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A Two-Method Comparison of Muscle Testing the Serratus Anterior: Daniels and Worthingham vs. Kendall and Mccreary

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A TWO-METHOD COMPARISON OF MUSCLE TESTING

THE SERRATUS ANTERIOR:

DANIELS AND WORTHINGHAM VS. KENDALL AND MCCREARY

By

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Bachelor of Arts in Physical Therapy
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An Independent Study

Submitted to the Graduate Faculty of the

Department of Physical Therapy

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for the degree of

Master of Physical Therapy

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1993

This independent study report, submitted by Arlene J. Proulx Johnson 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 Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Chairperson, Physical Therapy)

PERMISSION

Title	A Two-Method Comparison of Muscle Testing the Serratus Anterior: Daniels and Worthingham vs. Kendall and McCreary
Department	Physical Therapy
Degree	Master of Physical Therapy

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Signature Arlene J. Timke Johnson

Date 3-12-93

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ABSTRACT

The purpose of this study was to compare the amount of force produced by the left serratus anterior muscle when using two methods of muscle testing. Thirty subjects (5 men, 25 women) participated in this study. A manual muscle test was performed with each subject properly positioned for testing a good to normal muscle grade using the Daniels and Worthingham and Kendall and McCreary methods of muscle testing. A practice test of each method was performed and a rest period of one and a half minutes was allowed between tests. A hand-held dynamometer, the Dynatron II, measured objective data. Strength was recorded in pounds of force. Results reveal a significant difference in force produced by the left serratus anterior muscle when using two methods of muscle testing. The Daniels and Worthingham method of muscle testing revealed a larger production of force with a mean value of 41.37 pounds of force. The mean value of force produced with the Kendall and McCreary method of muscle testing was 27.39 pounds of force. This is statistically significant at the .0001 criterion level. There is, however, a strong positive correlation between the two methods of muscle testing.

INTRODUCTION

Muscle testing is an integral part of physical therapy evaluation. It is important to be able to isolate a specific muscle when testing its strength. When muscle weakness is present, it is the body's response to compensate for that weakness. This is accomplished by substituting stronger muscles for the weaker prime mover. Determining substitution can be a difficult task. It is important for the therapist to evaluate not only muscle strength but also muscle length, joint movement, posture, and neurological signs. It is necessary to distinguish between a strength problem, joint problem, or neurologic problem in order to direct an appropriate treatment plan. The body acts as a kinetic chain; therefore, one problem or limitation can lead to others. The therapist must view the "whole patient," and the affect the limitation has on the rest of the body's performance. Following the evaluation, an assessment is made, goals established, and treatment plan initiated. Muscle testing is then used to evaluate the effectiveness of the established treatment program.

Gonella[1] pointed out that three criteria must be met to ensure the success of any muscle testing method: 1) testing must be skillfully administered, 2) the method must allow for the collection of definitive data, and 3) the method must have the facility for controlled, repeated application. Skillful administration is the hallmark of the accomplished manual muscle tester. Without expertise and attention to detail, the tester may collect data that are less than useful. Validity, reliability, and accuracy of manual muscle testing techniques require attention to every detail of the testing procedure. Comprehensive knowledge of muscle action is necessary to accurately affix a muscle grade, and experience is required to detect muscle substitution.

Daniels and Worthingham[2] stated that observation, palpation, stabilization, and correct positioning are essential for validity in manual muscle testing. Reliability in manual muscle testing can be achieved only when testing is done in the same manner and at the same point in the range each time the technique is performed. Although manual muscle testing techniques are repeatable, they are subject to changes in the practitioner's level of attention, effort, and energy.

Currently, two major approaches to a formal manual muscle test exist: the Kendall and McCreary[3] method and the Daniels and Worthingham[2] method. While the goal of each approach is similar, there are differences in the techniques used. One major difference is that of grouping muscles together in the testing of a motion versus isolating specific muscles. The Daniels and Worthingham method primarily tests group muscle activity in a particular joint motion, whereas the Kendall and McCreary method tests a specific muscle's action. For example, the hip abductors are tested as a unit in the Daniels and Worthingham method. In the Kendall and McCreary method, the gluteus medius, tensor fascia lata, and gluteus minimus are separated out and require three different tests. Use of the Daniels and Worthingham method of assessing muscle strength may be more convenient, especially when a quick screening of muscle action is needed. In the Kendall and McCreary method, the body part is oriented in a particular direction to selectively test a particular muscle's action. This method requires more specific knowledge of a particular muscle's orientation and may be more time-consuming. However, it may also result in greater attention to a particular muscle's weakness and the awareness of possible substitution by other, stronger muscles.[4]

The purpose of this study is to perform manual muscle testing of the left serratus anterior muscle using the Daniels and Worthingham and Kendall and McCreary methods of muscle testing to determine if a significant difference in the force produced by the muscle is noted in "normal" subjects.

The serratus anterior muscle is a large, thin, foliate, powerful muscle which overlies the lateral portion of the thorax and the intercostal muscles.[5] The origin of this muscle is the outer surfaces of the first eight ribs, about midway between their angles and costal cartilages. Its lower three digitations interdigitate with the origin of the external oblique muscle of the abdomen. Its insertion is the entire anterior surface of the medial border of the scapula. It is innervated by the long thoracic nerve which arises from C_5, C_6, and C_7, and its action is to protract the scapula and hold it against the chest wall. By fixing the scapula to the chest, the serratus anterior acts as an anchor for the scapula. This fixation allows other muscles to use it as a base of support for producing movement of the humerus. The lower fibers of the serratus anterior help to rotate the glenoid cavity of the scapula upward. Factors limiting motion are: 1) tension of the trapezoid ligament (limits forward rotation of scapula upon clavicle) and 2) tension of the trapezius and rhomboideus major and minor muscles.[5]

To test for a good or normal muscle grade of the serratus anterior muscle using the Daniels and Worthingham method[2], the patient is placed supine with the arm flexed to 90 degrees in slight abduction with the elbow extended. The patient moves his arm upward by abducting the scapula. Resistance is given by the examiner by grasping around the patient's forearm and elbow. Pressure is then given downward and inward toward the table. The examiner should observe the scapula for "winging" and substitution by the anterior muscles of the shoulder.[2] In contrast, the Kendall and McCreary method[3] positions the patient in sitting. No fixation should be necessary by the examiner if the trunk is stable, but the shoulder flexors must be strong in order to use the arm as a lever in this test. The patient is asked to stabilize the scapula in abduction with lateral rotation of the inferior angle in order to maintain the humerus between 120 and 130 degrees of flexion. This test emphasizes the upward rotation action of the serratus anterior muscle in the abducted position. Pressure is given by the examiner against the dorsal surface of the arm between the shoulder and the elbow, in the direction of extension, and some against the lateral border of the scapula in the direction of rotating the inferior angle medially.[3]

Due to the subjectivity in manual muscle testing grades of good and normal, the Dynatron II dynamometer was used to determine the amount of force exerted with each test. The force exerted was documented in pounds. Use of this instrument reduces subjective errors in providing an objective measure against a fixed standard. A specially designed load cell eliminates errors due to non-perpendicular loading within the normal angles of force application.[6] Strength was recorded in pounds of force with the use of the Dynatron II dynamometer. Results of testing will be used to prove or disprove the null hypothesis: There is no significant difference in the amount of force exerted by the left serratus anterior muscle using the Daniels and Worthingham method or the Kendall and McCreary method of muscle testing.

LITERATURE REVIEW

History

Muscle testing originated in the United States in the early 1900s during the study of muscle function in patients with poliomyelitis.[7] Despite the change in the role of manual muscle testing with the end of the last poliomyelitis epidemic in this country, it remains an important clinical tool for assessing the muscular causes of movement dysfunction. Robert W. Lovett, M.D.[3] introduced a method of testing muscle strength using gravity resistance. A description of muscle grading based on the Lovett system published in 1932 is listed as follows:[3]

- Gone - no contraction felt.
- Trace - muscle can be felt to tighten, but cannot produce movement.
- Poor - produces movement with gravity eliminated, but cannot function against gravity.
- Fair - can raise part against gravity.
- Good - can raise part against outside resistance as well as against gravity.
- Normal - can overcome a greater amount of resistance than a good muscle.

While symbols may vary, the movement and weight factors set forth by Lovett form the basis of most present-day muscle grading.

Importance of Muscle Testing

The ability of the clinician to accurately and reliably identify early muscle weakness is particularly important because it had been documented by Lovett and Martin[8] in 1916 that 50% of the muscle's power may be lost before detectable difficulty in routine activities of daily living are seen. Therefore, early recognition of muscle weakness is critical not only for diagnosis, but as an essential prerequisite for planning and modification of the treatment program. The results of manual muscle testing are also used to make clinical judgments concerning the patient's progress or deterioration, as well as to assess the effectiveness of a particular treatment.

Reliability of Muscle Testing

The study of the reliability of examiners performing manual muscle tests is necessary if the tests are to be used. Lilienfeld, et al.[7] found muscle test grades from Zero to Normal assigned by 12 to 39 examiners in four different trials to be within one grade, although the testing method was controlled because the examiners were trained by the same instructor. Iddings, et al.[7] also found manual muscle testing to be reliable among 10 examiners whose ratings were within one grade in 90.6% of the trials. Other researchers who appraised manual muscle testing for standardization in the poliomyelitis vaccine trials also found it to be reliable.[7] In 1970, Silver, et al.[9] described the manual muscle test for use in the clinical research setting with patients with renal disease. The standardized test was administered to 20 nondisabled subjects by three evaluators who assessed 12 muscle groups per subject using the manual muscle test method of Daniels and Worthingham.[2] There was complete agreement among evaluators for 67% of muscles tested and 97% agreement within one-half of a muscle grade.[9]

In contrast, Beasley[10] found that physical therapists using manual muscle testing were unable to identify up to 50% loss of knee extensor muscle strength in patients with poliomyelitis. In this study, physical therapists assigned Normal grades to muscles that were able to produce up to only half the force on a cable tensiometer of age-matched norms. Also, therapists using manual muscle testing did not distinguish muscle strength differences of 20% to 25% between patients' strong and weak sides. In 1987, Frese, et al.[7] examined the interrater reliability of manual muscle testing grades obtained by assessing middle trapezius and gluteus medius muscle strength in the clinical setting. Eleven staff physical therapists, with an average of 2.3 ± 1.2 years of experience, performed the muscle testing on 110 patients referred for physical therapy. The therapists were allowed to use any method of testing with which they felt comfortable, including the methods of Kendall and McCreary and Daniels and Worthingham. Cohen's weighted kappa[11] was used to determine the interrater reliability, with coefficients ranging from .11 to .58, revealing poor agreement. Their conclusions indicated that the use of the manual muscle test to make accurate clinical assessments of patient status was of questionable value.[7] In this study, the sample was not strictly defined and the positions and procedures for testing were not standardized between examiners. This design probably gives us a realistic idea of the interrater reliability of grades in current clinical practice, but it does not address the reliability of manual muscle test grades as a measurement tool in the research setting.

Factors Affecting Muscle Testing

Many factors influence the reproducibility of a manual muscle test. The testing method may vary among therapists (e.g., Kendall and McCreary vs. Daniels and Worthingham), both because of the therapists' training and because physical therapists tend to develop their own techniques and standards for grading muscle strength. Other variables that influence the accuracy of a muscle test are:[7]

1) the point and line of application
2) the magnitude of resistive force
3) the speed of resistive force application
4) the duration of the contraction
5) the degree of cooperation from the patient
6) fatigue
7) various distracting influences
8) the type of instructions given
9) the tone of the therapist's voice

10) the amount of interaction between the therapist and the patient.

Strength also varies according to the type of muscle contraction--isometric (static), concentric (shortening), and eccentric (lengthening).[12] Eccentric contractions are generally believed to afford the greatest strength values, followed by isometric and concentric contractions, respectively. The tension produced by each type of contraction may be explained by length relationships between the contractile and static components. Muscle force production has been found to be dependent on the velocity of muscle contraction.[12] For concentric contractions, the muscular tension tends to decrease as the velocity of contraction increases. For eccentric contractions, the maximal contractile force increases with increasing velocity. Fluctuating demands are imposed on the muscle if the angular velocity is constant and if acceleration of the segment occurs. Such differences are thought to reflect the intrinsic mechanical characteristics of skeletal muscle.[12] Another influential factor of muscular strength is the moment arm, or perpendicular distance from the place of application of the musculotendinous unit to the axis of rotation for the joint. Principles of mechanics dictate that the greater the musculotendinous moment arm, the greater will be the strength because the joint torque at a given instant is equivalent to the product of the force output of a muscle and the length of the moment arm.[12] The moment arm of a muscle, and consequently the measured tension, may be altered with changes in joint angle.

When using a manual muscle test, or any other strength testing method, consideration must be given to the test position of the patient with regard to stabilization, joint angle, and comfort. Accurate stabilization of appropriate body segments is necessary to ensure isolation of the muscle or muscles being tested.[12]

The therapist must also decide whether to use a "make" or "break" test to assess strength.[12] The make test is performed by having the body segment impart a force to some external object (e.g., the therapist's hand, in the case of the manual muscle test) in an effort to "make" the completed motion. The break test is performed by imparting an external force to the body part in an attempt to break, or overcome, the contractile force being developed by the body part at a joint.[12] Smidt[13] has stated that because break tests involve eccentric contractions by preloaded muscles, break tests require more force application by the examiner than make tests. The extent to which external force differs under the two conditions, however, has not been documented. For isometric strength testing, the magnitude of the force alone is a valid indicator of muscular strength if the point of application, line of application, direction of force, and segment position are kept constant between measures.[12] Information is needed about the relative reliability of make tests and break tests. Although the reliability of each of the test procedures has been reported, the reliability of the two tests performed on the same muscles of the same subjects has not been published.

Instrumentation

The reliability of manual muscle tests has been the most difficult to achieve for grades greater than Fair because of the examiner's subjective judgment of the amount of resistance applied during the test. One of the problems central to manual muscle testing is the variable "frame of reference" for making an assessment.[7] Such subjective judgments include determining what is normal muscle strength for an individual given the person's age and size, in addition to the relative strengths of the tester and patient. Stuberg and Metcalf[8] suggest the variability of the grades Good through Normal may be increased because of the absence of an operational definition of "normal strength." They suggest that the use of instrumentation may eliminate the subjectivity of grading within these ranges of muscle strength.

Bohannon[14] noted that the hand-held dynamometer can be used to objectively record muscle strength and meets the requirements of a clinical setting where time, space, and ease of use are primary considerations. He reported highly significant correlation coefficients (r = .84-.99) for measurements recorded using a hand-held dynamometer. In Bohannon's[15] retrospective study to determine the test-retest reliability of hand-held dynamometer strength testing (for 18 extremity muscle groups), he found three repeated hand-held dynamometer strength scores, obtained by a single clinician during one test session of 30 patients, to be highly correlated. Stuberg and Metcalf[8] studied the reliability of quantitative muscle testing in healthy children and in children with Duchenne muscular dystrophy using a hand-held dynamometer. The results of their study further support the use of the hand-held dynamometer for clinical assessment of isometric muscle strength. These studies support the conclusion that quantitative measurement of muscle force, when possible, is superior to manual muscle testing.

METHODOLOGY

Subjects

Thirty subjects volunteered to participate in this study. Subjects included friends, acquaintances, and co-workers. Subjects were informed that participation was voluntary, and they could at any time discontinue their participation. Subjects consisted of five males (16.7%) and 25 females (83.3%) ages 23 to 45 years (mean age of 32 years with a standard deviation of 6 years) who met the following criteria:

1) no known weakness of the left serratus anterior muscle
2) no complaints of pain in the upper back, neck, or left shoulder
3) no previous injury to the upper back, neck, or left shoulder resulting in medical attention within the past year
4) no neurological deficits observed/reported.

Instrumentation

The Dynatron II hand-held transducer placed in the examiner's hand was used when testing the strength of the serratus anterior muscle, using the Daniels and Worthingham[2] and Kendall and McCreary[3] methods of muscle testing. The Dynatron II[6] allows an objective method of measuring the strength of individual muscles. The self-contained recorder automatically records test results, therefore eliminating mechanical adjustments between tests. The Dynatron II's transducer provides accurate readings, regardless of the angle of force being applied or the size or strength of the tester. The Dynatron II's electronic circuitry consistently and automatically recalibrates itself.[6]

Testing Procedure

Each subject was scheduled for testing on one specific day. Prior to actual testing, the subject answered a questionnaire (Appendix B) and signed a consent form (Appendix C). A verbal and written explanation and description of the testing procedures were given. The subject was draped appropriately to allow for full view of the left shoulder and scapular region. The subject performed a practice test of each of the two muscle testing methods to decrease anxiety and fear. The order of muscle testing using Daniels and Worthingham and Kendall and McCreary methods of manual muscle testing was randomly selected. The subject was then positioned appropriately for testing a Good to Normal muscle grade using each method. The Daniels and Worthingham[2] method of muscle testing the serratus anterior muscle requires the patient to assume the supine position with his/her arm held upward by abducting the scapula. Resistance was to be given by grasping around the patient's forearm and elbow; however, in order to use the Dynatron II manual muscle tester to achieve objective data, resistance was given at the patient's elbow and heel of the hand. The Dynatron II was placed on the heel of the hand and pressure was given downward and inward toward the table. The angle and direction of force remained the same. A rest period of one and a half minutes was given following the first test to allow for adequate muscle recovery and prevent any muscle strain.

The Kendall and McCreary[3] method of manual muscle testing the serratus anterior muscle required the patient to assume the sitting position. The subject was asked to stabilize the scapula in abduction with lateral rotation of the inferior angle in order to maintain the humerus between 120 and 130 degrees of flexion. Pressure was given by the examiner against the dorsal surface of the arm between the shoulder and the elbow in the direction of extension. The Dynatron II was held in the examiner's hand as this pressure was given. Some pressure was also given against the lateral border of the scapula in the direction of rotating the inferior angle medially. A break test was used when testing the strength of the serratus anterior muscle during both the Daniels and Worthingham and Kendall and McCreary methods of muscle testing.

Statistical Analysis

A comparison was made between the amount of force produced by the serratus anterior muscle using the Daniels and Worthingham[2] and Kendall and McCreary[3] methods of muscle testing. This was accomplished by performing a matched t-test for the set of data obtained. The Pearson coefficient was employed to determine the validity in the testing procedure.

The decision to reject or retain the null hypothesis: There is no significant difference in the amount of force produced by the serratus anterior muscle when using the Daniels and Worthingham[2] or Kendall and McCreary[3] methods of muscle testing, significance will be based on the .001 criterion level.

RESULTS

When using the Kendall and McCreary method of manual muscle testing the serratus anterior muscle, a mean value of 27.39 pounds of force was obtained (s = 1.21; s.d. = 6.61). A mean value of 41.37 pounds of force was obtained when manual muscle testing the serratus anterior muscle using the Daniels and Worthingham method of muscle testing (s = 1.44; s.d. = 7.88). (Table 1) A matched t-test was performed with a t value of -13.65 with 29 degrees of freedom. These data reveal a significant difference between the two methods of muscle testing when comparing force production. The difference noted in the mean values between the Kendall and McCreary[3] method and the Daniels and Worthingham[2] method reveal a larger force production with the Daniels and Worthingham method; however, there is a significant positive correlation between the two methods (r value .714). This indicates that both methods of muscle testing the serratus anterior muscle are valid in measuring strength. These findings are statistically significant at the .0001 level. See Table 1.

TABLE 1

Strength Comparisons of the Serratus Anterior Muscle

Using Two Methods of Muscle Testing

Method of Testing	Mean (lb. of force)	Standard Error	Standard Deviation
Kendall and McCreary	27.39	1.21	6.61
Daniels and Worthingham	41.37	1.44	7.88

DISCUSSION

In the clinic, therapists evaluate patients' posture, strength, flexibility, mobility, and functional status. Evaluation is performed through a variety of methods, including observation and testing procedures, such as muscle testing. At times, findings do not correlate; the patient comes in with mild "winging" of the scapula, yet when manual muscle testing the serratus anterior muscle, a normal muscle grade is determined. Perhaps this is due to the method of muscle testing used. The Daniels and Worthingham method of muscle testing allows for a greater production of force by the serratus anterior muscle but does not isolate the serratus anterior muscle during testing. The pectoralis minor (aided by the levator and rhomboids) is allowed to substitute for weakness of the serratus anterior muscle. In the Daniels and Worthingham method of muscle testing, emphasis is on the abduction action of the serratus anterior muscle and projection of the upper extremity. When using the Kendall and McCreary method of muscle testing, the serratus anterior muscle is isolated and emphasis is on the upward rotation action of the serratus anterior muscle in the abducted position. The electromyography studies of Inman, et al.[16] (1944) confirm the actions of the lower trapezius and serratus anterior muscles in scapular rotation. The lower part of the trapezius is the most active component of the lower force couple during abduction; but in flexion, it is less active than serratus anterior, apparently because the scapula must be pulled forward during flexion.

The Daniels and Worthingham method of muscle testing requires both of the tester's hands to be on the patient's arm. Without the ability to palpate the scapula, it is extremely difficult, if not impossible, to determine when the scapula begins to medially rotate. Hand placement for the Kendall and McCreary method of muscle testing allows for resistance to be given not only at the upper arm but also at the scapula. When the inferior angle of the scapula begins to medially rotate, it provides immediate feedback to the tester.

One limitation of this study is the use of the Dynatron II dynamometer. The hand-held dynamometer allowed for objective data; however, the information received is dependent on the accuracy of the unit. Another limitation is the amount of effort by the subject and the tester. Although there was only one tester and the subjects were instructed to resist the resistance given by the tester, it is possible that the amount of resistance given by the tester and the amount resisted by the subjects were not consistent. This would also cause variability in the test results.

Validity of the testing procedures has been established by the positive correlation between the two methods of muscle testing. This can be explained by comparing the force produced by the serratus anterior muscle using the Daniels and Worthingham and Kendall and McCreary methods of muscle testing on two individuals. The individual producing a greater force with the

Daniels and Worthingham method would also produce a greater force with the Kendall and McCreary method. Although reliability studies were not performed with this particular study, a similar study performed by Jodi Boettner, P.T.[17] comparing the Daniels and Worthingham and Kendall and McCreary methods of muscle testing the tensor fasciae latae, proved to be reliable. Future studies comparing the two methods of muscle testing and the reliability of this testing is recommended.

Both methods of muscle testing the serratus anterior muscle are useful; however, it is important that clinicians recognize their differences and interpret their results. The information obtained through muscle testing is a valuable tool used to develop and modify appropriate treatment programs.

CONCLUSION

There is a statistically significant difference in force produced by the serratus anterior muscle when comparing the Daniels and Worthingham and Kendall and McCreary methods of muscle testing. The Daniels and Worthingham method reveals a greater production of force by the serratus anterior muscle compared to the Kendall and McCreary method. This is felt to be attributed to the specificity of the Kendall and McCreary method to isolate the serratus anterior muscle during testing versus the group action of the serratus anterior, pectoralis minor, levator, and rhomboid muscles which are tested during the Daniels and Worthingham method. A positive correlation between the Daniels and Worthingham and Kendall and McCreary methods of muscle testing has been documented, therefore establishing validity of this study.

APPENDIX A

UNIVERSITY OF NORTH DAKOTA'S
INSTITUTIONAL REVIEW BOARD

ATE: November 4, 1992

AME: Arlene Johnson **DEPARTMENT/COLLEGE** Physical Therapy

ROJECT TITLE: A Two Method Comparison of Muscle Testing the Serratus Anterio: Daniels and Worthingham vs. Kendall and McCreary

he above referenced project was reviewed by a designated member for the University's nstitutional Review Board on November 9, 1992 and the following action was taken:

[X] Project approved. **EXPEDITED REVIEW NO.** 3.
Next scheduled review is on November, 1993.

[ ] Project approved. **EXEMPT CATEGORY NO.** _____. No periodic review scheduled unless so stated in REMARKS SECTION.

[ ] Project approval **deferred.**
(See REMARKS SECTION for further information.)

[ ] Project **denied.**
(See REMARKS SECTION for further information.)

EMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairman or ORPD.

H. C. Wessman, Adviser
Dean, Graduate School

Elvira [signature] 11/9/92
Signature of Chairperson or designated IRB Member Date
UND's Institutional Review Board

f the proposed project (clinical medical) is to be part of a research activity funded y a Federal Agency, a special assurance statement or a completed 596 Form may be equired. Contact ORPD to obtain the required documents. (9/87)

APPENDIX B

QUESTIONNAIRE

Age ______________ Sex ___________________

1. Are you aware of weakness in your left serratus anterior? yes ____ no ____

2. Do you have pain in your upper back, neck or left shoulder? yes ____ no ____

3. Have you had an injury to your upper back, neck, or left shoulder resulting in medical attention within the past year? yes ____ no ____

4. Do you have any burning, tingling, or numbness in your left arm, hand, or fingers? yes ____ no ____

Heads = Daniels and Worthingham ______

Tails = Kendall and McCreary ______

APPENDIX C

CONSENT FORM

You are invited to participate in a study designed to determine if there is any difference in the strength of a shoulder blade muscle when using two different methods of testing strength.

Your participation will be approximately thirty minutes on one specified day.

You will be positioned on your back with your left arm straight and pointing toward the ceiling. Resistance will be given by this therapist with her hands positioned on your elbow and heel of your hand in a downward and inward direction. You will also be positioned in sitting with your left arm straight and held in front of you slightly above shoulder height (120 to 130 degrees). You will be asked to hold your arm in the air while resistance is given by this therapist at the upper arm and outside border of the shoulder blade in a downward and inward direction, respectively. A hand-held dynamometer will be used to measure amount of force.

The order in which each test will be given is randomly selected. A practice test of each method will be performed prior to actual testing and a rest period between tests will be given.

To avoid the risk of a muscle strain, a verbal description of the testing procedure and a practice test will be given to you for each method.

This research will assess the accuracy of the two methods of testing the strength of the shoulder blade muscle.

All results will be recorded by group and no individual will be able to be identified.

Any questions/concerns regarding this research, the research subject's rights, or the event of an injury can be made to this researcher, Arlene Johnson, at 780-2315.

Participation in this research is strictly voluntary and you may at any time discontinue your participation.

I have read all of the above and willingly agree to participate in this study.

______________________________________ ____________________

Signature of Participant Date

APPENDIX D

RAW DATA

Subject #	M/F	Age	Kendall & McCreary Test Pounds of Force	Daniels & Worthingham Test Pounds of Force
1	F	31	22.8	40.0
2	F	28	27.0	45.4
3	F	29	29.0	37.8
4	F	36	21.4	30.6
5	F	36	23.8	38.2
6	M	28	40.6	44.6
7	F	35	38.3	47.8
8	F	24	25.4	49.0
9	F	24	21.6	25.4
10	M	45	35.4	48.6
11	F	26	17.8	38.8
12	F	31	28.0	31.9
13	F	36	21.9	41.0
14	F	33	21.6	41.2
15	F	33	30.2	37.6
16	F	38	23.4	34.4
17	F	43	23.0	34.8
18	F	33	22.8	38.0
19	F	23	36.4	52.6
20	F	30	25.6	48.4
21	M	23	46.4	64.6
22	F	45	21.8	32.0
23	F	31	24.2	39.2
24	F	36	27.2	43.2
25	M	28	31.0	48.2
26	F	34	28.2	45.4
27	F	28	24.2	38.6
28	F	27	28.4	49.4
29	F	39	21.4	34.4
30	M	29	33.0	40.8

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