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Clinical prediction rule validity to identify individuals with recurrent low back pain

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Abstract

Introduction. One set of clinical prediction rules (CPR) can be used clinically to identify patients with low back pain who are likely to benefit from motor control exercise. Individuals with a history of recurrent low back pain during remission (rLBP) still have persisting impaired trunk neuromuscular control. Accordingly, CPR should detect these individuals with rLBP. This study aimed to determine the predictive validity of CPR to identify individuals with rLBP.

Methods. Overall, 30 subjects aged less than 40 years (22 subjects with rLBP and 8 subjects without a history of low back pain) were recruited. We used the following criteria as CPR: (1) presence of aberrant movement during active forward bend and (2) passive straight leg raising result greater than 91°. Kappa statistics and the chi-square test were used to determine predictive validity. Diagnostic accuracy was also calculated.

Results. Kappa demonstrated substantial agreement (kappa = 0.73), while the chi-square test showed significant association ($\chi^2 = 16.28$; $p < 0.001$) between positive CPR and rLBP. Diagnostic accuracy demonstrated positive likelihood ratio of 3.82, while accuracy equalled 90%.

Conclusions. Our findings indicated the predictive validity of CPR to identify individuals with rLBP. The result from this study would help identify those predisposed to recurrent episodes of low back pain who would likely have a positive response to motor control exercise.

Key words: clinical prediction rule, lumbar instability, low back pain, predictive validity, aberrant movement, passive straight leg raising

Introduction

Low back pain (LBP) is a major problem among adults around the world because of its high prevalence and recurrence rates [1]. Research has found that the 1-year incidence of first ever LBP episode ranges from 6.3% to 15.4%, while the 1-year incidence of recurrent LBP episodes ranges from 24% to 80% [1]. Although several studies have demonstrated effective outcomes of physical therapy interventions, the recurrence rates are still high [1]. Such high recurrence rates could have resulted from the fact that we treated patients with LBP as a homogeneous group [2–4]. Current research evidence suggests that subgrouping LBP patients is necessary to provide a more specific intervention more effectively addressing the patients' problems [2–4].

Clinical lumbar instability (CLI) has been proposed as one subgroup of LBP [4–6]. Evidence indicates that this subgroup involves trunk neuromuscular control impairment, including an altered movement coordination pattern, decreased and delayed transverse abdominis muscle activation, as well as altered abdominal and back muscle activation patterns [7–11]. These impairments compromise the lumbar stabilizing system, which further causes the lumbar spine to be more vulnerable to excessive deformation and injury [3, 9, 12]. Studies have demonstrated that this CLI subgroup would benefit from motor control exercise (MCE) [4–6, 13].

One study has established a set of clinical criteria called clinical prediction rules (CPR) to identify patients with LBP (CLI subgroup) who would positively respond to MCE [5]. CPR with the greatest predictive power for successful MCE includes: (1) age less than 40 years, (2) passive straight leg raising (SLR) result greater than 91°, (3) the presence of an aberrant movement (ABM) during active forward bend test, and (4) a positive prone instability test result. Patients with LBP meeting 3 of these 4 criteria would result in positive likelihood ratio of 4.0 for successful outcomes with MCE; the probability of success increases from 33% to 67% [5]. Accordingly, CPR can be clinically used to identify patients with CLI.

Another study has cross-validated CPR for a CLI subgroup [6]. Although the authors were unable to statistically validate CPR, their findings showed that patients with positive CPR experienced less disability than those with negative CPR after receiving MCE [6]. Similarly, when comparing patients with positive CPR between MCE and manual therapy, the results still demonstrated that those receiving MCE had less disability than those receiving manual therapy [6]. These results support the utility of CPR in clinical practice.

Although patients with CLI would benefit from MCE, some might not have previously received MCE as one of physical therapy interventions. This would possibly result in unresolved CLI. Research evidence has demonstrated ex-

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isting trunk neuromuscular control impairment after episodes of LBP even when pain has subsided [14–18]. As a result, individuals with recurrent LBP during remission (rLBP) who did not previously receive MCE should still have persisting symptoms of CLI represented by positive CPR. However, research evidence to support the predictive validity of CPR to identify individuals with rLBP is still limited.

Therefore, this study aimed to investigate the predictive validity of CPR to identify individuals with rLBP. We hypothesized that patients with positive CPR would be those with rLBP. The results from this study would help identify those more likely to have a recurrence of LBP in order to provide appropriate prevention programs.

Subjects and methods

Subjects

A total of 22 subjects with rLBP and 8 subjects without a history of LBP were recruited in this study. The inclusion criteria for both groups were age of 20–40 years, male or female sex. Additional inclusion criteria for rLBP participants involved recurrent LBP: at least 2 episodes that interfered with activities of daily living or required treatment; the inclusion criterion for subjects without a history of LBP was never having experienced LBP in one's lifetime. All individuals with rLBP were recruited during symptom remission (pain-free). The exclusion criteria for both groups were as follows: clinical signs of a systemic disease, definitive neurologic signs including neural tension, weakness or numbness in a lower extremity, previous spinal surgery, diagnosed osteoporosis, severe spinal stenosis or inflammatory joint disease, any trunk or lower extremity condition that would potentially alter trunk movement, vestibular dysfunction, extreme psychosocial involvement, and previously receiving any type of MCE to improve trunk neuromuscular control and lumbar stability.

This study was a part of another project, approved by the Mahidol University institutional review board (COA No. MU-CIRB 2018/212.3011). Thus, we did not calculate the sample size for this study. However, the required sample size would be calculated for future replications of this study.

Study design

This study constituted methodologic research to determine the predictive validity of CPR to identify individuals with rLBP. We used 2 of the 4 criteria of CPR (passive SLR result greater than 91° and the presence of ABM during active forward bend test) because this was a part of another study, in which we selectively recruited individuals aged less than 40 years and the prone instability test requires the presence of pain as an indicator to determine positive test results. On the basis of the available research evidence, 3 positive CPR criteria would yield a positive likelihood ratio of 4.0 (CI: 1.6–10.0) [5].

Primary outcome measures

Clinical observation of ABM (sagittal plane deviation, instability catch or judder, and altered lumbopelvic rhythm) was performed by 2 physical therapists having experience with the musculoskeletal system, including LBP, of 3 and 5 years. The physical therapists had conducted 3 sessions of standardized physical examination before collecting data. Our operational definition for clinical observation was based on a related study [14]. To carry out the test, the subjects were asked to perform one repetition of active trunk forward flexion at a comfortable pace, while 2 physical therapists simultaneously and independently observed any ABM during performance. The presence of any ABM during an active forward bend was considered as positive ABM. The inter-rater reliability of clinical observation for each ABM during active forward bend is presented in Table 1. We decided to use the clinical observation data from the senior physical therapist with 5-year experience in the further analysis.

The passive SLR test was applied to determine signs of CLI among individuals with rLBP. The subjects were placed in the supine position on a treatment table. The first physical therapist passively lifted each leg until reaching maximal tolerance indicated by the subject and recorded the SLR angles [5]. Then, the second physical therapist repeated the same process. Our data demonstrated excellent inter-rater reliability of the passive SLR test ($ICC_{2,1}$ = 0.95; CI: 0.62–0.99). We again used the data from the senior physical therapist with 5-year experience in the further analysis. It should be noted that the passive SLR test served to identify CLI rather than lower extremity neural tension or hamstring muscle length [5]. Therefore, the test allows the contribution of the lumbar spine while being performed. An angle between the tibia and horizontal line greater than 91° for both legs was considered as a positive test result. A positive unilateral or bilateral test result was recognized as a positive passive SLR test result that was used to analyse data.

Procedure

This study used a sample of convenience. Potential subjects were recruited from Mahidol University and the surrounding areas by posters and word of mouth. They underwent an inclusion and exclusion criteria screening process. Those who met the inclusion and exclusion criteria were asked to sign a written informed consent form before participating in the study.

Table 1. Inter-rater reliability of clinical observation of aberrant movement pattern during active forward bend

Type of aberrance	Phase	Agreement (%)	Kappa (95% CI)	PABAK (95% CI)
Deviation	Forward	66.67	0.31 (0.02–0.60)	0.33 (0–0.67)
	Return	83.33	0.36 (0–0.79)	0.67 (0.49–0.98)
Instability catch	Forward	73.33	0.33 (0–0.69)	0.47 (0.15–0.78)
	Return	86.67	0.59 (0.23–0.95)	0.73 (0.49–0.98)
Altered lumbopelvic rhythm	Forward	60.00	0 (0–0.34)	0.20 (0–0.55)
	Return	70.00	0.20 (0–0.58)	0.40 (0–0.67)

PABAK – prevalence-adjusted and bias-adjusted kappa

Demographic data including age, sex, body mass index (BMI), and level of physical activity (International Physical Activity Questionnaire class and metabolic equivalent) [19] were collected. In addition, subjects with rLBP were asked to provide information regarding their history of LBP [15]. When the demographic data were collected, a physical therapist, blinded to the group of subjects, performed clinical observation of ABM during active forward bend and passive SLR test for both legs. These data and the frequency of positive results from those 2 tests were used to describe the subjects' characteristics in this study. The testing results were further applied in the main data analysis.

Data analysis

The subjects were classified as having or not having rLBP on the basis of their provided information. These data were used as actual outcomes (known groups) to determine the predictive validity of CPR. The testing results from the clinical observation of ABM and the passive SLR test served to classify the participants in the positive and negative CPR groups. The subjects had to exhibit positive ABM and positive passive SLR results to be classified as positive CPR. If one or more criteria were not met, the patient was classified as negative CPR. The frequency of positive and negative CPR results was used to construct a two-by-two table against known groups (having or not having rLBP). This two-by-two table was further employed in the statistical analysis to determine the predictive validity of CPR in identifying individuals with rLBP.

Statistical analysis

The statistics were analysed by using the SPSS software (IBM SPSS Statistics for Windows, version 21.0, Armonk, NY, USA). Descriptive statistical analysis was performed with demographic data to describe the subjects' characteristics. The Kolmogorov-Smirnov goodness-of-fit test served to determine normality of the data. An independent *t*-test was applied to compare the subjects' characteristics for normally distributed data. Otherwise, the nonparametric Man-Whitney *U* test was conducted. Kappa statistics (% of agreement, kappa, and prevalence-adjusted and bias-adjusted kappa) were calculated to determine the agreement between positive CPR and rLBP. The chi-square test was also performed with the two-by-two table to indicate the predictive validity. Sensitivity, specificity, positive and negative likelihood ratio, and percentage of accuracy were calculated for CPR and the clinical tests. The significance level was set at 0.05 for all statistical analyses.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Mahidol University institutional review board (COA No. MU-CIRB 2018/212.3011) as part of another project.

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

No significant difference ($p > 0.05$) was found in the demographic characteristics between the rLBP and non-rLBP groups, except for BMI, which showed a trend ($t = 2.04$; $p = 0.051$) indicating that rLBP was associated with greater BMI than no rLBP. The participants' characteristics are presented in Table 2.

The chi-square test demonstrated a significant association between positive CPR and rLBP ($\chi^2 = 16.28$; $p < 0.001$). The kappa statistics, chi-square test results, and diagnostic accuracy are presented in Table 3.

Table 2. Characteristics of individuals with and without a history of recurrent LBP

Variable	rLBP (*n* = 22)	No LBP (*n* = 8)
Age (years)	24.7 ± 5.6	25.6 ± 5.2
Sex (% female)	54.5	87.5
BMI (kg/m²)	23.5 ± 3.5	20.8 ± 2.0
IPAQ	1.9 ± 0.7	2.3 ± 1.1
MET (min/week)	1418.8 ± 1284.7	4515.9 ± 7716.9
ABM (% positive)	100	87.5
SLR (% positive)	95.5	25
Onset (months)	22.3 ± 21.6	NA
Frequency of episodes (*n* per year)	15.4 ± 35.3	NA
Time since last episode (days)	40.5 ± 55.3	NA
Duration of an episode (days)	12.4 ± 31.6	NA
Pain intensity during episode (0 – no pain at all, 10 – worst imaginable pain)	4.0 ± 1.5	NA
Disability during episode (0 – not disabled at all, 10 – totally disabled)	1.6 ± 1.3	NA

LBP – low back pain, rLBP – history of recurrent low back pain during remission, No LBP – no previous episode of low back pain, BMI – body mass index, IPAQ – International Physical Activity Questionnaire, MET – metabolic equivalent, ABM – aberrant movement, SLR – straight leg raising, NA – not applicable

Table 3. Kappa statistics, chi-square test results, and diagnostic accuracy of CPR and each clinical test

Parameter	Agreement (%)	Kappa	PABAK	χ^2	*p*	SN	SP	+LR	–LR	Accuracy
CPR	90.0	0.73 (0.45–1.00)	0.80 (0.49–1.00)	16.28	< 0.001	0.95 (0.77–0.99)	0.75 (0.35–0.97)	3.82 (1.15–12.72)	0.06 (0.01–0.43)	0.90 (0.73–0.98)
ABM	76.7	0.17 (0.45–1.00)	0.53 (0.20–0.80)	2.85	0.092	1.00 (0.85–1.00)	0.13 (0–0.53)	1.14 (0.88–1.49)	0.21 (0.02–2.05)*	0.77 (0.58–0.90)
SLR	90.0	0.73 (0.45–1.00)	0.80 (0.49–1.00)	16.28	< 0.001	0.95 (0.77–0.99)	0.75 (0.35–0.97)	3.82 (1.15–12.72	0.06 (0.01–0.43)	0.90 (0.73–0.98)

PABAK – prevalence-adjusted and bias-adjusted kappa, SN – sensitivity, SP – specificity, +LR – positive likelihood ratio, –LR – negative likelihood ratio, CPR – clinical prediction rule, ABM – aberrant movement, SLR – passive straight leg raising test
* There was zero value in the contingency table; therefore, 1 was added to each cell in the contingency table to calculate –LR.

Discussion

The results of the present study supported our hypothesis that individuals with positive CPR would have rLBP. It was indicated that positive CPR was significantly associated with rLBP. Although related studies have demonstrated the effectiveness of MCE to improve trunk neuromuscular control and lumbar stability [4–6, 20], the subjects with rLBP in our study did not previously receive any motor control training for their LBP. This information suggests that they would still have existing impairments [14–18]. These impairments are represented by our findings: individuals with rLBP demonstrated positive results in ABM during active forward bend and passive SLR tests. Therefore, CPR can be used clinically to identify patients with rLBP. CPR will enable us to identify individuals more likely to experience a recurrent episode of LBP and thereby to prescribe an appropriate physical therapy prevention program. This would further reduce the recurrence rate of LBP, which is the major problem in managing the condition.

Age less than 40 years was one of the clinical criteria in CPR and CPR validation studies on MCE [4–6]. Our study had a pre-specified age less than 40 years as one of the inclusion criteria. We purposely selected this age because related studies had demonstrated that individuals with LBP aged below 40 years were more likely to exhibit impaired trunk neuromuscular control resulting in CLI and would benefit from MCE. However, patients older than 40 years were more likely to have a specific low back condition, such as degenerative spine, spondylosis, or spinal stenosis [5, 21–23]. In addition, there is evidence that advanced age is associated with reduced lumbar extensor muscle mass. Accordingly, researchers have suggested that individuals older than 40 years might require other prevention programs in addition to MCE to achieve the same gains as their younger counterparts [5]. Our finding regarding age implied that patients with rLBP would be more likely to benefit from MCE to prevent recurrent episodes of LBP. However, additional studies are required to verify this benefit.

Several studies have implied that observing ABM during active trunk motion is a critical component in physical therapy examination to identify signs of CLI [5, 6, 14, 24]. Our finding demonstrated a trend indicating that the presence of ABM was associated with rLBP. The result is consistent with that of a study reporting that individuals with rLBP present a higher frequency of ABM patterns [14]. The presence of ABM among rLBP patients may represent existing impaired trunk neuromuscular control, contributing to the recurrence of LBP [9, 14–16, 18]. Our finding suggests that ABM could be clinically useful to identify unresolved dysfunctions among individuals with rLBP at risk of recurrence injury [14]. Thus, MCE should be recommended in these cases to prevent recurrent episodes of low back symptoms.

In addition, 87.5% of participants in the non-rLBP group had positive ABM results during active forward bend. One study found that ABM might be observed among asymptomatic individuals. The frequency of ABM ranged between 11% and 43% in subjects with no history of LBP and between 22% and 81% in those with a history of LBP [14]. We observed a higher ABM frequency among individuals with no LBP compared with that study. This could have been an indicator of an early phase of trunk neuromuscular control impairment, potentially compromising the lumbar stabilizing system [12]. Accordingly, individuals with no rLBP but having positive ABM results could be at risk of injury, constituting a probable further cause of their first ever LBP episode. However, future longitudinal studies are necessary to follow up this group to determine whether the presence of ABM is a predictor of an LBP episode in individuals with no history of LBP.

A passive SLR result greater than 91° was another criterion to identify patients with CLI [4–6]. Our result indicated a higher frequency of positive passive SLR results among participants with rLBP. This suggests that passive SLR can be used to differentiate individuals with rLBP from those without history of LBP. Thus, early MCE should be introduced in these groups to minimize the risk of recurrent LBP.

The passive SLR test in our study was intended to identify CLI rather than neural tension or hamstring muscle length [5]. An angle greater than 91° in this test could have resulted from lumbar spine contribution, particularly in CLI cases. Instability in the lumbar spine would exhibit less resistance and allow movement during the passive SLR test, creating a greater angle when compared with that in individuals without rLBP [3].

The demographic data demonstrated no significant difference between the rLBP and non-rLBP groups, indicating comparability between the groups, except for BMI, which was greater among individuals with rLBP. The presented BMI profile was consistent with that in another study investigating rLBP subjects [15]. This higher BMI could suggest that these individuals may have a risk of recurrent episodes of LBP. Studies examining the correlation between BMI and LBP prevalence revealed a significant association, indicating that greater BMI would increase the risk of recurrent LBP [25, 26]. It was speculated that higher BMI could alter body biomechanics by increasing the mechanical load on the spine, thereby raising the risk of injury to the lumbar spine [25, 26]. This stress could further change joint alignment, leading to postural malalignment or altered movement patterns [3, 9, 12]. Sustained poor posture or repetitive altered movements could cause tissue micro-trauma and micro-instability, which, in turn, increase the likelihood of recurrent LBP symptoms [3].

Although the statistical analysis revealed no significant difference in male-female proportion between the groups, the non-rLBP group involved a greater proportion of females (7 of 10), which could have affected our results. However, one study investigating the impact of sex on postural control among patients with chronic LBP reported no such influence on static or dynamic trunk postural control [27]. In our research, ABM patterns were presented during the initial phase of active forward bend. This suggests that the subjects' movement primarily relied on neuromuscular control rather than structures of the joint or muscle and soft tissue properties depending on sex. Therefore, sex difference should not have affected our outcome measures. However, research evidence is still needed to support our interpretation.

Our findings on rLBP characteristics demonstrate that the subjects had the first episode of LBP almost 2 years earlier, with an episode frequency as high as every month, and each episode lasting for almost 2 weeks. They typically experienced moderate pain with low level of disability. The onset time was still in the range reported in the literature (13–98 months), in which evidence indicated the existence of trunk neuromuscular control impairment and persistence of ABM [14, 15]. The frequency and duration data suggest that the affected individuals had problems with recurrent episodes [15], and prevention programs were required to minimize this risk of recurrence. The time since the last episode indicated that they had been currently pain-free for quite a while, and our findings demonstrated that they still experienced signs of persisting CLI, represented by positive CPR [4–6]. Therefore, individuals with rLBP might need interventions addressing their impairment to prevent episodes of LBP.

Limitations

Our study encountered some limitations. First, it constituted a part of another project, which limited our ability to control the subjects' characteristics. For example, the imbalance in the sample size between the groups (22 participants with rLBP and 8 with no LBP) could have caused prevalence bias. Future studies should balance the number of subjects to minimize this effect. All subjects in this study were purposively selected as aged below 40 years. This could have introduced selective bias. Further studies should validate the age to ensure that age less than 40 years possessed the ability to identify individuals with rLBP who would likely benefit from MCE. However, our demographic data indicated that the groups were comparable. Second, our study demonstrated that the prevalence of subjects with rLBP was higher than that of individuals without rLBP, which could have resulted in prevalence bias [28]. Future studies should control this prevalence bias to confirm the findings of our study. Another limitation was the clinical observation of ABM in which we applied only one repetition rather than 3 repetitions, as reported in a related study [14]. Consequently, a possibility exists that the physical therapists might have missed identifying ABM. Future researchers should take this issue into consideration when designing studies to investigate ABM during active forward bend test. All participants in this study were under 40 years of age, and we did not perform the prone instability test. This weakness of the study design accounted for a potential limitation. However, our findings are still useful for clinicians in that we know that individuals presenting ABM during active forward bend and having passive SLR greater than 91° were more likely to exhibit recurrent symptoms of LBP. Nevertheless, replication with the original set of CPR is still required. To reproduce our study, a minimum sample size of 18 (9 subjects per group) would be necessary to detect any significant association between CPR and rLBP on the basis of chi-square statistics with a true positive proportion in the rLBP group of 0.95, false positive proportion in the non-rLBP group of 0.33, 80% power, and confidence level of 0.05.

Conclusions

The present study aimed to validate CPR using the known-group method to identify individuals with rLBP of whom we hypothesized that they would have existing impaired trunk neuromuscular control causing CLI. CPR in this study included (1) a positive ABM result during active forward bend and (2) a positive passive SLR test result. Our findings support the predictive validity of CPR; therefore, CPR can be used to identify individuals with rLBP. This would help implement an early prevention program addressing trunk neuromuscular control with MCE in order to minimize the risk of recurrent low back symptoms.

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Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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