Acumar™ DIGITAL INCLINOMETER
User's Manual Version 5.0

ACUMAR
By

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Introduction

Inclinometers are instruments used to measure the angle of a subject with respect to a level or gravity. In medical or clinical applications, the inclinometer determines a person's range of motion. Typically, range of motion is referenced from the body's natural position. The flexion angle or extension angle of the body segment or joint under evaluation is then measured in degrees.

Several different types of manual inclinometers exist on the market. The water-filled "Bubble" Inclinometer and the water-filled "Pendulum" Inclinometer are widely used. These inclinometers usually offer a two-degree marking for readings. Digital inclinometers typically display angle in one-degree increments for ease of reading.

The Acumar Digital Inclinometer is the first digital inclinometer to provide easy-to-use, wireless data that can be logged into any PC. A built-in microprocessor automatically calculates and displays the actual range of motion of the joints. These special features of the Acumar Inclinometer assist evaluators to offer more objective range of motion measurements.

The sole purpose of this User's Manual is to describe the use of the Acumar Digital Inclinometer and/or its accessories and is not intended to describe medical procedures or standards. The user is advised to refer and follow specific procedures such as the AMA Guides* to the Evaluation of Permanent Impairment or any applicable state or local guidelines of procedures.

Background

The Acumar Digital Inclinometer was developed in response to many physicians and clinicians who expressed a need to have a modernized easy-to-use instrument to help document data in an objective manner.

Acumar Technology recognizes and is grateful for the numerous physicians, clinicians and others who willingly participated in guiding the development.

Acumar Technology is committed to continuing to serve the needs of the evaluation community and welcomes any input from the user in the field of evaluation and outcome assessment.

* AMA Guides to the Evaluation of Permanent Impairment 4th & 5th editions

1. **START** Starts reading, Power **ON / OFF**

2. **HOLD** Hold and store reading. The six most recent values are stored for review and comparison.

3. **VIEW** Stored data may be recalled and viewed - up to the last six held data entries. Also displayed are the high, low, and average values; to assist in consistent and valid testing.

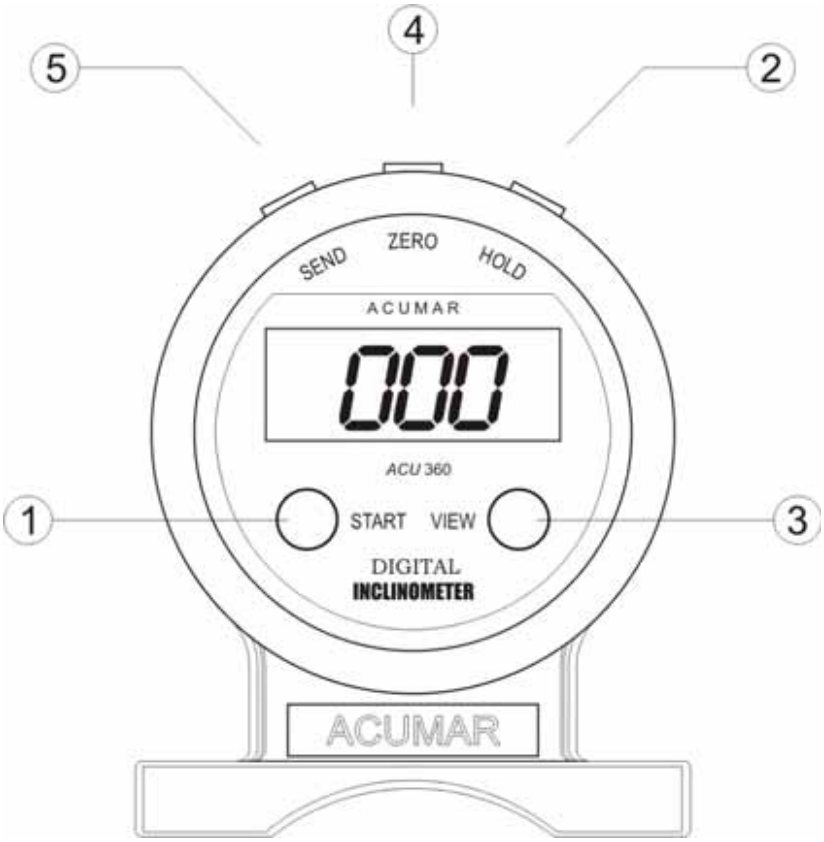


Figure 1: Main Unit

4. **ZERO** This will establish a relative 'zero' in any position. Angles will be read from the new reference position.

5. **SEND** Transmits **IR** data to optional data receiver for documentation and graphing, compatible with **WORD** and **EXCEL**.

Figure 2: Main Unit

1. Turn power on by pressing the **START** button located in the lower left of the unit.

2. To test range of motion, do the following:

   a.) First, establish a point of reference by placing the inclinometer on the arm or hand and read the angle while the body rests in a natural position.
   b.) Then move the body segment under evaluation to see the angle reading change.
   c.) The range of motion is displayed on the LCD in degrees.

3. Turn the unit off by pressing the **START** button again. (The unit will turn off automatically after three minutes if there is no further activity.)

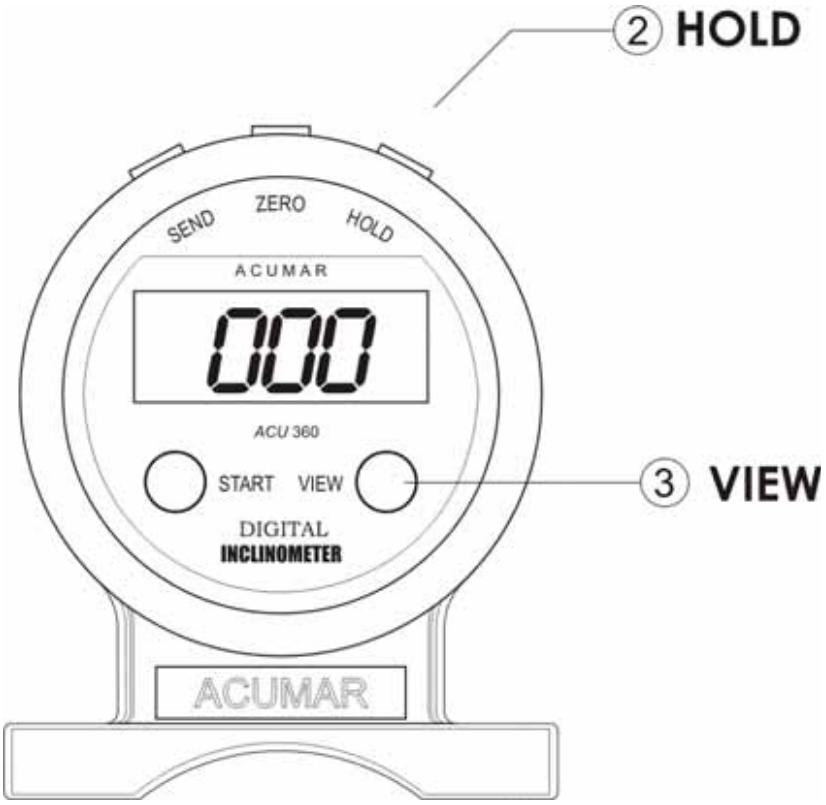


Figure 3: Main Unit

Sample Exercise:

1. Place the inclinometer on your hand in the natural, neutral position.
2. Flex your hand. When maximum flex has been reached, press the **HOLD** button on the top right side of the inclinometer. Repeat 1 and 2 to store up to six measurement readings.
3. After several readings have been stored, they may be displayed one-at-a-time with repeated pressing of the **VIEW** button. Readings will be viewed in sequential order of the last six readings. You will also see the highest reading, indicated by "H" followed by its value, the lowest reading, indicated by "L", and the average value, indicated by "A".



Prepare the Inclinometer:

1. Press the **START** button on the Main Unit.
2. Ask individual to place head in neutral position.
3. Place the Main Unit over the calvarium.

Take Measurements:

1. Ask individual to bend their head to the left.
2. When individual reaches maximum range of motion, press the **HOLD** button to store the maximum left cervical lateral bending angle.
3. Ask individual to return to the neutral position.
4. Repeat measurement steps one through three 3 to 6 times to achieve validity criteria* of $\pm 5^{O}$ or 10%.
5. Follow steps one through four for right cervical lateral bending.

View Data:

1. To recall stored data, press the **VIEW** button to activate View Mode.
2. Pressing the **VIEW** button repeatedly will display the stored readings, as well as the "H" (high), "L" (low) and "A" (average) values.

* Refer to AMA Guides to the Evaluation of Permanent Impairment

1. **VIEW** (momentary press):
    - Subsequent presses display previously stored data, up to last six stored values. Also the high and low absolute stored angles are displayed, followed by the average angular value.

2. **ZERO** (momentary press):
    - Will mark the new reference point as "zero."
    - All subsequent readings are referenced to the marked zero point until the **START** button is pressed to clear the memory setting.

    When **ZERO** is pressed and held for three seconds:
    - The "zero" reference is set to the nearest 90º axis - for plumb measurements.

3. **HOLD** (momentary press):
    - Stores the current reading.
    - Up to six data readings. If you press more than six times, only the last six readings will be stored.
    - AMA Guides suggest a minimum of three data and maximum of 6 data readings.

4. **SEND** (momentary press):
    - Sends stored data.
    - If no data has been stored, it will tab to the next data field.

Q. How long can readings be stored?

A. Indefinitely, until the **START** button is pressed. The unit will automatically shut off power after 3 minutes of inactivity. However, the last set of data will still be in memory. Data remains even if the LCD display is off and the internal computer is in sleep mode. To wake up the memory and resume all functions, simply press **VIEW**. If you want to start a new series of measurements, press **START**. This will clear all data and settings so that the inclinometer is ready for a new set of tests.

Q. Can you set zero at any angle as a new zero reference?

A. Yes. By pressing the **ZERO** button at any angle, the inclinometer will establish a new reference angle for subsequent readings.

Q. Can you rotate the axis of reading?

A. Yes. Normally the inclinometer reads zero degrees when the base is placed on a horizontal level. If you want the base of the inclinometer as a vertical line to read zero, rotate the inclinometer base approximately 90° (plus or minus 30°), then press the **ZERO** button down and hold for three seconds. The inclinometer automatically seeks for a new gravity axis. From there on, any reading will be taken with reference to the new rotated axis.

Press and hold for five seconds
to seek and rotate to a new gravity axis

Figure 4: Rotating axis of reading

Range: 360° (reads 0 to ±185°).

Resolution: 1°

Memory: Holds up to 6 readings

LCD Display: Reads in degrees

Auto Shut Off: After 3 minutes, unit enters a 'sleep' state to save battery life.

Battery: 6V Alkaline (½ AA) (Radio Shack 23-469, Kodak K28A, Energizer A544, Duracell PX28A, Panasonic 4LR44)
Or, for additional battery life:
6V Lithium (½ AA) (Kodak K28L, Energizer L544, Duracell PX28L)
NOTE: The companion unit does not need a battery.

Size: 3.3w; 4h; 0.8d (inches)

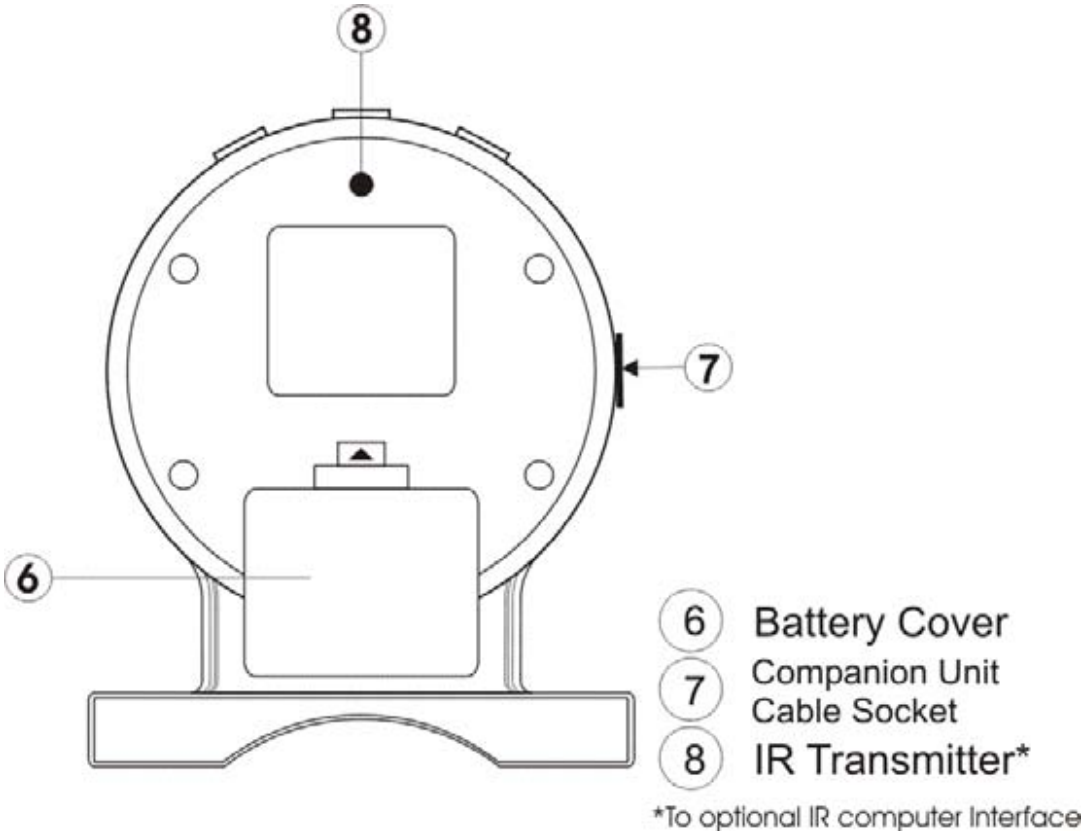


Figure 5: Main Unit Back View

Dual Inclinometer

Dual Inclinometers

Dual Inclinometer Basic Operations

The Dual Inclinometer consists of Main and Companion units. When connected together, it reads both the Main (A) and Companion (C) angle and automatically computes and displays the Joint angle (A-C). When the **COMPANION** button is pressed the display only shows the angle of the Companion unit. When the **MAIN UNIT** button is pressed the display only shows the angle of the Main unit. The **VIEW** button steps through Main (A), Companion (C), and Joint (J = A-C). The **MAIN UNIT** and **COMPANION** buttons will move directly to the appropriate value within the reading when pressed while in **VIEW** mode.

Storing data:

1. Press the **START** button to begin new measurements.
2. Press the **HOLD** button to capture all three angles simultaneously: A, C, and J (A-C).
3. Up to six readings can be stored.

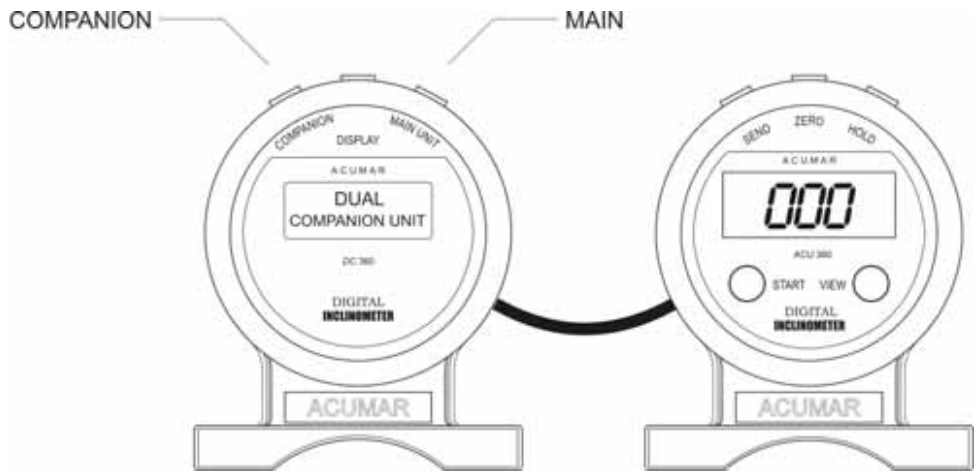
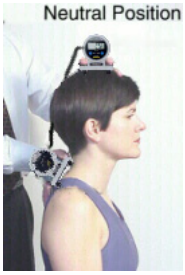


Figure 6: Companion Unit and Main Unit with Connecting Cable

Sample Exercise:

1. Place both units on a flat surface and observe that the reading is zero. Incline the units in opposite directions and notice that the display shows A-C = the angle between them. (Note: use the **ZERO** button to a relative zero at any starting angle, as desired.)
2. Now press and hold the **COMPANION** button. Notice that the display only responds to the movement of the companion unit.
3. Press and hold **MAIN UNIT** button to display the angle of the main unit. Notice that the display only responds to the movement of the main unit.



Take Measurements:

1. Place the Main Unit over the calvarium and the Companion Unit over the skin covering the T1 spinous process. Then press the **START** button on the Main Unit.
2. When individual is in the neutral position, press **ZERO**.
3. To measure cervical flexion ask individual to flex head forward completely and press the **HOLD** button to store the maximum flexion angle (Main angle minus Companion Angle).
4. Ask individual to return to the neutral position and repeat measurements two to five times to achieve validity criteria* of ±5° or 10%.

For cervical extension measurements, the above instructions may be repeated starting with the neutral position and asking the individual to extend the head backward instead.

View Data:

1. To view stored data, press the **VIEW** button to activate View Mode.
2. Pressing the **VIEW** button repeatedly will display stored readings (main, companion, and joint), maximum, minimum, and average values.

* Refer to AMA Guides to the Evaluation of Permanent Impairment, 4th & 5th editions

This manual is designed solely to illustrate the use of the Acumar Digital Inclinometer and/or its accessories, and is not intended nor implied to describe medical examination procedures. Selecting methods of examination and interpreting measured results are the responsibility of practitioners.

Acumar will not warrant that any procedures described herein meet any current or past medical examination guides or procedures required by state or any local governments or other organizations. Acumar expressly disclaims all liability arising from use of this manual. Acumar Digital Inclinometer or related product(s) as stated in the warranty in the latter part of this user's manual.

The use of Acumar Digital Inclinometers to take objective measurements combined with Acumar™ excel templates or any other forms can produce patient files. Like any other patient data, if protection of the privacy of patient files is required, it is the sole responsibility of the provider and of the practitioner. Acumar disclaims all liability for any and all claims.

Acumar™ does not express or imply that the any reference values that may appear on any forms are accurate, relevant, or clinically significant and hereby disclaims all liability for their clinical use herein. Medical judgment should be the ultimate faculty of the practitioner.

One Year Limited Warranty

Digital Inclinometer, Accessories "product(s)"

If, within one year from the date of original purchase, the Acumar Technology's Digital Inclinometer fails to function because of defects in materials or workmanship, the manufacturer will, at its option, either repair or replace such product(s).

To be eligible for warranty service on your product(s), the registration card must be returned within 60 days of initial purchase. To obtain warranty service, contact your dealer for return address. Deliver the product (postpaid) to the location specified by your dealer. Purchaser must include the dated sales receipt (as proof of purchase), and a brief explanation describing why the product is inoperable or how it was damaged.

This warranty does not cover damage resulting from accident, misuse or abuse, water, extreme temperatures, tampering, attachment of unauthorized accessories, servicing performed or attempted by unauthorized agencies, product(s) that have been modified in any fashion, product(s) that have not been maintained in accordance with the instructions in the manual, or any other conditions whatsoever that are beyond the control of the manufacturer.

This product(s) are intended to be used by professional practitioners who are knowledgeable in examination procedures and applicability of test method and proper use. The manufacturer is not responsible for the interpretation of results and use of the information gathered by this product(s). Interpretation of the results are the sole responsibility of the user. In no event will the manufacturer be liable for damages, incidental or consequential, domestic or international, rising from the purchase and use or inability to use the product(s) even if the manufacturer has been advised of the possibility of such damages.

Except as provided herein, the manufacturer makes no warranties, express or implied, including without limitation the implied warranties without limitation of merchantability and fitness for a particular purpose, loss of business, business interruption, loss of business information or other indirect or consequential loss arising out of the use or inability to use or supply or non-supply of the product(s). All warranties for the product(s), expressed or implied, are limited to the warranty period set forth above.

If the product(s) do not perform as warranted herein, the original purchaser's sole remedy will be the repair or replacement of the product(s) as provided above. This warranty gives you specific legal rights. You may also have other rights, which vary from state to state. Because of individual state regulations, some of the above limitations and exclusions may not apply to you.

Appendix A

Acumar Ruler Attachment

Horizontal

Optional Accessory Ruler Attachment

The Digital Inclinometer may be attached to the ruler. Use for orthopedic, podiatric, chiropractic, x-ray film evaluations.

Installation

1. Remove the battery cover of the Main unit. Replace it with the accessory adaptor cover that comes with the Ruler attachment. Store the old battery cover.
2. The Ruler attachment is snapped onto the Main unit in the Horizontal position. It is held by the magnet, and positioned by plastic index pins which fit snuggly into the lower 2 screw holes on the back of the main unit. (See picture)
3. Make certain the latch on the battery cover is snapped securely in place. Check that the Main unit is flat against the ruler. It is held by a magnet to the ruler.

Hint: It may be easier to insert the index pins into the lower screw holes first, and then let the magnet swing the ruler snug with the lower index pins against the top to the Main unit feet.

Left or Right Side Ruler Mounting

Right and Left Side Ruler

The ruler may be mounted either direction on the accessory attachment pattern for your convenience.

The Ruler may be attached either on the Right Side or Left Side by rotating the ruler 180° as shown in the illustration. This may be useful for taking readings on the opposite side of the body.

Vertical Ruler Orientation

Vertical

The measurement axis may be rotated 90°, electronically, to read angles with respect to the vertical gravity axis.

The measurement axis may be rotated 90°, to read vertical as zero degrees by holding the Ruler close to vertical and pressing **ZERO** for about 5 seconds until the readout switches to the vertical angle, for example, **-70° goes to 20**°. Note: the Main unit remains mounted to the Ruler, the measurement axis is shifted electronically. In order to switch back to horizontal as gravity reference, press **START** twice to turn the unit off and back on.

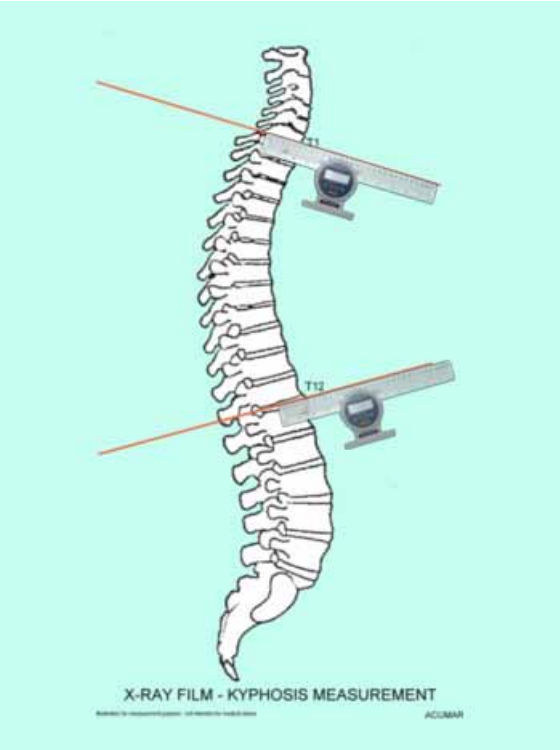
How to use ruler attachment for Extremity Measurements

The ruler attachment may be used to assist in measurements of the upper and lower extremities. It can be used as a place to hold the inclinometer and for alignment. The Inclinometer inherently reads angles with respect to gravity, so Inclinometer need to be set to initial Zero angle the neutral position. The Inclinometer may be zeroed by pressing the ZERO button while the subject is in the neutral position

X-Ray Film reading

Place the X-Ray film on the lighted box mounted on the wall. Place the ruler in line of reference position and then press **ZERO** to initialize reference angle.

Then move the ruler to the second angle to be read and press **HOLD**. The difference angle will be stored and can be viewed by pressing **VIEW**.



Place the X Ray film on the wall mounted light box.

Place the ruler in line of reference position and then press **ZERO** to initialize reference angle to zero.

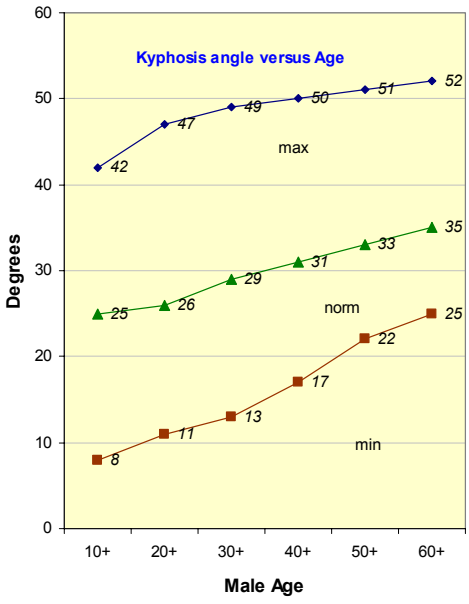
Then move the ruler to the second angle to be read and press **HOLD**.

The difference angle will be stored and can be viewed by pressing **VIEW**.

Disclaimers: This example is not medical advice, but only for illustrating the intended use of the ruler.

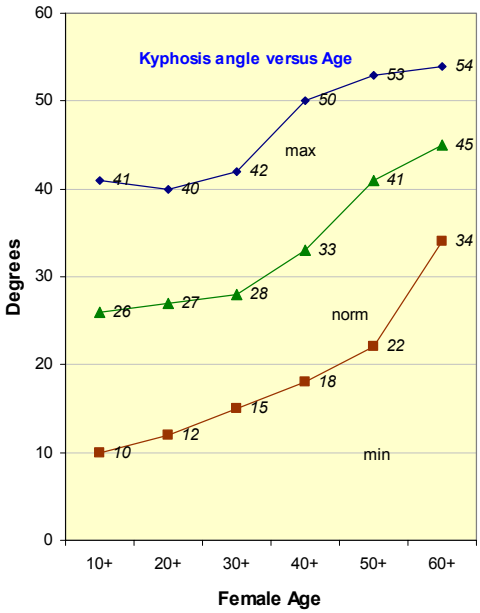
Male Kyphosis Versus Age

Age	10+	20+	30+	40+	50+	60+
Max	42	47	49	50	51	52
Min	8	11	13	17	22	25
Norm	25	26	29	31	33	35



Female Kyphosis Angle Versus Age

Age	10+	20+	30+	40+	50+	60+
Max	41	40	42	50	53	54
Min	10	12	15	18	22	34
Norm	26	27	28	33	41	45



extended wrist

Wrist

Place arm on a flat surface such as table. Wrist at the neutral position place inclinometer on top side of the wrist , then press **ZERO** to mark starting reference position.
Ask individual to extend wrist maximally then press **HOLD** to record reading.
Likewise, Flex of the wrist may be measured .
(Inclinometer adjustable legs may be removed)

neutral position extended position

Upper Extremity Arm

Ruler attachment may be used to assist measurements of Upper or lower extremity.
The ruler may be placed on the side of moving part of joints.

mutual position

leg straight up position

Lower Extremity

Place inclinometer upper portion of the leg (or side of leg if the ruler attachment is used) At the neutral position press **ZERO**.
Straight leg raised position press **HOLD** to store the angle.
This measurements may be used for a validity check for extension/flexion of the lumber spine.

Appendix B

Acumar Sample Data Recording Forms

The following seven pages of forms are included for your convenience. They cover spinal, upper extremity, and lower extremity range of motion measurements.

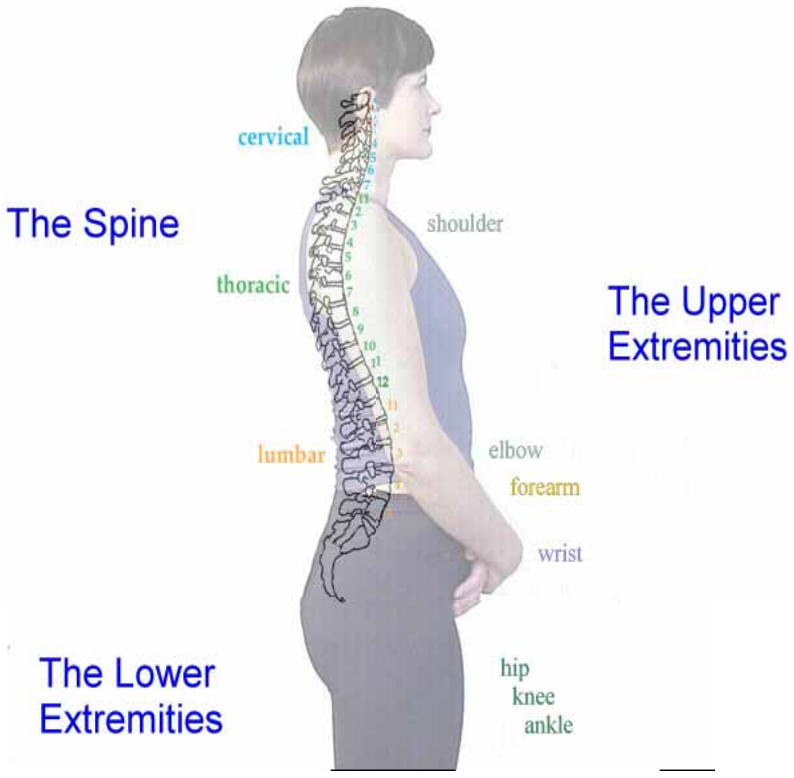
These forms may be copied for the purpose of taking measurements using Acumar Technology Digital Inclinometers, all other rights are reserved.

Acumar™ Range of Motion:

Name:

Session Info.	ID:
	Date:
	Comments:

Examined By:



Acumar™ Range of Motion:
The Spine

Session Info.	
Name:	
ID:	
Date:	
Comments:	

Examined By:

Cervical Range of Motion											
Section	**Description**	**Test**						**Max.**	**Ave.**	**Var.**
1 Cervical Flexion	Calvarium flexion angle									
	T1 angle									
	Cervical flexion ROM									
2 Cervical Extension	Calvarium extension angle									
	T1 angle									
	Cervical extension ROM									
3 Cervical Sagittal Ankylosis	**Flex. / exten. ankylosis (SINGLE)**									
4 Cervical Left Lateral Bending	Calvarium left lateral flexion angle									
	T1 angle									
	Cervical left lateral flexion ROM									
5 Cervical Right Lateral Bending	Calvarium right lateral flexion angle									
	T1 angle									
	Cervical right lateral flexion ROM									
6 Cervical Lateral Ankylosis	**Lateral flexion ankylosis (SINGLE)**									
7 Cervical Left Rotation	**Cervical left rotation ROM (SINGLE)**									
8 Cervical Right Rotation	**Cervical right rotation ROM (SINGLE)**									
9 Cervical Rotational Ankylosis	**Rotation ankylosis (SINGLE)**									

Thoracic Range of Motion

Section	Description	Test						Max.	Ave.	Var.
1 Thoracic Extension Ankylosis	T1 angle									
	T12 angle									
	Kyphosis in Thoracic extension									
2 Thoracic Flexion	T1 flexion angle									
	T12 angle									
	Thoracic flexion ROM									
3 Thoracic Left Rotation	T1 left rotation angle									
	T12 angle									
	Thoracic left rotation ROM									
4 Thoracic Right Rotation	T1 right rotation angle									
	T12 angle									
	Thoracic right rotation ROM									
5 Thoracic Rotation Ankylosis	**Rotation ankylosis (SINGLE)**									

Lumbar Range of Motion

Section	Description	Test						Max.	Ave.	Var.
1 Lumbar Flexion	T12 flexion angle									
	Sacral angle									
	Lumbar flexion ROM									
2 Lumbar Extension	T12 extension angle									
	Sacral angle									
	Lumbar extension ROM									
3 Lumbar Left Straight Leg Raising	**Left SLR angle (SINGLE)**									
4 Lumbar Right Straight Leg Raising	**Right SLR angle (SINGLE)**									
5 Lumbar Left Lateral Bending	T12 left lateral flexion angle									
	Sacral angle									
	Lumbar left lateral flexion ROM									
6 Lumbar Right Lateral Bending	T12 right lateral flexion angle									
	Sacral angle									
	Lumbar right lateral flexion ROM									
7 Lumbar Ankylosis	**Lumbar lateral ankylosis (SINGLE)**									

Acumar™ Range of Motion:
The Upper Extremities

Session Info.	
Name:	
ID:	
Date:	
Comments:	

Examined By:

Shoulder Range of Motion											
Section	**Description**	**Test**						**Max.**	**Ave.**	**Var.**
1 Left Shoulder Flexion	**Left shoulder flexion ROM**									
2 Left Shoulder Extension	**Left shoulder extension ROM**									
3 Right Shoulder Flexion	**Right shoulder flexion ROM**									
4 Right Shoulder Extension	**Right shoulder extension ROM**									
5 Left Shoulder Abduction	**Left shoudler abduction ROM**									
6 Left Shoulder Adduction	**Left shoulder adduction ROM**									
7 Right Shoulder Abduction	**Right shoulder abduction ROM**									
8 Right Shoulder Adduction	**Right shoulder adduction ROM**									
9 Left Shoulder External Rotation	**Left shoulder external rotation ROM**									
10 Left Shoulder Internal Rotation	**Left shoulder internal rotation ROM**									
11 Right Shoulder External Rotation	**Right shoulder external rotation ROM**									
12 Right Shoulder Internal Rotation	**Right shoulder internal rotation ROM**									

Elbow Range of Motion

Section	Description	Test						Max.	Ave.	Var.
1 Left Elbow Flexion										
	Left elbow flexion ROM									
2 Left Elbow Extension										
	Left elbow extension ROM									
3 Right Elbow Flexion										
	Right elbow flexion ROM									
4 Right Elbow Extension										
	Right elbow extension ROM									

Forearm Range of Motion

Section	Description	Test						Max.	Ave.	Var.
1 Left Forearm Supination										
	Left forearm supination ROM									
2 Left Forearm Pronation										
	Left forearm pronation ROM									
3 Right Forearm Supination										
	Right forearm supination ROM									
4 Right Forearm Pronation										
	Right forearm pronation ROM									

Wrist Range of Motion

Section	Description	Test						Max.	Ave.	Var.
1 Left Wrist Flexion										
	Left wrist flexion ROM									
2 Left Wrist Extension										
	Left wrist extension ROM									
3 Right Wrist Flexion										
	Right wrist flexion ROM									
4 Right Wrist Extension										
	Right wrist extension ROM									
5 Left Wrist Radial Deviation										
	Left wrist radial deviation ROM									
6 Left Wrist Ulnar Deviation										
	Left wrist ulnar deviation ROM									
7 Right Wrist Radial Deviation										
	Right wrist radial deviation ROM									
8 Right Wrist Ulnar Deviation										
	Right wrist ulnar deviation ROM									

Acumar™ Range of Motion:
The Lower Extremities

Session Info.	
Name:	
ID:	
Date:	
Comments:	

Examined By:

Hip Range of Motion											
Section	**Description**	**Test**						**Max.**	**Ave.**	**Var.**
1 Left Hip Flexion										
	Left hip flexion ROM									
2 Left Hip Extension										
	Left hip extension ROM									
3 Right Hip Flexion										
	Right hip flexion ROM									
4 Right Hip Extension										
	Right hip extension ROM									
5 Left Hip Abduction										
	Left hip abduction ROM									
6 Left Hip Adduction										
	Left hip adduction ROM									
7 Right Hip Abduction										
	Right hip abduction ROM									
8 Right Hip Adduction										
	Right hip adduction ROM									
9 Left Hip External Rotation										
	Left hip external rotation ROM									
10 Left Hip Internal Rotation										
	Left hip internal rotation ROM									
11 Right Hip External Rotation										
	Right hip external rotation ROM									
12 Right Hip Internal Rotation										
	Right hip internal rotation ROM									

Knee Range of Motion

Section	Description	Test						Max.	Ave.	Var.
1 Left Knee Flexion										
	Left knee flexion ROM									
2 Left Knee Extension										
	Left knee extension ROM									
3 Right Knee Flexion										
	Right knee flexion ROM									
4 Right Knee Extension										
	Right knee extension ROM									

Ankle Range of Motion

Section	Description	Test						Max.	Ave.	Var.
1 Left Ankle Flexion										
	Left ankle flexion ROM									
2 Left Ankle Extension										
	Left ankle extension ROM									
3 Right Ankle Flexion										
	Right ankle flexion ROM									
4 Right Ankle Extension										
	Right ankle extension ROM									
5 Left Ankle Inversion										
	Left ankle inversion ROM									
6 Left Ankle Eversion										
	Left ankle eversion ROM									
7 Right Ankle Inversion										
	Right ankle inversion ROM									
8 Right Ankle Eversion										
	Right ankle eversion ROM									

ACUMAR
By

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