ABSTRACT

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This study determined the intratester and intertester reliability of the STP Electronic Inclinometer for measuring lumbar flexion. Twenty-eight college age female volunteers were tested on two occasions by two testers. Pearson product-moment correlations for the intertester reliability were .72 for day one and .65 for day two. Analysis of variance was used to derive intraclass correlation coefficients (ICC) for intratester reliability of true lumbar flexion measurements. Intraclass correlation coefficients were .92 for tester one and .88 for tester two. There were no significant differences ($p < .05$) between the means within each tester. ANOVA was used to derive ICC for intratester reliabilities for separate lumbar measurements used to determine true lumbar flexion. The ICC of gross lumbar flexion measured at thoracic number 12 and pelvis-hip flexion measured at the sacrum for tester one were .99 for both sites. For tester two the ICC for gross lumbar flexion and pelvis-hip flexion were .98 for both sites. There were no significant differences ($p < .05$) between the means for each measure within each tester. The results suggest that the STP Electronic Inclinometer has acceptable intratester and intertester reliability. More research is needed on clinical patients with spinal dysfunction.

INTRATESTER AND INTERTESTER RELIABILITY OF THE STP ELECTRONIC INCLINOMETER

A MANUSCRIPT STYLE THESIS PRESENTED

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Finally, to the memory of my mother, Mary C. Greany, (1929-1993) in who's memory I dedicate this research project. This year I have experienced the hills and the valleys of life. Thank you for all your love and support.

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INTRODUCTION

Low back pain is one of the most common medical conditions in the United States, affecting almost 85% of the population at some time in their lives, and has been shown to influence lumbar range of motion.[1]

There are many instruments used in the medical field to measure spinal motion,[2-11] such as goniometers, plumb lines, flexible rulers, radiographs, finger to floor measurements, tape measures, and inclinometers. These instruments are necessary for precise spinal range of motion measurements for determining impairments, supporting therapeutics, and providing feedback regarding changes in functional status.[4 7 10] The techniques that incorporate these instruments have advantages and disadvantages such as cost, exposure to radiation, time involved, and special equipment.

These different devices for measuring spinal motion have been investigated extensively.[2 4-18] At this time, many are currently being utilized in the clinical setting. The choice of which device to use can be difficult for the clinician. There is a need to objectively assess the reliability of these instruments.

One potentially useful instrument for measuring spinal motion is the inclinometer. It is used with an associated inclinometer technique which reports available spinal motion in degrees. When determining impairment ratings for a person with spinal dysfunction, a physician requires this information.

At this time there are two types of inclinometer devices on the market: 1.) a hand held circular fluid filled disc with a rotating graduated scale relative to the base which is maintained in the vertical direction and 2.) an electronic inclinometer which utilizes a liquid screen that provides a digital display of its position.

The American Medical Association (AMA) recommends the inclinometer technique as the surface measurement technique for determining spinal mobility in the impairment rating process.[3] The technique for measuring spinal motion is described in the book, Guides to the Evaluation of Permanent Impairment.[3] This technique can be used with a single inclinometer or two inclinometers: both are recommended by the AMA for measuring spinal lumbar motion.

The single inclinometer technique is generally attributed to Loebl[8] and Troup[10] and was used to investigate lumbar flexion mobility in this study. The subject stands and one inclinometer is placed over the point between thoracic spinous process number 12 and lumbar spinous process number 1 to measure a combined hip and lumbar motion. The subject moves in the desired direction until the end range and the value on the readout is recorded. The subject returns to the neutral standing posture and the inclinometer is then moved to the sacral midpoint to measure hip motion. The subject again moves in the desired direction until the end range and the value on the readout is recorded. True lumbar range of motion can then be derived by subtracting the hip inclination from the combined hip and lumbar inclination.[3]

Reliability may be defined as the consistency or repeatability of a measurement.[19,20] The inclinometer has generally been found to be of moderate reliability;[2 4 6,7 9 16,17] however, it is difficult to compare studies due to the different testing methods and devices used as well as different statistical tools. The validity of the inclinometer has been studied by Mayer et al.[9] and Adams et al.[2] where inclinometer measurements were compared to radiographic measurements and were found to be good, but this was not supported by Portek et al.[15] in their study.

Mayer et al.[9] reported no difference between the double and single inclinometer techniques in measuring spinal mobility. Reports on the reliability of lumbar movement measurements obtained by different techniques and with various inclinometers devices are variable. Furthermore, there have been numerous studies done with the circular fluid filled disk regarding the reliability of the measurements,[4 6-11 17] and only one study which investigated an electronic inclinometer.[2] The electronic inclinometer that was investigated was not a device that can be found on the market for clinical use. Therefore, the objective of this investigation was to determine the intertester and intratester reliability of lumbar flexion measurements using the STP Electronic Inclinometer (Saunders Therapy Products, Bloomington, MN)[22] on healthy female subjects. The STP Electronic Inclinometer has not been validated for measuring spinal motion.

METHODS

Subjects

Twenty-eight female college age volunteers participated as subjects. Informed consent was obtained from each of the subjects. All subjects were between the ages of 19 and 40 years, and had no current history of lumbar pathology.

Instrumentation

The STP electronic inclinometer is a portable, hand held inclinometer designed to measure the mobility of the spine. It has a liquid crystal screen that shows a digital display of its position in degrees. The inclinometer consists of an outer plastic casing, liquid crystal display area, operating controls, and attachments. The inclinometer is powered by a standard 9 volt battery.

Procedure

Prior to the initiation of the study, the therapists were given a written description of the procedure for measuring spinal lumbar flexion. Each therapist became thoroughly familiar with the device through review of reference material and practice trials. The author was one of the testers in this investigation. A similar procedure to the single inclinometer method was used as described in the AMA's book, Guides to the Evaluation of Permanent Impairment.[3]

Two exact inclinometer devices were used in this research study. Both devices were calibrated to each other prior to the data collection and half way through each data collection days. No discrepancy was found between the display of the devices while measuring the same stationary angle.

After signing the consent form, subjects were given verbal instruction concerning the purpose and procedure of the research investigation. This was followed by a warm up period consisting of five repetitions of lumbar flexion. Subjects were then randomly assigned to a testing area by the data recording sheet. They were instructed to lie prone on a plinth table. The spinous process of thoracic number 12 and lumbar number 1 were located and a circular sticker was placed at the midpoint. The posterior superior iliac spines were located and the midline point horizontal to this was located and marked with a circular sticker.

The subjects were then instructed to stand in the testing area on a set of stickers taped to the floor approximately 22 cm apart. The subjects were to stand erect with knees straight and weight evenly distributed on both feet. Subjects were asked to keep their eyes focused horizontally with their arms at their sides. The inclinometer was placed on the thoracic mark and set on zero by pressing the zero button. While holding the inclinometer on the thoracic area the subjects were instructed to "bend forward as far as you can." When the subject reported that they were at the end range the value was recorded on the data collection sheet. The inclinometer was then placed over the sticker on the sacrum and set on zero by pressing the zero button. The subjects were then instructed to "bend forward as far as you can." The value was then recorded on the data collection sheet. This procedure was repeated three times for lumbar flexion. The stickers were removed prior to leaving the testing area. The angle measured on the superiorly placed inclinometer indicated gross motion of the lumbar spine and pelvis-hips. The angle from the sacral reading indicated pelvis-hip motion alone. True lumbar motion was determined by the subtraction of the hip-pelvis angle from the gross lumbar motion. The data were collected over a two day period. All subjects were measured by both therapists on both days. See Appendix C for the complete instructions for the therapist and subjects.

Data Analysis

Pearson product-moment correlation coefficients and analysis of variance (ANOVA)-derived interclass correlation coefficients (ICC) [20,21] were used to calculate the intertester and intratester reliability, respectively, of the measurements taken by the therapists. Independent t-tests were done to compare the means of the two therapist's measurements for each day. A one way and a two way ANOVA with repeated measures were used to determine significant differences. Richman et al.[19] have suggested the following reliability coefficient values: .80 to 1.00 as very reliable, .60 to .79 as moderately reliable, and .59 and below as questionable reliability.

RESULTS

Intratester Reliability

The mean age of the subjects was 24.8 years with a range of 19 - 40 years. The mean and standard deviations of the lumbar flexion measurements are listed in Table 1.

The means of the true lumbar flexion measurements reported in this investigation fall into the normal range for healthy females.[14] The ANOVA-derived ICC for intratester relaibility (R) are reported in Table 2.

The correlation was .92 for tester one and .88 for tester two.

Table 1. Mean, standard deviation, and range of true lumbar flexion measurements

	Mean degrees	SD	Range degrees
Tester 1			
Day 1	45.41°	±8.06	30.3 - 62.6°
Day 2	45.09°	±6.24	32.0 - 58.7°
Tester 2			
Day 1	42.96°	±7.36	24.6 - 57.3°
Day 2	44.47°	±6.47	35.6 - 66.7°

Analysis of variance-derived ICC for intratester reliability of the component measurements used to determine true lumbar flexion are reported in Table 3.

Table 2: ANOVA-derived ICC for intratester reliability of true lumbar flexion

Motion	Tester 1	Tester 2
LUMBAR FLEXION	R = .92	R = .88

No significant difference ($p < .05$) between the means within each tester.

True lumbar flexion is found by subtracting pelvic-hip motion from gross lumbar flexion. The intratester reliability (R) of these measurements were calculated and reported as .99 for tester one for both measurements and .98 for tester two for both measurements.

Table 3: ANOVA-derived ICC for intratester reliabilities of component measurements of true lumbar flexion

MOTION	TESTER 1	TESTER 2
GROSS LUMBAR FLEX	R = .99	R = .98
PELVIS-HIP	R = .99	R = .98

No significant difference ($p < .05$) between the means for each measurement within each tester.

Intertester Reliability

The Pearson product-moment correlation coefficients (r) for intertester reliability were .72 for day one and .65 for day two and are listed in Table 4.

Table 4: Pearson product-moment correlation coefficients (r) for intertester reliability

MOTION	DAY 1	DAY 2
LUMBAR FLEXION	r = .72	r = .65

Day 1: Independent t-test showed no significant difference between the means. ($p = .24$) $p < .05$

Day 2: Independent t-test showed no significant difference between the means. ($p = .71$) $p < .05$

A two way ANOVA with repeated measures was used to test for significant differences between the means of lumbar flexion measurements taken by the STP Electronic Inclinometer by two testers over two days. No significant main effects were found for tester or day ($p < .05$). Similarly, there was no significant interaction.

DISCUSSION

Intratester Reliability

Reliable methods of measuring lumbar motion are critical in assessing spinal mobility for those who suffer from spinal dysfunction.[3 18] According to the reliability coefficient values discussed in Richman et al.[19], the results of this study show that intratester reliability for the STP Electronic Inclinometer is very reliable (tester 1, $R = .92$; tester 2, $R = .88$). A correlation of .8 to 1.0 is considered very reliable and .60 to .79 as moderately reliable.[19]

This study and that of Keeley[7] and Mellin[12] reported very high intratester reliability coefficients for the component measurements of true lumbar flexion. Rondinelli et al.[17] have also reported the single and double inclinometer technique to be very reliable for intratester measurements of true lumbar flexion. They also found that intratester reliabilities were higher than intertester. The results of the present study support those findings.

Intertester Reliability

In this study the results of intertester reliability were not as high as intratester reliability. Intertester reliability utilized Pearson product-moment correlation coefficients (r) to determine the correlation between testers for true lumbar flexion measurements. This test shows the parallelism of two sets of measurements and is used when comparing two distinct variables. Both correlations were only moderately reliable, with day one being ($r = .72$) and day two being ($r = .65$). It would appear that the measurements of true lumbar flexion on day one were more reliable than day two.

A possible explanation for a lower reliability with day two could be the subjects experienced fatigue or boredom with the multiple repetitions and therefore did not go to the same end range. Another explanation for this lower correlation on day two could be the subject's awareness of the testing goals. Some of the subjects appeared to maximize the available range of motion by overstretching into flexion. This can be supported by the complaints of muscle soreness in the lumbar and posterior thighs on day two from the repeated movements they performed on day one. Since they experienced discomfort in flexing their performance may have been affected.

The results in this investigation differ from those reported by Mellin[12] who studied lumbar flexion measurements with a Myrin inclinometer (needle pendulum) and showed higher intertester reliability than intratester. This was also reported in a study done by Capuano-Pucci et al.[5] who studied cervical range of motion with a cervical device.

They suggested the reason for higher intertester reliability was that the time interval between intertester measurements was less than intratester measurements.[5]

Their suggestion could not explain why the current investigation found intratester reliability to be higher than intertester reliability. A possible explanation for lower intertester reliability is that the inclinometer technique requires exact location of bony landmarks. There may have been a discrepancy in the two therapist's techniques in locating and marking these bony landmarks. Another explanation for lower intertester reliability is that the recommended technique[3] does not address the definition of end range. The therapists define their own point of end range, which may have been consistent within themselves, but different between the two. Since the subjects complained of muscle soreness on day two the possibility of overstretching must be a confounding consideration. When measuring a person with spinal dysfunction the end range is usually limited by the perception of pain. When healthy subjects are investigated there is limited correlation to patients who have spinal pathology.

Other studies have found more reliable techniques for measuring spinal motion. Gill et al.[6] and Williams et al.[11] found the modified Schöber test to be more reliable than the inclinometer technique. However, the clinical significance of the inclinometer technique is that the measurements are reported in degrees of motion. This information is pertinent to the physician, when determining impairment ratings for the spinal patient.

Recommendations

The therapists in this investigation commented on numerous difficulties in using the STP Electronic Inclinometer. Most notably, the device was too large to handle securely on the subjects spine. They both also reported, while practicing with the unit, that the double inclinometer technique was too cumbersome. The "hold" buttons were located on the front surface of the unit, which made it impossible to manipulate the buttons when performing this technique. Furthermore, due to the size of the device lumbar extension was impossible to measure with the double inclinometer technique. Possible structural changes may include streamlining the device and moving the controls to the point where the fingers hold the device on the subject.

CONCLUSION

The results of this study confirm that the STP Electronic Inclinometer is a reliable device in measuring lumbar flexion of healthy female subjects by the same experienced tester. If more than one tester is going to measure the same subject, greater caution should be employed when taking the measurements to account for greater variability in the measurements. Further research is required to validate the STP Electronic Inclinometer. This can be done by comparing the measurements found with the electronic inclinometer to radiographs of the spine. The reliability of the device with patients who have spinal dysfunction and other lumbar movements (extension and lateral flexion) should also be investigated.

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22. STP Electronic Inclinometer can be purchased from the Saunders Therapy Products, Bloomington, MN.

APPENDIX A

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Many clinical techniques have been described for measuring spinal motion: radiographs, finger to floor methods, goniometer, tape measures, and inclinometers.[1-22] Each of these techniques has advantages and disadvantages, such as cost, exposure to radiation, need for special equipment, and questionable reliability. The two most frequently used methods for measuring lumbar flexion that have been investigated are the tape measure (Schöber method)[18] and inclinometer method.[7 9]

Schöber Method

One method of measuring the spine that has been investigated previously is the Schöber[18] technique which utilizes a tape measure. This technique is also known as the skin distraction method. This method involves using a tape measure over the spine between points 10 cm above the lumbosacral junction with the subject in the neutral standing posture. The subject moves into a full flexed posture and the increase in distance between the marks is reported as spinal flexion range of motion.

Macrae and Wright[21] modified this method by Schöber by marking a point 5 cm below and 10 cm above the lumbosacral junction. The rationale for this was that when a subject moved into flexion both the lumbosacral and 10 cm points moved superiorly relative to the spinous processes and the skin was more stationary 5 cm below on the sacrum.

Moll et al.[22] examined the modified Schöber method in measuring spinal extension instead of flexion. The distance between the marks were measured as they approached each other while moving backwards into extension.

Several investigations [3 5 10 12,13 15 20,21] have reported reliability of lumbar measurements obtained by the modified Schöber method. Beattie et al.[20] reported high intratester reliability on 200 subjects for lumbar extension (ICC) R ≥ .90 for both healthy and low back pain patients. Intertester reliability was ICC = .94 for healthy subjects. Fitzgerald et al.[19] reported very high interobserver reliability for lumbar flexion (1.0) and lumbar extension (.88) on healthy subjects. Merritt et al.[12] measured lumbar movements comparing three methods; the modified Schöber was found to be acceptable for interobserver and intraobserver reliability estimates based on coefficients of variation.

Inclinometer

The inclinometer method is the recommended surface measurement technique for determining lumbar spinal motion by the American Medical Association[2] and utilizes an inclinometer device. The technique for measuring spinal motion is described in the book, Guides to the Evaluation of

Permanent Impairment.[2] The technique can be performed with a single inclinometer or two inclinometers: both are recommended by the AMA for measuring spinal lumbar motion. The single inclinometer technique is generally attributed to Loebl[7] and Troup.[9]

Two inclinometer devices are presently available, a hand held and an electronic. The hand held inclinometer consists of a circular fluid filled disc with a rotating graduated scale relative to the base which is maintained in the vertical direction. The electronic inclinometer utilizes a liquid screen that provides a digital display of its position.

There have been numerous studies conducted with the circular fluid filled disk regarding the reliability of the measurements,[3 5-10 16] and only one study which investigated an electronic inclinometer.[1] The electronic inclinometer that was investigated was not a device that can be found on the market for clinical use.

The single inclinometer technique is conducted by having the subject standing and one inclinometer is placed over the point between thoracic spinous process number 12 and lumbar spinous process number 1 to measure a combined hip and lumbar motion. The subject moves in the desired direction until the end range and the value on the readout is recorded. The subject returns to the neutral standing posture and the inclinometer is then moved to the sacral midpoint to measure hip motion. The subject again moves in the desired direction until the end range and the value on the readout is recorded. True lumbar range of motion can then be derived by subtracting the pelvis-hip inclination from the combined pelvis-hip and lumbar inclination.[2]

The inclinometer has generally been found to be of moderate reliability. However, it is difficult to compare studies due to the various testing methods and devices used as well as different statistical tools.[3 5,6 8 14-16] The validity of the inclinometer has been studied by Mayer et al.[8] and Adams et al.[1] where inclinometer measurements were compared to radiographic measurements and were found to be good, but this was not supported by Portek and associates.[14]

Adams et al.[1] studied 15 healthy subjects by measuring lumbar curvature in 7 lumbar postures with an electronic inclinometer. Their investigation looked at postures verses measuring lumbar flexion measurements. Flexion radiographs were compared with the electronic inclinometer measurements. The investigators concluded that no significant difference existed between flexion angles as measured by the inclinometer and angles from the radiographs. The correlation coefficient was determined to be .91 indicating high validity. They also reported excellent reproducibility using this electronic inclinometer.

Keeley et al.[6] examined lumbar flexion and extension using the double inclinometer technique and reported intertester and intratester reliabilities by calculating correlation coefficients for component measurements of true lumbar motion. They reported consistently high correlations ($r \geq .90$) for component measurements of true lumbar flexion and extension. They concluded the measurements were reliable from test to test but the inferior (sacral) inclinometer measurement would need greater attention when measuring.

Using a gravity goniometer, Burdett et al.[3] reported intertester reliability values of .91 and .71 for lumbar curvature for flexion and extension respectively. They concluded that the gravity goniometer was highly reliable for measuring lumbar curvature during flexion.

Merritt et al.[12] studied trunk flexibility in 25 healthy subjects by various techniques. They concluded that the single inclinometer method for measuring spinal lumbar flexion was good but lumbar extension measurements showed poor reliability. They reported the reliability of the measurements as coefficient of variations for interexaminer and intraexaminer as 9.6 and 13.4%, respectively for lumbar flexion.

Mellin[11] reported intertester correlation coefficients of .97 and .95 for the component measurements of true lumbar flexion using the Myrin inclinometer (a needle pendulum).

Fifteen subjects were measured by two testers on two consecutive days in a seated flexed posture. He also reported intratester reliability measurements of .86 and .93 for the component measurements of true lumbar flexion, using Pearson product-moment correlation coefficients. He concluded that the inclinometer has acceptable reproducible measurements.

In 1993, Williams and associates[10] compared two methods of measuring lumbar flexion and extension on 15 patients and concluded that the double inclinometer technique was less reliable than the modified-modified Schöber test (They modified the modified-Schöber method). Their results showed intraclass correlation coefficients (ICC) for intertester reliability for the double inclinometer technique to be .60 for lumbar flexion. They also reported intratester reliability coefficient (Pearson product-moment) for the double inclinometer technique in the range of r = .13 - .87 for lumbar flexion and r = .28 - .66 for extension. They concluded that the double inclinometer method needs improvement.

Rondinelli et al.[16] in 1992, looked at the magnitude and clinical significance of surface measurement error in determining lumbar flexion by investigating three methods. They evaluated the lumbar flexion of eight healthy subjects and found the ICC's of the single and double inclinometer methods to be .70 to .86. They also reported the intertester reliability for the single and double inclinometer to be .76 and .69. Therefore, they concluded the reliabilities of these methods to be moderate.

Age and Sex Differences

Moll and Wright[13] reported a difference between men and women in spinal mobility. Lumbar flexion of males exceeded female mobility by 10%. This was also the case for lumbar extension but not for lateral flexion. They also reported that normal mobility increased from the 15 to 24 year-old group to the 25 to 34 year-old group followed by a progressive decrease with advancing age. This trend was also supported by Fitzgerald and associates.[19]

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APPENDIX B

DEFINITION OF TERMS, ASSUMPTIONS, LIMITATIONS AND DELIMITATIONS

Definition of Terms

Selected terms as interpreted and applied in the content of this study are as follows:

Double Inclinometer Technique - a technique in which two inclinometers are used to measure spinal mobility (Mayer, 1984).

Intertester Reliability - is the consistency or repeatability of different testers obtaining the same measurement on the same subject (Richman, 1980).

Intratester Reliability - is the consistency or repeatability of one tester obtaining the same measurement on the same subject (Richman, 1980).

Modified Schöber Technique - a technique to measure lumbar flexion in which a horizontal line between the posterior superior iliac spines is noted and marks in the midline 10 centimeters proximal and 5 centimeters distal are made on the skin surface. The subject bends in a forward direction and the distance is measured with a tape measure in centimeters (Macrae, 1969).

Reliability - is the consistency or repeatability of measurements (Richman, 1980).

Schöber Technique - a technique to measure lumbar flexion in which a mark is made at the lumbosacral junction and a mark 10 cm above while the subject stands in the neutral standing posture. The subject moves into a full flexed posture and the increase in distance between the marks is reported as spinal flexion range of motion in centimeters (Schöber, 1937).

Single Inclinometer Technique - a technique to measure spinal mobility in which one inclinometer is used on the subject. Two separate measurements are taken for each direction of movement tested (AMA, 1990).

STP Electronic Inclinometer - an electronic device that measures changes in angulation from a zero starting point and records the angle in degrees (Saunders Therapy Products).

True Lumbar Motion - the angle of the inferiorly placed inclinometer (which represents sacral inclination) subtracted from the angle of the superiorly placed inclinometer (which represents gross lumbar and pelvis-hip inclination). The resulting angle is the true lumbar motion (AMA, 1990).

Assumptions

The following assumptions were relative to this study:

1. The subjects performed maximal lumbar movements each time tested.

2. The administration of the test procedure was consistent with the procedure given.
3. All subjects were in "good" health during their testing period.
4. The location of thoracic #12 spinous process and posterior iliac spines were consistent with each test.
5. The STP Electronic Inclinometers were functioning properly and calibrated to each other throughout the data collection sessions.

Limitations

The results from measuring healthy volunteers without active low back pain will have limited value and applicability to persons with lumbar pathologies.

The results of this study have indicated that the STP electronic inclinometer is a reliable device in measuring spinal mobility in healthy volunteers without active low back pain. Because the purpose of the device is to measure spinal mobility in a clinical setting, it would be appropriate to conduct further studies with subjects who have low back dysfunction.

Delimitations

The delimitations of this study were:

1. Subjects were volunteers available from the University of Wisconsin-La Crosse and the surrounding community.

2. All subjects were healthy and had no active low back pain for the past 5 years.
3. All subjects were to be over the age of 18.
4. Twenty eight female volunteers were tested over a two day period, twice each day.
5. The two physical therapists were from the community of La Crosse, WI and were volunteers.
6. Both physical therapists were actively practicing in orthopaedics with at least 5 years of experience.

APPENDIX C

SINGLE ELECTRONIC INCLINOMETER TECHNIQUE FOR LUMBAR FLEXION

SINGLE ELECTRONIC INCLINOMETER TECHNIQUE FOR LUMBAR FLEXION

1. In the testing area stickers will be secured to the floor with the toes facing the wall and the heels about 22 cm apart.

2. Patients will be directed to a plinth where they will lie prone and the spinous process of thoracic number 12 will be located and an adhesive sticker will be placed over that area and the posterior superior iliac spines will be located and a line connecting the two points horizontally will be marked with an adhesive sticker. Subjects will wear loose fitting shorts and a halter or bikini top for easy access to reference points.

3. The subject will stand on stickers on the floor, standing erect with their eyes focused on the wall horizontally with their arms at their sides.

4. The therapist will sit on a movable stool or kneel and place the inclinometer on the subjects over the thoracic marker and set the inclinometer to zero by pressing the zero button.

5. The subject will be instructed to "bend forward as far as you possibly can."

6. When the subject has reached the maximum forward range the digital read out will be recorded on the data sheet. This will be done three times.

7. The inclinometer will then be placed over the sacral marker and set the inclinometer to zero by pressing the zero button.

8. The subject will be instructed to "bend forward as far as you possibly can."

9. When the subject has reached the maximum forward range the digital read out will be recorded on the data sheet. This will be done three times.

10. The stickers will be removed from the subject prior to leaving the testing area.

APPENDIX D

INFORMED CONSENT FORM

INFORMED CONSENT FORM

The University of Wisconsin-La Crosse
La Crosse, Wisconsin

INTERTESTER AND INTRATESTER RELIABILITY OF THE (STP) ELECTRONIC INCLINOMETER
(John F. Greany)

I, ________________________________, being of sound mind and _______ years of age, do hereby consent to, authorize and request John F. Greany P.T. and a licensed Physical Therapist to undertake and perform on me the proposed procedure, research or investigation. I agree to participate in the reliability study of the STP Electronic inclinometer being conducted in the physical therapy department at the University of Wisconsin-La Crosse. I understand that the participation in this study will involve two visits to the Physical Therapy department over a two day period. At the time of testing I will have spinal lumbar measurements taken for lumbar flexion. I will also be asked to move in the complete available lumbar range for measurement.

In any type of testing situation some potential risk is involved. When working with moving through the complete range of motion for the lumbar area these risks may include, strained muscles, cramping, joint compression and derangement of the nucleus pulposus. The testing will be supervised by John F. Greany P.T., a graduate student in the Adult Fitness and Cardiac Rehabilitation program at the University of Wisconsin-La Crosse. The testing will be done by two licensed Physical Therapists, one being John F. Greany. They will be under the supervision of Dennis Fater, Ph.D. P.T.

I,__________________________________, approve of the procedure as explained for the measurement of spinal lumbar movement via the electronic inclinometer study at the University of Wisconsin-La Crosse Physical Therapy department and agree to participate. I have read the above document, and I have been fully advised of the nature of the Procedure and the possible risks and complications involved in it, all of which risks and complication I hereby assume voluntarily. Any questions which may have occurred to me have been fully answered to my satisfaction. I hereby acknowledge that no representation, warranties, guarantee, or assurances of any kind pertaining to the procedures have been made to me by the University of Wisconsin-La Crosse, the officers, administrators, employees, or by anyone acting on behalf of them.

I understand that I may withdraw from the program at any time.

Signed at ___________________________ this _________ day of _____, 19___, in the presence of the witnesses whose signatures appear below opposite my signature.

____
(Subject)

Witnessed By:

____

____

APPENDIX E

DATA COLLECTION FORM

DATA COLLECTION FORM

JOHN F. GREANY

NAME: ____________________

THERAPIST: ____________________ A B

DATE: ____________________

LUMBAR FLEXION MEASUREMENTS

	#1	#2	#3
T12	______	______	______
SACRAL	______	______	______