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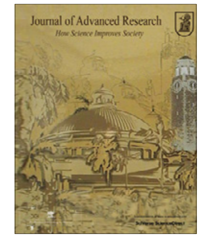

ORIGINAL ARTICLE

The validity of spinal mobility for prediction of functional disability in male patients with low back pain

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Abstract Clinical assessment of functional disability is an integral part of management in patients with low back pain (LBP). The range of spinal motion is one of LBP disability measure. The aim of this study was to investigate the validity of spinal range of motion as a predictable measure of disability and to analyze the intrarater reliability of back range of motion (BROM) instrument for measurement of active lumber spine range of motion. Forty men patients with chronic low back pain over 6 month's duration were participated in the study. Their ages ranged from 20 to 40 years. Lumber range of motion was measured with BROM device and disability was evaluated by self reported Roland Morris disability questionnaire (RMDQ). Data were analyzed using Spearman's correlation, multiple regression analysis models and ICC. Statistical analysis revealed that there was a highly significant moderate to good relation between forward trunk flexion and RMDQ score (rho = −0.59, $p < 0.001$). While there was a weak correlation between trunk extensions, lateral trunk flexion and trunk rotation with the RMDQ scores ($p > 0.05$). The main predictors of disability were forward and lateral trunk flexion. Furthermore, intrarater reliability for forward trunk flexion was good (ICC, 0.84), for extension was high (ICC, 0.91), for rotation was good (ICC range, 0.86–0.88), and for lateral flexion was good (ICC range, 0.81–0.82). It was suggested that spinal ROM do not appear to be a valid measure for prediction of the functional disability in patients with chronic low back pain.

Introduction

Low back pain is a most costly problem that plagues the developed world; it is considered the common cause of disability in men and women less than 45 years [1]. In the industrialized countries back problems is an elusive disorders encountered modern medical practice that puts a large social and economic burden on society as well as affected individuals [2]. Although most of the patients who reported back pain returned to work within 2–3 months, about 80% of them were complaining from recurrent attack of LBP with prolonged disability [3].

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Clinical assessment for individuals with LBP has traditionally relied on tests of disability which has been reported to correlate poorly with patients' pain and dysfunction [4]. Evaluating the disability of patients with LBP requires selecting appropriate disability measures. A key disability measure for studying patients with LBP is a self-report questionnaire which entity dependent on patients subjective feelings including: Roland Morris disability questionnaire (RMDQ), Oswestry Disability Index (ODI), and Quebec Back Pain Disability Scale (QBPDS) [5]. However most of patients' self-reports of disability may not be adequate in making precise judgment of their condition without the objective evaluation of their physical performance [6].

Spinal range of motion is a routinely method for LBP assessment, however there is a lack of evident correlation between impaired spinal mobility and level of disability in patient with chronic LBP [7]. The use of range of motion scores to make inferences about a patient's level of permanent disability in chronic low back pain requires evidence of criterion-related validity, if the validity was approved, range of motion could be used to predict the level of disability in LBP patients [8,9].

Measurements of active lumber ROM can be obtained with various techniques. Radiographs have been considered the standard for quantifying spinal mobility. However, the use of ionizing radiation raises ethical questions for sequential documentation of spinal ROM with human subjects [10]. For this reason, previous studies used various noninvasive methods for measuring lumber ROM including flexible ruler [11], inclinometer [12], tape measures [13], and the modified Schober test [14]. The tape measure or flexible rules are often used to obtain spinal measurement in sagittal plane. A tracing of the subject lumbar spinal curve is made on piece of paper after molding the rule according to the patient lumbar curve. To determine the degree of the curve a mathematical calculation has been done, making this method tedious and time consuming [15]. Also there has been a considerable restriction in its wide application because of difficulties in measurements due to complex spinal mobility [16]. So results of the previous studies that investigated this relation based on unvalidated measures were not confirmed [17].

Back range of motion (BROM) device (Performance Attainment Associates, Roseville, Minn) is an objective and reliable method for measuring lumbar spine ROM in all planes independent of thoracic and/or hip motion [18]. It is a modified protractor goniometer to measure lumbar spinal mobility in all three plans. An advantage of the BROM device is that it can measure all lumbar motions independent of thoracic and hip motions [19]. The only other aforementioned devices capable of isolating lumbar motion are the skin-distraction techniques and the flexiruler. However, studies using skin-distraction techniques have inconsistent reliability and validity results and the flexiruler technique is only limited to measure the sagittal motion [20].

The reliability of the BROM instrument in measuring lumber ROM has been tested in different studies. The results showed that BROM provide a reliable means of measuring lumber forward flexion, side bending, and pelvic inclination when performed in subjects without a current complaint of LBP [21,22]. Tousignant et al. [23] investigated the criterion validity of the BROM and Electronic Digital Inclinometer devices. They compared the range of motion measurements of low back pain (LBP) patients taken with the BROM II and digital inclinometer with measurements using the double inclinometer (DI) method as the gold standard. Forty subjects with LBP volunteered for the study. The subjects were asked to do three forward flexion movements. A measurement was taken with each of the three different devices for each movement the results showed that the BROM demonstrated good linear relationship (Pearson $r = 0.78$; 95% CI: 0.78–0.94) with the gold standard [23]. Up to our knowledge, there is no established data about the reliability of BROM device in measuring lumber ROM in patients with LBP.

The current study aimed to investigate the criterion validity of spinal ROM as a predictable measure for functional disability more thoroughly using an accurate and reliable BROM instrument and to test the intrarater reliability for measurements of lumbar spine ROM by using BROM device.

Patients and methods

Subjects

A total of 50 chronic low back pain patients were recruited from the orthopedic and neurological outpatient clinics of Cairo university hospitals based on neurological assessment and MRI investigation. Eligible patients included male patients ranging in age from 20 to 40 years. Patients have primary compliant of low back pain that altering normal activities but without neurological findings (muscle weakness, loss of sensibility or reflexes). Pain was nonspecific in nature lasting more than 6 months, rating $\geqslant 5$ points on a 10-cm visual analog scale at the time of screening. Patients were excluded if they had cervical or thoracic involvement, degenerative disc disease, spinal stenosis, history of visceral pathology that could refer pain to back or lower limb, surgical approach at lumber area, spinal tumor, ankylosing spondylitis, idiopathic scoliosis, spondylolysis, and infectious arthritis [24]. Out of 50 patients screened for eligibility, six patients were excluded because they did not fulfill the inclusion criteria. Four patients refused to participate and 40 patients were eligible to enroll in the study.

A pilot study was conducted on five male patients with chronic non-specific LBP aged from (20–40) years to estimate the intrarater reliability for measurements of lumbar spine ROM by using BROM device.

Instrumentations

Back range of motion (BROM) device

It consists of two plastic units: an inclinometer for measuring pelvic inclination and sagittal plane motions and a combination gravity goniometer/compass for side bending and rotational motions, respectively. For measuring flexion and extension ROM, the inclinometer device is secured to the skin overlying the subject's sacrum by using self-adhesive straps around the pelvis to hold the device in place. The unit is then positioned so that the level vial is centered, and a reading is recorded in degrees. An L-shaped slide arm is inserted into the distal portion of the unit to record the distance between the T12 and S1 spinous processes Fig. 1.

During flexion and extension movements, the L-shaped slide arm is held at T12 to guide the plastic protractor. With the motions tested in standing, the pelvis is not fixated. How-

Fig. 1 Flexion–extension unit.

ever, placement of the device over S1 pelvic component allows for isolation of lumbar motion without including pelvic motion. Range of motion (ROM) is recorded in degrees from the protractor side of the device that is marked in 1° increments [21].

The second plastic unit consists of a compass positioned at a right angle above a gravity goniometer. During rotation, a magnet is suspended at the level of S1 from a waist strap and degrees of rotation (marked in 2° increments) are read from a superior position looking down on the compass. During side bending, degrees of motion are read posteriorly from the gravity goniometer that is marked in 2° increments Fig. 2. The BROM devise with its two measuring units provides more efficiency and objectivity of the back ROM measurement, as the flexion/extension unit has not been moved during measurement, so there is no repositioning error, the protractor base was designed to minimize the movement of the base on the sacrum, the sliding arm tip eliminated rocking on the upper measurement point, and the magnet booster in the rotation/lateral flexion unit compensated for unwanted patient's movements [19].

Methods

The sample size was calculated based on previous studies [25,26]. A power analysis with 95% CI of ±10% estimated that 47 subjects would be required to clinically significant the validity of spinal mobility for prediction of disability with 35% SD. Approval for this cross-sectional study was obtained from the local research ethics committee in the faculty of physical therapy, Cairo University. Informed written consent was obtained from all patients. The evaluation procedures should be started with pain assessment followed by disability and finally with spinal mobility assessment to avoid the pain behavior effects on disability and ROM assessment.

Pain assessment

The pain intensity was measured using VAS. This is a 10 cm calibrated line with 0 (zero) representing no pain and 10 (ten) representing worst pain. The patients were asked to make a mark/point on the scale that best represent the intensity of average estimated pain experienced over the day. The distance between zero and the mark/point was then measured and recorded [27].

Disability assessment

The level of disability was assessed by Roland Morris disability questionnaire (RMDQ). It is one of the most common instruments used to assess the functional status of patients with LBP. In particular, the phrase "because of my back" was added to relevant questions in the RMDQ to elicit back pain-specific responses. It consists of 24 statements concerning restriction of daily living activities due to back pain, including items related to mobility, self-care and sleep. Each item that is answered "yes" is scored one point. Score summation ranging from 0 representing "no disability" to 24 representing "extremely severe disability" reliability and validity were well supported across a range of clinical studies [28].

Back ROM assessment

Lumber ROM was assessed with the subjects in erect standing position, on a line that was previously fixed on the floor, so that they formed a right angle, keeping feet and knees aligned with

Fig. 2 Rotation–lateral flexion unit.

the hip. During the measurement, patients were advised to maintain the eyes focused on the horizon while remaind standing in front of and the back turned to the examiner, who, in the sitting position, performed the palpation and marked the anatomical references related to the instrument with a marker pen.

All lumbar motions and subsequent measurements were performed according to the manufacturer's specifications. Each patient was given three warm-ups repetitious for each movement to provide a pre-condition stretch to the soft tissue of the lumber spine in each plane of motion. S1 vertebra was located by using the technique described by Hoppenfeld [29] and the T12 spinous process was palpated by following the twelfth rib medially and superiorly or by counting up from S1, depending on the degree to which landmarks were palpable.

The examiner positioned the BROM over the spinal process S1 and the patient was asked to fix the straps crossing them over the lower abdominal region. Then, the examiner verified whether the inclinometer was fixed and positioned on the reference and placed him or herself to the right side of the volunteer, looking at the right side of the volunteer's body. The shaft of the BROM was placed on T12, so that the shaft line was positioned in the middle of the markings made by the marking pen. The examiner carried out the reading for the assistant so that his or her eyes were fixed on the straight line marking.

Subsequently, the patient was asked to perform a trunk flexion, sliding his or her hands along the legs and letting the arms hang down at the end of the movement. Once more, the examiner read the angle registered at the BROM and asked the patient to return to the initial position. The same procedures were repeated for extension. The reading was taken and the difference between the base line measurement and position of full extension that documenting the full range of spine extension.

During lateral flexion measurements, the patients stood parallel to a wall to avoid substitution pattern of forward trunk flexion. Reading was taken from the inclinometer. The positioning frame was leveled at the upper measurement point and directed to zero, the patient was instructed to slide his hand down the side of his thigh while maintaining his weight over the other leg and foot.

During trunk rotation measurements, the magnetic booster was placed around the patient's pelvis at the level of iliac crest. The arrow pointed to the north; the positioning frame was parallel to the ground. The patient was instructed to twist his trunk to one side as far as he can. The rotation reading was taken from the compass. During spinal range of motion assessment including forward flexion, lateral flexion, rotation and extension, the patients was instructed to hold movement if back discomfort was perceived.

Data analysis

Data analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 18 (Norusis/SPSS, Chicago, IL). Descriptive statistics were used for mean and standard deviations including patient's demographic data Spearman's rho correlation was calculated to describe the association between spinal range of motion and Roland Morris disability score. Multiple regression analysis (enter model) were used to test spinal mobility as valid predictor for functional disability.

The intratester reliability has been calculated by the intraclass correlation coefficient (ICC). Three trials were obtained from each patient, Measurements of each trial were conducted on the same day and within the same session. ICC values were calculated between the 1st and 3rd trial using *t*-test. Inter class correlation was analyzed using the following previously established categories for expressing levels of reliability: high reliability, .90–.99; good reliability, .80–.89; fair reliability, .70–.79; and poor reliability, .69 or less [30]. The level of significant was 0.05 for all statistical analysis.

Results

Forty male patients with chronic low back pain, aged from 20 to 40 years who fulfilled the inclusion criteria participated in the study. Demographic characteristics and mean value of self reported Roland Morris disability score are clarified in Table 1. The descriptive statistics of the spinal rang of motion including: forward trunk flexion, trunk extension, lateral flexion and rotation are shown in Table 2.

The correlation between spinal rang of motion and RMDQ score are listed in Table 3. Analysis of these results revealed that there was an inverse moderate correlation between forward trunk flexion ROM and RMDQ score (rho = −0.590, $p < 0.001$) Fig. 3. Spearman's rho correlation between trunk extension ROM and Roland Morris disability score is shown in Fig. 4, the results revealed that there was an inverse weak correlation between trunk extension ROM and RMDQ score (rho = −0.11, $p < 0.001$).

Table 4 shows the multiple regression analysis predicting functional disability in LBP patients. Predictors include spinal ROM (flexion, extension, lateral flexion and rotation). As the main focus of this study was to investigate the relation between spinal mobility and self reported functional disability (RMDQ), the influence of patient's demographic characteristics were not included in the regression analysis model. As illustrated in this table adjusted $R^2 = 0.366$ which indicated that spinal ROM accounting for 0.366 of the variance in RMDQ score in patients with chronic LBP.

Standardized Beta coefficient revealed that forward trunk flexion is a good to fair predictor for function disability in patients with LBP ($p < 0.01$), however lateral trunk flexion, trunk extension and rotation are weak predictors ($p > 0.05$).

The results of the pilot study showed that intrarater reliability for forward trunk flexion was good (ICC, 0.84), for extension was high (ICC, 0.91), for rotation was good (ICC range, 0.86–0.88), and for lateral flexion was good (ICC range, 0.81–0.82) as illustrated in Table 5.

Table 1 Demographic data of 40 LBP patients.

Characteristics	Mean ± SD
Age (years)	30 ± 5.72
Weight (kg)	78.8 ± 13.71
Height (cm)	168 ± 5.34
Duration (months)	9.2 ± 1.75
RMDQ[a]	6.85 ± 3.5
Pain	8.07 ± 1.16

[a] Roland Morris disability questionnaire.

Table 2 Descriptive statistics for spinal range of motion.

Movements	Mean	SD
Forward trunk flexion	16.67	±4.0
Trunk extension	3.32	±2.0
Right trunk flexion	14.27	±3.0
Left trunk flexion	15.76	±3.2
Right trunk rotation	11.78	±3.8
Left trunk rotation	11.72	±4.4

Table 3 Spearman's rho correlation between spinal ROM and Roland Morris disability score.

Rang of motion	Roland's score	
	Correlation (rho)	*p*-Value
Forward trunk flexion	−.590**	0.000
Trunk extension	−.299	0.061
Left trunk flexion	−.087	0.597
Right trunk flexion	−.345*	0.029
Left trunk rotation	−.145	0.371
Right trunk rotation	−.216	0.181

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

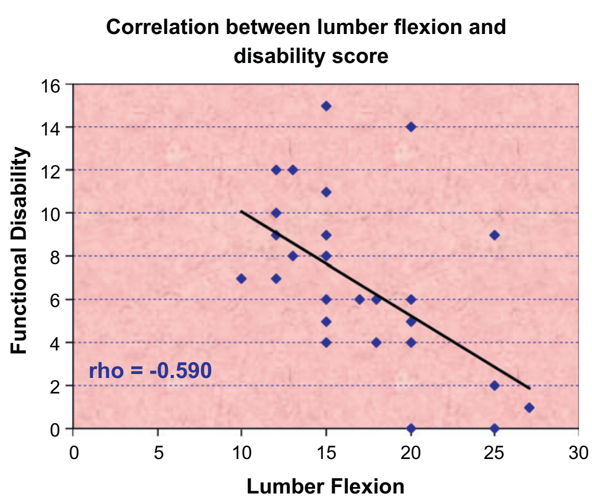

Fig. 3 Correlation between ROM of trunk forward flexion and disability score.

Discussion

This study was conducted to investigate the validity of spinal mobility for prediction of functional disability in cohort of male patients with chronic low back pain. The results revealed that all spinal ROM measurements except forward trunk flexion have a weak relation with the Roland's disability score. This finding indicates that spinal ROM cannot be used as a valid measure for disability in patients with LBP and numerous other factors such as psychological and environmental factors may interfere with the LBP disability determination.

The relation between forward trunk flexion and disability score may be attributed to the dominance of trunk flexion in almost all human functional activities. Moreover forward

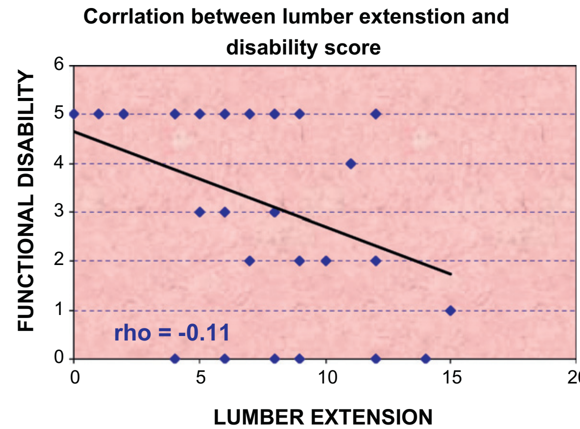

Fig. 4 Correlation between ROM of trunk extension and disability score.

trunk flexion test is the most commonly quick test for patients with LBP. So restriction of trunk flexion may have a major impact on the individual performance in daily activities leading to high level of disability specially in patients with chronic LBP. Based on the finding of this study, trunk flexion represents the most related ROM to the level of disability which indicates that forward trunk flexion is the most painful ROM in chronic LBP patients.

Regarding the prediction of disability, it was found that almost 34% of the variance of RMDQ is explained by forward bending. All other measures show weak or non-relationship to RMDQ. As, in the multiple regression analysis, all the independent variables together explained the variance of the dependent variable (36%) at the same level as the forward bending alone. Thus, lumber flexion cannot be used separately as a collective score or index for disability.

In the area of impairment and disability, many research works were conducted to identify the relation between impaired spinal mobility and patient' disability in LBP. Parks et al., reported no relationship between lumbar motion and functional test scores in chronic back pain [25], Poitras et al. reported weak positive associations between lumbar range of motion and disability in sub-acute and chronic back pain [26]. Also Simmonds et al., found that lumbar flexion was inversely related to disability in chronic back pain patients [31].

In the current study, different method of lumber ROM measurement was used to eliminate the source of measuring error detected by other used techniques. These errors including repositioning the inclinometer four times for measuring both flexion and extension, rocking of the device on the sacrum and upper measuring point, movement of the patient between the upper and lower reading, relocating the measuring points at subsequent reading, and the isolation between hip and spinal component during measurements [18].

Intrarater reliability using the BROM in this study was good to fair for forward flexion (ICC_.84), and high for extension (ICC_0.91) which was substantially better than the findings of Madson et al. [22], who reported poor intrarater reliability for flexion (ICC_.67) and fair for extension (ICC_78). The improved reliability when measuring flexion in this study is likely because of controlling for device slippage on clothing, which was noted to be a factor in the Madson study. Instructing the subjects to wear cotton shorts with an

Table 4 Regression analysis between spinal ROM and disability score.

Dependant variable functional disability			Adjusted R^2 = 0.366, regression constant = 16.863	
Predictors	Standardized coefficients Beta	*p*-Value	*F*-value	*p*
Forward trunk flexion	−.496	.002**	4.750	0.001**
Trunk extension	−.293	.066		
Left trunk flexion	−.460	.040*		
Right trunk flexion	−.457	.019*		
Left trunk rotation	−.104	.538		
Right trunk rotation	−.013	.940		

Predictors: Right rotation, extension, right flexion, forward flexion, left rotation, left flexion.
* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

Table 5 Intrraterter reliability of the BROM device for lumbar motion measurements.

Motion	Trial 1		Trial 3		ICC
	Mean ± SD	Range	Mean ± SD	Range	
Forward trunk flexion	15.6 ± 1.3	3	15.4 ± 2.7	7	0.84
Trunk extension	3 ± 1.8	5	3.2 ± 1.7	4	0.91
Left trunk flexion	15.2 ± 3.1	8	15 ± 2.1	6	0.86
Right trunk flexion	12.8 ± 1.9	5	13.6 ± 1.5	3	0.88
Left trunk rotation	12.2 ± 1.7	5	11.6 ± 3.8	10	0.82
Right trunk rotation	12.4 ± 2.8	7	12 ± 4.4	10	0.81

elastic waistband helped to control device slippage, and every effort was made to apply the device directly on the skin. One explanation for improved reliability for extension was the ability of the examiner to consistently maintain equal hand pressure at the points of contact and prevention of the distal end of the L-shaped arm to come into contact with the body or with the plastic protractor component which could limit movement during lumber extension.

However The results of Madson showed a slightly better intrarater reliability for side bending compared with the present study (ICC range, .95–.91 vs ICC range, .88–.86) and substantially better reliability for rotation measurements (ICC range, .93–.88 vs ICC range, .82–.81) [22]. the lower reliability in the current study may attributed to the procedural errors during measurement of lateral flexion and rotation which included errors in zeroing the compass between left and right direction, the compass not remaining level, and/or movement of the magnet during AROM.

The results of the current study lend support to previous research on the relation between lumber ROM and Self reported questionnaires. Nattrass et al. concluded that there was no evidence for a relationship between back ROM measured by long arm goniometer and impairment [7]. Gronblad et al., used the Oswestry questionnaire to measure disability and a dual inclinometer to measure back ROM, the results indicated that there was a weak or non-existent relation between lumbar range of motion measures and subjective functional disability scales in LBP [32]. Sullivan et al., stated that lumbar flexion explains a very small percentage of variance in disability [33].

In contrast with the current study Waddell et al. who found a highest correlation ($r = -0.47$) between single inclinometer measured total spinal flexion and the Roland Morris scale in 120 patients with chronic low back pain [34]. Also data obtained by Battié et al. [35] and Jette et al. [36] suggested that physical therapists believe that spinal ROM and disability are closely linked and therapists frequently establish treatment goals of increasing a patient's spinal ROM. Presumably, therapists believe that changes in AROM represent clinically meaningful changes in the disability Jette et al.

There are notable limitations to this study. One of them was the eliciting of pain during testing procedures. Although spinal ROM measurements are an objective method, it is most likely influenced by the patient motivation, effort and psychological state. Therefore spinal mobility may reflect the patient perceived abilities to move through available rang of motion. Also the number of subjects was somewhat low, but nonetheless still enabled correlative analysis. Although the criteria for patient selection excluded patients with complicated LBP whose are rarely located in the community.

Another limiting factor was the results of this study cannot be generalized to specific types of LBP such as spinal stenosis in which flexion restriction cannot be used as indicator for functional disability because bending forward in those patients increases the space in the spinal canal and vertebral foramen and improved symptoms. Future researches should focus on the association between forward flexion and pain behavior in LBP patients.

Conclusion

Based on the finding of this study, it was concluded that spinal ROM do not appear to be a valid predictor for disability in chronic LBP patients. This indicates that the restriction of the spinal ROM is quit independent of the level of disability. The implication of our finding for the wider health care arena is that clinicians should assess both spinal mobility and disability in making clinical assessment and selecting treatment for patients with chronic LBP.

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