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The Effects of Torque Production Using a Stationary Hand-Held Dynamometer on Different Points of the Forearm when Manual Muscle Testing Elbow Flexors

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THE EFFECTS OF TORQUE PRODUCTION USING A STATIONARY HAND-HELD DYNAMOMETER ON DIFFERENT POINTS OF THE FOREARM WHEN MANUAL MUSCLE TESTING ELBOW FLEXORS.

By

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

Grand Forks, North Dakota
May
2005
This Scholarly Project, submitted by Justin Allred, Ross Homstad, and Eugene Monette in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Faculty Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Signed)

(Signed)

(G Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title The Effects of Torque Production Using a Stationary Hand-Held Dynamometer on Different Points of the Forearm When Manual Muscle Testing Elbow Flexors

Department Physical Therapy

Degree Doctor of Physical Therapy

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ACKNOWLEDGMENT

We would like to thank Dr. Sue Jeno, our advisor, for all of her patience and guidance throughout our work on this scholarly project. Without her help and insight this project would not have been possible.

Next, we would like to thank Dr Renee Mabey for helping us compile and statistically analyze our data.

We would like to extend a special thanks to all of the volunteer subjects who took time out of their busy day to participate in our study.

Lastly, we would like to thank our families, friends, faculty, and classmates for all of the support they have given us throughout this process and throughout our years in physical therapy school.
ABSTRACT

Muscle testing using a stationary dynamometer has given therapists a more objective method of assessing a patient’s strength. However, few studies have been performed as to the effects that dynamometer placement has on force production.

The purpose of this randomized, repeated measure study was to determine whether there was a significant difference in reliability between torque measurements with dynamometer placement at two well-defined points on the forearm. The differences in torque values from the two points of application (distal wrist crease and the midpoint of the forearm) were also compared to assess for differences between these values.

Thirty-two healthy subjects (23 female and 9 males) were tested in this study. For inclusion in this study, the subjects had to be between 18 and 30 years of age and must have had no prior history of wrist, elbow, or shoulder pathology.

The test protocol consisted of measuring and marking the patient’s right forearm at both the distal wrist crease (DW) and the midpoint (MP) of the forearm. Following the measurement, the subject was placed in a rigid chair with the right arm placed into 90° of elbow flexion and 0° of shoulder abduction. Instructions were given once the patient was in this test position. The patient was asked to perform a maximal isometric contraction against the dynamometer for 5 seconds during each of the 6 trials. Three of these trials were performed at each test location (DW and MP) for a total of 6 trials. The subject received a 30 second rest between each trial.
The results of the study showed that both the DW and the MP of the forearm produced highly reliable results; \( r = .99 \) and \( r = .98 \), respectively. There was, however, a significant difference when the torque (ft-lbs) and the pounds of force were compared between the two application points. The mean torque value for the DW was 36.80 ± 17.09 ft-lbs, while the mean torque value for the midpoint was 22.94 ± 8.86 ft-lbs. The mean pounds of force production at the DW was 40.72 ± 17.16 pounds of force, while the mean pounds of force production at the MP was 51.07 ± 18.22 pounds of force.

When testing elbow flexor strength with a stationary dynamometer, reliable results can be expected as long as the dynamometer is placed at the same point on the limb for each trial. The significant difference noted between both the DW and the MP in terms of torque values and pounds of force production indicates that consistent dynamometer placement is essential for reliable results. If a subject is tested at different points of the forearm when assessing elbow flexor strength, reliable results may be compromised since different amounts of torque and pounds of force are produced at different points of the forearm. The dynamometer must be placed at the same point during each trial to ensure reliability.
CHAPTER I

INTRODUCTION

Manual muscle testing continues to be a frequently practiced method of assessing patients' strength in the clinic. This method is highly subjective and only gives the therapist a choice of 5 grades in which to quantify the strength of the muscle. While the hand held dynamometer (small pressure sensitive electronic device) has given therapists an objective means of assessing a patient’s strength, this method proves unreliable when measuring contractions greater than 13 kg of force as the tester’s strength may influence the results. One way of improving the reliability of a dynamometer is to fixate it to a stationary object. By using a stationary dynamometer, one is able to eliminate the variable of the tester strength when measuring a patient’s strength.

Problem Statement

There is little published research that clearly states the most effective placement of a dynamometer when testing torque values for the elbow flexors. No studies have looked at the differences in either torque or force production at different points of the forearm when testing the elbow flexion. Without this knowledge, one cannot be certain as to the amount of difference that exists when the dynamometer is placed at 2 varying points of the forearm. If there is a significant difference between the amounts of either torque or force production between the 2 points of application, it could lead to unreliable results of strength measurements.
Purpose
The purpose of this study was to determine whether there was a significant difference in reliability between torque measurements with dynamometer placement at 2 well-defined points on the forearm. The 2 points included the distal wrist crease (DW) and the midpoint of the forearm (MP).

Significance of Study
This study is important to the field of physical therapy as strength testing is commonly performed in the clinic. While the use of dynamometer testing has taken much of the subjectivity out of manual muscle testing, there has still been little research published to indicate the best placement of the dynamometer. This study will help to establish the most reliable placement of the dynamometer when testing elbow flexor strength. This study will also indicate if there is a difference in terms of torque production between the DW and the MP.

Research Questions
1) Is strength testing more reliable at the distal wrist crease or the midpoint of the forearm?
2) Is there a significant difference in elbow flexor torque production between 2 well-defined points on the forearm when testing with a stationary dynamometer?

Hypothesis
Null Hypothesis: There is no significant difference in reliability between the two points of application.

Alternative Hypothesis: There is a significant difference in reliability between the two points of application.
Null Hypothesis: There is no significant difference, in terms of torque production, between the two points of application.

Alternative Hypothesis: There is a significant difference, in terms of torque production, between the two points of application.
CHAPTER II

LITERATURE REVIEW

An important aspect in the physical therapy profession is the ability to accurately test a patient’s strength. Strength testing is a necessary component in determining the patient’s functional limitations. Strength testing can give therapists insight as to where strength deficits exist as well as provide therapists with a way to monitor the recovery process. There are many ways of testing a patient’s strength in the clinic. A few of these common techniques include manual muscle testing, hand-held dynamometer testing, and stationary dynamometer testing. Each of these techniques will be further analyzed as to how they are performed and give insight into their strengths and weaknesses of accurately measuring a patient’s strength.

Muscle Testing

The technique of manual muscle testing was developed by Wilhelmine Write and Robert W. Lovett at the Harvard University Medical School in the year 1912. The technique consisted of grading a patient’s strength of contraction on a scale of 0-5 (see table 1). A grade of 5 indicates a normal grade in which a patient is able to move the muscle through the full range of motion (ROM) and provide a maximal contraction which cannot be broken by the therapist. A grade of 4, or good muscle grade, is achieved when a patient can move the muscle through the entire ROM and can withstand a moderate amount of force from the therapist before the contraction is broken. A grade 3, or fair muscle grade, means the patient is able to move the muscle through the entire ROM against gravity but is unable to sustain the contraction against any resistance. A grade of 2, or poor muscle grade, is given when the patient can complete the full ROM in
a gravity eliminated position. A grade 1, or trace grade, means contractile activity in the muscle is either seen or palpated but without any movement of the joint. A grade 0, or flaccid muscle, is given when no activity is detected in the muscle.

Table 1. Manual Muscle Testing Grades.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Score</th>
</tr>
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<tbody>
<tr>
<td>Zero</td>
<td>0</td>
</tr>
<tr>
<td>Trace</td>
<td>1</td>
</tr>
<tr>
<td>Poor</td>
<td>2</td>
</tr>
<tr>
<td>Fair</td>
<td>3</td>
</tr>
<tr>
<td>Good</td>
<td>4</td>
</tr>
<tr>
<td>Normal</td>
<td>5</td>
</tr>
</tbody>
</table>


According to the guidelines for manual muscle testing, the application of resistance should be applied near the distal end of the segment or near the muscle insertion. When testing one-joint muscles, the force should be applied with the joint at the end of the ROM, while testing of two-joint muscles calls for positioning of the muscle at or near mid-range.

While manual muscle testing provides a simple, quick, and cost effective manner in which to assess a patient’s strength, it is highly subjective. Different variables may impact the results while using this technique. Variation in scores can result from therapist characteristics such as strength, perception of patient strength, experience in
testing, height, weight, gender, and age.\textsuperscript{3,4} Determination of manual strength can also vary due to patient variables (age, gender, pain, type of disease, voluntary control, type of work or fitness).\textsuperscript{4} For example, a stronger therapist may be able to break a patient’s contraction leading to a score of 4, or good. However, this same contraction may not be able to be broken by a weaker therapist and scored as a grade 5, or normal. Differences between body sizes of the therapist and patient may also lead to different MMT scores (ie; 110 lb female measuring the leg strength of a 250 lb male athlete). While manual muscle testing remains the conventional strength measurement method, research indicates a high level of subjectivity involved with this type of testing that threatens accuracy.\textsuperscript{5-8}

As far as reliability with manual muscle testing is concerned, a study performed by Byl, Richards, and Asturias\textsuperscript{4} found that therapists were in complete agreement of what grade to give a muscle contraction 70\% of the time and were in agreement within one grade 90\% of the time. Another study by Iddings et al\textsuperscript{9} reported agreement between raters within one grade occurred 96-98\% of the time, however, it needs to be noted that a one point difference represents an error of 20\% in a 5 grade system.

The invention of the dynamometer helped to create a more objective approach to testing muscle strength. A dynamometer is a small, electronic, pressure sensitive device that is able to record the strength of a contraction in pounds of force. The dynamometer is placed at the desired location on the patient. The patient then produces a force to the dynamometer (make test) or resists a force provided by the therapist (break test). Once the contraction has been held for the desired amount of time, the dynamometer will display the maximum pounds of force produced by the patient. The dynamometer can be used in one of two ways. The first method, hand-held dynamometer (HHD) testing, is
performed with the therapist holding the dynamometer while the patient exerts a force to the device. The second method, stationary dynamometer testing, involves mounting the dynamometer onto an immovable object so the force applied to the dynamometer by the patient is resisted by the immovable object. The type of test performed depends on whether the patient is applying the force to the dynamometer (concentric contraction) or resisting pressure from the therapist (eccentric contraction).

The two types of tests that can be performed when it comes to muscle testing are the make test and the break test. During the make test, the subject is required to apply a maximal isometric force to the dynamometer while the therapist reads the highest value that registers on the dynamometer. The make test is the type of test used in both HHD testing and stationary dynamometer testing. The break test is the test utilized with manual muscle testing and can also be performed using a HHD. The break test requires both adequate strength and skills of the therapist. With the break test, the therapist pushes against a patient’s limb until the patient’s maximal muscular contraction is overcome and the joint being tested gives way. The maximum pounds of force exerted by the patient can then be recorded as a measure of strength.

Research has shown that because break tests involve eccentric contractions by preloaded muscles, break tests require more force by the examiner than make tests. This concept was confirmed in a study by Bohannon which compared make tests and break tests of elbow flexor strength. This study reported that the forces produced by the elbow flexor muscles during break tests were significantly higher than the forces produced during make tests. Another important finding in this study was that both make and break tests were found to have reliability greater than 0.90. Because the
reliability of the make tests and break tests was similar (differing by less than 1.5%), one testing method cannot be interpreted as preferable to the other based on relative reliability.\textsuperscript{13} As long as the therapist has adequate muscle strength, both make tests and break tests can be repeated reliably by the same therapist using a hand-held dynamometer. While the previous studies have shown a high level of intra-rater reliability, additional studies have shown much lower levels of inter-rater reliability for HHD testing.\textsuperscript{1,4,14-16}

The variable that seems to have the greatest impact on the inter-rater reliability of HHD testing is therapist strength.\textsuperscript{14} Strength differences between examiners may result in differing force readings despite standardized testing applications.\textsuperscript{1} A study performed by Byl et al\textsuperscript{4} found a significant difference in maximum force recorded during HHD testing determined to be caused by strength differences in the examiners. In a study by Wikholm and Bohannon,\textsuperscript{1} which assessed the difference tester strength can make during strength testing, there was found to be a significant difference in the magnitude of force measured by three different examiners leading to the belief that tester strength affects the magnitude and reliability of HHD measurements. Although HHD testing is more objective and more precise than MMT, differing levels of strength between therapists can lead to poor inter-rater reliability.\textsuperscript{4} The gender of the therapist may also influence the results of strength testing as male therapists frequently recorded higher levels of force production when compared to female therapists.\textsuperscript{14} The HHD readings taken were reflective of examiner strength rather than the patient's ability, in cases where the patient was stronger than the examiner.\textsuperscript{14} If the therapist is not strong enough to withstand the
force applied by the patient, it is impossible to get an accurate measurement as to the patient’s maximum strength.

Researchers have found that HHD measurements are both valid and reliable when used to test naturally weak and pathologically weakened muscles.\textsuperscript{1} It is when a therapist must test stronger muscle groups that the therapist’s level of strength can influence the results of the strength testing. Once the strength of the muscle contraction being measured reaches 13 kg or above, therapist strength appeared to be a major determinant of the magnitude and reliability of the test.\textsuperscript{1}

The results of 18 studies assessing inter-tester reliability of HHD testing were compiled by Bohannon.\textsuperscript{2} The findings showed that high inter-tester reliability can be obtained through use of a HHD; however, reliability is in jeopardy if tester strength is low relative to the forces being measured on the patient.\textsuperscript{15} Because tester strength has the ability to affect the reliability of strength measurements when using a HHD, a more accurate method of testing strength was needed to determine the patient’s strength. Stationary dynamometer testing solved this problem as it eliminated the variable of tester strength. While many studies have been performed on the reliability of HHD testing, little research has been published on the reliability of strength testing of healthy, young to middle-aged individuals using a stationary dynamometer. The studies that do exist were performed on elderly patients weakened secondary to a disease process. As previously noted, HHD testing carries a high level of intra-rater reliability when measuring force production up to approximately 13 kg after which the reliability begins to decrease.\textsuperscript{1}

Brinkman\textsuperscript{16} performed a study comparing reliability between both a HHD and a stationary dynamometer in measuring strength of patient’s with neuromuscular diseases.
The study found muscles producing less than 15 kg. of force could be accurately tested with either a HHD or a stationary dynamometer, but muscle groups producing higher forces required additional stabilization (such as stationary dynamometer testing) making HHD testing impractical for stronger muscle groups.

A study comparing the reliability of make and break tests using a HHD and a Kin-Com machine (stationary) was performed by Stratford and Balsor. The researchers found that while the make test using a Kin-Com (stationary) carried the highest degree of reliability, all tests produced reliability greater or equal to 0.90. The literature reviewed seemed to agree that strength testing using a stationary dynamometer while measuring a make test produces the most reliable results when compared to MMT and HHD testing. While the results of most studies were reported in pounds, kilograms, or Newtons of force, this study determined the amount of torque produced by the elbow flexors at both the DW and the MP.

Torque

Theoretically, torque production should be equal at all points of the forearm as long as the distance from the axis of rotation is noted. When testing the elbow flexors, the axis of rotation would be the elbow joint. For example, in assessing elbow flexor strength using a stationary dynamometer, it is hypothesized that if a subject is tested on two different days and on two different point of the forearm (one point each day), the force production in terms of pounds will be different, but the torque production will be equal, as long as the subject exerts a maximal isometric force at the same angle and when the distance from the center of rotation to the point of application is factored into the
equation. In the book, Muscle Strength Testing, Amundson stated that the potential problem of measuring strength in terms of pounds of force can be solved by measuring the length of the output lever arm and multiplying it by the force produced, giving a torque production readout. As stated previously, the torque equation accounts for differences in lever arm length. With this in consideration, torque proves to be the preferred method of reporting strength values. Unfortunately, many of the studies to date continue to report their findings in pounds of force, versus torque values. Torque is defined as taking the perpendicular distance (lever arm length) multiplied by both the force produced and the angular acceleration (sin θ). Because this was an isometric contraction, there was no motion occurring at the elbow joint. Since the elbow was at 90 degrees, angular force was eliminated as sin 90° = 1.0. Therefore, in this study, the torque equation can be written as: Torque = force x distance. The force would be the pounds of force applied to the dynamometer by the subject while the distance would be the measurement of how far the dynamometer was placed from the axis of the elbow joint.

Anatomy

The elbow joint is a uniaxial joint of the hinge type permitting both flexion and extension by means of mixed gliding and rolling. The elbow’s strong structural stability is derived from a combination of both the bony configuration and the collateral ligaments. The axis for flexion and extension is represented by a line through the centers of the trochlea and the capitulum. The bony structures making up the elbow include the distal end of the humerus, the proximal radius, and the proximal ulna. The elbow joint complex is made up of 3 separate synovial articulations: the humeroulnar, humeroradial,
and the proximal radioulnar joint. Flexion and extension occurs at the humeroulnar and humeroradial joints with pronation and supination occurring at the proximal radioulnar joint. The elbow joint possesses significant stability due to the inter-locking configurations of the articulation surfaces, the collateral ligaments, and surrounding musculature.

The elbow flexor muscle group consists of three primary muscles: the biceps brachii (long and short head), brachialis, and brachioradialis. The biceps brachii originates from the coracoid process and the supraglenoid tubercle of the scapula and inserts onto the radial tuberosity of the radius and the bicipital aponeurosis. The brachialis originates from the anterior, distal one-half of the humerus and inserts on the ulna (tuberosity and coronoid process). The brachioradialis originates from the proximal two-thirds of the lateral supracondylar ridge of the humerus and inserts onto the radius just proximal to the styloid process. The biceps brachii works most efficiently between 80 to 90° of elbow flexion due to the line of pull of this muscle. Since this study calls for the elbow to be flexed to 90° with forearm in full supination, the biceps brachii will be the primary muscle involved in the contraction. The test position of 90° of elbow flexion was chosen as this is the range of motion in which the biceps brachii works most efficiently. By placing the subject’s elbow in 90° of flexion, the factor of angular force was eliminated allowing for the calculation of torque to be force multiplied by distance.
CHAPTER III

METHODS

Subjects

Thirty-two subjects (23 female and 9 males) were voluntarily recruited and gave written informed consent to participate in this study (Appendix B). The criteria for inclusion in this study were: subjects must be between the ages of 18 and 30 years; subjects could have no previous history of shoulder, elbow, or wrist pathology; subjects were also screened for any conditions that would not permit them to perform a maximal isometric muscle contraction. This study was approved by the Institutional Review Board at the University of North Dakota (IRB # 200410-084, see Appendix A) and all testing was performed in the Physical Therapy Department at the University of North Dakota.

Instrumentation

All trials were performed using a Microfet hand-held dynamometer (Hogan Health Industries, P.O. Box 957, Draper, UT). The Microfet hand-held dynamometer was fixated to a parallel bar which was attached to a high/low mat (see figure 1). Equipment was used from the University of North Dakota Physical Therapy Department. A universal goniometer was used for elbow angle measurement.
Figure 1. Testing equipment setup with dynamometer fix to parallel bar attached to a high low mat.
Muscle Testing

After giving informed consent, measurements of the subject's forearm were taken to determine points of application (the point at which the Microfet). The measurement was obtained by using a standard tape measure to measure the distance in centimeters between the medial epicondyle of the humerus and the DW. The halfway point of this distance was used as the MP for testing. A reference mark was then applied to the subject's forearm using a skin safe washable marker to ensure the Microfet was accurately placed for each trial (see figure 2). The location at which testing began for each subject was randomly determined using the flip of a coin prior to the strength testing (heads = DW and tails = MP).

The subjects were then asked to sit in a rigid chair with their right arm adducted to their side, the forearm flexed to 90°, and fully supinated (see figures 3, 4, and 5). Goniometric measurements were taken both prior to and following each trial to ensure the subject maintained 90° of elbow flexion for each trial.

After the subject was placed in the test position, the high/low mat was lowered until the Microfet came into contact with the subject’s forearm. Before the trials began, each subject was given a standardized set of instructions. Testing began after the subject indicated comprehension of the instructions. During the trials, the subject was asked to apply a maximal isometric force to the dynamometer for 5 seconds. A stopwatch was used to ensure each contraction lasted the full 5 seconds. The stopwatch was started following a verbal cue from the tester and was stopped once the 5 seconds had elapsed. The subject was instructed to relax following the contraction. Three consecutive trials were performed at each point of application, DW and MP, for a total of 6 trials. A 30
Figure 2. Measurement of the right forearm with tape measure and reference marks for dynamometer testing.
Figure 3. Subject in testing position with alignment of goniometric at 90° of elbow flexion.
Figure 4. Test position at midpoint.
Figure 5. Test position at distal wrist crease.
second rest period was given between each trial. The force measurement from each trial was recorded for statistical analysis. At the conclusion of the final trial, the subject were thanked for their participation and allowed to view their own results.

Statistical Analysis

Data analysis was calculated using the SPSS Data Editor for Windows Version 11.5.0 (6 Sept 2002). An ICC Correlation Coefficient with a significance level of
CHAPTER IV

RESULTS

Subjects

Thirty-two subjects met the inclusion criteria for this study. See Table 2 for the subject profile.

Table 2. Subject Profile

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Age in Years</th>
<th>Right Hand Dominant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>23</td>
<td>22.78 ± 1.76</td>
<td>21</td>
</tr>
<tr>
<td>Male</td>
<td>9</td>
<td>23.44 ± 2.27</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>22.97 ± 1.89</td>
<td>29</td>
</tr>
</tbody>
</table>

Reliability of Pilot Study

Reliability of testing procedures was established with 9 subjects prior to data collection. The ICC values for mean torque (of 3 trials) between days 1, 2, and 3 were high, with the ICC for DW testing at .98 and the ICC midpoint testing at .99. The ICC values for first repetition testing between days was acceptable, producing similar results. In addition, Pearson correlation coefficients between repetitions were established on research subjects to determine if a single repetition effort would be appropriate for clinical practice. See Tables 3 and 4.
Table 3. Force Measurements and Correlation Matrix for Measurements at the Distal Wrist Crease of the Forearm, n = 32.

<table>
<thead>
<tr>
<th></th>
<th>Force in R</th>
<th>R</th>
<th>R</th>
<th>r</th>
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<tbody>
<tr>
<td></td>
<td>Pounds</td>
<td>Trial1</td>
<td>Trial2</td>
<td>Trial3</td>
</tr>
<tr>
<td>Trial 1</td>
<td>40.41</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 2</td>
<td>40.88</td>
<td>.9619</td>
<td>1.00</td>
<td></td>
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<tr>
<td>Trial 3</td>
<td>40.88</td>
<td>.9708</td>
<td>.9886</td>
<td>1.00</td>
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</tbody>
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Table 4. Force Measurements and Correlation Matrix for Measurements at the Midpoint of the Forearm, n = 32.

<table>
<thead>
<tr>
<th></th>
<th>Force in R</th>
<th>R</th>
<th>R</th>
<th>r</th>
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Torque Measures

Initial measurements were recorded as pounds of force. Values were converted to foot-pounds of torque and are displayed in Table 5. Table 6 and 7 contain values for each of the trials at MP and DW in pounds, the means of each subject's three trials, the distance from the point of application to the axis of rotation in inches, and the torque values in foot-pounds.

Table 5. Means and Standard Deviations for Force and Torque at the Distal Wrist crease and the Midpoint of the Forearm.

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<th>Mean Torque in Foot Pounds</th>
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<td>Midpoint</td>
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Table 6. Distal Wrist Crease Values for the 1st, 2nd, and 3rd Trials, Mean from all Trials, Distance from Axis of Rotation, and Torque Values for each Subject.

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<th>Torque (ft-lbs)</th>
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Table 7. Midpoint Values for the 1st, 2nd, and 3rd Trials, Mean from all Trials, Distance from Axis of Rotation, and Torque Values for each Subject.

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Related samples t-tests demonstrated a significant difference in mean torque values of 13.86 ± 10.19 foot-pounds between the test positions (t(31) = 7.962, p<.001) with torque production at the DW higher than torque production at the MP.

Related samples t-tests demonstrated a significant difference in first repetition torque values of 13.97 ± 10.95 foot-pounds between the test positions (t(31) = 7.215, p<.001), with torque production at the DW higher than torque production at the MP.
CHAPTER V
DISCUSSION

Following data analysis, testing at both the DW and the MP was highly reliable. The results of this study indicate that a stationary dynamometer can be effectively used at either point of attachment as long as the tester is consistent with dynamometer placement. The second hypothesis stating that there is no significant difference in terms of torque production between the two points of application was rejected. This study indicated a significant difference between torque production measured at two different points on the forearm.

Reliability

Both points of application, the DW and MP, yielded high reliability. Reliability at the DW was slightly higher (r = 0.99), while reliability at the MP was found to be r = 0.98. These results are consistent with those of Bohannon, Lusardi, Stratford, Balsor, and Krinkman.5,12,16

The subjects were initially measured and marked to ensure testing occurred at the same point for every trial at both of the points on the forearm. By using a stationary dynamometer, the variable of tester strength was eliminated. The variable of tester strength has led to poor reliability in previous studies assessing hand-held dynamometry.1,4,15,16,19 By taking out the variable of tester strength, the only force registered is the force the subject applied to the dynamometer.
Torque Production

In terms of torque production, it was found that there was more torque produced at the DW (mean torque = 36.80 ± 17.09 ft-lbs) than at the MP (mean torque = 22.94 ± 8.86 ft-lbs). While the torque equation, force x distance, should account for the difference in lever arm length, this was found not to hold true. When the force production readout given by the dynamometer (pounds of force) was converted to torque (ft-lbs), a significant difference was found between the results when comparing the two points of application. While most of the published research reviewed gave results in terms of pounds of force, Newtons, or kilograms of force, some also stated that torque production measurements would be ideal in terms of assessing muscle strength. Despite this fact, most of the published literature continues to give results of force production in pounds, Newtons, or kilograms.

Limitations

One possible limitation of this study is the fact that many of the subjects mentioned that testing performed at the DW was more comfortable than testing performed at the midpoint of the forearm. This discomfort noted at the MP test position may have prevented some subjects from giving a maximal contraction. The torque values recorded for the MP were less than the torque values recorded at the DW due to the fact that the elbow is a third-class lever. It would be expected that torque production at the MP would be greater than the torque production at the DW. The discomfort may have led to an inability for some subjects to produce a maximal contraction leading to the lower torque values.
Another limitation could be the test position. Most previous studies used a supine position with the arm flexed to 90° to test elbow flexor strength. This study used a sitting position with the arm flexed to 90°. This position was used because it is the standard position for manual muscle testing of the elbow flexors. Testing in this position also provided the most convenient method of mounting the dynamometer. Since testing was performed against gravity, this may account for the fact that force values were lower than the force values of previous studies which incorporated the gravity eliminated supine test position.4,10,12,15-17

While this method of stationary dynamometer testing proved effective when assessing elbow flexor strength, this method of fixing the stationary dynamometer may not be applicable in the clinic for all muscle groups. Alternate methods of assessing strength with a fixed dynamometer may be needed, especially when assessing strength of the lower extremity musculature.

Conclusion

The results from this study show that when strength testing for the elbow flexors is repeated at the same point on the forearm with a stationary dynamometer, reliable results can be expected (r = .99 for the DW and r = .98 for the MP). These results are comparable to previous research performed using a stationary dynamometer. However, since there was a significant difference in both torque production (ft-lbs) and force production (lbs) between the two points of application, the importance of remaining consistent with dynamometer placement is verified. Future studies designed to assess whether these results are comparable to the results from other muscle groups would be beneficial.
REPORT OF ACTION: EXEMPT/EXPEDITED REVIEW
University of North Dakota Institutional Review Board

Date: 10/11/2004  Project Number: IRB-200410-084

Principal Investigator: Jeno, Sue; Allred, Justin; Homstad, Ross; Monette, Eugene

Department: Physical Therapy

Project Title: The Effects of Torque Production using a Stationary Hand-Held Dynamometer on Different Points of the Forearm when Manual Muscle Testing Elbow Flexors

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on October 12, 2004 and the following action was taken:

☑ Project approved. Expedited Review Category No. 4

Next scheduled review must be before: October 11, 2005

☑ Copies of the attached consent form with the IRB approval stamp dated October 12, 2004 must be used in obtaining consent for this study.

☐ Project approved. Exempt Review Category No. __________________________ as long as approved procedures are followed. No periodic review scheduled unless so stated in the Remarks Section.

☐ Copies of the attached consent form with the IRB approval stamp dated __________________________ must be used in obtaining consent for this study.

☐ Minor modifications required. The required corrections/additions must be submitted to ORPD for review and approval. This study may NOT be started UNTIL final IRB approval has been received.

(See Remarks Section for further information.)

☐ Project approval deferred. This study may not be started until final IRB approval has been received.

(See Remarks Section for further information.)

REMARKS: Any unanticipated problem or adverse occurrence in the course of the research project must be reported within 72 hours to the IRB Chairperson or ORPD by submitting an Unanticipated Problem/Adverse Event Form.

Any changes in protocol or Consent Forms must receive IRB approval prior to being implemented. You must submit a Protocol Change Form with all revised research documents to include changes to protocol, consent forms, or supportive materials, with the appropriate signatures, to the Office of Research and Program Development for review and approval.

PLEASE NOTE: Requested revisions for student proposals MUST include adviser’s signature. All revisions MUST be highlighted.

☑ Education Requirements Completed. (Project cannot be started until IRB education requirements are met.)

cc: Chair, Physical Therapy; Dean, School of Medicine

Signature of Designated IRB Member 10-12-04
UND's Institutional Review Board Date

If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 310 Form may be required. Contact ORPD to obtain the required documents.

(Revised 07/2004)
University of North Dakota Human Subjects Review Form

All research with human participants conducted by faculty, staff, and students associated with the University of North Dakota, must be reviewed and approved as prescribed by the University's policies and procedures governing the use of human subjects. It is the intent of the University of North Dakota (UND), through the Institutional Review Board (IRB) and the Office of Research and Program Development (ORPD), to assist investigators engaged in human subject research to conduct their research along ethical guidelines reflecting professional as well as community standards. The University has an obligation to ensure that all research involving human subjects meets regulations established by the United States Code of Federal Regulations (CFR). When completing the Human Subjects Review Form, use the “IRB Checklist” for additional guidance.

Please provide the information requested below:

**Principal Investigator:** Dr. Sue Jeno, Justin Allred, Ross Homstad, Eugene Monette

Telephone: (701) 777-2831  
E-mail Address: sujeno@medicine.nodak.edu

Complete Mailing Address: University of North Dakota, P.O. Box 9037, Grand Forks, ND 58202

School/College: School of Medicine and Health Sciences  
Department: Physical Therapy

**Student Adviser (if applicable):** Dr. Sue Jeno

Telephone: (701) 777-2831  
E-mail Address: sujeno@medicine.nodak.edu

Address or Box #: University of North Dakota, P.O. Box 9037, Grand Forks, ND 58202

School/College: School of Medicine and Health Sciences  
Department: Physical Therapy

Project Title: The effect of torque production using a stationary hand-held dynamometer on different points of the forearm when Manual Muscle testing elbow flexors

Proposed Project Dates: Beginning Date: 10-10-04  
Completion Date: 5-1-05  
(Including data analysis)

Funding agencies supporting this research: None

(A copy of the funding proposal for each agency identified above MUST be attached to this proposal when submitted.)

Does the Principal Investigator or any researcher associated with this project have a financial interest in the results of this project? If yes, please submit, on a separate piece of paper, an additional explanation of the financial interest (other than receipt of a grant)

YES or NO

If your project has been or will be submitted to other IRBs, list those Boards below, along with the status of each proposal.

<table>
<thead>
<tr>
<th>Date submitted</th>
<th>Status</th>
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Type of Project: Check “Yes” or “No” for each of the following.

- **YES or NO** New Project
- **YES or NO** Continuation/Renewal
- **YES or NO** Dissertation/Thesis
- **YES or NO** Student Research Project
- **YES or NO** Is this a Protocol Change for previously approved project? If yes, submit a signed copy of this form with changes bolded or highlighted
- **YES or NO** Does your project involve medical record information? If yes, complete the HIPAA Compliance Application and submit it with this form.
- **YES or NO** Does your project include Genetic Research? If yes, refer to Chapter 3 of the Researcher Handbook for additional guidelines regarding your topic.
- **YES or NO** Does your project include Internet Research? If yes, refer to Chapter 3 of the Researcher Handbook for additional guidelines regarding your topic.
- **YES or NO** Will subjects or data be provided by Altru Health Systems? If yes, submit two copies of the proposal. A copy of the proposal will be provided to Altru.
- **YES or NO** Will research subjects be recruited at another organization (e.g., hospitals, schools, YMCA) or will assistance with the data collection be obtained from another organization?

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If yes, list all institutions:

Letters from each organization must accompany this proposal. Each letter must illustrate that the organization understands their involvement in the study, and agrees to participate in the study. Letters must include the name and title of the individual signing the letter and, if possible, should be printed on letterhead.

Subject Classification: This study will involve subjects who are in the following special populations: Check all that apply.

- Minors (< 18 years)
- Prisoners
- Persons with impaired ability to understand their involvement and/or consequences of participation in this research
- Other:

For information about protections for each of the special populations, refer to Chapter 5 of the Researcher Handbook.

This study will involve: Check all that apply.

- Deception
- Radiation
- New Drugs (IND)
- Non-approved Use of Drug(s)
- Recombinant DNA
- None of the above

I. Project Overview

Provide a brief explanation (limit to 200 words or less) of the rationale and purpose of the study, introduction of any sponsor(s) of the study, and justification for use of human subjects and/or special populations (e.g., vulnerable populations such as minors, prisoners, pregnant women/fetuses).

There is little published research that clearly states the most effective placement of a dynamometer (small pressure sensitive electronic device) when testing torque values for the elbow flexors.

The purpose of this study is to determine whether there is a significant difference in reliability between torque measurements with dynamometer placement at two well defined points on the forearm. The two points will include the distal wrist crease and a point halfway between the medial humeral epicondyle (elbow) and the distal wrist crease. The muscle torque values from 30-40 subjects will be obtained using a stationary dynamometer and forearm length measurements.

Normal healthy adult (18-30 years of age) subjects will be used in this research project. Human subjects are needed for this research study in order to measure elbow flexor torque at the two different points on the forearm.

II. Protocol Description

Provide a succinct description of the procedures to be used by addressing the instructions under each of the following categories. Individuals conducting clinical research should refer to the “Guidelines For Clinical-Research Proposals” in Appendix A of the Researcher Handbook.

1. Subject Selection.
   a) Describe recruitment procedures (i.e., how subjects will be recruited, who will recruit them, where and when they will be recruited and for how long) and include copies of any advertisements, fliers, etc., that will be used to recruit subjects. If incentive payments will be made to anyone for enrolling participants, describe the incentive package.

   We will recruit 30-40 subjects (male and female) between 18-30 years of age. The subjects for this study will be recruited from the University of North Dakota student population by the principal investigators and by placing flyers throughout the School of Medicine and Health Science Building (see attached flyer).

   b) Describe your subject selection procedures and criteria, paying special attention to the rationale for including subjects from any of the categories listed in the “Subject Classification” section above.

   Subjects will be chosen based on their age, health status, and availability to perform the study.
c) Describe your exclusionary criteria and provide a rationale for excluding subject categories.

Only those with no history of right shoulder, elbow, or wrist pathology will qualify as subjects for this study. Only healthy subjects will be tested to obtain the most normative data. Shoulder, elbow, and wrist pathology will be defined as any condition that required physician intervention or any condition that has the ability to affect the subjects ability to produce a maximal muscle contraction of the elbow flexors.

d) Describe the estimated number of subjects that will participate and the rationale for using that number of subjects.

We anticipate we will recruit 30-40 subjects (both male and female) between 18-30 years of age. The number of subjects will be used in order to add power and validity to the statistical analysis of the data obtained.

e) Specify the potential for valid results. If you have used a power analysis to determine the number of subjects, describe your method.

With 30-40 subjects following a standard protocol for dynamometer placement, for our measurement techniques, and for subject instruction, the risk for errors is reduced and the potential of obtaining valid results is high.

2. Description of Methodology.

a) Describe the procedures used to obtain informed consent.

Informed consent will be obtained by asking each subject to read and complete an informed consent form (see attached form). All individuals participating in this study will be capable of individual decision making and will sign a consent form stating their understanding and willingness to participate in the study. A copy of the consent form will be provided to each participant.

b) Describe where the research will be conducted. Document the resources and facilities to be used to carry out the proposed research. Please note staffing, funding, and space available to conduct this research.

The research will be conducted in a private room in the Physical Therapy Department at the University of North Dakota to ensure confidentiality of involved participants.

c) Indicate who will carry out the research procedures.

The research procedures will be conducted by Dr. Sue Jeno, PT, PhD, and three graduate students: Justin Allred, Ross Homstad, and Eugene Monette.

d) Briefly describe the procedures and techniques to be used, and the amount of time that will be required of the subjects to complete them.

After obtaining informed consent, demographic information will be taken including height, weight, and age. Measurements of forearm length and midpoint of the forearm will be obtained using a tape measure. The subjects will then receive standardized verbal instructions describing what they need to do to perform the strength tests. Once the subject indicates comprehension of the instructions, the strength measurement will be taken using a stationary dynamometer. The subject will be seated with his/her elbow flexed to 90 degrees during each trial. For each trial, the subject will be asked to exert a maximal force against the dynamometer and hold the contraction for five seconds. This procedure will be repeated three times in each test position. The test positions are 1) with the dynamometer placed at the distal wrist crease and 2) with the dynamometer paced at the midpoint of the forearm. There will be a 30 second rest between each trial. The testing will take approximately 10 minutes for the entire procedure.

e) Describe audio/visual procedures and proper disposal of tapes.

No videotapes, audiotapes or photographs will be used in this study.

f) Describe the qualifications of the individuals conducting all procedures used in the study.

All individuals who are conducting the study are currently faculty or Graduate Physical Therapy Students at the University of North Dakota, all of whom have completed an instrumentation course in the use of the equipment.

g) Describe compensation procedures (payment or class credit, etc.).

Subjects will receive no payment or class credit for participation in this study. Participation will be on a volunteer basis.

Necessary Attachments: Copies of all instruments (such as survey/interview questions, data collection forms completed by subjects, etc.) must be attached to this proposal.

a) Clearly describe the anticipated risks to the subjects/others including any physical, emotional, and financial risks that might result from this study.

The risks involved in this research project are minimal. This type of strength measurement is commonly used in the clinic without adverse effects. As with any form of strength testing, there is always the potential for minimal risk of muscle injury, but not greater than would be anticipated with exercise. There may be a slight redness of the skin at the points of the forearm at which the dynamometer was placed simply due to the pressure of pushing against the dynamometer. This should only be temporary and reside within minutes. There is minimal risk the participant may experience discomfort, pain, fatigue, or other symptoms associated with light exercise such as increased heart rate, sweating, or dizziness. The testing will occur in a controlled setting and because only healthy subjects will be used, the risk of injury is low.

b) Indicate whether there will be a way to link subject responses and/or data sheets to consent forms, and if so, what the justification is for having that link.

The subject’s name will not be used in any reports of the results of this study. Any information that is obtained in connection with this study and that can be identified with the subject will remain confidential and will be disclosed only with permission from the subject. The research data and the subject’s consent form will be connected by a single number, which will be known only by the investigators. At the completion of the study, the research data and the subject’s consent forms will be stored at separate locked locations in the Physical Therapy Department for three years at which point the research data will be shredded. Data will be reported in aggregate form only.

4. Subject Protection.

a) Describe precautions you will take to minimize potential risks to the subjects (e.g., sterile conditions, informing subjects that some individuals may have strong emotional reactions to the procedures, debriefing, etc.).

Subjects will be excluded if they have a history of any prior musculoskeletal diagnoses of the upper right extremity. Subjects will also be excluded if they have a history of any cardiovascular diagnosis. Prior to testing, each subject will receive a standardized set of instructions. Subjects will also be closely monitored throughout the testing session to decrease potential for harm. The investigator or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his or her health.

b) Describe procedures you will implement to protect confidentiality (such as coding subject data, removing identifying information, reporting data in aggregate form, etc.).

Subject and result information will not be linked to the consent form in order to protect the confidentiality of the subjects. Names will not be included on the subject research data forms. Subjects will be assigned a number which will be used to identify the participants.

c) Indicate that the subject will be provided with a copy of the consent form and how this will be done.

Prior to participation in this study, subjects will be given a copy of a consent form (see attached form) to read. They will then be asked to sign the form. Participants will be able to read and understand the document and will be competent and independent in their decision making. The participants will be encouraged to ask any questions regarding the consent form to ensure they understand the document. Participants will be provided a copy of the consent form to keep for their own records.

d) Describe the protocol regarding record retention. Indicate that research data from this study and consent forms will both be retained in separate locked locations for a minimum of three years following the completion of the study.

Describe: 1) the storage location of the research data (separate from consent forms and subject personal data)
2) who will have access to the data
3) how the data will be destroyed
4) the storage location of consent forms and personal data (separate from research data)
5) how the consent forms will be destroyed

The results of this study will be secured in the Physical Therapy Department at the University of North Dakota in a separate, locked filing cabinet for a minimum of three years. Participant consent forms will be kept separate from subject research
data forms. Only the student researchers and student advisor will have access to this information. After 3 years, the forms and data will be shredded for final disposition.

e) Describe procedures to deal with adverse reactions (referrals to helping agencies, procedures for dealing with trauma, etc.).

The investigators or participants may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his or her health. The decision whether or not to participate will not prejudice the individual’s future relationship with the Department of Physical Therapy at the University of North Dakota. If subjects decide to participate, they are free to discontinue participation at any time without prejudice.

f) Include an explanation of medical treatment available if injury or adverse reaction occurs and responsibility for costs involved.

If injury occurs while this study is conducted, medical treatment will be available as it is to a member of the general public in similar circumstances. The participants and his/her third party payer are responsible for payment for any such treatment.

III. Benefits of the Study
Clearly describe the benefits to the subject and to society resulting from this study (such as learning experiences, services received, etc.). Please note: payment is not a benefit and should be listed in the Protocol Description section under Methodology.

The anticipated benefits of this study will be better knowledge for the therapist about the reliability of performing muscle testing in the clinic. The results of this study will show whether the reliability of stationary dynamometer testing is dependent upon where the dynamometer is placed on the forearm when testing the elbow flexors. This knowledge will give therapists insight as to the best placement of the stationary dynamometer when testing their patient’s elbow flexor strength as measured in torque in the clinic and the need for consistency of placement for repeated testing.

IV. Consent Form
A copy of the consent form must be attached to this proposal. If no consent form is to be used, document the procedures to be used to protect human subjects. Refer to the ORPD website for further information regarding consent form regulations. Please note: Regulations require that all consent forms, and all pages of the consent forms, be kept for a minimum of 3 years after the completion of the study, even if the subject does not continue participation. The consent form must be written at the fifth grade level, and any use of jargon or technical language should be avoided. It is recommended that the consent form be written in the third person (please see the examples on the ORPD website). A two inch by two inch blank space must be left on the bottom of each page of the consent form for the IRB approval stamp, and only copies of the consent form with the stamp may be used in the research. The consent form must include the following elements:

a) An introduction of the principal investigator
b) An explanation of the purposes of the research
c) The expected duration of subject participation
d) A brief summary of the project procedures
e) A description of the benefits to the subject/others anticipated from this study
f) A paragraph describing any reasonably foreseeable risks or discomforts to the subject
g) Disclosure of any alternative procedures/treatments that are advantageous to the subject
h) An explanation of compensation/medical treatment available if injury occurs.
i) A description of how confidentiality of subjects and data will be maintained. Indicate that the data and consent forms will be stored separately for at least three years following the completion of the study. Indicate where, in general, the data and consent documents will be stored and who will have access. The following statement must be included in all consent forms and informational letters: “Only the researcher, the adviser, [if applicable] and people who audit IRB procedures will have access to the data.” Please make appropriate additions to the persons that may have access to your research data. Indicate how the data will be disposed of. Be sure to list any mandatory reporting requirements that may require breaking confidentiality.

j) The names, telephone numbers and addresses of two individuals to contact for information (generally the student and student adviser). This information should be included in the following statement: “If you have questions about the research, please call (insert Principal Investigator’s name) at (insert phone number of Principal Investigator) or (insert
Adviser’s name) at (insert Adviser’s phone number). If you have any other questions or concerns, please call the Office of Research and Program Development at 777-4279.”

k) If applicable, an explanation of who to contact in the event of a research-related injury to the subject.

l) If applicable, an explanation of financial interest must be included.

m) Regarding participation in the study:

1) An indication that participation is voluntary and that no penalties or loss of benefits will result from refusal to participate.

2) An indication that the subject may discontinue participation at any time without penalty, with an explanation of how they can discontinue participation.

3) An explanation of circumstances which may result in the termination of a subject’s participation in the study.

4) A description of any anticipated costs to the subject.

5) A statement indicating whether the subject will be informed of the findings of the study.

6) A statement indicating that the subject will receive a copy of the consent form.

By signing below, you are verifying that the information provided in the Human Subjects Review Form and attached information is accurate, and that the project will be completed as indicated.

Signatures:

__(Principal Investigator) Date:__

__(Student Adviser) Date:__

Requirements for submitting proposals:

Additional information can be found at the ORPD website at www.und.nodak.edu/dept/orpd

Original Proposals and all attachments should be submitted to the Office of Research and Program Development, P.O. Box 7134, Grand Forks, ND 58202-7134, or brought to Room 105, Twamley Hall.

Prior to receiving IRB approval, researchers must complete the required IRB human subjects education. Please go to http://www.und.nodak.edu/dept/orpd/regucomm/irb/Default.htm for more information.

The criteria for determining what category your proposal will be reviewed under is listed on page 3 of the IRB Checklist. Your reviewer will assign a review category to your proposal. Should your protocol require full Board review, you will need to provide additional copies. Further information regarding required copies and IRB review categories can be found on the ORPD website, or you may call the ORPD office at 701 777-4279.

In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form if the proposal is non-clinical; 7 copies if the proposal is clinical-medical. If the proposed work is being conducted for a pharmaceutical company, 7 copies of the company’s protocol must be provided.

Please Note: Student Researchers must complete the “Student Consent to Release of Educational Record”.

Revised 6/7/04
INFORMATION AND CONSENT FORM

Title: The effects of torque production using a stationary hand-held dynamometer on different points of the forearm when manual muscle testing elbow flexors.

Principal Investigators: Sue Jeno, Eugene Monette, Justin Allred, Ross Homstad from the Department of Physical Therapy at the University of North Dakota

You are being invited to participate in this study of torque production of the elbow flexors using a stationary hand-held dynamometer on two points of the forearm. The purpose of this study is to determine which point produces the most accurate and reliable measurement of torque/strength. The results of this study will aid physical therapists in the reliability and validity of manual muscle testing.

As a subject in this study, you will be asked to report to the Physical Therapy Department at the University of North Dakota, located in the School of Medicine and Health Science. You will also be asked to fill out a questionnaire about your past medical history as it pertains to the shoulder, elbow, and wrist. Your age, height, and weight will be recorded. You will be seated in a chair and you will be told a set of standard instructions. With your elbow at bent to 90° you will be asked to perform 3 maximal voluntary contractions against a stationary hand-held dynamometer at two different location of the forearm. You will be given 30 seconds of rest between each repetition. The testing procedure will take approximately 10 minutes of your time.

Although the process of physical performance testing always involves some degree of risk, the investigators in this study feel that, because of your age and health the risk of injury or discomfort is minimal. Minor muscle soreness may result following the repeated activity. No costs to you are expected. You may be excluded from this study if you have any past medical history that requires medical attention of a physician. Also if you have any history of high blood pressure or heart conditions that may prevent you from performing a maximal isometric contraction.

Your name will not be used in any reports of the results of this study. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. The data will be identified by a number known only to the investigators and kept separate from the consent forms in a secured locked cabinet in the Physical Therapy Department at the University of North Dakota. Only the researchers and the people who audit IRB procedures will have access to the data. The forms will be placed in the secured cabinet for a period of three years from the date of the completion of this study, after this time period the information will be shredded. After your testing, you may review your results.

You or the investigators may stop the experiment at any time if you experience discomfort, pain, fatigue, or any other symptoms that may be detrimental to your health.
Your decision whether or not to participate will not prejudice your future relationship with the Physical Therapy Department at the University of North Dakota. If you decide to participate, you are free to discontinue your participation at any time without prejudice.

The investigators involved are available to answer any questions you have concerning this study. In addition, you are encouraged to ask any questions concerning this study that you may have in the future. Questions may be asked by calling Dr. Sue Jeno at (701) 777-2831, Eugene Monette at (701) 787-9279, Justin Allred at (701) 772-0777, or Ross Homstad at (701) 740-2300. At your request, you will be given a copy of this form for future reference. If you have any other questions or concerns, please call the Office of Research and Program Development at 777-4279.

In the event that this research activity results in a physical injury, medical treatment will be as available as it is to a member of the general public in similar circumstances. You and/or your third party payer are responsible for providing payment for any such treatment. If you decide to participate in this study, you are free to discontinue at any time.

All of my questions have been answered and I am encouraged to ask any questions that I may have concerning this study in the future. I have read all of the above and willingly agree to participate in this study as it is explained to me by Eugene Monette, Ross Homstad, and Justin Allred.

I have read all of the above and willingly agree to participate in this study explained to me by one of the investigators. I have received a copy of this informed consent for my records.

Subject's signature Date

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University of North Dakota
Institutional Review Board
Approved on OCT 12 2004
Expires on OCT 11 2005
Questionnaire

Age: ________  Hand dominance: Right  Left

1. Have you had any previous surgeries, or injuries to your shoulders, arms, elbows, or wrist that required medical attention from a physician? Yes / No
   If yes when and were.

2. Do you have any pain in your right shoulder, arm, elbow, or wrist at this time? Yes / No. Describe?

3. Have you ever been diagnosed with:
   ______ Rotator cuff  ______ Tennis Elbow
   ______ Tendonitis     ______ Fracture
   ______ Carpal tunnel   ______ Arthritis

   If so please explain:
   __________________________________________
   __________________________________________
   __________________________________________

4. Past Medical History:
   ______ High blood pressure  ______ Aneurysm
   ______ Heart condition     ______ Stroke

   Other:
   __________________________________________
   __________________________________________

5. Are you taking any medication(s)? Y/N
   If so please list.
   __________________________________________
   __________________________________________

Thank you for your time in completing this questionnaire. Please return this form to the investigator when completed to determine if you qualify for participation in this study.
Data Collection Sheet

Height: _____  Weight: _____  Gender: M / F  Age: _____

Date: _____  Start Time: _____ am/pm

Measurements:
Medial Epicondyle to Distal Wrist Crease: _____ cm.
Mid Point: _____ cm.
Start point: DWC / MP

Distal Wrist Crease  Mid Point
Trial 1 _____ lbs  Trial 1 _____ lbs
Trial 2 _____ lbs  Trial 2 _____ lbs
Trial 3 _____ lbs  Trial 3 _____ lbs

Mean _____ lbs  Mean _____ lbs
APPENDIX E
Consent for Taking and Publication of Photographs

Name: Ashlee Jesperson

Location: University of North Dakota School of Medicine and Health Science

Date: 12/04/04

In connection with Justin Allred, Ross Homstad, and Eugene Monette’s scholarly project entitled, The Effects of Torque Production Using a Stationary Hand-Held Dynamometer on Different Points of the Forearm when Manual Muscle Testing Elbow Flexors, I consent that photographs may be taken of me and be published under the following conditions:

1. The photographs shall be used if the researchers, Justin Allred, Ross Homstad, and Eugene Monette, deem that medical or clinical research, education, or science will benefit 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 publication or use I shall not be identified by name.

2. The aforementioned photographs may be modified or retouched in any way that the researchers, Justin Allred, Ross Homstad, and Eugene Monette, may consider desirable.

Signed

Witness
REFERENCES CITED
REFERENCES


