



# Novel assessment of physiotherapy outcomes in adults with structural spinal disorders

Keita Sato<sup>1</sup> · Toshikazu Ito<sup>1,2</sup> · Tatsuya Endo<sup>1</sup> · Takuya Miura<sup>1</sup> · Masumi Iwabuchi<sup>1</sup> · Osamu Shirado<sup>1</sup>

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## Abstract

**Purpose** The aim is to investigate whether a simple prone posture assessment test (P-test) at baseline can be predict the effectiveness of at least 3 months of physiotherapy for adults with structural spinal disorders.

**Methods** Seventy-six adults (age  $71.0 \pm 7.1$  years) with structural spinal disorders who visited our outpatient clinic and underwent physiotherapy, which included muscle strength and range of motion training was provided once a week for a minimum of 3 months, and where the load was adjusted individually by the physiotherapist. The P-test is performed with the subject lying on the bed in a prone position and is positive if no low back pain is seen and the abdomen touches the bed. The Oswestry Disability Index (ODI) was used to assess disability. The minimum clinically important difference (MCID) was set at 10% improvement of the ODI score. Logistic regression analysis was performed to investigate the association between baseline P-test and achievement of ODI-MCID.

**Results** The study population characteristics were: Sagittal vertical axis  $138.1 \pm 73.2$  mm; Pelvic tilt,  $36.9 \pm 9.8$  degrees; Pelvic incidence minus lumbar lordosis,  $45.3 \pm 22.1$  degrees; and maximum coronal Cobb angle,  $21.3 \pm 19.7$  degrees. Logistic regression analysis showed that being positive on the P-test was associated with the achievement of ODI-MCID (Odds ratio, 8.381; 95% confidence interval, 2.487–35.257).

**Conclusions** This study found that our developed P-test was a useful predictor of achieving the ODI-MCID in a cohort of adults with structural spinal disorders receiving at least 3 months of physiotherapy.

**Keywords** Spine · Spinal disorders · Conservative treatment · Physical therapy · Disability evaluation

## Introduction

With the aging of society, structural spinal disorder as a musculoskeletal disease has become an important health issue for the elderly [1–3]. Structural spinal disorder has been reported to cause low back pain and to be associated with an increased risk of falls, resulting in a worse clinical outcome [4–6]. Surgical treatment or non-surgical treatment is indicated for improving clinical outcome in adults with structural spinal disorder [7–11].

Non-surgical treatment has been considered to be the first choice for adults with structural spinal disorder, although there is no high-quality evidence [1, 12, 13]. Among non-surgical treatments for structural spinal disorder, physiotherapy focusing on exercise therapy and cognitive-behavioral therapy has been reported to have some effect on improving posture and disability [10, 11]. In the case of surgical treatment for structural spinal disorders in adults, a simple "kitchen elbow sign" indicating abnormal skin changes, such as skin pigmentation from the elbow to the forearm, was reported to predict improvement in disability [14]. For physiotherapy, however, there is no report about a predictor that can predict the clinical outcome for adults with structural spinal disorder. Identifying outcome predictors of physiotherapy for patients with structural spinal disorder would be helpful for planning and decision making regarding treatment. In a previous study, it was reported that lumbar lordosis is increased in the prone position compared to the standing position [15]. Based on these results, we hypothesized

✉ Keita Sato  
keita-s@fmu.ac.jp

<sup>1</sup> Departments of Rehabilitation/Orthopaedic and Spinal Surgery, Aizu Medical Center, Fukushima Medical University, 21-2, Tanisawa-Aza-Maeda, Kawahigashi, Aizuwakamatsu, Fukushima 969-3492, Japan

<sup>2</sup> Hokkaido Chitose College of Rehabilitation, Chitose, Hokkaido, Japan

that participants would maintain lumbar flexibility if they had no difficulty in the prone posture, and we designed a simple prone posture assessment (prone test; P-test). The P-test was developed to simply evaluate spinal flexibility. The P-test is performed by having the subject lie on the bed in a prone position. The P-test is a positive if the abdomen touches the bed without the appearance of low back pain.

The purpose of this study was to determine whether a P-test at baseline could predict improvement in disability with at least three months of physiotherapy for adults with structural spinal disorder. The findings from this study may expand the evidence for physiotherapy for adults with structural spinal disorder.

## Materials and methods

### Study design

This study was a retrospective cohort study conducted in a single hospital. The guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement were followed [16]. The current study was approved by our institutional review board (IRB No. 2369).

### Patient population

The study population consisted of adults with structural spinal disorder who visited our outpatient clinic between April 2013 and December 2021 and underwent physiotherapy for at least 3 months. The facility where this study was conducted is an academic and affiliated acute care hospital, where surgical treatment is the main focus, but also provides conservative treatment as a regional core hospital. The outpatient clinic is one of its departments. The inclusion criteria were patients aged 50 years or older with the presence of at least one of the following measures of structural spinal disorder on the whole spine standing radiographs: (1) sagittal vertical axis (SVA) of 40 mm or more; (2) pelvic tilt (PT) of 20 degrees or greater; (3) pelvic incidence minus lumbar lordosis (PI-LL) of 10 degrees or greater; or (4) coronal Cobb angle (CCA) of 30 degrees or greater [17]. The X-ray parameters were measured by two spinal surgeons using full-length spine standing radiographs with the patient in the fist-on-clavicle position. The measured spinopelvic parameters were as follows: (1) SVA, the sagittal distance between the C7 plumb line and the posterior superior corner on the top margin of S1; (2) lumbar lordosis (LL), the angle between the superior endplate of L1 and the superior endplate of S1; (3) PT, the angle between the vertical line drawn up from the center of the femoral head and the line connecting this point to the midpoint of the sacral endplate; (4) pelvic

incidence (PI), the angle between the line perpendicular to the sacral plate at its midpoint and the line connecting this point to the femoral head axis; (5) PI-LL; and (6) CCA, the maximum angle of the coronal curve between the upper and lower vertebrae. Patients with neuromuscular diseases, spinal infections, spinal deformities due to tumors, previous spinal surgeries, lower extremity pain due to lumbar spinal canal stenosis, previous surgery for lower limb osteoarthritis, and having undergone facet joint or epidural injection were excluded.

All patients were referred to the outpatient clinic by their respective primary care physicians. Eligible patients for the study who were referred during the inclusion period were included in the study, with the exception of those who refused treatment with physiotherapy. Acetaminophen and non-steroidal anti-inflammatory drugs medications were allowed as needed.

### Details of outpatient rehabilitation

The protocol for outpatient rehabilitation is as follows: The patients visited the clinic once a week and received an individualized physiotherapy program for 60 min based on the physical function assessment and complaints, consisting of 40 min of physiotherapy and 20 min of self-exercises. The purpose of the self-exercises was to be able to perform them at home, and the physiotherapist in charge provided feedback on the intensity and frequency of the exercises as appropriate. The physiotherapy program mainly consists of lumbar extension exercise, posture correction, and aerobic exercises, aiming at both strengthening of the trunk and hip extensor muscles, and improving flexibility in the direction of trunk and hip extension through joint range of motion training. Programs were individually conducted by the one physiotherapist (Figs. 1 and 2).

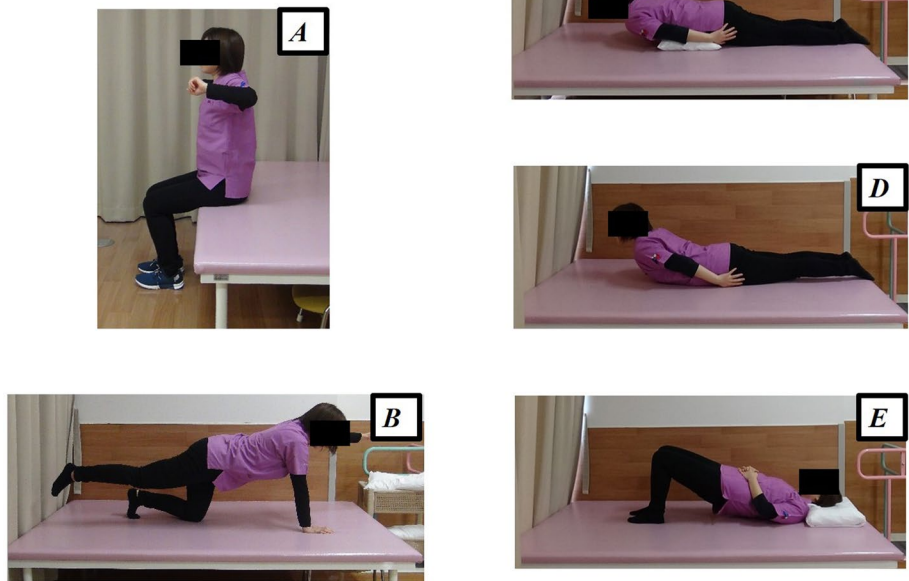
Correlations among patient complaints and physical function and treatment were based on commonly performed physical assessments (range of motion measurements and manual muscle testing). Exercise therapy given to the patient began with a goal of five sets of 20 times for muscle strengthening and 10 sets of 20 s for range of motion training. The amount of load was gradually increased based on the patients' ability and their comfort performing the specified exercises.

### Measurement of the P-test

The patient was instructed to lie in the prone position on the bed and no time limit was set for performing the P-test. The patients were required to lie prone on the bed, and the P-test was judged positive if the abdomen touched the bed during the test without the appearance of low back pain. On the other hand, if low back pain appeared during

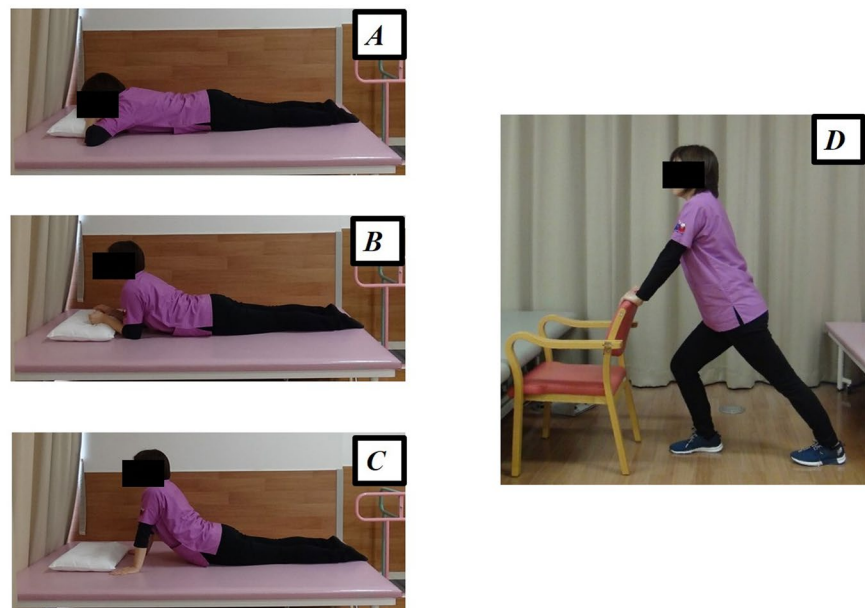
**Fig. 1** Examples of muscle strengthening programs provided to patients. **A:** Back extension exercise, in sitting position. **B:** Back and hip extension exercises, in all fours posture (bird dog exercise). **C,** **D:** Back extension exercises, in prone position. **E:** Hip extension exercises (bridge exercise)

**Muscle strengthening**



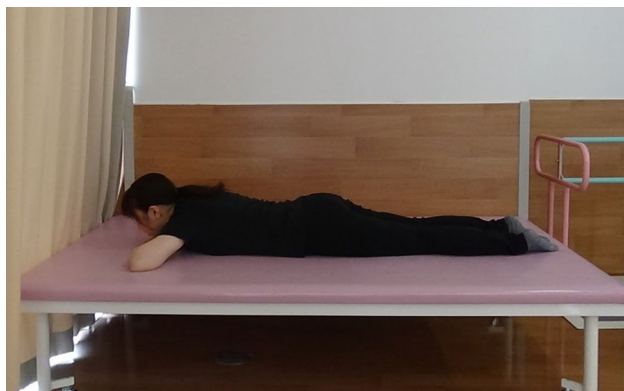
**Fig. 2** Examples of joint range of motion training programs provided to patients. **A:** Lumbar spine neutral exercise (prone position). **B:** Lumbar spine extension exercise (on elbow). **C:** Lumbar spine extension exercise (on hand). **D:** Hip flexors stretches (lunge position)

**Range of motion training**



the test or the abdomen did not touch the bed, the test was judged negative (Figs. 3 and 4). The P-test does not take into account the effect of abdominal circumference, but even patients with large abdominal circumference and abdominal contact with the bed were considered negative if they had the appearance of pain. The P-test was blinded to patient information, including medical history, and was

judged by a physiotherapist who was not in charge of the patient care. The P-test was performed prior to the start of physiotherapy. In our preliminary study, the results of the P-test assessment performed on 20 participants by two physiotherapists showed perfect agreement with a kappa coefficient of 1.00.



**Fig. 3** Positive prone test, The test is considered positive if the patient can lie prone without any pain and the abdomen is in contact with the bed



**Fig. 4** Negative prone test, The test is considered negative if back pain is present, the abdomen does not touch the bed due to pain, or the patient cannot lie prone without assistance

### Clinical outcome measurement

Clinical outcomes were assessed using the Oswestry disability index (ODI) administered before the start of physiotherapy and at the last follow-up. Last follow-up was at least 3 months, depending on each patient. The ODI was assessed using paper-based questions by a medical clerk independent of the physician and physiotherapist who diagnosed and treated the patient. In this study, the ODI scores were calculated excluding an item related to "sex life" [18]. Changes in scores of ODI administered twice were calculated and were assessed whether or not the minimum clinically important difference (MCID), set at 10 points, was achieved [19, 20].

### Statistical analysis

After the data were collected, those were analyzed using SPSS (version 27.0; IBM, NY, USA). Continuous variables represented means and standard deviations (SD) or median

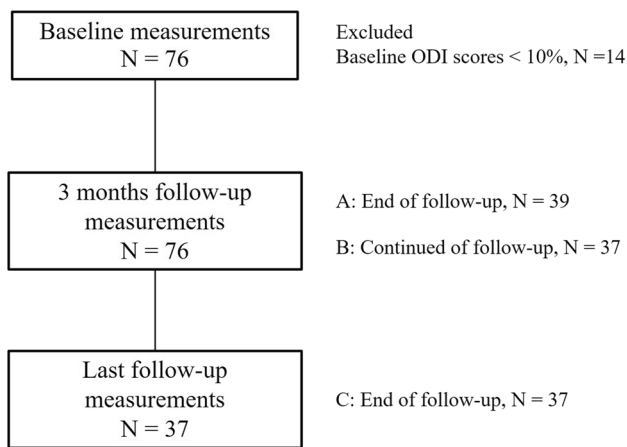
and inter-quartile range [IQR], and dichotomous variables represented percentages. First, measurement parameters including the P-test were compared between the patients who achieved the ODI-MCID and those who did not, using Student t-test, Mann–Whitney U test and Chi-square test. Subsequently, multivariable logistic regression analysis was used to investigate the association between baseline P-test and achievement of ODI-MCID. For covariates, demographic data such as gender, age, body mass index (BMI), and radiographic parameters (SVA, PT, PI-LL, and CCA), which are considered important in clinical practice, were selected and forced into the model, regardless of whether they were statistically significant. The predictive performance of the P-test for achieving ODI-MCID was evaluated using the receiver operating characteristic (ROC) curve. The main analysis in this study was performed using the assessment at a 3 months follow-up. If any participants continued physiotherapy after 3 months, a secondary analysis was performed using the assessment at the end of the follow-up. P values less than 0.05 were considered statistically significant.

## Results

### Patient characteristics

Fourteen participants were excluded because their ODI scores prior to the start of physiotherapy were less than 10%. As a result, 76 adults with structural spinal disorder (male, nine; female, 67) were included in the analysis. The main analysis in this study was performed on 76 participants using assessments at the 3 months follow-up. The secondary analysis was performed using the last follow-up assessment of each of the 37 participants who were terminated at the 3-month follow-up and the 39 who continued physiotherapy (Fig. 5). Their basic characteristics are shown: age,  $71.0 \pm 7.1$  years; height,  $150.8 \pm 7.1$  cm; weight,  $53.9 \pm 8.4$  kg; and BMI,  $23.7 \pm 3.5$  kg/m<sup>2</sup>. The follow-up duration for physiotherapy was 3.0 [3.0, 6.0] months. All participants completed three months of physiotherapy and did not drop out before the last outcome assessment was conducted. The averages of the parameters in the sagittal and coronal planes that were obtained from full-length spine standing radiographs were: SVA,  $138.1 \pm 73.2$  mm; PT,  $36.9 \pm 9.8$  degrees; PI-LL,  $45.3 \pm 22.1$  degrees; and CCA,  $21.3 \pm 19.7$  degrees. The ODI score of the study participants was: before the start of physiotherapy,  $36.3 \pm 10.5\%$ ; and at the last follow-up,  $26.0 \pm 14.4\%$ . The results of the P-test of the participants were positive in 39 patients and negative in 37 patients (Table 1). Table 2 shows a detailed severity of x-ray parameters of the study participants, and Table 3 shows details of patients who were P-test negative. Table 4





**Fig. 5** Study protocol. The main analysis was performed using measurements at 3 months for (A) and (B). Secondary analysis was performed using the end of follow-up measurements for (A) and (C). Fourteen participants were excluded because their ODI at baseline was below 10%. The median [IQR] of the final follow-up period was 6.0 [5.0, 6.0] months. IQR—inter-quartile range; ODI—Oswestry disability index

**Table 1** Background data of the subjects

| Variables                                 | N = 76         |
|---|----------------|
| Gender, female, N                         | 67 (88.2%)     |
| Age (years)                               | 71.0 ± 7.1     |
| Height (cm)                               | 150.8 ± 7.7    |
| Weight (kg)                               | 53.9 ± 8.4     |
| BMI (kg/m <sup>2</sup> )                  | 23.7 ± 3.5     |
| Follow-up duration (months)               | 3.0 (3.0, 6.0) |
| SVA (mm)                                  | 138.1 ± 73.2   |
| PT (degrees)                              | 36.9 ± 9.8     |
| PI-LL (degrees)                           | 45.3 ± 22.1    |
| CCA (degrees)                             | 21.3 ± 19.7    |
| ODI before the start of physiotherapy (%) | 36.3 ± 10.5    |
| ODI at the last follow-up (%)             | 26.0 ± 14.4    |
| Positive P-test, N                        | 39 (51.3%)     |

The mean and standard deviation (SD) of each measurement item  
*BMI*—body mass index; *CCA*—maximum coronal Cobb angle; *ODI*—Oswestry disability index; *P-test*—prone test; *PT*—pelvic tilt; *PI-LL*—pelvic incidence minus lumbar lordosis; *SVA*—sagittal vertical axis

shows the predictive performance of the P-test using the ROC curve: the P-test had a percentage of correct classifications of 69.7%.

**Association of the P-test with the achievement of ODI-MCID**

Thirty participants (39.5%) achieved ODI-MCID after 3 months, and all participants adhered to the weekly visits

**Table 2** Percentage of subjects based on SRS-schwab classification [17]

|                      |                            | Number of subjects (%) |
|----------------------|----------------------------|------------------------|
| SVA:                 | < 40 mm                    | 4 (5.3%)               |
|                      | 40–95 mm                   | 22 (28.9%)             |
|                      | 95 mm <                    | 50 (65.8%)             |
| PT:                  | < 20 degrees               | 4 (5.3%)               |
|                      | 20–30 degrees              | 10 (13.2%)             |
|                      | 30 degrees <               | 62 (81.5%)             |
| PI-LL:               | within 10 degrees          | 2 (2.6%)               |
|                      | Moderate 10–20 degrees     | 8 (10.6%)              |
|                      | Marked > 20 degrees        | 66 (86.8%)             |
| Coronal curve types: | No Major coronal deformity | 52 (68.4%)             |
|                      | Thoracic only              | 6 (7.9%)               |
|                      | TL/Lumbar only             | 15 (19.7%)             |
|                      | Double Curve               | 3 (4.0%)               |

The mean and standard deviation (SD) of each measurement item  
*PT*—pelvic tilt; *PI-LL*—pelvic incidence minus lumbar lordosis; *SVA*—sagittal vertical axis

**Table 3** Detailed data on subjects with negative P-test

|   | N = 37     |
|---|------------|
| Low back pain                               | 16 (43.2%) |
| Abdomen not touching the bed                | 21 (56.8%) |
| Patient cannot lie prone without assistance | 0 (0%)     |

*P-test*—prone test

**Table 4** The performance of the P-test to predict the achievement of ODI-MCID

|                 | ODI-MCID achieved | ODI-MCID non-achieved |
|-----------------|-------------------|-----------------------|
| P-test positive | N = 23            | N = 16                |
| P-test negative | N = 7             | N = 30                |

*ODI-MCID*—Oswestry disability index-minimum clinically important difference; *P-test*—prone test

Percentage of correct classifications: 69.7%, Sensitivity: 0.77 (0.62–0.92), Specificity: 0.65 (0.51–0.79), Positive likelihood ratio: 2.20 (1.43–3.40), Negative likelihood ratio: 0.36 (0.19–0.69)

without deviating from the study protocol. Comparison of each parameter between the ODI-MCID attainment and non-attainment groups showed significant differences in P-test results between the groups. There was no significant difference between the groups in other measurement parameters (Table 5). Multivariable analysis, adjusted for covariates, showed that a positive P-test was a factor associated with the

**Table 5** Comparison of each measurement item between the achievement and non-achievement groups of ODI-MCID

| Variables  | Achievement <i>N</i> =30 | Non-achievement <i>N</i> =46 | OR (95% CI)          | <i>P</i> value |
|--|--------------------------|------------------------------|----------------------|----------------|
| Gender, female, <i>N</i> *                                   | 25 (83.3%)               | 42 (91.3%)                   | 0.476 (0.109–1.959)  | 0.30           |
| Age (years) <sup>#</sup>                                     | 72.2 ± 7.1               | 70.2 ± 7.1                   | –                    | 0.25           |
| Height (cm) <sup>#</sup>                                     | 151.8 ± 7.6              | 150.2 ± 7.9                  | –                    | 0.38           |
| Weight (kg) <sup>†</sup>                                     | 52.3 (47.0, 59.0)        | 52.8 (47.5, 57.7)            | –                    | 0.86           |
| BMI (kg/m <sup>2</sup> ) <sup>†</sup>                        | 23.2 (21.5, 24.2)        | 23.7 (21.3, 25.6)            | –                    | 0.41           |
| Follow-up duration (months) <sup>†</sup>                     | 3.0 (3.0, 6.0)           | 5.0 (3.0, 6.0)               | –                    | 0.43           |
| SVA (mm) <sup>†</sup>  | 135.6 (70.8, 168.3)      | 121.2 (91.9, 204.6)          | –                    | 0.44           |
| PT (degrees) <sup>#</sup>                                    | 34.8 ± 11.3              | 38.3 ± 8.5                   | –                    | 0.12           |
| PI-LL (degrees) <sup>†</sup>                                 | 36.0 (21.5, 60.5)        | 47.0 (35.3, 54.8)            | –                    | 0.24           |
| CCA (degrees) <sup>†</sup>                                   | 20.0 (5.3, 26.0)         | 16.5 (2.5, 40.0)             | –                    | 0.63           |
| ODI score before the start of physiotherapy (%) <sup>#</sup> | 36.4 ± 11.9              | 36.3 ± 9.7                   | –                    | 0.94           |
| ODI score at the last follow-up (%) <sup>#</sup>             | 18.4 ± 10.9              | 33.1 ± 11.2                  | –                    | <0.01          |
| Positive P-test, <i>N</i> *                                  | 23 (76.6%)               | 16 (34.8%)                   | 6.161 (2.264–18.505) | <0.01          |

The mean and standard deviation (SD) of each measurement item

*BMI*—body mass index; *CCA*—maximum coronal Cobb angle; *ODI*—Oswestry disability index; *OR*—odds ratio; *P-test*—prone test; *PT*—pelvic tilt; *PI-LL*—pelvic incidence minus lumbar lordosis; *SVA*—sagittal vertical axis; *95% CI*, 95% confidence interval

<sup>#</sup>Student t-test, <sup>†</sup>Mann–Whitney U test, \*Chi-square test

**Table 6** Multivariable logistic regression analysis of factors associated with achievement of ODI-MCID

| Variables  | OR (95%CI)           | <i>P</i> value |
|--|----------------------|----------------|
| Main analysis ( <i>N</i> =76) positive P-test      | 8.381 (2.487–35.257) | <0.01          |
| Secondary analysis ( <i>N</i> =76) positive P-test | 6.224 (2.017–22.151) | <0.01          |

The multivariable logistic regression analysis was adjusted for confounding factors (gender, age, body mass index, sagittal vertical axis, pelvic tilt, pelvic incidence minus lumbar lordosis, and maximum coronal Cobb angle)

*ODI-MCID*—Oswestry disability index-minimum clinically important difference; *OR*—odds ratio; *P-test*—prone test; *95%CI*, 95% confidence interval

achievement of ODI-MCID (Odds ratio (OR), 8.381; 95% confidence interval (95%CI), 2.487–35.257). Similarly in the secondary analysis, P-test positivity was a factor associated with the achievement of ODI-MCID (Table 6).

## Discussion

This study examined whether our P-test was associated with clinical outcome of physiotherapy for adults with structural spinal disorder. The results showed that the P-test positivity had an association with improved ODI scores after physiotherapy.

Surgical treatment for adults with structural spinal disorders improves clinical outcomes, but because of the high

complication rate, non-surgical treatment is usually the first choice for adults with structural spinal disorders [7–13, 21, 22]. Among non-surgical treatments, physiotherapy has been shown to be effective to a certain extent, especially in clinical practice where muscle strengthening exercises and stretching in the direction of trunk extension are performed [10]. The predictive factors for surgical treatments in adults with structural spinal disorder have been reported, and studies have been conducted on decision making to determine treatment strategies [14, 23, 24]. However, the predictive factors for physiotherapeutic treatments in adults with structural spinal disorder are still unknown, and methods to determine the indications for physiotherapy have not been established. The current study is the first investigation to examine factors associated with clinical outcome in adults with structural spinal disorder undergoing specific physiotherapy with a focus on active and passive hip and spine extension.

In this study, the achievement of ODI-MCID with physiotherapy for adults with structural spinal disorder was associated with the positivity of the P-test. This means that patients with a positive P-test are approximately six times more likely to achieve ODI-MCID than those with a negative P-test. Adults with structural spinal disorder with a positive P-test may have preserved flexibility of the spine and lower extremity joints. In the presence of severe lumbar extension limitation or flexion contracture of the lower extremities, it is difficult to lie in the prone position. With the use of the P-test, joint flexibility in the spine and lower extremities could be visually assessed, and the P-test may be able to

identify adults with structural spinal disorders that would not benefit from physiotherapy. In a previous study similar to the present study, Cheung et al. examined factors predicting achievement of ODI-MCID in adults with structural spinal disorder who received non-surgical treatment but were unable to identify factors predicting achievement of ODI-MCID [25]. Despite differences in treatment protocols, this study suggests that achievement of ODI-MCID may be predicted by P-test. This would have a positive impact on clinical practice, as it would provide information for physicians and physiotherapists treating adults with structural spinal disorder to predict treatment effectiveness and prognosis.

The strength of this study is that the P-test is a simple and feasible screening method in clinical situation, which can determine the indications for physiotherapy in adults with structural spinal disorder. The P-test can be performed in a small space, such as an outpatient examination room, and does not require special equipment or a lot of time. Furthermore, judging the results of the P-test does not require any special skills. The P-test can be judged by whether the abdomen touches the bed or not. Therefore, the influence of the examiner's experience can be expected to be small, thus the test can be performed by both inexperienced and experienced examiners (Kappa coefficient of 1.00).

This study contains several limitations. First, the physiotherapy administered to the adults with structural spinal disorder included in the analysis was an individualized program and was not performed according to a uniform protocol. Therefore, it is impossible to describe the effects of physiotherapy in detail. However, in this study, although there was no clear standardized protocol, an individualized physiotherapy program was proposed and implemented by one physiotherapist based on the patient's symptoms and complaints and the results of the physiotherapy evaluation (measurement of joint range of motion and muscle strength) before physiotherapy was performed. Intervention by one trained physiotherapist would work to reduce the variability of treatment effects. Since the complaints and symptoms of actual patients are not identical, the results of this study may be more relevant to clinical practice. Because this study included only one cohort where all participants received physiotherapy, it is unclear if the patients with a positive P-test would present good response to other treatment or even without treatment. Future studies, will be needed to clarify if being positive on the P-test predict good response specifically to our physiotherapy program or if it is a global indicator of good prognosis to many other treatments or even to no treatment. Nevertheless, patients negative on the P-test could not be expected to recovered with our physiotherapy program. Second, the P-test used in this study is not a globally standardized method. The P-test we devised does not consider account the time required for evaluation or the time it takes for pain to appear. Nor does it consider account the

influence of abdominal shape. The multivariable analysis shows that the 95%CI for the OR for being positive on the P-test was wide going from 2.487 to 35.257. Although P-test positivity is a relevant factor in achieving ODI-MCID, caution should be exercised in interpreting its accuracy. The results of the P-test assessment showed perfect agreement with a kappa coefficient of 1.00. This may be due to the very simplicity of the P-test judgments. These results may indicate differences in patient characteristics due to functional impairment or pathophysiology as indicated by the P-test, and classification of the participants into several subgroups may make the results of this study more robust. Future study to determine the detailed measurement conditions of the P-test and to investigate the functional impairment and pathophysiology of structural spinal disorders in adults as demonstrated by the P-test will bring the P-test closer to a standardized method. Third, this study had only a short-term follow-up. With a median follow-up and IQR of 3.0 [3.0, 6.0] months in this study, we were unable to determine the long-term effects of physiotherapy. A long-term follow-up is needed in future. Finally, Type 2 error may be present due to the small sample size. However, Type 2 error is problematic when the results of the analysis are above the significance level. In this study, the P-test was shown to be a significantly associated factor improved outcomes from physiotherapy for adult with structural spinal disorders, suggesting that the impact of Type2 error in this study is small.

## Conclusion

The P-test developed in this study was found to be associated with clinical outcomes in a cohort of adults receiving a minimum of 3 months of physiotherapy for structural spinal disorders. P-test negative adult with structural spinal disorders who receive physiotherapy are unlikely to achieve good clinical outcomes by performing specific physiotherapy with a focus on active and passive hip and spine extension. In future, it is necessary to verify in a larger population whether the positive P-test results are a prognostic factor for any treatment or event to natural history of whether the P-test predicts good outcome specifically with the physiotherapy program focused on active and passive hip and spine extension.

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**Data availability** The datasets generated and/or analyzed in the current study are available from the corresponding author on reasonable request.

## Declarations

**Conflict of interest** The authors have no relevant financial or non-financial interests to disclose.

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