

HEALTH SERVICES RESEARCH

OPEN

A Screening Tool for Patients With Lumbar Instability

*A Criteria-related Validity of Thai Version*Thiwaphon Chatprem, PhD, candidate, PT,^{a,b,c} Rungthip Puntumetakul, PhD, PT,^b Rose Boucaut, PhD, PT,^d Sawitri Wanpen, PhD, PT,^b and Uraivan Chatchawan, PhD, PT^b

Study Design. The study is a cross-sectional, diagnostic validity study.

Objective. The aim of this study was to examine the performance characteristics and validity of an existing lumbar instability questionnaire as a screening tool for lumbar instability among chronic low back pain (CLBP) patients.

Summary of Background Data. Lumbar instability is an initial stage of more severe spinal pathology. Early screening for this condition should help prevent more structural damage. To meet this need, the present study developed numerical cutoff scores for the lumbar instability screening tool.

Methods. Lumbar instability screening tool responses and x-ray assessments were reviewed from a sample of 110 patients with CLBP (aged 20–59 years). Receiver operator curves were constructed to optimize sensitivity and specificity of the tool.

Results. Fourteen (12.73%) patients had radiological lumbar instability. These patients reported a higher mean lumbar instability questionnaire score than those without radiological lumbar instability. A questionnaire score of at least 7 had a

sensitivity of 100% (95% CI, 100–100) and a specificity of 26.04% (95% CI = 17.84–34.24) for detecting lumbar instability when compared with x-ray examination. Receiver operator curve analysis revealed the lumbar instability screening had an area under the curve of 0.62 (95% CI, 0.47–0.77).

Conclusion. A lumbar instability screening tool total score of at least 7 was ruled out lumbar instability in CLBP patients. This cutoff score may be used as a marker of conservative treatment response. The sample size of patients with lumbar instability in this study was small, which may hinder the reliability of the data. Further studies are needed.

Key words: chronic low back pain, cutoff score, diagnosis, flexion and extension radiograph, gold standard, lumbar instability screening tool, radiological lumbar instability, sensitivity, specificity, x-ray.

Level of Evidence: 4

Spine 2020;45:E1431–E1438

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Acknowledgment date: December 10, 2019. First revision date: March 2, 2020. Second revision date: May 1, 2020. Acceptance date: May 4, 2020.

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The manuscript submitted does not contain information about medical device(s)/drug(s).

The Royal Golden Jubilee (RGJ) Ph.D. Program, the Thailand Research Fund (TRF) funds were received in support of this work.

No relevant financial activities outside the submitted work.

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DOI: 10.1097/BRS.0000000000003606

Lumbar instability is highly prevalent (up to 57%) in patients with chronic low back pain (CLBP).¹ X-Ray examination has been the criterion standard for identifying these patients, with excessive translation and/or rotation of at least one lumbar segment relative to its inferior neighboring segment a critical characteristic finding.² However, diagnosis of CLBP using an x-ray examination has some limitations, including the time and cost to administer the examination, access to the equipment, and radiation exposure.^{3,4} Delayed diagnosis may result in invasive therapy such as surgery with or without spinal fusion.⁵ Early detection of lumbar instability enables timely noninvasive treatment and helps prevent further structural degeneration.^{6,7}

Questionnaires are widely used in the medical profession. Although many questionnaires have been developed to measure disability and activity limitations in patients with low back pain, specific diagnostic tools, particularly for lumbar instability, remain sparse. Questionnaires tailored for particular conditions can provide diagnostic assistance and can measure treatment progress, are beneficial where there is insufficient equipment, and do not require professional skills to administer.

A lumbar instability screening tool comprises questions that are part of a subjective examination. The tool is used to identify patients with low back pain who are likely to have lumbar instability.^{8,9} A questionnaire about specific clinical signs of lumbar instability was developed from a Delphi study of physical therapists.⁸ Lumbar instability signs were subsequently used in later studies by other investigators as inclusion criteria for patients with lumbar instability^{10,11} and for monitoring the effect of exercise intervention on these patients.¹² Subsequently, the questionnaire was translated into Thai and Brazilian Portuguese^{13,14} and its reliability tested.¹³⁻¹⁵ Chatprem *et al*¹³ (in press) developed a Thai version of the lumbar instability screening tool for physical therapists to administer to patients with CLBP.

Despite the extensive use of the Thai lumbar instability screening tool, it has not been validated against the criterion standard. Generally, users of an instrument should always check whether it is sufficiently relevant and comprehensive to meet their measurement needs. The present study aimed to determine the criteria-related validity of the Thai lumbar instability questionnaire compared with that of the x-ray examination when the questionnaire is used as a screening instrument for Thai patients with CLBP.

MATERIALS AND METHODS

Participants and Procedure

After our study was cleared by the Ethics Committee in Human Research for abiding by the Declaration of Helsinki (HE 602379) and received approval from the Thai Clinical Trials Registry (TCTR 20180820001), data were collected from October 2018 through May 2019. Two formulas were used to calculate the screening test sample size: number of people with lumbar instability = $(z_{\alpha/2}^2 \times \text{sensitivity value} [1 - \text{sensitivity value}] / (\text{acceptable error in the estimate})^2)$, and sample size = number of people with lumbar instability $\times 100 / \text{rate of lumbar instability}$.¹⁶ We set the $z_{\alpha/2}$ at 1.96, acceptable error in the estimate at 0.10, sensitivity value at 0.80, and rate of lumbar instability at 0.57, which was adapted from the Fritz *et al*'s study.¹ Although there was a high rate of lumbar instability in the formula, their study was the most similar one to the present study. The calculation resulted in requiring 110 participants for our study. Patients aged 20 to 60 years with CLBP, with or without referred pain to the lower limbs,¹⁷ were enrolled via poster and social advertisements. Patients were assessed in two visits. In the first visit, all patients were asked to sign a consent form and were evaluated for existing CLBP. The investigators collected demographic data: age, sex, body mass index, education level, pain information, and response to the lumbar instability screening tool. Patients were excluded if they were pregnant or had had spinal surgery, serious spinal pathologies, spondylolisthesis due to a pars interarticularis defect, degenerative scoliosis of $>10^\circ$, and any contraindication for an x-ray examination.

During the second visit, all patients were evaluated by an orthopedic surgeon who ordered an x-ray assessment. Plain

radiographs of the patients at six positions were obtained by a radiologist: anteroposterior, lateral, two oblique, and lateral flexion and extension with the patients in the lying position. The latter posture was used to avoid a reflexive or voluntary muscle-bracing response to pain.¹⁸⁻²⁰ The lateral flexion and extension radiographs were then inspected for lumbar instability by a trained observer.

Lumbar Instability Screening Tool

The lumbar instability screening tool has been used to classify patients with CLBP into a lumbar instability group,^{10,11} to predict successful outcomes following a course of motor control exercise or graded activity.¹² The Thai version was created for use by Thai physical therapists.¹³ The tool score ranges from 0 (not related to having lumbar instability) to 14 (strongly related to having lumbar instability). The screening tool questions are presented in Table 1. It has undergone cross-cultural translation^{13,14} and its reliability has been tested.¹³⁻¹⁵ Briefly, the questionnaire comprises 14 items related to how the patient feels and his or her behavior, activity, and positions adopted.

TABLE 1. Lumbar Instability Screening for Patients With Chronic Low Back Pain

Items	Patient Responds	
	Yes	Never
1. You feel like your back has collapsed		
2. You feel better with self-manipulation		
3. Your back pain symptoms come and go all the time		
4. You have a history of stiff back or sudden back pain when twisting or bending down		
5. You have back pain when you change posture, for example, when standing up from sitting among others		
6. You have increased back pain when stretching up from a bending posture		
7. You have sudden back pain even with a minor movement		
8. Your back pain increases when sitting on a chair that lacks a backrest, and is alleviated when sitting on a chair with backrest		
9. You have increased back pain when you are in one posture for a long time		
10. Your back pain is becoming steadily worse		
11. Your back pain is temporarily alleviated when you wear a back support		
12. You frequently experience back muscle spasm		
13. You are afraid, not wanting to move, when you have back pain		
14. You have a previous history of back pain		
Total score		

X-Ray Measurement and Evaluation

Translation and/or rotation of a superior vertebra relative to its neighboring inferior vertebra² were used to confirm the existence of lumbar instability for each of the five lumbar segments. Sagittal translation and angulation are shown on the lateral plain film when a patient performs flexion and extension. Translation was defined as >4.5 mm at L₁₋₂ to L_{5-S1} and rotation was defined as $>15^\circ$ at L₁₋₂, L₂₋₃, and L₃₋₄, $>20^\circ$ at L₄₋₅, and $>25^\circ$ at L_{5-S1}.² The measurement procedure is illustrated in Figure 1. Because x-ray films of flexion and extension have been reported to show large variability and have high false-positive rates,²¹ we required patients to meet one of the following criteria to be categorized as having radiological lumbar instability: have two segments with either rotational or translational instability or have one segment with both translational and rotational instability.¹

One trained observer (researcher T.C.), who was blinded to other clinical information, identified translational and rotational instability on digitalized radiographs stored in a picture archiving and communication system (PACS) on a computer in Srinagarind Hospital, Khon Kaen, Thailand. Researcher T.C. was trained by a radiologist with 30 years of clinical experience on how to use the PACS, including accessing x-ray films, using measurement tools, identifying spinal borders, and how to draw measurement lines. Training proceeded until the radiologist was satisfied with the accuracy of the results from researcher T.C. All lumbar levels were measured three times and the average was used to compare the level against the lumbar instability criteria. The reliability of the x-ray measurements was assessed using those of 10 randomly selected patients.

Statistical Analysis

Descriptive analysis of the demographic characteristics of the patients was performed using percentages, means, standard deviations, and minimum and maximum values. Intra-observer reliability was measured using the intraclass correlation coefficient (ICC) for the radiographic measurements.

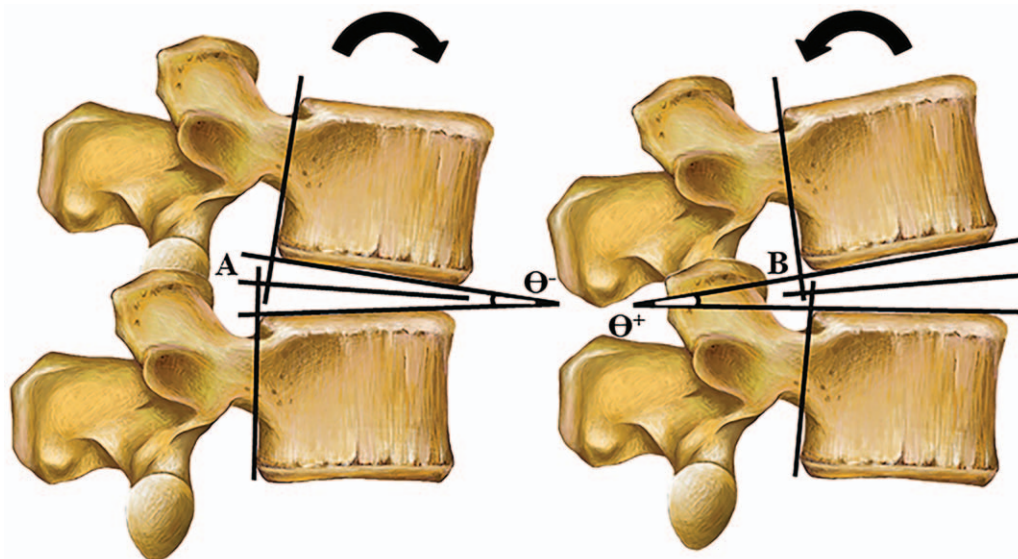
A receiver-operating characteristic (ROC) curve was used to identify the best cutoff point for the total screening score to predict lumbar instability. Sensitivity, specificity, positive likelihood ratio (LR+), and negative likelihood ratio (LR-) for several cutoff scores were calculated. The cutoff score that yielded the maximum sum of sensitivity and specificity was taken as the maximum score. Statistical analysis was conducted using STATA ver. 10.0 (StataCorp, College Station, TX).

RESULTS

One hundred ten consenting patients with CLBP were recruited for the study. Of them, 14 (12.73%) patients presented with radiological lumbar instability: eight (57.14%) showed rotational and translational instability, two (14.29%) showed only rotational instability, and four (28.57%) showed only translational instability. The lumbar instability screening tool score of the 14 patients with instability (8.43 ± 1.50) was higher than that of the 96 patients without instability (7.59 ± 1.68). Additional characteristics are presented in Table 2.

Reliability of the Measurement Technique

Ten x-ray films were randomly selected to determine the reliability of the measurement technique. Intraobserver



Sagittal translation (mm)=A-(-B) and rotation (degree)=θ⁺-(-θ⁻)

Figure 1. Measurement technique of sagittal angulation and translation. **Angulation:** It is formed by the intersection of two straight lines drawn along the inferior endplate of the upper vertebra and the superior endplate of the lower vertebra. The difference of intervertebral angles between flexion (\ominus^-) and extension (\ominus^+) is defined as the amount of rotation. **Translation:** Drawing lines bisect the endplate angle. The difference between the two distances from flexion (A) and (B) extension is defined as the amount of translation.

TABLE 2. Demographic Characteristics of the 110 Participants With Chronic Low Back Pain

Demographic Characteristics	n (%)	Mean ± SD	Range
Age, y		35.92 ± 12.10	20–59
Sex			
Male	41 (37.27)		
Female	69 (62.73)		
X-Ray evidence			
Instability	14 (12.73)		
Noninstability	96 (87.27)		
Screening score			
Instability		8.43 ± 1.50	7–11
Noninstability		7.59 ± 1.68	3–12
BMI		22.32 ± 2.50	15.82–29.36
Exercise status			
Yes	55 (50.93)		
No	53 (49.07)		
Drug			
Yes	35 (32.41)		
No	73 (67.59)		
Other treatment			
Yes	45 (41.67)		
No	63 (58.33)		
Education			
Primary school	26 (23.64)		
High school	34 (30.91)		
Bachelor degree	35 (31.82)		
Master degree	14 (12.73)		
Doctor degree	1 (0.90)		
Pain duration, mo		27.95 ± 32.98	3–192
Underlying disease			
Yes	27 (25.00)		
No	81 (75.00)		
Smoking status			
Yes	80 (74.07)		
No	28 (25.93)		
Pain episode			
First	59 (53.64)		
Recurrent	51 (46.36)		
Pain radiation			
Yes	60 (55.56)		
No	48 (44.44)		
Pain scale (Numerical rating scale)		4.66 ± 1.45	2–8

BMI indicates body mass index; SD, standard deviation.

reliability was 0.97 (95% CI: 0.94–1.00) for rotation and 0.94 (95% CI: 0.86–1.00) for translation. The reliability results showed good measurement consistency.

Validity of the Lumbar Instability Screening Tool

The score obtained with the lumbar instability screening tool for patients with CLBP ranges from 0 to 14. In the present study, the mean tool score of the patients with radiological instability was higher than that of the patients without instability (Table 2). The ROC curve was used to evaluate the performance of the tool. Table 3 presents 10 pairs of

sensitivity and specificity values for predicting patients with lumbar instability. One pair for each cutoff score revealed a difference in sensitivities, specificities, LR+, and LR-. As the cutoff score decreased, the sensitivity increased, whereas the specificity decreased. A cutoff score of at least 7 had an optimized sensitivity of 100% (95% CI: 100–100) and a specificity of 26.04% (95% CI: 17.84–34.24). The positive and negative predictive values were 16.47% (95% CI: 9.57–23.40) and 100% (95% CI: 100–100), respectively, and the LR+ and LR- were 1.35 and 0.00, respectively. The ROC curve was 0.62 (95% CI: 0.47–0.77).

TABLE 3. The Diagnosis Accuracy of Each Cutoff Value for Identifying Patients With Lumbar Instability Among Chronic Low Back Pain

Cut-point	Sensitivity	Specificity	Correctly Classification	LR+	LR–
≥3	100.00%	0.00%	12.73%	1.00	
≥4	100.00%	1.04%	13.64%	1.01	0.00
≥5	100.00%	4.17%	16.36%	1.04	0.00
≥6	100.00%	9.38%	20.91%	1.10	0.00
≥7	100.00%	26.04%	35.45%	1.35	0.00
≥8	64.29%	45.83%	48.18%	1.19	0.78
≥9	35.71%	69.79%	65.45%	1.18	0.92
≥10	28.57%	87.50%	80.00%	2.29	0.82
≥11	14.29%	97.92%	87.27%	6.86	0.88
≥12	0.00%	98.96%	86.36%	0.00	1.01
>12	0.00%	100.00%	87.27%	0.00	1.00

DISCUSSION

Many researchers are interested in specific subjective information from patients with lumbar instability^{8,9} because this condition may be the initial stage of other severe spinal pathologies. Previous studies have used the lumbar instability screening tool for various purposes,^{10–12} but to date the efficacy of the tool compared with that of the gold standard of x-ray radiographs has not been determined. This study is the first to examine the diagnostic accuracy (sensitivity and specificity) of the lumbar instability screening tool in patients with CLBP across a wide age range.

Patients with CLBP who scored at least 7 on the screening tool (maximum score = 14) demonstrated 100% sensitivity and 26.04% specificity of lumbar instability. The area under the ROC curve (AUC) was 0.62, which is relatively poor,²² maybe because of the small number of participants with radiological lumbar instability (14 or 12.73%).²³ There are several possible reasons for this low number. First, the age range inclusion criterion (20–60 years) may have been too broad. Second, the radiological translation and rotation criteria for lumbar instability proved more challenging to meet than previously reported.^{24,25} However, our small percentage of 12.73% was in accord with the 12% of subjects with lumbar instability confirmed by x-ray examination in earlier study.²⁶

We accepted one pair of diagnostic accuracy results yielded a maximum sum of sensitivity (100%) and specificity (26.04%) because we propose to use the questionnaire as a screening tool that requires high sensitivity.²⁷ With a cutoff score of at least 7, the ability to exclude patients with CLBP without lumbar instability was 26.04%. However, patients who scored 7 required further evaluation with subsequent diagnostic tests such as passive lumbar extension (84% sensitivity and 90% specificity).¹⁹

We compared the percentage of positive scores of patients with radiological lumbar instability with that of patients without instability (Figure 2). Three items of the tool received a 100% positive response from patients with radiological instability. These items were as follows: patients reported having back pain when they changed their posture (question

5), patients reported increased back pain when sitting on a chair without a backrest and that the pain was alleviated when sitting on a chair with a backrest (question 8), and patients reported increased back pain when maintaining one posture for a long time (question 9). These three situations coincided with the findings on the medical images by the observer and are in accord with results from previous studies.^{28,29} Indeed, the literature informs us that lumbar instability occurs when at least one of the passive, active, and neural control subsystems is compromised and that the symptoms are posture-related.^{30,31}

Patients with radiological lumbar instability reported experiencing back pain when they changed their posture (eg, from sitting to standing or turning to the left and the right while in the supine position). Previous studies reported that patients with CLBP have impaired lower trunk muscle function such as weakness of a segmental muscle or high activation of multiple segmental muscles.^{32,33} Furthermore, patients with instability have demonstrated delayed activation of the lumbar multifidus and erector spinae.³⁴ These abnormal muscle recruitment patterns lead to an inability to respond successfully to the command to move, resulting in the loss of spinal stiffness, which produces pain when transitioning from one posture to another.^{8,35}

Patients with lumbar instability reported that their back pain increased when sitting on a chair without a backrest, and it was reduced when sitting on a chair with a backrest. Even healthy individuals can experience discomfort in the sitting position so it was not surprising to find that patients with CLBP also experienced pain in this position.³⁶ Studies have reported that sitting requires great muscle activation^{37,38} and can lead to fatigue of the deep lower trunk muscles.³⁶ This fatigue can produce a higher force on the spine^{39,40} and consequently translate vertebrae of the lumbar spine. However, a chair with a backrest can decrease muscle activity,⁴¹ thus minimizing the stress and strain on the spine^{42,43} and reducing these adverse effects.

Patients with lumbar instability reported increased back pain when they were in one position for a long time.

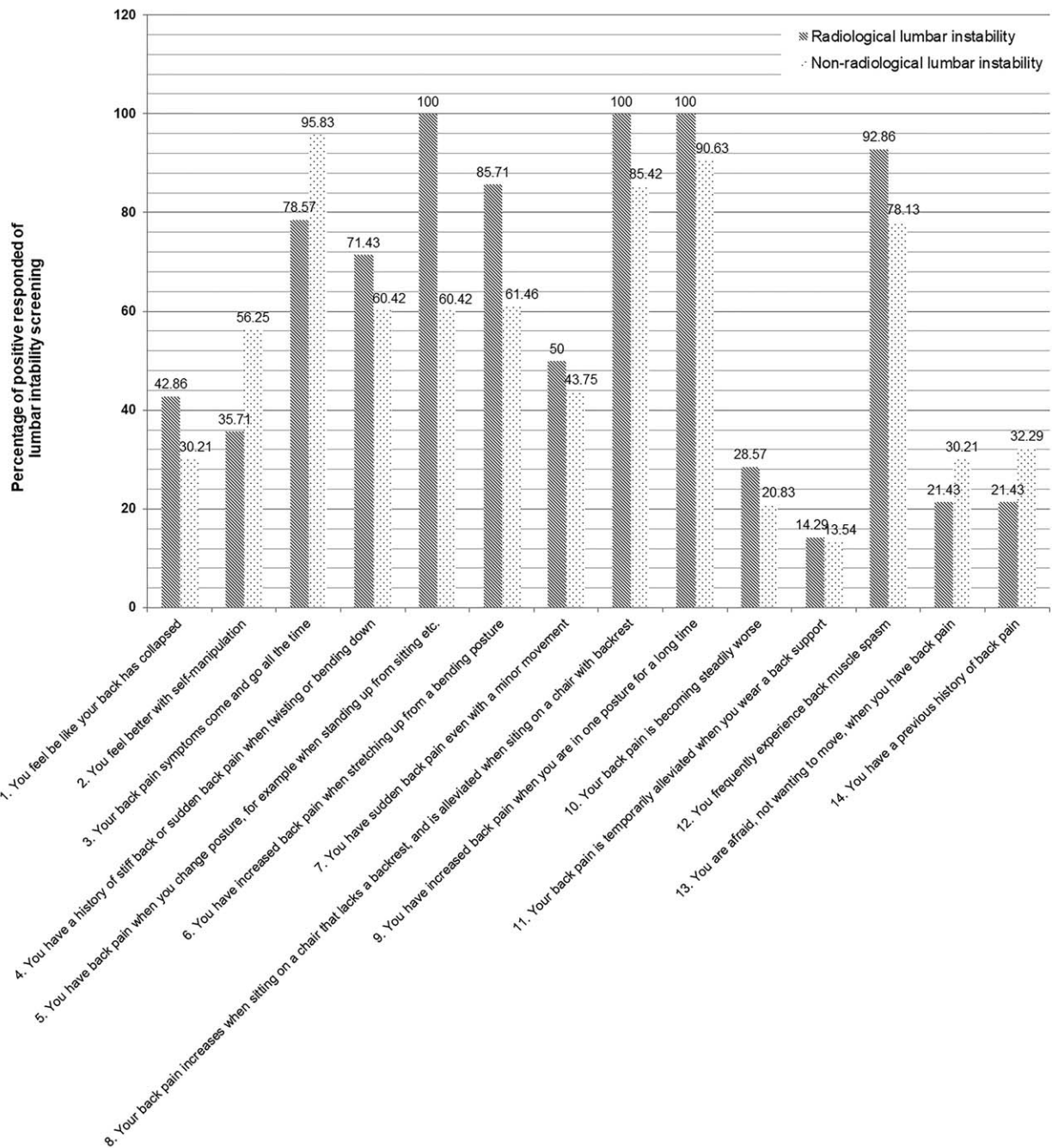


Figure 2. Comparison the percentage of positive responded of lumbar instability screening between patients with chronic low back with and without radiological lumbar instability.

Maintaining one position (eg, walking, sitting, or standing) increases pain over time.³⁸ Sustained activity results in fatigue of the lower trunk muscles.^{39,44,45} Additionally, patients with lumbar instability have decreased segmental muscle strength.⁴⁶ This puts a strain on the disk or facet joint,⁴⁷ which progresses to vertebral translation. Hence, it is reasonable that a patient would have an increased level of pain in a prolonged posture.

Patients without lumbar instability had a higher percentage of positive responses to questions 2, 3, 13, and 14 than did patients with lumbar instability. These four items could

indicate that pain in patients with CLBP has various structural sources besides instability.^{48,49}

Lumbar instability occurred most often in the L₄₋₅ segment of patients with an average age of 41 ± 10.91 years. The finding that radiological instability was highest at the L₄₋₅ segment is similar to the findings of other studies. The instability is due to the facet joints tending to align closest to the sagittal plane.^{35,50} Interestingly, the youngest patient with radiological lumbar instability in the present study was 23 years' old, which was concordant with that of a previous study⁷ in which the authors reported that instability started

in patients in their 20s. They suggested that those patients could have been in the initial stage of disk degeneration.⁷

The present study has a number of limitations. First, this study assessed only intrarater reliability, whereas assessment of interrater reliability between the radiologist and the trained observer would have strengthened the results. Second, the sample size was small. Although the number of participants needed for the study was calculated before conducting the study, the effect size was still medium.⁵¹ The use of more participants in future studies will address this issue.

In conclusion, this study was the first to examine the validity of a lumbar instability questionnaire. Such a screening tool could be useful for detecting lumbar instability in Thai patients with CLBP. We recommend early lumbar instability screening of patients in geographical areas with limited access to x-ray equipment and that lack the professional expertise to perform an assessment to identify patients suspected of having lumbar instability. The instrument is brief, easy to understand, simple to score, available without cost, and has strong performance characteristics (100% sensitivity). It can be administered to people of all ages. However, using the lumbar instability screening tool with other physical examination tests is recommended to ensure that the patient has lumbar instability. More studies with a larger sample size are required to validate the tool.

➤ Key Points

- ❑ Patients with CLBP who get 7 score form lumbar instability screening tool have to concern of existed lumbar instability and directly received specific treatment.
- ❑ Lumbar instability screening tool seems to be useful to rule out patients who were suspected to be lumbar instability more than rule in patients who really have not lumbar instability.
- ❑ Lumbar instability screening tool is simply to score for physical therapists and available to apply where the area insufficient of specialist and x-ray equipment.

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