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# Reliability of the Modified-Modified Schober Method of Measuring Lumbar Range of Motion

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# RELIABILITY OF THE MODIFIED-MODIFIED SCHÖBER METHOD OF MEASURING LUMBAR RANGE OF MOTION

by

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ABSTRACT

RELIABILITY OF THE MODIFIED-MODIFIED SCHÖBER TECHNIQUE OF MEASURING LUMBAR RANGE OF MOTION.

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The purpose of this study was to determine the reliability of the Modified-modified Schöber (MMS) method of measuring lumbar flexion and extension on subjects with low back pain. Thirty patients (19 females, 11 males) between the ages of 18 to 61 years (mean=40.0 , SD=11.7) were measured by two physical therapists who each had six years of orthopedic experience.

Each subject was evaluated twice, in random order, by each tester using the MMS method. Trials 1 and 2 were used to calculate intratester reliability for each tester and intertester reliability was calculated between the two testers. Intraclass correlation coefficients (ICCs) for intratester reliability during flexion were .98 and .93 for tester 1 and 2, respectively. ICCs for intratester reliability during extension were .96 and .91 for tester 1 and 2, respectively. Intertester reliability was .93 and .83 for lumbar flexion and extension, respectively.

The MMS method appears to be a reliable method of measuring lumbar flexion and extension in patients with low back pain.

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# CHAPTER ONE

## INTRODUCTION

Low back pain is one of the most common musculoskeletal disorders in the United States. Close to 80% of the general population will experience low back pain at some point in their life and low back pain's impact on society in terms of cost to health care, lost productivity, and disability is quite high.[1] Diagnosis and treatment of low back pain provides a challenge for clinicians because in 80 to 90% of low back pain patients, the exact diagnosis is not known.[2] The objective measurements recorded during a low back evaluation are very important for documenting functional deficits and recording patient progress.

Low back pain can produce significant impairment and disability. One of these impairments is the loss of range of motion.[3] Range of motion measurements are used to evaluate function, measure patient progress, and determine effective treatment methods. Range of motion measurements of the extremities are used to document improvement of function and have shown to be reliable in past studies.[4,5] Evaluation of lumbar spine range of motion has been difficult to measure due to the presence of hip motion during trunk motion, difficulty in palpating bony landmarks, wide variability of postures in both a normal and patient population, and excessive soft tissue in the trunk area.[5]

Many techniques of measuring spine range of motion exist and there have been numerous studies examining the reliability or repeatability of the various techniques of

measuring lumbar spine range of motion. If a measurement is to be a useful clinical tool, it must demonstrate both reliability and validity. The techniques of measuring lumbar spine range of motion include tape measure,[6-23] goniometer,[24-26,8,10,5,21] inclinometer,[6,9,12,26-34,15,23] radiographs,[14,18,20] digital or video systems,[25,34-35] and various other instruments.[8,12,26,36] It is difficult to compare the reliability results in these studies due to differences in methodology, statistical analysis, and subject population. Due to distinct disadvantages with these techniques ranging from accessibility to expensive equipment, cost, exposure to radiation, and lengthy training, no one method has achieved acceptance as the "gold standard" for measuring spinal range of motion. The use of visual estimation of spinal range of motion also appears to be the most prevalent method used by clinicians.[37] The purpose of this study is to examine the intertester and intratester reliability of the Modified-modified Schöber (MMS) method of measuring lumbar flexion and extension in patients with low back pain.

Tape measure

One of the most popular and common methods of measuring lumbar range of motion clinically is with the use of a tape measure. Lumbar flexion and extension are measured using distraction or attraction methods which measure the change in the distance between points on anatomical landmarks of the spine during a neutral standing position and full flexion or extension. Lateral flexion can also be measured with a tape

measure using a technique described by Moll et al.[19] The fingertip-to-floor method of measuring lumbar range of motion involves measuring the distance between the tips of the fingers and the floor during full lumbar flexion. This method, although commonly used clinically, has been reported to have poor reproducibility and reliability. Gill et al, reported a coefficient of variation (CV) of 14.1% and Merritt et al, reported mean CVs ranging from 76-83% for intertester and intratester CVs. Many factors contribute to measurement error in the fingertip-to-floor method including error from shoulder, hamstring, and upper extremity involvement.[12,15]

The Schöber method or skin distraction test, was originated in 1937.[38] This technique involved using a tape measure held over the spine to measure the distance between a point 10 cm above the lumbosacral junction and a point on the lumbosacral junction with the patient standing in an erect position and while fully flexed. The increase in distance between the points during flexion, measured in centimeters, gives the spinal flexion range of motion.

Macrae and Wright modified the Schöber method in 1969 by modifying the skin marks.[14] The superior mark remained 10 cm above the lumbosacral junction using the "dimples of Venus" as the identifying landmark, and a point 5 cm below the lumbosacral junction was added. The rationale for this modification was that the inferior mark decreased the measurement error due to the skin's movement over the spinous processes during trunk movement. The researchers believed that the skin was more firmly attached

5 cm lower on the sacrum. Using the original Schöber method, placing the skin marks 2 cm too high caused an underestimate of up to 15° and placing the skin marks 2 cm too low caused an overestimate of up to 14°. The error using the modified method were decreased to 5° and 3°, respectively. Moll et al, suggested that the modified Schöber method might be useful to assess lumbar extension.[18] This attraction technique would involve measuring the skin marks as they got closer together during lumbar extension.[17-18] The Schöber method and the modified Schöber method were only used to measure spinal flexion previous to the Moll et al, studies.

The reliability of the modified Schöber method has been examined by several authors.[7-9,12-13,15-17,20-21] Beattie et al, examined the intratester reliability of the attraction method for measuring lumbar extension on 100 subjects without "significant" limiting low back pain (LBP) and 100 subjects with "significant" limiting LBP. *Significant limiting* LBP was defined as episodes of LBP that limited work, school, or recreational activity within the two-month period before the testing.[7] Intratester intraclass correlation coefficients (ICCs) of .93 and .90 were obtained for the subjects with significant limiting LBP and for the subjects without significant limiting LBP, respectively. An ICC of .94 was obtained for intertester reliability on a group of 11 subjects without LBP. Intertester reliability was not assessed on the subjects with significant LBP.

Burdett et al, examined the reliability of the modified Schöber method, a gravity goniometer, a standard goniometer, and a parallelogram goniometer to measure lumbar

motion and pelvic position. Twenty-seven normal subjects were used to determine the various forms of validity of these measurements and 23 of these subjects were used to determine the reliability of these measurements. An ICC of .72 and a Pearson Product-Moment Correlation Coefficient (r) of .71 were obtained for the intertester reliability of the modified Schöber technique. The other instruments r values and ICCs were higher with the following results: gravity goniometer r= .93 and ICC=.91; parallelogram goniometer r=.93 and ICC=.92; and standard goniometer r=.85 and ICC=.85. A correlation coefficient of .80 or greater was chosen as the indicator of high intertester reliability. Validity of the modified Schöber technique was not addressed because the researchers only x-rayed the subjects once to limit the exposure to radiation. Although the results of this study indicated that the tape measure was not a highly reliable method of measuring lumbar motion, the researchers discussed the possibility that the lower reliability might be due to the homogeneity of the subject group. They concluded that no particular method was superior for measuring lumbar and pelvic range of motion when specific instrument advantages and disadvantages are taken into account.

Gill et al, compared the repeatability of the modified Schöber method, the fingertip-to-floor method, the two-inclinometer method, and a photometric technique on 10 normal subjects. This study reported the repeatability as a coefficient of variation (CV). They found that the repeatability was best for the modified Schöber method and the two-inclinometer method. The CV for the modified Schöber method for lumbar

flexion was 0.9% and lumbar extension was 2.8%, the two-inclinometer method was 33.9% for upper inclinometer flexion and 3.6% for upper inclinometer extension, and 9.3% for lower inclinometer flexion and 4.7% for lower inclinometer extension. The CV, however, reflects the amount of variation of the measurements, not the reliability.

Another study that compared different techniques for measuring trunk mobility was conducted by Merritt et al.[15] This study examined the intertester and intratester reproducibility of the fingertip-to-floor, the modified Schöber and Moll tests, and the Loebl inclinometer method on 50 normal subjects. The Moll test is a method of measuring spinal lateral flexion devised by Moll and associates.[19] CVs were also used to analyze the data in this study. The intertester CV mean was 6.3% and the intratester CV mean was 6.6% for the modified Schöber test. The fingertip-to-floor test proved to have poor reproducibility with a CV mean of 83% for intertester reproducibility and 76.4% for intratester reproducibility. The CVs for the inclinometer during flexion were much better than during extension with CV means of 9.6-13.4% and 65.4-50.7%, respectively.

Fitzgerald et al, reported CVs of 19.5-36.7% for a distraction test on 172 normal subjects. The higher CVs produced in this study could be due to the researcher's use of the original Schöber method and not the modified Schöber test. This study examined normal values of lumbar motion in age groups from 20 to 79 (10-year intervals). As expected, as age increased the spine range of motion decreased. The CVs, however, indicate more variability in range of motion as age increased. Intertester reliability was

examined on 17 physical therapy students using the Schöber technique in this study. Pearson correlation coefficients (r) of 1.0 for flexion and .88 for extension were reported.

Reproducibility of measuring spine mobility and trunk muscle strength was examined by Hyytiäinen et al, on 30 healthy employees of a shipyard as part of their occupational health service. This study involved three experienced physical therapists examining the employees three times during one day. The subjects were measured a fourth time by one of the examiners one week later for intratester reliability. One of the tests used to measure mobility was the modified Schöber test. A Pearson correlation coefficient (r) of .88 for intratester and .87 for intertester reproducibility was found.

It is difficult to generalize the findings of many of the studies involving the reliability of measuring lumbar spine motion to a patient population because all of the above studies, with the exception of Beattie et al, were conducted on healthy individuals with no history of back pain. Population-specific reliability refers to reliability that is established on one subject population that cannot be automatically attributed to another subject population.[39] Factors such as pain, spasm, weakness, anxiety, or malingering can alter the consistency of measurements taken in patients with low back pain. There are a few reliability studies that involve patients with low back pain using various techniques of measuring lumbar range of motion.

Reynolds compared the spondylometer, the goniometer, and the distraction/attraction method in 30 subjects (10 subjects with arthritic disorders and 20

volunteers who were either inpatients in a general medical ward or medical students). Intratester reproducibility was reported as coefficients of variation (CV) of measurements taken by the same tester on 10 separate occasions. A CV of 11.65% for lumbar flexion and 21.75% for lumbar extension were reported for the distraction/attraction methods. Intertester reliability was calculated by comparing the results of two testers on 10 subjects. The researcher did not report if the 10 subjects were the subjects with the arthritic disorders, inpatients, or medical students. Pearson correlation coefficients (r) of .59 for lumbar flexion and .75 for lumbar extension were reported for the distraction and attraction methods.[21]

When Macrae and Wright investigated the original Schöber method in 1969, they wanted a better technique for documenting spine mobility in ankylosing spondylitis (AS) patients. Miller (Marian) et al, also investigated a new skin contraction method and compared it to the modified Schöber method, fingertip-to-floor method, and gravity goniometer in three male ankylosing spondylitis patients. They called this new method the 10 cm segment method.[16] A mark was placed at the spinal intersection of a line joining the dimples of Venus with the subject standing erect. The subject flexes the trunk reaching toward the toes and three more marks are made on the spine at 10 centimeter intervals superior to the first mark. The subject then lays prone and extends the trunk maximally pushing up with their arms. The change in the measurements, both in each segment and the sum of the segments, during the fully flexed position and the fully

extended position is the measurement of spine mobility. When the 10 cm segment was compared to the modified Schöber method, r values of .98 to 1.0 were reported on the three healthy males and r values of .77 were reported on the three AS patients. The researchers felt that this new method was more sensitive to mobility changes in the upper lumbar and thoracic spine. The Schöber method and the modified Schöber method have two disadvantages. They do not include measuring mobility above the lower lumbar area and they only involve measuring spinal flexion.

Although previous studies[7,10-13,15] have shown that the skin distraction or attraction methods are reliable, there are some problems associated with these methods. Miller (Sandra) et al, evaluated 50 normal subjects using the modified Schöber method for measuring lumbar flexion to test interrater reliability in a "worst case" scenario.[17] Two testers were used to evaluate the subjects in a double-blind procedure. "Worst-case" sources of error were produced by having one tester identify the top of the dimples of Venus and the other therapist identify the bottom of the dimples of Venus. This would maximize error produced by improper identification of bony landmarks or by large dimples of Venus. Independent identification of bony landmarks was emphasized by each tester by marking landmarks on a piece of tape on the subject and then removing it prior to the next tester's evaluation. The testers used the modified Schöber method as described by Moll and Wright.[18,20]

Several problems were identified in the Miller et al study. Proper anatomic

landmark identification is imperative for the Schöber and modified Schöber technique. The dimples of Venus were lacking in 26% of the subjects and the intersection of the dimple line was found to be generally over S1 or S2, not the lumbosacral junction as described by Moll and Wright.[18,20] A large source of error can be introduced by inconsistent marking of the dimple. The authors found the diameter of the dimples of Venus to be between 1 and 2.5 centimeters. Whether the intersection of the dimples is marked at the top, middle, or bottom can either add or eliminate one or more lumbar segments. Also examined was the 5 cm mark inferior to the intersection of the dimple of Venus. Macrae and Wright modified the original Schöber method to include this mark because they felt that this would eliminate error from skin distraction because the skin was more strongly tethered to the sacrum at this point.[14] Miller et al, observed changes in the inferior 5 cm segment which would represent skin distraction without any actual bony movement over the body of the fused sacrum.

Validity of the modified Schöber method was addressed by Miller et al, by examining the 10 cm superior landmark. This method purports to assess the mobility of all six lumbar segments. Miller and associates found that on average, the 10 cm superior landmark corresponded to the L2-L3 interspace. This means that only 3.5 of the 6 spinal segments (T12-L1) were being assessed. Another problem involves the expression of terms of the measurement. Measuring spine mobility using this method documents movement in linear terms (centimeters) and actual spinal motion is expressed in angular

terms (in degrees).

In an effort to eliminate some of the problems addressed above, Williams et al, chose to study the Modified-modified Schöber method (MMS). This method was first described by van Adrichem and van der Korst in research assessing the flexibility of the lumbar spine in children and adolescents.[22] Van Adrichem and van der Korst used a tape measure to measure the distance between a mark on the posterior superior iliac spines (PSISs) and marks 5, 10, 15, and 20 cm above the PSISs in five healthy young men (ages 20 to 25 years). The subject was marked first in the erect standing position. With the tape measure against the back, the subject bent forward as far as possible and measurements were taken between the lowest mark and each of the four superior marks. The measurements were taken at one-week intervals a total of seven times. They suggested that only a 15 cm segment was needed to measure lumbar flexion because the more superior the landmark, the smaller the increase in length. They eliminated the 15 to 20 cm segment because it did not contribute much to the overall measure of lumbar flexion.

Further measurement was conducted on 248 healthy children (age 6 to 18 years) with the same conclusion. Therefore, the MMS method uses the PSISs for the inferior landmark and 15 cm superior to the PSISs as the superior landmark, eliminating the need for a third landmark inferior to the first mark (PSISs) as in the modified Schöber method.

Williams et al, examined the reliability of the MMS method of measuring lumbar flexion and extension in 15 patients with chronic low back pain.[23] They compared the

MMS method to the double inclinometer method (DI). They also studied the length of time taken to perform the two tests. Three testers took lumbar measurements on two separate occasions, two days apart. Pearson product-Moment correlation coefficients were used to determine test-retest reliability and analysis of variance (ANOVA)-derived ICCs (3,1) were used to determine intertester reliability between the three testers. Pearson correlation coefficients of .78-.89 for the MMS lumbar flexion, .69-.91 for the MMS lumbar extension, .13-.87 for the DI lumbar flexion, and .28-.66 for DI lumbar extension were reported. ICCs of .72 for MMS lumbar flexion, .76 for MMS lumbar extension, .60 for DI lumbar flexion, and .48 for DI lumbar extension were reported for intertester reliability. The mean time to obtain lumbar flexion and extension measurements for the MMS and DI methods was 10.2 seconds and 23.1 seconds, respectively. The authors concluded in their study that the MMS method was a moderately reliable method of measuring lumbar flexion and extension and that it is also a time-efficient method. Reliability of the DI method was questionable. Validity of the measurements was only partially addressed by the authors.

In reviewing the literature on measurement of spine range of motion, validity is rarely addressed. Miller et al, addressed construct validity of the modified Schöber method by palpating the number of lumbar segments the measurement technique includes.[17] One problem with the technique is that it does not always include all the lumbar segments. The validity of the MMS method appears to be improved by extending

the 10 cm segment to 15 cm, including all of the lumbar segments. Criterion-related validity of the MMS method could be assessed by comparing lumbar spine range of motion measurements to measurements obtained radiographically. Cost and exposure of the patient to radiation are limiting factors for research using radiographs.

Inclinometer method

Another commonly used method of measuring lumbar range of motion is the double inclinometer (DI) method, as first decribed by Loebl in 1967. This is the standard of measurement used by the American Medical Association's *Guide to the Evaluation of Permanent Impairment*.[3] An inclinometer is a circular, fluid-filled hand-held disc with a weighted needle indicator that is maintained in the vertical position.[29,31] The disc is marked in 0.5° intervals over the 360° range and is attached to either a two-point base or a plastic straight edge. The two-point base is preferred because it can maintain contact over the convex dorsal aspect of the spine or sacrum during trunk movement.[31] With the patient erect, one inclinometer is placed on the sacrum and the second inclinometer is placed on the first lumbar vertebra (L1). The superior inclinometer measures gross motion while the inferior inclinometer measures hip motion. The subject is instructed to bend forward maximally and recordings of both inclinometers are taken again. The lumbar flexion range of motion is the difference between the two measurements taken during erect standing and full flexion. Lumbar extension is measured using the same

landmarks as measuring lumbar extension, but the subject is instructed to extend backwards and the inclinometers are read during full extension. The lumbar extension range of motion is the difference between the two measurements taken during erect standing and full extension.

Several authors have used the DI method for measuring lumbar range of motion in studies of spinal mobility.[12,27-29,31,15,33-34,23] In two studies involving subjects without low back pain (LBP),[12,15] the modified Schöber method was shown to be more repeatable than the DI method. Both studies used coefficients of variance (CVs) to determine repeatability. Gill et al, and Merritt et al, however, reported much variation in their results although their technique appeared to be similar. Most studies involving measuring lumbar spine flexion and extension show more variation during the extension measurement and Gill et al, showed more variation in their measurements during flexion. Tester error was suggested to be the cause of the variation of the extension measurement.

Williams et al, compared the MMS method with the DI method in 15 patients with LBP and found the MMS method to be more reliable and time-efficient than the DI method.[23] An advantage of using the DI method is that the measurement is reported in degrees rather than centimeters. Assessing range of motion function and impairment is easier because motion assessment is based on degrees and the impairment guide printed by the AMA uses the DI method to assess spine motion.

In studies using subjects with LBP, the DI has been reported to be a reliable,

useful technique for measuring lumbar range of motion.[27-28,31,33-34] One distinct advantage of using the DI method is this method reports values in angular terms, or degrees of motion. Disadvantages reported in DI method studies include extensive training required to perform the method consistently, cost of the inclinometers, increased time to take the measurements as compared to other techniques, difficulty in handling and reading both inclinometers during trunk motion, and occasional problems with maintaining inclinometer contact on the skin if the two-point inclinometer is not used.

Goniometer

The use of a goniometer is a standard in physical therapy and has been proven to be reliable in measurement of extremity range of motion.[24] Measuring trunk range of motion with a goniometer, however, has been less studied. Disadvantages of using the goniometer to measure spine range of motion is that the goniometer is designed to measure movement at a single axis of rotation, not motion over several segments, and patients may have difficulty maintaining the position while the goniometer is lined up and the measurement is read.[10,21]

Other measurement instruments

Various other devices have been reported in the literature for measuring trunk range of motion. These include radiographs,[14,18,20] B200 machine,[25,32] Spinetrak™,[34]

MedX™,[34] potentiometric analysis system,[35] spondylometers,[40,21] kyphometers,[26] and electric goniometers.[26] Disadvantages with these techniques range from lack of accessibility to the device, increased cost, exposure to radiation, and extensive training needed to use the device.

The review of the literature examines the original Schöber method of measuring lumbar flexion and provides an explanation for the rationale for the two modifications made to change the technique to the MMS method as described by Williams et al. A pilot study on normal subjects was conducted prior to this research study using the modified Schöber (MS) method. The MS method was chosen for the pilot study because I was, at the time, unaware of the recent study by Williams et al, on the MMS method and most of the literature focused on the MS method rather than the Schöber method. The purpose of the pilot study was to gain experience in data collection, to test the procedures and methods, and to gather some normative data on lumbar spine motion in young healthy individuals. The results from previous research as well as knowledge gained from the pilot study (refer to the Methods section) led me to investigate the reliability of the MMS method in this research.

The MMS method of measuring lumbar flexion and extension was chosen for this study for the following reasons: (1) the ease of use; (2) tape measures are accessible and portable; (3) the device is cost-effective; (4) the measurement is time-efficient; and (5) the technique is easily learned with minimal to moderate training and practice. Because of

these factors, the MMS method seems to be a very practical way of measuring lumbar flexion and extension. It can only be a useful clinical tool, however, if it is shown to be reliable for measuring lumbar flexion and extension in a relevant patient population.

My research hypothesis is that the MMS method of measuring lumbar flexion and extension will show good intrarater and interrater reliability in subjects with symptomatic low back pain. Good reliability is defined by Portney and Watkins as an ICC of .75 or greater.[39]

# CHAPTER TWO

# METHODS AND PROCEDURES

## The Pilot Study

An initial pilot study was conducted on 51 normal subjects (39 females and 12 males). The purpose of the pilot study was for the testers to gain experience in data collection, to test the methods and procedures, and to gather normative data on spine motion in healthy individuals. The sample of convenience of volunteers from Old Dominion University's physical therapy program consisted of healthy individuals without low back pain. The mean age was 26.4 years (range 22-41 years). Mean height was 65.9 inches ± 3.3 (range 60.0- 75.0 inches) and mean weight was 144.3 pounds ± 29.8 (range 102.0 - 240.0 pounds). Subject characteristics are listed in Table 1. Subjects were excluded from the study if they had a history of spinal fusion or an obvious scoliosis. An explanation of the procedures was given and informed consent and demographic information forms were signed.

In the pilot study, the intratester and intertester reliability of the MS method of measuring lumbar flexion and extension were examined. Two physical therapists, each with six years of orthopedic experience who routinely use the MS method, took two consecutive measurements of lumbar flexion and extension on each subject. The order of testing was randomized by having the subject pick a card, each card having the name of one of the testers on it. A standard plastic flexible tape measure (Figure 1) was used to

take the measurements. Each tester used her own tape measure. Both tape measures were blinded by applying tape to one side to prevent tester bias during the two consecutive measurements. Rubbing alcohol was used to remove the skin marks made by each tester before the second tester took her measurements. Subjects were not asked to stretch or warm-up prior to taking the measurements.

Each subject was instructed to stand erect with feet shoulder width apart. The PSISs were palpated and a skin mark was made on the spine at the intersection of the middle of the PSIS. A superior mark on the spine was made 10 cm above the first mark and an inferior mark was made 5 cm below first mark for a total of 15 cm (Figure 2 and 3). Each subject was instructed to keep her knees straight and bend forward as far as possible. The tape measure was held firmly against the skin. The distance between the superior and inferior mark was measured in centimeters with the subject fully flexed (Figure 4). The range of motion of lumbar flexion was represented by the change in the distance between the marks in erect standing and full flexion. Lumbar flexion was repeated and the second flexion measurement was taken by the first tester.

The subject was then instructed to keep her knees straight and with her hands on her buttocks, bend backwards as far as she could (Figure 5). The tape measure was held firmly against the skin during full extension. The distance between the superior and inferior marks was measured in centimeters with the subject extended. The range of lumbar extension was represented by the change in the distance between the marks in

erect standing and full extension. Lumbar extension was repeated and the second lumbar extension measurement was taken by the first tester. The first tester would erase the skin marks and the entire procedure was repeated by the second tester.

ICCs (3,1) and (2,1) were used to calculate the intratester and intertester reliability. Good reliability was defined as an ICC of .75 or greater.[39] Data results of the pilot study are shown in Table 2. An ICC of .96 was calculated for Tester 1 intrarater reliability for both lumbar flexion and extension. ICCs of .96 and .84 for lumbar flexion and extension, respectively, was calculated for Tester 2 intrarater reliability. Intertester reliability was significantly lower with ICCs of .63 for lumbar flexion and .35 for lumbar extension. Mean lumbar flexion was 6.5 cm ± 1.2 (range 3.4- 9.1) and mean lumbar extension was 2.7 cm ± 1.0 (range 0.8 - 5.7).

I concluded from the pilot study that the MS method was reliable for repeated measurement by the same tester but was not reliable between different testers. The experience gained from the pilot study led to modification of the methods and procedures. The modifications made were: (1) include a short warm-up period for the subjects prior to data collection to decrease a stretching effect during the eight motions; (2) change the skin marks to the MMS method due to difficulty marking the inferior mark in the natal cleft in most individuals; (3) measure lumbar extension with the tape measure held taut between the two points instead of flush against the skin due to difficulty in maintaining the tape over creases and skin folds; and (4) standardize precisely the verbal instructions

given to the subjects.

Subjects

The subjects in this study were volunteers who were patients at five outpatient physical therapy clinics in the Hampton Roads area. Inclusion criteria for the study required that the subjects (1) be diagnosed as having low back pain (LBP), with or without leg pain. *Low back pain* was defined as pain on the posterior aspect of the trunk below the basilar costal margins or above the greater trochanter [7]; (2) be 18 years or older; (3) be able to tolerate repeated forward and backward bending; and (4) be currently receiving treatment for their LBP. Patients were excluded from the study if they had acute LBP of less than one week, known nonmechanical back pain (eg, neurological impairment, neoplasm, spinal infection), spinal fusion, history of connective tissue disease, or obvious scoliosis. None of the females thought they were pregnant at the time of testing. The procedure was explained to the patient and informed consent and demographic forms were signed.

Thirty subjects (19 females, 11 males) ranged in age from 18 to 61 years (mean age=40.0 years ± 11.7). Subject characteristics are listed in Table 3. Mean height was 66.6 inches ± 4.0 and mean weight was 180.3 pounds ± 60.0. Mean duration of LBP was 31 weeks ± 61.

The same testers that were used in the pilot study served as testers in this study.

Both routinely use the MS method to measure lumbar flexion and extension in clinical practice. Because both testers were unfamiliar with the MMS method, a short training session was conducted to standardize the method between the two testers and provide practice time to become proficient with the technique.

## Instrumentation

One flexible plastic tape measure, marked in 1-mm increments, was used to collect the data (Figure 1). Both testers used the same tape measure to reduce the chance of tape measure variations due to stretching or wear. The tape measure was covered on one side with white tape to blind the testers to the increments. The blinded side was toward the testers during the measurement taking. Each tester would mark the measurement on the blank side of the tape with her fingernail and then read the measurement against the centimeter side of the tape measure.

## Procedure

All data were collected after the subjects completed their physical therapy treatment for that visit. The subjects were warmed up and had completed their exercise or stretching programs. The procedure was explained to the subjects and informed consent forms were signed (Appendix A). To randomize the order of testing, the subjects picked a card. Each card had one of the tester's names on it. Both testers followed the procedure

instructions in Appendix B.

In an examination room, the subjects disrobed to expose their backs from the upper thoracic area to the mid-buttock area. The patients were instructed to stand erect with their arms at their side, head facing forward, with their feet shoulder width apart. The tester knelt behind the patient and palpated the inferior margins of the PSISs with her thumbs. An ink mark was made on the lumbar spine at a point between the middle of the thumbs. A second mark was made 15 cm superior to the first mark on the upper lumbar spine (Figures 6 and 7). The tape measure was lined up between the two marks, with zero end of the tape (eg, end of the tape) on the inferior mark. With the tape measure held firmly against the skin, the subject was instructed to bend forward. The difference between the new measurement and the original 15 cm measurement represented the lumbar flexion range of motion. After the flexion measurement, tester 1 removed all skin marks with rubbing alcohol and exited the examination room. The same procedure was repeated by tester 2. Lumbar flexion was always measured first.

Tester 1 would then re-enter the examination room to measure lumbar extension. The same starting position was used, the landmarks identified, and skin marks made. The subject was instructed to place her hands on her buttocks and extend back as far as she could. With the subject in the extended position, the tape measure was placed between the two marks in a straight line (eg, not held against the skin) and the measurement was taken (Figure 8). The change in the 15 cm segment and the measurement taken during full

extension represented the lumbar extension range of motion. Tester 1 removed the skin marks and the procedure for measuring lumbar extension was repeated by tester 2. Both testers recorded their measurements in centimeters.

Data analysis

ICCs (3,1) and (2,1) were used to calculate the intrarater reliability and interrater reliability of the therapist's measurements.[39] ICC (3,1) is most often used to calculate intrarater reliability and is represented by the following equation:

$$ICC\ (3,1) = \frac{BMS - EMS}{BMS + (k - 1)EMS}$$

BMS = between-subjects mean square

EMS = error mean square

$k$ = number of raters

Intratester reliability represents the stability, or consistency, of a measurement over time.[41] It reflects the consistency of the same tester's measurements on the same subject at different times.

ICC (2,1) is used to calculate intertester reliability, or the consistency of measurements when more than one tester takes the measurement.[41] The testers are considered representative of a larger population of similar testers.[39] It is assumed that all therapists would be instructed in the MMS method prior to performing these

measurements. ICC (2,1) is represented by the following equation:

$$\text{ICC (2,1)} = \frac{\text{BMS} - \text{EMS}}{\text{BMS} + (k\text{-}1)\text{EMS} + \frac{k(\text{RMS} - \text{EMS})}{n}}$$

BMS = between-subjects mean square

EMS = error mean square

RMS = between-raters mean square

$k$ = number of raters

$n$ = number of subjects tested

The ICC ranges between 0 and 1.0, with values closer to 1.0 representing stronger reliability. Portney and Watkins suggest that values above .75 are indicative of good reliability. They also suggest that reliability exceeding .90 may indicate reasonable validity.[39]

# CHAPTER THREE

## RESULTS

The lumbar flexion and extension measurements for the two testers are shown in Table 4. For trial 1, the mean lumbar flexion measurements for tester 1 and tester 2 were 5.4 cm and 5.3 cm, respectively. For trial 2, the mean lumbar flexion measurements for tester 1 and tester 2 were 5.5 cm and 5.1 cm, respectively. For trial 1, the mean lumbar extension measurements for tester 1 and tester 2 were 2.5 cm and 2.3 cm, respectively. For trial 2, the mean lumbar extension measurement was 2.5 cm for both testers. Overall, the subjects demonstrated a mean forward bending of 5.3 cm (SD= 1.9) with a range of 0 to 9.1. The mean backward bending was 2.5 cm (SD=1.3) with a range of 0 to 6.0.

Beattie et al, reported a mean backward bending value of 0.6 cm with a range of 0 to 2.8 centimeters.[7] Williams et al, did not report mean forward and back bending values in their study but reported mean values for each tester. The mean values reported for forward bending ranged from 6.10 to 6.55 cm with a range from 3.5 to 9.5 cm. The mean values reported for backward bending ranged from 2.16 to 2.62 cm with a range of 0.5 to 4.8 cm.[23]

Table 5 shows the results of the ICC calculations. Intratester reliability ranged from .91 to .98. Tester 1 intratester reliability ICCs were .98 and .96 for lumbar flexion and lumbar extension, respectively. Tester 2 intratester reliability ICCs were .93 and .91 for lumbar flexion and lumbar extension, respectively. The ICC values for intertester

reliability were .93 and .83 for lumbar flexion and lumbar extension, respectively.

# CHAPTER FOUR

## DISCUSSION AND CONCLUSION

The results of this study indicate that the MMS method for measuring lumbar flexion and extension shows good intratester and intertester reliability in subjects with symptomatic low back pain and the research hypothesis is accepted.

The results from the pilot study indicate that the MS method of measuring lumbar flexion and extension range of motion is not completely reliable, but there are many limitations of that study. A potentially large source of error for both the MS and MMS methods is inaccurate identification of bony landmarks and inconsistent marking of the skin. In the MS method, identification of the lumbosacral junction is required and marks 10 cm above and 5 cm below the lumbosacral junction are made. The inferior mark, on most individuals, lies in the natal cleft. Since it is impossible to make the skin mark in the cleft, the testers marked on either side of the cleft. The testers felt that this adjustment was a potential source of error. Identification of the lumbosacral junction can be difficult and both skin marks can be inaccurate if the initial mark is incorrect. Macrae and Wright, in their research found that faulty placement of skin marks seriously impaired the accuracy of the unmodified method. An overestimate of 14 degrees can occur if the skin marks are 2 cm too low and an underestimate of 15 degrees can occur if the marks are placed 2 cm too high. Modification of the original Schöber method, by adding the mark 5 cm below the lumbosacral junction, decreased the overestimates and underestimates, with

the same errors, to 5 degrees and 3 degrees, respectively.[14] With further modification, the MMS method eliminates these problems by using the PSISs as the inferior landmark and measures 15 cm superior to the PSISs for the superior landmark. The testers felt that identification of the PSISs was easier than identification of the lumbosacral junction even in obese individuals.

Miller (Sandra) et al, questioned the validity of the MS method because they found that the MS method only included, on average, 3.5 of the 6 lower spinal segments.[17] This measurement technique leaves out mobility from at least 2 to 3 segments of the lower spine. Although data were not collected in the pilot study regarding at what level the 10 cm mark occurred, the testers did note that in taller individuals the superior 10 cm mark did not occur near the level of T12 or L1. The MMS method attempts to correct this problem by adding 5 cm to the superior mark. Van Adrichem and van der Korst concluded that 15 cm is an adequate length to measure the lumbar spine because any larger segments do not contribute very much to the measurement.[22] It would be interesting in future research to identify at what level the 15 cm mark occurs in subjects of varying height.

The subjects in the pilot study were not instructed to warm-up or stretch prior to data collection. This could have been a source of error because some stretching could have occurred during the subjects' eight movements. Although the order of testing was randomized, it was noted that range of motion often improved as each trial was

completed. Subjects also reported that the test movements were easier with the second tester because they had already completed the movements once with tester one. During data collection for the MMS method, the procedure was changed to allow for data collection after the subjects completed their treatment program. The treatment programs always included exercise, stretching, and/or manual therapy. Modalities were also completed before data collection.

The testers felt that the training session prior to data collection during the MMS method study helped to decrease variations in tester measurement technique and verbal instructions. Previous to the training session, one tester held the tape measure with the end of the tape measure on the superior mark while the other tester held the end of the tape measure on the inferior mark. Frequently verbal instructions used by the two testers were not identical. The training session standardized the procedure so that both testers' technique and verbal instructions were the same.

This study slightly changed the measurement technique used for lumbar extension. In the MMS method used in Williams et al, research, the tape measure is firmly held against the skin during lumbar extension.[23] During the pilot study, holding the tape measure against the skin was used and was found to be very difficult in our normal subjects. Since our subject group consisted of normal, mostly younger people, the range of motion values were higher than the values reported in the patient group. Two problems were encountered with holding the tape measure against the skin. The first problem was

difficulty in measuring lumbar extension in subjects with a normal amount of extension. With increased extension, the subject's back is almost on top of the tester during data collection and holding the tape measure against the skin while stooping under the subject to measure them is difficult. The second problem with holding the tape measure against the skin was increased variability due to the subject's skin folds during extension. This potential source of variation increased in subjects who were more obese because the skin folds were bigger and there were more creases in the back during extension.

An attempt was made in the MMS method study to eliminate the potential for measurement error during lumbar extension. Instead of holding the tape measure against the skin during the extension measurement, the testers measured the distance between the superior and inferior skin marks in a straight line. (Figure 8) Although this would change the initial 15 cm segment in erect standing (this measurement is taken with the tape measure against the skin) the relative change in the measurement would stay the same. The testers felt that measuring the lumbar extension in a straight line was easier than against the skin because holding the tape measure against the many skin folds was difficult. This was important while measuring the subjects in the MMS study because the subjects in this study tended to be heavier than in the pilot study.

The data and experience gained from the pilot study enabled the testers to make modifications in their technique and data collection procedures. Results from these changes appeared to produce favorable results in the MMS study. The results of this

study indicate that the MMS method of measuring lumbar flexion and extension has good to excellent intertester reliability with ICCs of .93 and .83, respectively. Intratester reliabilities were even higher with ICCs ranging from .91 to .98. The results from this study are similar to the study by Williams et al.[23] They found moderate reliability (ICCs of .72 and .76 for flexion and extension, respectively) with the MMS method. It is difficult to compare this study with other previous studies because those studies used either the Schöber method or the MS method for measuring lumbar flexion and extension.

Without validity, reliability cannot be fully established.[41,42] Criterion-related validity of this method is difficult to assess without comparing lumbar measurements to lumbar measurements obtained radiographically. Construct validity for the use of the MMS method appears reasonable because the distance measured by the tape measure is a measurement of flexion and extension of the lumbar spine.[23] Future research should address the criterion-related validity of the MMS method, include a larger sample, and include a larger number of testers. Reasonable validity of the MMS method can be suggested due to some of the ICC values in this study being greater than .90.[39] It also would be interesting to study how much change in linear distance is measured with each degree change in curvature angle.

In conclusion, the results from this study indicate that the MMS method appears to be a very simple, reliable, cost-effective, clinical tool for measuring lumbar spine

flexion and extension in patients with symptomatic low back pain.

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**TABLE 1.** Characteristics of the Pilot study subjects*

| Variable | Mean | SD | Range |
|---|---|---|---|
| Age (years) | 26.4 | 5.0 | 22.0-41.0 |
| Height (inches) | 65.9 | 3.3 | 60.0-75.0 |
| Weight (pounds) | 144.3 | 29.8 | 102.0-240.0 |

*Sample consisted of 51 subjects (39 females, 12 males)

**TABLE 2.** Analysis of the ANOVA-derived ICCs for the Pilot study

| | **Tester 1 Intratester ICC** | **Tester 2 Intratester ICC** | **Intertester ICC** |
|---|---|---|---|
| Flexion | .96 | .96 | .63 |
| Extension | .96 | .84 | .35 |

**TABLE 3.** Characteristics of the study sample**

| Variable | Mean | SD | Range |
|---|---|---|---|
| Age (years) | 40.0 | 11.7 | 18.0-61.0 |
| Height (inches) | 66.7 | 4.0 | 59.0-74.0 |
| Weight (pounds) | 180.3 | 51.0 | 119.0-350.0 |

**Sample consisted of 30 subjects (19 females, 11 males)

**TABLE 4.** Lumbar Flexion & Extension Measurements for MMS* Method

| | Trial | Tester | Mean | SD | Range |
|---|---|---|---|---|---|
| Lumbar Flexion | 1 | 1 | 5.4 | 2.0 | .0-9.1 |
| | | 2 | 5.3 | 1.8 | 1.0-8.0 |
| | 2 | 1 | 5.5 | 1.9 | .4-8.8 |
| | | 2 | 5.1 | 1.9 | 1.0-7.5 |
| Lumbar Extension | 1 | 1 | 2.5 | 1.3 | .2-5.5 |
| | | 2 | 2.3 | 1.2 | .0-5.0 |
| | 2 | 1 | 2.5 | 1.3 | 1.0-6.0 |
| | | 2 | 2.5 | 1.2 | .0-5.0 |

*MMS = modified-modified Schöber method

**TABLE 5.** Analysis of the ANOVA-derived ICCs for the MMS Method

| | **Tester 1 Intratester ICC** | **Tester 2 Intratester ICC** | **Intertester ICC** |
|---|---|---|---|
| Flexion | .98 | .93 | .93 |
| Extension | .96 | .91 | .83 |

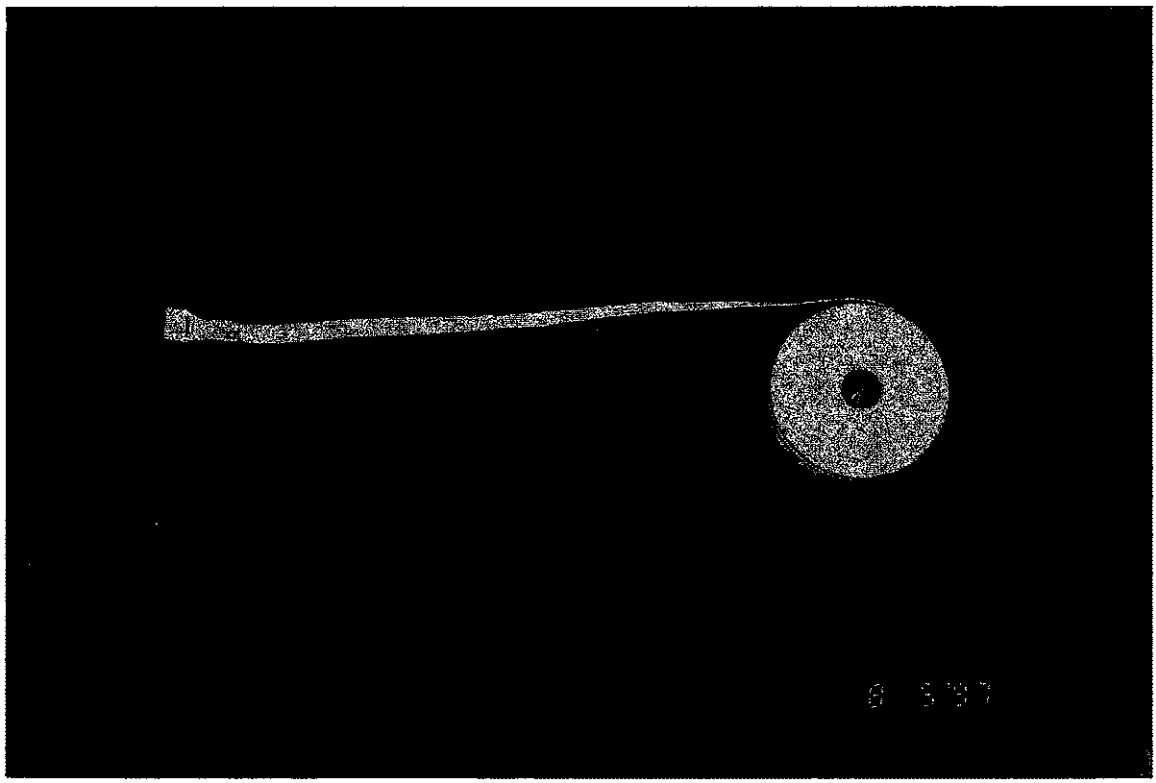

**Figure 1.** Tape measure used to obtain the measurements with the pilot study and the Modified-modified Schöber method.

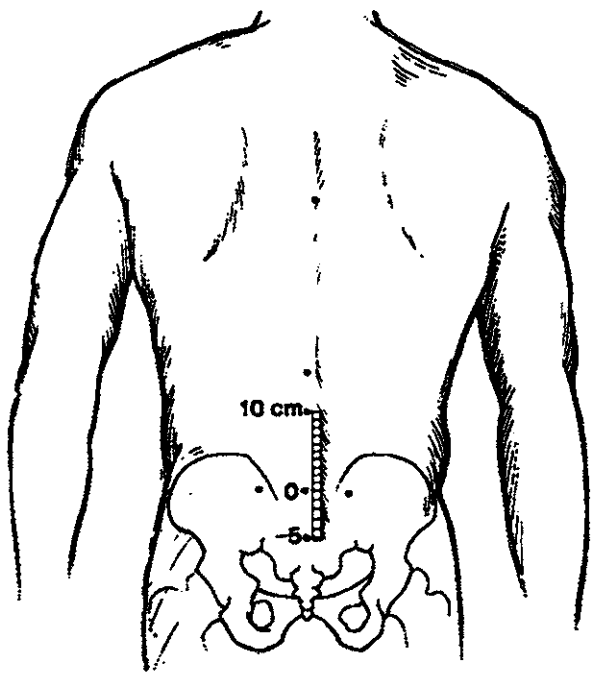


**Figure 2.** Diagram showing the landmarks for the Modified Schöber method. "0" is the midpoint between the dimples of Venus (identified by the circular marks to the left and right of the zero). The superior mark is 10 cm above the zero mark and the inferior mark is 5 cm below the zero mark. (Adapted from Merritt et al.[15])

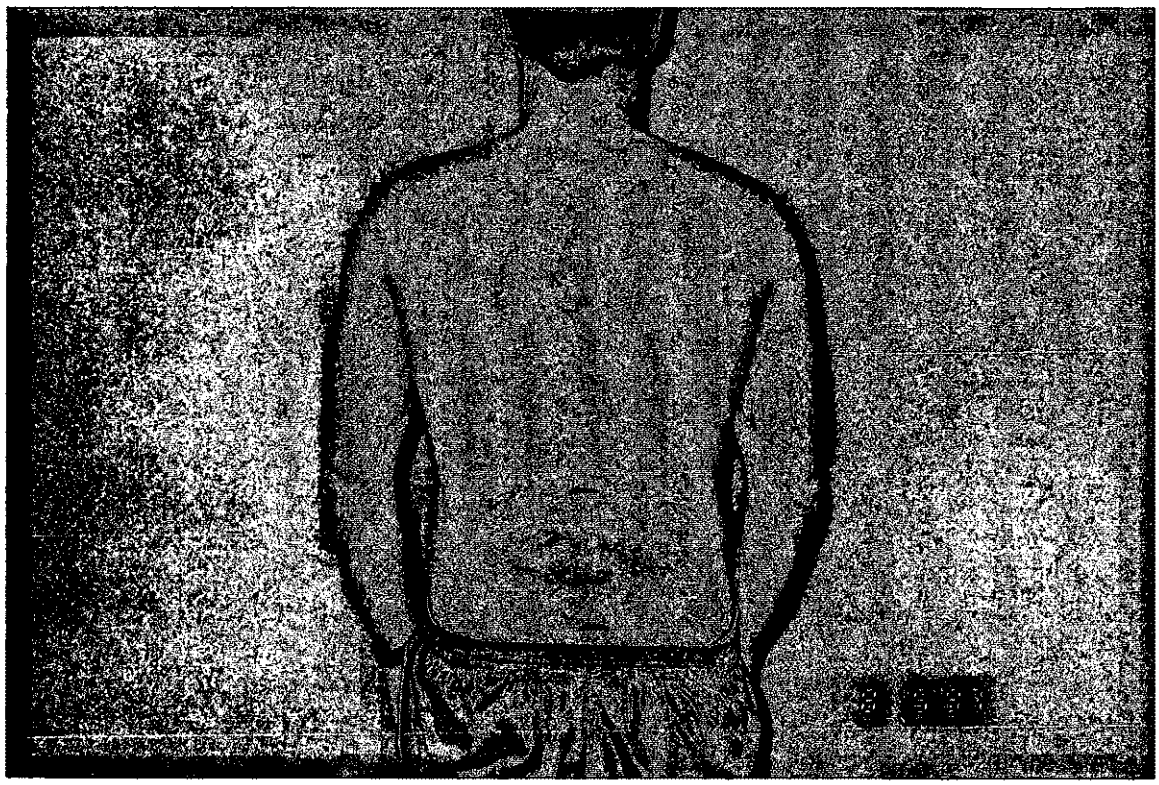

**Figure 3.** Landmarks for the Modified Schöber method. The middle mark is at the midpoint on the spine between the dimples of Venus. The superior mark is 10 cm above the middle mark and the inferior mark is 5 cm below the middle mark.

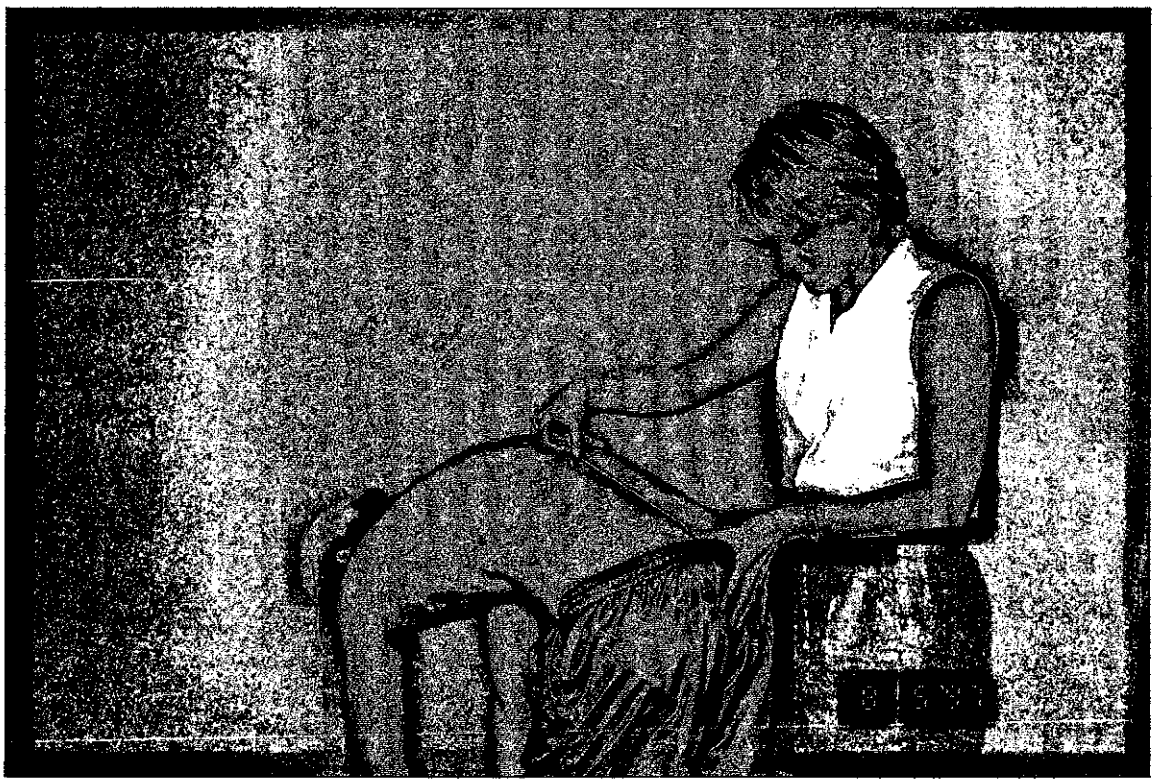

**Figure 4.** Modified Schöber method for measuring lumbar flexion. The subject is instructed to bend forward as far as he can. While in the flexed position, the tape measure is held against the skin and the distance between the superior and inferior marks is measured. The flexion range of motion is the difference between the initial length between the skin markings (15 cm) and the length measured in full flexion.

**Figure 5.** Modified Schöber method for measuring lumbar extension. The subject is instructed to extend backwards as far as he can. While in the extended position, the tape measure is held against the skin and the distance between the superior and inferior marks is measured. The extension range of motion is the difference between the initial length between the skin markings (15 cm) and the length measured in full extension.

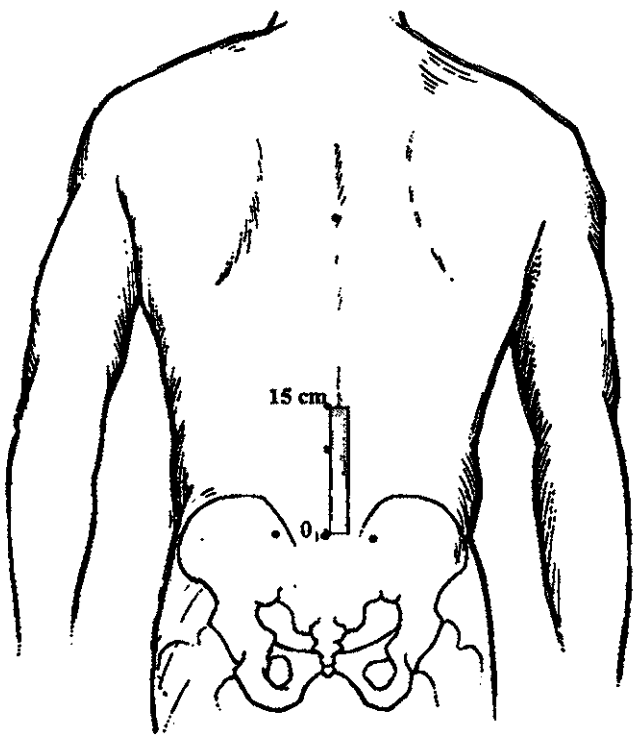


**Figure 6.** Diagram showing the landmarks for the Modified-modified Schöber method. "0" is the midpoint between the posterior superior iliac spines (PSISs). The superior mark is 15 cm above the zero mark. (Adapted from Merritt et al.[15])

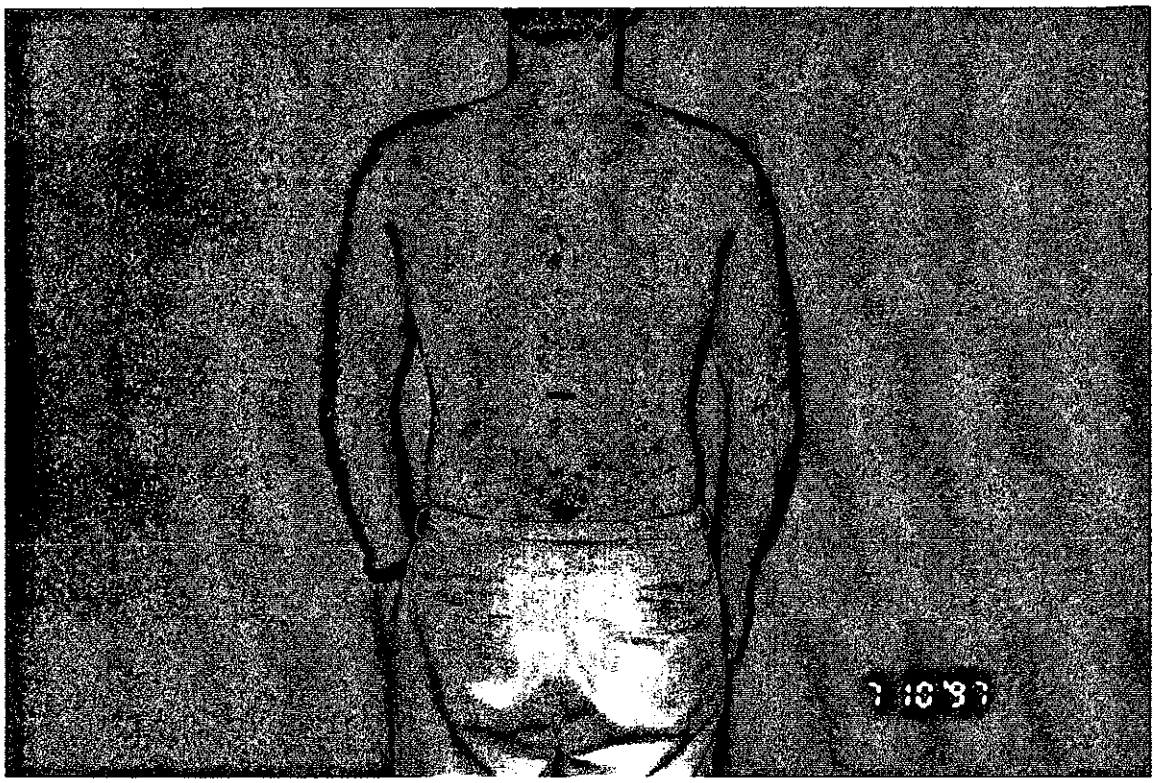

**Figure 7.** Landmarks for the Modified-modified Schöber method. The inferior mark is on the spine at the midpoint between the posterior superior iliac spines (PSISs). The superior mark is 15 cm above the inferior mark.

**Figure 8.** Modified-modified Schöber method for measuring lumbar extension. The subject is instructed to extend backwards as far as he can. While in the extended position, the tape measure is held in a straight line, away from the skin, and the distance between the two skin marks is measured. The extension range of motion is the difference between the initial length between the skin markings (15 cm) and the length measured in full extension.

**OLD DOMINION UNIVERSITY- PROGRAM IN PHYSICAL THERAPY**

INFORMED CONSENT FORM

Project name: Reliability of the Modified-modified Schöber Method for Measuring Lumbar Range of Motion.

Investigators: Mira Mariano, PT and Kim Dunn, PT

Date: May 1, 1997

I,_____, consent to participate as a volunteer in a scientific investigation as part of the educational and research program of Old Dominion University. I understand that the purpose of this investigation is to determine the reliability of non invasive measurements of lumbar range of motion using a tape measure. The procedure will be completed in one session and will involve measurement of two lumbar motions. The nature of the movements are active and gentle so no risk to myself as a subject is anticipated. I understand that the benefits of participation in this study include advancing clinical evaluation techniques of the lumbar spine, gaining knowledge and understanding of measurement techniques, and the personal satisfaction which comes with participation in research.

The investigation and the nature of my participation have been described above and explained to me, and I understand the explanation. I understand that I am one of 30 individuals participating in this research project and that I may withdraw from this project at any time without penalty or prejudice.

I have been afforded the opportunity to ask questions concerning the purpose of this project and all such questions have been answered to my satisfaction. I understand that should I have additional questions in the future about this project or the manner in which it is conducted, I may contact: Mira Mariano, PT 683-6111 or Kim Dunn, PT 440-8471.

I understand that I am free to withhold any answer to specific items or questions in any questionnaire submitted to me for this project. I understand that any data or answers to questions will remain confidential with regard to my identity. I further understand that no data which can be identified with me will be released to persons outside the research team without the team first obtaining my written permission.

I acknowledge that I was informed about any possible risks to my health and well-being that may be associated with my participation in this research. I understand that no medical or psychological assistance will be made available to me by either Old Dominion University or any member of the research team as a result of any physical or emotional harm I may experience as a result of this research project.

I acknowledge that I have been advised of how I may obtain a copy of the results of this research project and that upon my making such a request, a copy will be provided without charge.

_____ Date:_____
Signature of Volunteer

_____ Date:_____
Witnessed By

Age:____ Weight:_____ Height:_____ Sex:_____ of participant. Duration of low back pain_____wks/mo

## PROCEDURE FOR MODIFIED-MODIFIED SCHÖBER TECHNIQUE FOR MEASURING LUMBAR FLEXION:

1. Patient position: The patient stands erect, eyes focusing horizontally, arms at the side, with feet shoulder width apart.

2. Skin markings: The therapist stands behind the patient and identifies the posterior superior iliac spines (PSISs) by marking the PSISs with his or her thumbs. Make an ink mark on the midline of the lumbar spines horizontal to the PSIS. Make another mark on the spinous processes 15 cm superior to the PSIS line (to the nearest millimeter). The distance between the superior and inferior skin marks on the spinous processes is 15 cm.

3. Align the tape measure between the two skin marks, with zero at the inferior skin mark and 15 cm at the superior mark. Keep the tape measure firmly against the patient's skin while the patient bends forward.

4. Verbal cue to the patient: "Keep your knees straight and bend forward as far as you can".

5. Measurement procedure: When the patient has bent forward, the new distance between the superior and inferior skin marking is measured (to the nearest millimeter) with the patient positioned in full lumbar flexion.

6. Verbal cue to the patient: "You can come back up to a comfortable standing position".

7. Recording the measurement: The flexion range of motion is the difference between the initial length between skin markings (15 cm) and the length measured in full flexion.

8. Remove all skin marks with rubbing alcohol.

9. The patient repeats the same procedure with tester #2.

10. The patient returns to tester #1 to repeat the above procedures.

11. The patient returns to tester #2 to repeat the above procedures.

## PROCEDURE FOR MODIFIED-MODIFIED SCHÖBER TECHNIQUE FOR MEASURING LUMBAR EXTENSION:

1. Patient position: The patient stands erect, eyes focusing horizontally, arms at the side, with feet shoulder width apart.

2. Skin markings: The therapist stands behind the patient and identifies the posterior superior iliac spines (PSISs) by marking the PSISs with his or her thumbs. Make an ink mark on the midline of the lumbar spines horizontal to the PSIS. Make another mark on the spinous processes 15 cm superior tot he PSIS line (to the nearest millimeter). The distance between the superior and inferior skin marks on the spinous processes is 15 cm.

3. Align the tape measure between the two skin marks, with zero at the inferior skin mark and 15 cm at the superior skin mark. The tape measure should form a straight line between the superior and inferior skin marks when the patient bends backward.

4. Verbal cue to the patient: "Place the palms of your hands on your buttocks, keep your knees straight, and bend backwards as far as you can".

5. Measurement procedure: When the patient has bent backward, the new distance between the superior and inferior skin markings is measured (to the nearest millimeter) with the patient positioned in full lumbar extension.

6. Verbal cue to the patient: "You can come back up to a comfortable standing position".

7. Recording the measurement: The extension range of motion is the difference between the initial length between skin markings (15 cm) and the length measured in full lumbar extension.

8. Remove all skin marks with rubbing alcohol.

9. The patient repeats the same procedure with tester #2.

10. The patient returns to tester #1 to repeat the above procedures.

11. The patient returns to tester #2 to repeat the above procedures.