and external rotation range.
of motion. Nonetheless, if this study can be replicated, calculated work values may have significant implications in preventative training or rehabilitation protocols for baseball players.

Replication of this study with baseball players using similar range of motion parameters may provide useful information for the rehabilitation of these athletes. This study used range of motion parameters that approximate a concentric internal rotation to eccentric external rotation ratio of 0.7:1.00. Calculated work values in this study were discovered to be approximately 1.6:1.00 (concentric to eccentric work). A comparison between the ratios of normal subjects and baseball players under the same range of motion parameters may provide useful information for the rehabilitation of the throwing athlete. In any case, range of motion parameters must be kept constant as the amount of work generated will be relative to muscle length/tension ratios of the shoulder rotators during the arc of movement.

Current literature on the athletic shoulder recommends the use of isokinetic units in rehabilitation of the injured athlete.\textsuperscript{2,10,11} Other suggestions for athletic rehabilitation include consideration of unique patient characteristics and their athletic activity.\textsuperscript{4} Therefore, the overhead baseball pitcher's rehabilitation should include strengthening in the thrower's functional pattern of movement. Additionally, the pitcher's therapy should emphasize eccentrics, concentrics, and plyometrics. Litchfield et al\textsuperscript{2} believe that because most injuries occur during eccentric loading of muscle, eccentric strengthening is imperative. Such strength training would allow more effective control of arm deceleration during the throwing motion. Conditioning programs for pitchers should also focus on the maintenance of good muscle balance and coordination. Authur M. Pappas, MD, believes, "some players, if too directed in a power
weight-training program, get too tight and lose muscle balance...you rarely see a pitcher with big bulky shoulders and arms."10

Isokinetic testing should not be the sole evaluation tool used during shoulder assessment. Clinicians should also examine the condition of the shoulder based on special tests and other functional tests.11

Nevertheless, knowing the ratios of concentric work to eccentric work in a baseball population may help establish preseason training or rehabilitation protocols to reduce deficits in either concentric or eccentric motion. Using parameters adapted from this study for a population of baseball players with shoulder pathologies such as anterior instability or impingement, may also help determine contributing factors and deficits in motion during a pattern similar to the throw. Additionally, further research on the reliability and validity of isokinetic testing in functional patterns of movement, such as concentric internal rotation and eccentric external rotation, should be conducted.
The purpose of this study was to establish normative ratios of concentric to eccentric work of internal to external shoulder rotators respectively. Additionally, this research sought to provide information on the balance of strength in shoulder rotators during a simulated overhead activity. Twenty-seven subjects without shoulder pathology were used to determine this ratio and testing was conducted on the KIN-COM isokinetic dynamometer. For each individual, the average work in concentric internal rotation and the average work in eccentric external rotation were taken for one repetition and a ratio of the two values was established. Statistics for the group as a whole revealed 55% more concentric internal rotation work in relation to eccentric external work given the range of motion parameters used in this study.

For a number of reasons, replication of this study with a sedentary population may be difficult. Specific range of motion requirements may exclude people from the study based on individuals' limitations in external and/or internal rotation, intolerance to testing speeds, and intolerance to testing range of motion without shoulder pain. The use of this study for a population of overhead athletes such as swimmers, water polo players, and tennis players is also not beneficial. Factors divergent from throwing exist in the aforementioned sports. Therefore, these sports should be tested in their separate functional patterns of movement in order for data to be meaningful.
However, further research into ratios of work for shoulder rotator musculature in baseball players will be a useful adjunct to this study. Calculated work values for a population of baseball players may have significant implications in preventative training or rehabilitation protocols for these individuals. An analysis of these ratios may help to establish protocols to decrease deficits in either concentric or eccentric motion. Using parameters adapted from this study for a population of baseball players with shoulder pathologies such as anterior instability or impingement may also help determine contributing factors and deficits in motion during a pattern similar to the throw. Further research into the reliability and validity of functional pattern isokinetic testing, such as concentric internal rotation with eccentric external rotation, will also be of great value.
The forces generated during a simulated throwing motion of the shoulder will be investigated. Twenty to forty healthy University of North Dakota students with no shoulder pathology will participate in the study. The study will consist of approximately two practice sessions on the Kin-Com isokinetic dynamometer and one final isokinetic test for each individual. The ratios of concentric internal rotation (acceleration muscles) and
eccentric external rotation (deceleration muscles) will be calculated as normative ratios of shoulder muscle strength during the throwing motion. These normative ratios will be calculated as percentages. Human subjects are an essential component to this study as the results may be applicable to the rehabilitation of the overhead athlete as well as other individuals with shoulder pathologies.

PLEASE NOTE: Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding).

2. PROTOCOL: (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

Methods Section:

Subjects
Subjects will consist of a volunteer population: twenty to forty University of North Dakota students with no history of shoulder problems or pathology. All subjects will be grossly cleared of anterior/posterior shoulder instability through standard orthopedic evaluative procedures prior to testing and each will be required to fill out a medical screening form clearing any respiratory/cardiac or other health conditions. The subjects will be required to take part in two practice sessions and one final testing of the shoulder on the KinCom isokinetic dynamometer

Materials
All tests will be conducted on the KinCom isokinetic dynamometer (Chattex Corp., 101 Memorial Drive, P.O. Box 42887, Chattanooga, TN 37405).

Procedure
The subjects will be positioned as follows: seated with the dominant arm in 85 degrees of shoulder abduction and 90 degrees of elbow flexion. Stabilization of the subjects will be uniform as described in the KinCom instruction manual.

All subjects will be required to participate in two practice sessions on the KinCom isokinetic dynamometer. The practice sessions will be approximately 20 minutes in length and include: three sets of six submaximal repetitions at 90, 120, and 200 degrees/second for concentric internal rotation and eccentric external rotation. The practice sessions will be conducted to increase subject familiarity with the isokinetic machine.

Prior to the actual test, all subjects will be provided with information regarding the isokinetic unit and testing procedure. Standard verbal commands will also be given to help facilitate maximal effort during the actual test. In addition, the subjects will be given a safety button which will allow the subjects to stop the testing at any point during the test if either discomfort or apprehension arises.

The final test will be separated into two parts: (1) concentric internal rotation (2) eccentric external rotation. All subjects will be required to participate in an isokinetic warm-up prior to both tests: shoulder stretches followed by two sets of six submaximal repetitions at 120 and 200 degrees/seconds. A one minute rest period will then be given between the isokinetic warm-up and the tests. For the actual test, the subjects will be asked to participate with maximal effort. The
testing procedure will be conducted as follows: ten maximal repetitions of concentric internal rotation (range-100 degrees shoulder external rotation to 44 degrees of shoulder internal rotation) at 250 degrees/second forward speed, five minute rest period, ten maximal repetitions of eccentric external rotation (range-8 degrees shoulder external rotation to 90 degrees internal rotation) at 200 degrees/second forward speed.

Data Analysis
For each individual, the best work repetition for concentric internal rotation and eccentric external rotation will be taken and the ratios of the two values will then be calculated. Statistical analysis will consist of the average and standard deviations for the group as a whole for both the concentric test and eccentric test. These average values will then be evaluated as normative ratios of concentric internal rotation and eccentric external rotation for the group as a whole. The data calculated for men and women will be analyzed as two separate groups.

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

The benefits of this study include:

1. Use of normative ratios in the rehabilitation of individuals recovering from overhead shoulder injuries.
2. Possible correlation of normative ratios for prevention of shoulder injuries in overhead athletes.
3. Establishment of methodology and procedure for testing shoulder muscles in a simulated throwing pattern for further research on the overhead athlete.

4. RISKS: (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psychological, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)

The risks in this study will remain minimal as individuals with shoulder pathology will not be part of this study. All subjects will be cleared for anterior/posterior shoulder instability prior to any participation in this study. However, the eccentric portion of this study may also cause delayed onset muscle soreness. Delayed onset muscle soreness is a common and transient phenomenon with any kind of eccentric muscle activity. The protocol for this study limits the amount of isokinetic testing to the minimal amount needed for data analysis. Therefore, the likelihood of delayed onset muscle soreness will be minimized. Muscle strain is also a risk whenever maximal effort is demonstrated. However, adequate warm-up prior to any isokinetic activity during this study will be established. The subjects in this study will also have adequate rest time allowed between testing procedures to prevent fatigue whether fatigue becomes a factor or not.
5. CONSENT FORM: A copy of the CONSENT FORM to be signed by the subject (if applicable) and or any statement to be read to the subject should be attached to this form. If no CONSENT FORM is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

   Describe where signed consent forms will be kept and for what period of time.

CONSENT FORM: see attached

Consent forms will be kept at the Department of Physical Therapy, University of North Dakota for 2 years.

6. For FULL IRB REVIEW forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

   Office of Research & Program Development
   University of North Dakota
   Box 8138, University Station
   Grand Forks, North Dakota 58202

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

   For EXEMPT or EXPEDITED REVIEW forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.

SIGNATURES:

Principal Investigator

DATE: __________________________

Project Director or Student Adviser

DATE: __________________________

Training or Center Grant Director

DATE: __________________________
Isokinetic ratios of concentric/eccentric torque production of internal/external rotators in a simulated throwing pattern

Name of investigator: Deane M. Chinen
Name of client: _________________________ has been asked to take part in a research study to
determine isokinetic torque production of shoulder muscles during a simulated throwing motion. The
purpose of this study is to establish normative ratios of shoulder internal/external rotation through the
acceleration and deceleration phases of a simulated throw.

You are being asked to participate in two practice sessions on the KinCom isokinetic
dynamometer followed by one final testing of the shoulder internal/external rotators in a simulated
throwing pattern. This study will require a total of 60 minutes of participation: (2) 20 minute practice
sessions and (1) 20 minute test session. The exercise sessions will not be held on consecutive days,
frequent rest periods during the testing will be allowed, and all three sessions will be scheduled to your
convenience. Participation is entirely voluntary, and you have the right to withdraw consent and
discontinue participation in the study at any time without penalty or prejudice. The discomfort of delayed
onset muscle soreness may occur. However, the parameters of this study will be modified to prevent such
discomfort/risks from resulting. In the event that this research results in
any physical treatment will be available to you as it is to any member of the general public under similar circumstances.
Payment of such treatment will be provided by you or your third party payer if any. It is hoped that you
will enjoy and benefit from participating in this study. Information from this study will be anonymously
coded to ensure confidentiality and you will not be personally identified in any publication containing the
results of this study. Isokinetic testing results from this study will be kept in a locked cabinet and will be
viewed solely by members of the physical therapy staff at the University of North Dakota. The written
material will be destroyed upon completion of the data analysis. You may view your collected data from
the study upon request. Mark Romanick, P.T., instructor in the Department of Physical Therapy at the
University of North Dakota (701) 777-2831, and the investigator in this study, Deane M. Chinen, will be
available to answer any questions you may have concerning the study, procedures, and any risks or
benefits that may arise from participating in this study. In addition, you are encouraged to ask questions
concerning this study in the future.

As a volunteer subject, all of my questions have been answered and I participate in the research
described willingly. A copy of this consent form has been given to me.

Signed ________________________________
(Volunteer Subject's Signature) (date)

______________________________
(Principal Investigator's Signature) (date)

______________________________
(Witness Signature) (date)
Isokinetic Shoulder Study Questionnaire

Name: ________________________
Age: ______ Sex: ______

Please check the following that apply:

Have you ever played recreational softball/baseball? yes ___ no ___
if yes, have you ever played in a softball/baseball league? yes ___ no ___

Are you a recreational swimmer? yes ___ no ___
if yes, how often do you swim? ____________________________

Are you a recreational tennis player? yes ___ no ___
if yes, how often do you play tennis? ____________________________

Do you or have you ever participated in any other sport involving overhead movements of the shoulder? yes ___ no ___
if yes, please state the sport and the amount of participation ____________________________

______________________________
______________________________

Have you ever participated in an organized softball/baseball/tennis/swimming/or other overhead sport? (i.e. highschool swimming, college baseball, etc.) yes ___ no ___
if yes, please state when and which sport(s) ____________________________

______________________________
### Medical History Form

**Client's name:**

#### I. Past injuries

Do you have or have had any of the following conditions? If so, please state when and the care you received if any.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Treatment of injury</th>
<th>Do you have this injury now? If not, please state when</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concussion(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skull fracture(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arm/wrist/hand injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rib cage injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thigh injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower leg injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle strains/pulls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any injury to any body part not mentioned</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Have you been advised to restrict activity during the past five years? If yes, please state reason.

#### II. Past illnesses or medical problems

Do you now have, or have ever had any of the following conditions? If so, please state when and what kind of care you received.

<table>
<thead>
<tr>
<th>Illness</th>
<th>Do you have this illness/problem now?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent headaches</td>
<td></td>
</tr>
<tr>
<td>Fainting spells, dizziness, weakness</td>
<td></td>
</tr>
<tr>
<td>Weakness or illness when exposed to high temperatures</td>
<td></td>
</tr>
<tr>
<td>Epilepsy or convulsions</td>
<td></td>
</tr>
<tr>
<td>Numbness or tingling</td>
<td></td>
</tr>
<tr>
<td>Nosebleeds</td>
<td></td>
</tr>
<tr>
<td>Difficulty breathing</td>
<td></td>
</tr>
<tr>
<td>Frequent colds</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td></td>
</tr>
<tr>
<td>Tuberculosis</td>
<td></td>
</tr>
<tr>
<td>Rheumatic fever</td>
<td></td>
</tr>
<tr>
<td>Scarlet fever</td>
<td></td>
</tr>
<tr>
<td>Heart murmur</td>
<td></td>
</tr>
</tbody>
</table>

Have you ever had an electrocardiogram? If yes, please state when and by whom.

<table>
<thead>
<tr>
<th>Illness</th>
<th>Do you have this illness/problem now?</th>
</tr>
</thead>
<tbody>
<tr>
<td>High blood pressure</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
</tr>
<tr>
<td>Arthritis</td>
<td></td>
</tr>
<tr>
<td>Any abnormal bleeding tendencies</td>
<td></td>
</tr>
<tr>
<td>Anemia</td>
<td></td>
</tr>
<tr>
<td>Thyroid disorders</td>
<td></td>
</tr>
<tr>
<td>Skin disorders</td>
<td></td>
</tr>
<tr>
<td>Allergies to food</td>
<td></td>
</tr>
<tr>
<td>drugs/medications</td>
<td></td>
</tr>
<tr>
<td>skin</td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td></td>
</tr>
</tbody>
</table>
Loss of, or serious impairment of a paired organ (i.e., kidney, eye, lung) If yes, please state organ and time of incident:
- Hepatitis or jaundice
- Infectious mononucleosis (mono)
- Bowel cramps or upsets
- Frequent indigestion or heartburn
- Stomach ulcer
- Kidney and bladder problems
- Menstrual problems

III. Current Health History

Do you smoke? ___ No ___ Yes (if yes, state how many packs/day)
(if yes, state how long you have been smoking)
Are you taking any prescription medications? If so, what are they?

IV. Exercise Routine

Check the one which you feel describes your level of exercise over the past year:
- Intensive occupational and recreational exertion
- Moderate occupational and recreational exertion
- Sedentary work and intense recreational exertion
- Sedentary work and light recreational exertion
- Sedentary work and no recreational exertion

V. Present Illness

Are you presently having any pain, limitation of motion, or musculoskeletal problems? If so, please describe the problem?
Where is it located?
How long have you had the problem?
What makes it better?
What makes it worse?
Are you currently under treatment for the problem? If yes, please state the treatment
Does this condition limit your physical activity? If yes, please explain how
September 14, 1995

Journal of Bone and Joint Surgery-American Office
Editorial Department-Attn. Steven Tilton
20 Pickering Street
Needham, MA
02192-3157

Dear Steven Tilton:

I am a graduate student at the University of North Dakota working on my independent study entitled, "Iso kinetic Ratios of Concentric/Eccentric Work Production of Internal/External Rotators in a Simulated Throwing Pattern." I would like to use figure 1 in the journal article, "Dynamic Electromyographic Analysis of the Throwing Shoulder with Glenohumeral Instability" (Vol 70-A, No. 2 February 1988, p. 221). The figure will be used to provide additional information to complement the literature review.

Per our conversation on 9/14/95, I am sending you a written request for permission to use this figure. Enclosed you will also find a copy of the illustration. For your convenience, please return this letter with the bottom portion signed and approved in the envelope provided.

Thank you for your kind attention to this matter. If there are any questions or concerns regarding this request, please feel free to contact me at the above stated address.

Sincerely,

Deane M. Chinen

I hereby give Deane M. Chinen permission to use figure 1 from the journal article entitled, "Dynamic Electromyographic Analysis of the Throwing Shoulder" (Vol. 70-A, No. 2, February 1988, p. 221) for academic/educational use in her independent study paper.

Steven Tilton, Managing Editor
Journal of Bone and Joint Surgery
Consent for Taking and Publication of Photographs

Name: Carolyn Brown  Place: University of North Dakota  Date: 10/6/95
Physical Therapy Department

In connection with Deane M. Chinen's independent study project entitled, Isokinetic Ratios of Concentric and Eccentric Work Production of Internal and External Rotators in a Simulated Throwing Pattern, I consent that photographs may be taken of me and may be published under the following conditions:

1. The photographs shall be used if the researcher, Deane M. Chinen deems that medical research, education, or science will be benefited by their use. Such photographs may be published and republished, either separately or in connection with each other, in professional journals or medical books; provided that it is specifically understood that in any such publication or use I shall not be identified by name.

2. The aforementioned photographs may be modified or retouched in any way that the researcher, Deane M. Chinen may consider desirable.

Signed  Carolyn Brown

Witness  Donna Ho

Carolyn Brown

Donna Ho
REFERENCES


