



# **Analysis of the Specificity, Sensitivity and Accuracy of Goniometry Method Compared to Tape Method for Measuring Trunk Mobility in Normal Adults**

**Purvi Patel<sup>1\*</sup>**

<sup>1</sup>College of Physiotherapy, Sumandeep Vidyapeeth An Institution Deemed To Be University, Piparia, Waghodia, Vadodara, Gujarat-391760, India.

## **Author's contribution**

*The sole author designed, analyzed, interpreted and prepared the manuscript.*

## **Article Information**

DOI: 10.9734/JPRI/2021/v33i32B31755

### Editor(s):

(1) Dr. Syed A. A. Rizvi, Nova Southeastern University, USA.

### Reviewers:

(1) Summaiya Zareen Shaikh, D. Y. Patil University, India.

(2) Vladimir Bitsoev, Academy of Medical and Engineering Sciences, Russia.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/70074>

**Original Research Article**

**Received 12 April 2021**  
**Accepted 18 June 2021**  
**Published 22 June 2021**

## **ABSTRACT**

Measurement of lumbar range of motion (LROM) is a routine method in the examination of patients with low back pain. There is no standard technique which may be used to accurately describe the range of motion in the different plane. So in present study, an attempt has been made to compare goniometric measurement with tape measurement for its sensitivity, specificity and accuracy for measuring spine mobility in normal adults. In this cross sectional study, 137 healthy adults between the ages of 18-26 years of age were included consecutively and assessed using Tape method and goniometry for trunk mobility in all planes (sagittal, frontal and transverse). The association of goniometry with tape method was assessed using chi square test. The study showed that the difference between goniometry and tape method was statistically significant (p value <0.05) for all movements except flexion (p value 0.215). Also the sensitivity, specificity and accuracy of goniometry is not as good as tape method except for flexion compared to tape method. So, from this study we can conclude that Goniometry was not as good as tape method for all movements except forward flexion where both can be equally used.

**Keywords:** *Tape method; goniometry; trunk mobility; spinal range of motion.*

## 1. INTRODUCTION

The human spine has crucial role to play in day to day activities which require bending and twisting motion and it also helps in supporting the skull and provides leverage to upper limbs to produce and deliver forces [1,2].

Physiotherapy includes clinical range of motion (ROM) measurement a primary procedure to be performed. Measuring range of motion is considered quantitative and objective method to check the outcomes of physiotherapy compared to pain which is subjective. Its correct interpretation can form a scientific basis for all therapeutic interventions [3].

The physical and anatomical characteristics play an important role in mobility of the spine. Measurement of lumbar range of motion (LROM) is a routine method in the examination of patients with low back pain and it helps determine the degree of permanent impairment in subjects with lumbar dysfunction [4,5,6]. The uses of assessment of spinal range of motion are to monitor the progression of therapeutic intervention, for fitness purpose and to evaluate person with back problems [7,8,9,10].

As the spinal column is a series of joints, the flexibility of spine is complex and not like other limb joints. It is primarily affected by some intrinsic factors like elastic muscle tissue, tendon, ligaments, and skin as well as by extrinsic factors like age of the person, gender, stage of disease and time of measurement. These all factors are mentioned as determinants of joint ROM as stated by Egwu et al. [11].

Studies have shown some validity and reliability for extremity ROM measurements, whereas measurement for trunk motion has proven to be more difficult. These include the use of visual estimation, radiographs, inclinometers, spondylometers, fingertip-to-floor methods, goniometers, plumb lines, and tape measures [12,13]. The literature reveals wide disparity in the values of the ranges of movements in the lumbar region. As a result, there is no standard technique which may be used to accurately describe the range of motion in the different plane. None of these studies investigated mobility for all trunk motions or the reliability estimates of the measurement techniques [9].

Many studies have reported the attempts to accurately measure the spinal mobility range.

Margeret Frost developed a method of measuring spinal extension using a tape measure, plumb bob, and skin marks on the lateral trunk [9]. Margaret and Stuckey described a method of measuring trunk flexion and extension using a flexi-rule and fixed landmarks on the back [9]. Stuckey et al and Hart et al both used a spondylometer to measure spinal mobility [9,14]. Tape measures or flexible rulers are often used to obtain spinal measurements in the sagittal plane [8].

Tape method is considered as the standard and most commonly used method for measuring spine mobility as the spine is a curved structure and so it is very easy to accommodate tape with spine movements and gain accurate results. The goniometric method of measuring spinal mobility, although not the most accurate, seems to be clinically accessible, objective and easy to use [10,15]. It is readily accessible to the physical therapist.

But till now little research has been conducted on comparison of goniometric measurement of spine with tape method. Especially in India, such studies are rare. So in present study, an attempt has been made to compare goniometric measurement with tape measurement for its sensitivity, specificity and accuracy for measuring spine mobility in normal adults. This would help the therapist to assess the trunk mobility with feasibility and still with reliable tools.

## 2. MATERIALS AND METHODS

This cross sectional study was approved by SVIEC (Sumandeep Vidyapeeth institutional Ethical Committee). Written informed consent was obtained from normal healthy adults (apparently without any known disease or condition) between the ages of 18-26 years of age who were willing to participate in the study. A total 137 subjects (66 males & 71 females) for the study were recruited using a convenient sampling from three colleges of Sumandeep Vidyapeeth campus. Subjects who were having history of trauma, thoracic pain, past medical history of a malignant tumour, structural deformity, prolonged use of corticosteroids, drug abuse, immunosuppressant, HIV, any systemic disease, unexplained weight loss, any neurological diseases, fever were excluded.

Demographic details in form of age, gender, height, weight and BMI were taken in all the subjects. All movements of the trunk (flexion with

and without stabilization and extension in sagittal plane, lateral flexion to both the sides in frontal plane and rotation to both the sides in horizontal plane) were measured three times and an average of three was taken. The data then documented for analysis.

For ROM measurement of trunk with tape, the following procedure was used.

### **2.1 Thoracic and Lumbar Flexion and Extension [16]**

The subject was asked to stand erect with no lateral flexion and rotation at cervical, thoracic and lumbar spine. Marking of C7 and S1 spinous processes was done using skin marker. By aligning the tape, Distance between two marks was measured and recorded. The tape was held in place and the subject was asked to perform flexion and then extension (allowing the tape to accommodate the motion.). Hip and knee flexion was avoided. The distance was recorded once patient completes the motion. Discrepancy among the measurements indicated the amount of thoracic and lumbar flexion and extension.

### **2.2 Flexion with Stabilization [16]**

The subject was asked to stand erect with no lateral flexion and rotation at cervical, thoracic and lumbar spine. Subject's pelvis was stabilized by a belt which was attached with a wooden chair to prevent pelvic motion. Rest all Procedure was same as measuring flexion.

#### **2.2.1 Thoracic and Lumbar Lateral Flexion [16]**

The subject was placed in standing position with the arms resting by the side and the distance between the tip of middle finger and the floor at the leg level was measured using tape. With both feet lying flat to the ground and knees in full extension, the subject was asked to arch sideways as much as possible. The distance was measured again and discrepancy was recorded. The same procedure was performed for the opposite side.

#### **2.2.2 Thoracic and Lumbar Rotation [9]**

The subject was asked to be in sitting position keeping knees together and hip 90<sup>0</sup> flexed, arms placed across chest. For right rotation, Left posterior clavicular Prominence to right greater trochanter was marked and measuring tape was

placed. The subject was asked to sit erect and then turn to right side as much as he can. Initial and final distances were recorded. The same procedure was performed for the left side.

For ROM measurement with goniometer, the following procedure was used [17].

### **2.2.3 Spinal Flexion and Extension**

The subject was asked to be in erect standing position keeping feet shoulder width apart. The goniometer was aligned keeping the fulcrum at superior aspect of iliac crest while stationary arm and movable arm were placed perpendicular to the floor and parallel to midaxillary line respectively. The subject was then asked to bend forward and backward as far as possible for flexion and extension respectively keeping the knees extended. At the end of the maximum spinal motion attained by subject, the degrees of motion were recorded.

### **2.3 Flexion with Stabilization**

The subject was standing erect with feet approximately shoulder-width apart. Subject's pelvis was stabilized by a belt which was attached with a wooden chair to prevent pelvic motion. Rest all procedure was same as measuring spinal flexion.

#### **2.3.1 Lateral Flexion**

Subject was positioned in erect standing keeping the feet shoulder-width apart, the fulcrum of goniometer was placed at the level of lumbosacral junction. The position of stationary arm was perpendicular to the floor while movable arm was positioned parallel to spine taking reference point of C7 spinous process. To keep the goniometer at eye level, the observer was sitting behind the subject. Then subject was asked to bend sideward as far as possible. The degrees of motion were recorded for both right and left side.

#### **2.3.2 Thoracic and Lumbar Rotation**

The subject was placed in sitting without back support, keeping the feet flat on the floor to stabilize the pelvis. The goniometer was aligned keeping the fulcrum over the center of cranial aspect of patient's head and the stationary arm was kept parallel to imaginary line joining both prominent tubercles of iliac crests. The movable arm was aligned parallel to line joining two

acromion processes. Now the subject was asked to perform the motion. At the end of the rotation, the degrees of motion were recorded for both right and left side.

### 3. RESULTS

The data were analyzed with using SPSS software (version 14).

Trunk mobility was assessed using Goniometry and tape method

Total participants ---137  
 Age range was ---18 to 26 years  
 Percentage of Males --- 66(48%)  
 Percentage of Females --- 71(52%)  
 Mean age of total participants ---20.42±2.32 (male-19.56, female-21.22) years  
 Mean BMI of total participants --- 20.94±4.03 (male-20.71, female-21.16) kg/m<sup>2</sup>

Table 1 shows descriptive values of all Rom of trunk which has been measured with goniometer as well as tape method.

For measuring specificity, sensitivity and accuracy of goniometry compared to tape method, cut off value was set. The cut off values for flexion were 7 cm and 70 degrees, for flexion with stabilization were 10 cm and 99 degrees, for extension 4 cm and 25 degrees, for lateral flexion 17 cm and 35 degrees and for rotation 5 cm and 45 degrees for tape method and goniometry respectively. Fig. 1 to 7 shows sensitivity, specificity and accuracy of goniometry compared with tape method for measuring trunk mobility (flexion with stabilization, flexion, extension, right and left lateral flexion, right and left rotation). Using these values, percentage of sensitivity, specificity and accuracy were counted. These percentages were analyzed using chi square test to find out the association between both the methods. The level of significance was kept at <0.05. The Table 2 suggests, all movements except flexion shows significant difference between tape method and goniometry.

**Table 1. Mean, Standard deviation for different movements using both methods**

Method	Variables	Mean	Std. Deviation
Tape measurement	Flexion Stabilization (cm)	6.95	0.64
	Flexion (cm)	9.59	0.73
	Extension (cm)	4.71	0.51
	Rt Lateral Flexion (cm)	17.28	2.59
	Lt Lateral Flexion (cm)	17.06	2.54
	Rt. Rotation (cm)	5.49	0.55
	Lt. Rotation (cm)	5.38	0.55
Goniometry	Flexion Stabilization (degrees)	74.68	5.67
	Flexion (degrees)	99.33	5.53
	Extension (degrees)	26.03	3.29
	Rt Lateral Flexion (degrees)	32.95	3.38
	Lt Lateral Flexion (degrees)	32.60	3.44
	Rt. Rotation (degrees)	41.93	3.35
	Lt. Rotation (degrees)	41.65	3.39

**Table 2. Association between tape measurement and goniometry**

Variables	Chi square value	P value
Flexion with stabilization	13.56	.000*
Flexion	1.538	.215
Extension	16.92	.000*
Rt. Lateral flexion	6.458	.011*
Lt. lateral flexion	4.227	.040*
Rt. Rotation	5.993	.014*
Lt. Rotation	8.877	.003*

\*shows significant result at 0.05 level Sensitivity, specificity and accuracy of Goniometry method

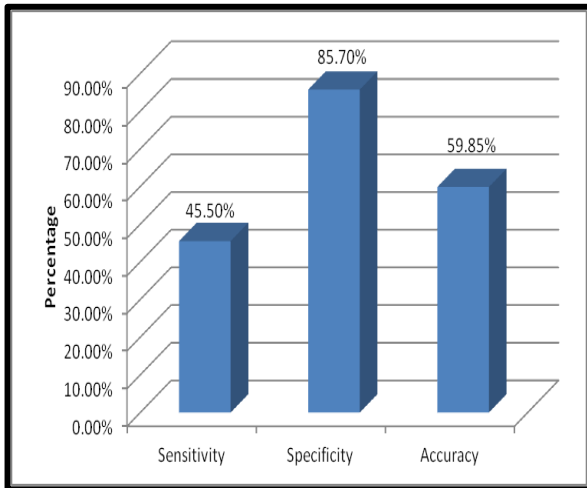


Fig. 1. Flexion with stabilization

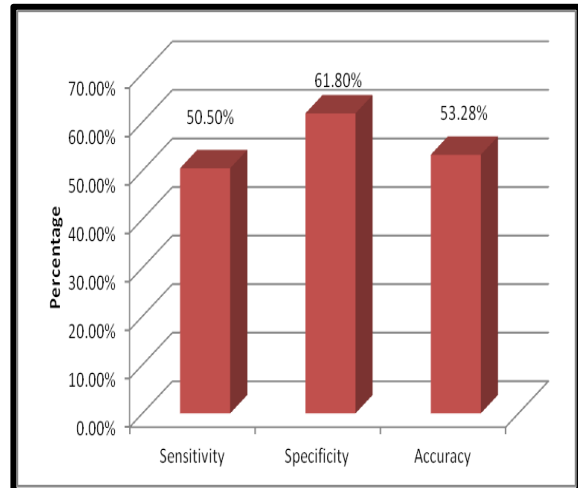


Fig. 2. Flexion

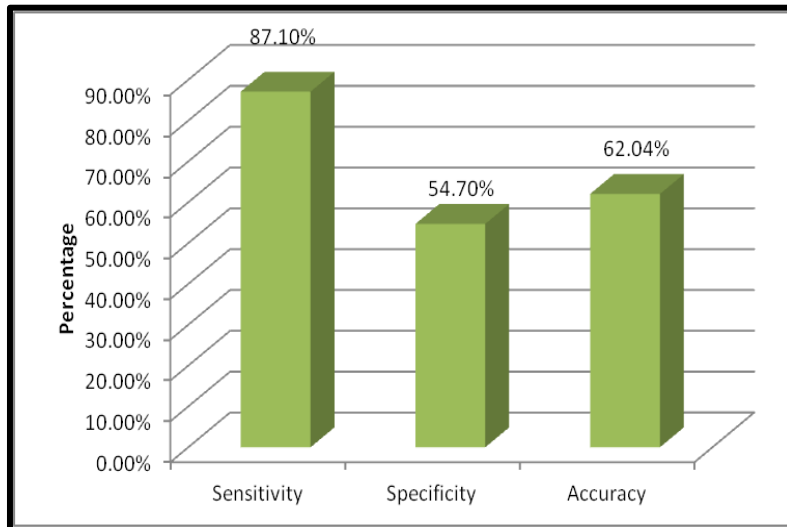


Fig. 3. Extension

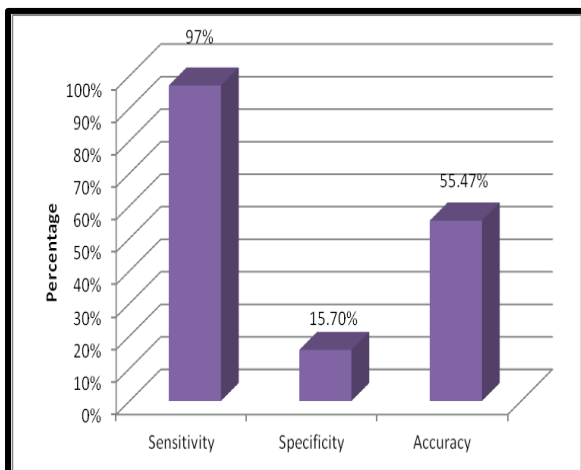


Fig. 4. Rt. Lateral Flexion

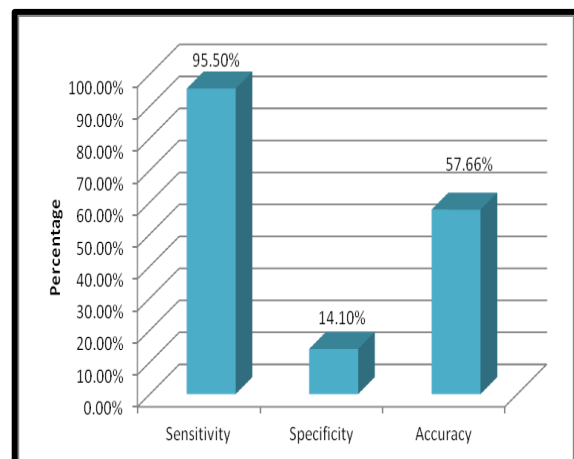


Fig. 5. Lt. Lateral Flexion

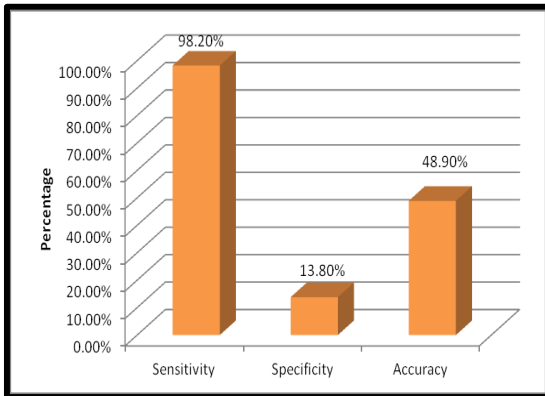


Fig. 6. Rt. Rotation

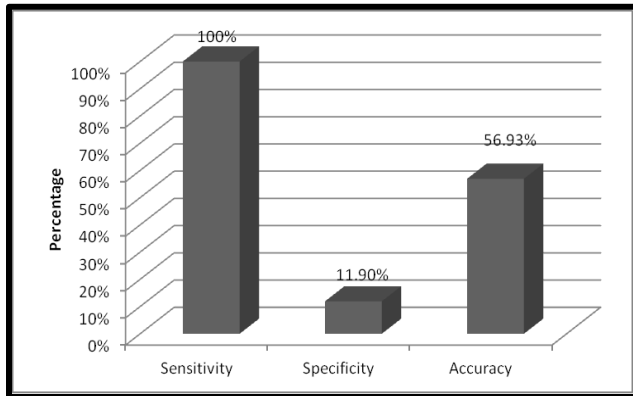


Fig. 7. Lt. Rotation

#### 4. DISCUSSION

The purpose of the study was to compare goniometric measurement with tape measurement for its sensitivity, specificity and accuracy for measuring spine mobility in all planes (sagittal, frontal and transverse) in normal adults.

In the present study, each movement was measured three times and an average of three was taken. Devra K Einkauf et al suggest performing only once to eliminate the possibility of a "practice effect" that might increase their ROM progressively with each trial and by allowing the subjects only one attempt to reach their Maximum range for each movement can give an accurate result. However, Margaret Frost suggested that taking an average of successive repetitions improve the reliability of all measurements [9,10].

Mayerson and Milano tested reliability of goniometer in their study on lumbar spine and they found goniometric measurements as doubtful and reasoned that the spine has multiple joint axes with positions that change during the movement so measurement of movement of the lumbar spine is a challenge. For all spinal movements except forward flexion, the present study also found that the accuracy of goniometry was not as good as tape method (table 2). However Nattrass CL stated that the goniometric method of measuring spinal mobility, although not the most accurate, seems to be clinically accessible and easy to use [18,19].

##### 4.1 Sagittal Plane Movements

On comparing Goniometry with tape method for flexion, the sensitivity of goniometry for flexion

with and without stabilization in the study were 45.5% & 50.5%, specificity were 85.7% & 61.8% and accuracy were 59.85% & 53.28% respectively (Fig. 1 and 2). So from this result, both methods can be recommended to measure spinal flexion. Bedekar found high intra rater and moderate inter rater reliability for trunk flexion with goniometry. However, Margaret Frost found good reliability of tape method for forward flexion though the possible error in palpating bony prominence exists but it can be reduced by repeating several times [9,20].

On comparing goniometry with tape method for extension, the Sensitivity of goniometry for spinal extension was found to be 87.1%, Specificity was 54.7% and Accuracy was 62.04 % Fig. 3). So from this study, tape method is recommended to measure spinal extension. Paul Beattie found that attraction method for measuring trunk extension in cm is highly reliable. Nattrass CL showed poor reliability of goniometer for trunk measurement [19,21].

##### 4.2 Frontal Plane Movements

On comparing goniometry with tape method for lateral flexion, the sensitivity of goniometry for right and left lateral flexion in the study was 97.0% & 95.5%, specificity was 15.7% & 14.1% and accuracy was 55.47% & 57.66% respectively (Fig. 4 and 5). So from this study, tape method is recommended to measure spinal lateral flexion. Caroline Perret et al found high reliability of finger tip to floor test by tape method [21].

##### 4.3 Transverse Plane Movements

On comparing goniometry with tape method for rotation, the sensitivity of goniometry for right and left rotation in the study was 98.2% & 100%, specificity was 13.8% & 11.9% and accuracy was

48.90% & 56.93% respectively (Fig. 6 and 7). So from this study, tape method is recommended to measure spinal rotation. However, Olson KA found good reliability of goniometer to measure rotation of the trunk [20].

## 5. CONCLUSION

This study analyzed the sensitivity, specificity and accuracy of goniometry compared to tape method for measuring trunk mobility and shows that specificity and accuracy of goniometry is not as good as tape method for measuring extension, lateral flexion and rotation of trunk. So author conclude here that Goniometry can be used for measuring forward flexion and it is comparable to Tape method however for the rest of all other movements, where tape measurement is not possible, goniometry should be chosen with caution while measuring trunk mobility.

## CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

## ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

## COMPETING INTERESTS

Author has declared that no competing interests exist.

## REFERENCES

1. Schenkman M, Shipp KM, Chandler J, Studenski SA, Kuchibhatla M. Relationships between mobility of axial structures and physical performance. *Physical Therapy*. 1996;76(3):276-85.
2. Zhao GR, Ren L, Ren LQ, Hutchinson JR, Tian LM, Dai JS. Segmental kinematic coupling of the human spinal column during locomotion. *Journal of Bionic Engineering*. 2008;5(4):328-34.
3. Gajdosik RL, Bohannon RW. Clinical measurement of range of motion: review of goniometry emphasizing reliability and validity. *Physical Therapy*. 1987; 67(12):1867-72.
4. Peharec S, Jerković R, Bačić P, Azman J, Bobinac D. Kinematic measurement of the lumbar spine and pelvis in the normal population. *Collegium Antropologicum*. 2007;31(4):1039-42.
5. Saur PM, Ensink FB, Frese K, Seeger D, Hildebrandt J. Lumbar range of motion: reliability and validity of the inclinometer technique in the clinical measurement of trunk flexibility. *Spine*. 1996;21(11):1332-8.
6. Perret C, Poiraudou S, Fermanian J, Colau MM, Benhamou MA, Revel M. Validity, reliability, and responsiveness of the fingertip-to-floor test. *Archives of Physical Medicine and Rehabilitation*. 2001;82(11):1566-70.
7. Cupon LN, Jahn WT. Current standards for measuring spinal range of motion for impairment. *Journal of Chiropractic Medicine*. 2003;2(1):8-12.
8. Madson TJ, Youdas JW, Suman VJ. Reproducibility of lumbar spine range of motion measurements using the back range of motion device. *Journal of Orthopaedic & Sports Physical Therapy*. 1999;29(8):470-7.
9. Frost M, Stuckey S, Smalley LA, Dorman G. Reliability of measuring trunk motions in centimeters. *Physical Therapy*. 1982;62(10):1431-7.
10. Einkauf DK, Gohdes ML, Jensen GM, Jewell MJ. Changes in spinal mobility with increasing age in women. *Physical Therapy*. 1987;67(3):370-5.
11. Egwu MO, Mbada CE, Olowosejeje D. Normative values of spinal flexibility for Nigerians using the inclinometric technique. *Journal of Exercise Science and Physiotherapy*. 2012 Dec;8(2):93.
12. Johnson KD, Grindstaff TL. Thoracic region self-mobilization: a clinical suggestion. *International Journal of Sports Physical Therapy*. 2012;7(2):252.
13. Beattie P, Rothstein JM, Lamb RL. Reliability of the attraction method for measuring lumbar spine backward bending. *Physical Therapy*. 1987;67(3):364-9.
14. Hart FD, Strickland D, Cliffe P. Measurement of spinal mobility. *Annals of the Rheumatic Diseases*. 1974;33(2):136.
15. Adach Z, Latour E, Tomaszewski W. The use of accelerometric goniometry for evaluation of spineflexion. *Chirurgia Narzadow Ruchu i Ortopedia Polska*. 2005;70(4):275-8.
16. Norkin CC, White DJ. Measurement of joint motion. A guide to Goniometry. 2003;3:345-61.

17. Fitzgerald GK, Wynveen KJ, Rheault W, Rothschild B. Objective assessment with establishment of normal values for lumbar spinal range of motion. *Physical Therapy*. 1983;63(11):1776-81.
18. Chertman C, Santos HM, Pires L, Wajchenberg M, Martins DE, Puertas EB. A comparative study of lumbar range of movement in healthy athletes and non-athletes. *Revista Brasileira de Ortopedia*. 2010;45(4):389-94.
19. Natrass CL, Nitschke JE, Disler PB, Chou MJ, Ooi KT. Lumbar spine range of motion as a measure of physical and functional impairment: an investigation of validity. *Clinical Rehabilitation*. 1999;13(3):211-8.
20. Olson KA, Goehring MT. Intra and inter-rater reliability of a goniometric lower trunk rotation measurement 1. *Journal of Back and Musculoskeletal Rehabilitation*. 2009;22(3):157-64.
21. Bedekar N, Suryawanshi M, Rairikar S, Sancheti P, Shyam A. Inter and intra-rater reliability of mobile device goniometer in measuring lumbar flexion range of motion. *Journal of Back and Musculoskeletal Rehabilitation*. 2014;27(2):161-6.

---

© 2021 Patel; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*  
<http://www.sdiarticle4.com/review-history/70074>