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Clinical Observation of Standing Trunk Movements: What Do the Aberrant Movement Patterns Tell Us?

Observation of trunk movement is considered an important part of the clinical examination of patients with low back pain (LBP). Limitations in the quantity of motion have been associated with myofascial restriction and facet joint dysfunction,[6,25] and changes in pain location or pain behavior (centralization and peripheralization) have been used to prescribe directionally specific exercises.[9,24] However, observation of the quality of trunk movement is also an essential component of the clinical examination. Aberrant movement patterns, or patterns that deviate from the typical or expected movement pattern, are associated with low back dysfunction[8] and with a particular subgroup of patients thought to have segmental hypermobility, clinical lumbar instability, or movement coordination impairment.[7-9,28]

STUDY DESIGN: Clinical measurement, cross-sectional study.

OBJECTIVES: To investigate the reliability of observation of aberrant movement patterns (altered lumbopelvic rhythm, deviation from sagittal plane, instability catch or judder, and painful arc of motion) and to determine whether each pattern is associated with current low back pain (LBP).

BACKGROUND: Identification of aberrant movement patterns during trunk motion is an important component of subclassifying patients with LBP and prescribing evidence-based interventions. However, reported reliability for observation of specific aberrant patterns is low, and observation of any aberrant pattern (clinical definition of positive test) has ranged from poor to moderate. In addition, the validity of the association of clinical observations of aberrant movements during forward bending with LBP or dysfunction has yet to be determined.

METHODS: Experienced physical therapists simultaneously observed trunk movements of 102 subjects with no LBP, current LBP, or history of LBP. Kappa statistics were used to evaluate interrater agreement in identifying different types of aberrant patterns. Associations were used to determine the validity of the hypothesized relationship between aberrant patterns and LBP.

RESULTS: Interrater reliability of identifying the different types of aberrant patterns in subjects with LBP ranged from fair (κ = 0.35; 95% confidence interval: 0.00, 0.71) to excellent (κ = 0.89; 95% confidence interval: 0.69, 1.00). Using the clinical definition of 1 observation of any aberrant motion, interrater agreement was substantial (κ = 0.65; 95% confidence interval: 0.00, 1.00). Significant association was found between judder, deviation, and LBP. The frequency of observed aberrant patterns was significantly associated with LBP.

CONCLUSION: Simultaneous observation for specific aberrant movement patterns suggests that identification can be performed with at least fair interrater agreement, and observation of any pattern with substantial agreement. Aberrant patterns are more frequently observed in patients with current complaints of LBP; however, they also appear in individuals with a history of LBP and no LBP. *J Orthop Sports Phys Ther 2014;44(4):262-272. Epub 22 January 2014. doi:10.2519/jospt.2014.4988*

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Several investigators have explored the ability of physical therapists to identify aberrant movement patterns during standing trunk movements.[10,14,17,30] Hicks et al[17] found that the interrater agreement ranged from poor for Gowers' sign (κ = 0.00) to substantial for a painful arc of motion in flexion (κ = 0.69). Because of low kappa values for the instability catch (κ = 0.25), Gowers' sign (κ = 0.00), and reversal of lumbopelvic rhythm (LPR) (κ = 0.16), Hicks et al[17] chose to consolidate aberrant movement into a single dichotomous variable. They operationally defined a clinically positive aberrant movement pattern as observation of any 1 or more of the 5 different aberrant movement pat-

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TABLE 1 Operational Definitions of Aberrant Movement Patterns

Aberrant Pattern	Operational Definition
Altered lumbopelvic rhythm	• In forward bending, hip motion greater than lumbar spine motion during the first third of the movement and/or lumbar spine motion greater than hip motion during the last third of the movement • In return to upright, lumbar spine motion greater than hip motion during the first third of the movement and/or hip motion greater than lumbar spine motion during the last third of the movement
Gowers' sign	• Return to upright stance performed by using hands to climb up the thighs, which is considered a type of altered lumbopelvic rhythm
Deviation from sagittal plane	• Movement away from the primary sagittal plane (flexion/extension), including rotations and/or lateral flexion; movement lasting more than a few degrees of the primary sagittal plane movement
Instability catch, shake, or judder	• A sudden acceleration, stop, or deceleration; observations of a momentary quiver, vibration, or shake seen in the paravertebral muscles; or brief out-of-plane movements
Painful arc of motion	• Pain, noted by the patient, that increases through a portion of the total arc of movement; a general increase in pain throughout the motion does not constitute painful arc

TABLE 2 Interrater Agreement From Previous Studies for Observation of Aberrant Movement Patterns

	Agreement, %	Kappa Value*
Hicks et al[17] (n = 63)		
Painful arc with flexion	92	0.69 (0.54, 0.84)
Painful arc with return	90	0.61 (0.44, 0.78)
Instability catch	92	0.25 (–0.10, 0.60)
Reversal of lumbopelvic rhythm	87	0.16 (–0.15, 0.46)
Gowers' sign	98	0.00 (–1.09, 1.09)
At least 1 aberrant movement	84	0.60 (0.47, 0.73)
Fritz et al[14] (n = 38)		
At least 1 aberrant movement	87	–0.07 (–0.45, 0.31)
Fritz et al[10] (n = 60)		
At least 1 aberrant movement	59	0.18 (–0.07, 0.43)
Stanton et al[30] (n = 30)		
At least 1 aberrant movement	50	0.00 (–0.32, 0.62)
Rabin et al[28] (n = 30)		
At least 1 aberrant movement	83	0.64 (0.32, 0.90)

Values in parentheses are 95% confidence interval.

terns assessed in their study, including painful arc of motion in flexion, painful arc of motion in return to standing, instability catch, Gowers' sign, and reversal of LPR. These aberrant movements are operationally defined in **TABLE 1**. The interrater agreement on the clinical observation of any aberrant movement was moderate (κ = 0.60). These authors[17] suggested that the different aberrant movements should be analyzed separately if evidence suggested that one aberrant pattern was potentially more diagnostic than another. Using the clinically positive operational definition, a recent study found similar moderate interrater agreement (κ = 0.64).[28] However, other investigators found poor (κ = –0.07[14]) and slight (κ = 0.00,[30] κ = 0.18[10]) interrater agreement. The inconsistent results of these interrater reliability studies suggest potential differences in study methodology and raise questions about the ability to reliably detect 1 or more aberrant movement patterns in patients with current low back symptoms (**TABLE 2**).

Observations of trunk aberrant movement patterns during forward bending and return to upright standing have long been associated with episodes of current LBP.[5] Though one would anticipate aberrant motion to be absent or diminished in patients who have no history of LBP or have recovered from an LBP episode, clinical experience indicates that this is not always the case. It has been suggested that aberrant movements may be a manifestation of unresolved underlying muscle dysfunction or motor control impairments that contribute to the recurrence of symptoms.[18,23] Aberrant trunk movement patterns are included in the cluster of clinical signs and symptoms associated with patients suspected of having segmental hypermobility or clinical lumbar instability.[8,27] Initial attempts at identifying patients in this subgroup have been based largely on expert opinion and included observation of aberrant patterns of movement, complaints of chronic or recurrent back pain, acute episodes provoked by relatively trivial incidents, history of frequent manipulations, improvement with spine support, and worsening with prolonged static postures.[7] The types of aberrant movement patterns traditionally included painful arc of motion,[21,26] an instability catch or judder,[27] Gowers' sign (thigh climbing),[2] and reversal of LPR.[2]

More recently, Hicks et al[16] attempted to validate the association between clinical signs and symptoms and the subgroup of patients with suspected clinical lumbar instability using a single-arm clinical prediction rule and the framework of the treatment-based classification (TBC) system. The TBC subgroups (specific exercise, manipulation, stabilization, and traction) are named by the primary intervention prescribed for the subgroup. The stabilization subgroup consists of patients who are thought to have segmental hypermobility, clinical lumbar instability, or movement coordination impairment. They are managed through an intervention of lumbar or core stabilization exercises.[16] Hicks et al[16] examined clinical signs and symptoms associated with subjects who improved or failed to improve with stabilization exercises. Aberrant movement patterns appeared as one of the criteria in both scenarios. Their presence indicated successful clinical outcomes and their absence indicated poor clinical outcomes with lumbar stabilization exercises. The ability to use the cluster of clinical characteristics (aberrant movement, age less than 40 years, positive prone instability test, average straight leg raise greater than 91°) to identify patients with acute and subacute LBP who fall into the stabilization subgroup has been supported by additional studies.[3,12,13,15] However, Stanton et al[30] suggested the need for revision of the TBC algorithm based on findings that 25% of the study participants did not fit into a single subgroup and another 25% met criteria for more than 1 subgroup, with 6.4% demonstrating overlap of the stabilization with the manipulation and specific exercise subgroups.[30]

To date, research conducted to determine whether clinicians can reliably detect individual types of aberrant movement patterns has been limited and equivocal. One factor that may account for the lower reliability in some studies is the use of subsequent rather than simultaneous observations of movement patterns. Pilot work has shown that aberrant movements may not occur consistently with every forward-bending motion.[1] Therefore, studies that use subsequent observations may find lower interrater agreement. Only 1 study[28] has used simultaneous observations and reported substantial interrater agreement using the criterion of observation of any 1 aberrant motion. This study did not assess the reliability of specific aberrant patterns. In addition, to our knowledge, no systematic investigation has been conducted to determine whether any of these aberrant movements are solely associated with individuals who have current LBP. Thus, the overall purpose of this study was to explore the clinical utility of observation of aberrant movement patterns. We hypothesized that (1) physical therapists observing aberrant patterns simultaneously would demonstrate at least moderate reliability and (2) each type of aberrant movement would be more frequently observed in subjects with current LBP than in asymptomatic subjects with a history of LBP or no history of LBP, thus supporting the construct validity of aberrant movements being associated with current LBP.

METHODS

Subjects

A sample of convenience was obtained from advertisements posted for patients and visitors at 2 outpatient physical therapy clinics. Subjects consisted of patients and the friends and relatives of patients. None of the subjects had a known musculoskeletal complaint other than LBP at the time of testing. Subjects were assigned to 1 of 3 groups on the basis of their current symptoms and/or history of LBP: group 1 (no LBP) had no current symptoms or history of LBP that exceeded 3 days or caused them to seek health care; group 2 (current LBP) had a current episode of LBP that started within the last 7 weeks that caused them to seek professional health care and was rated as 4 or greater on an 11-point numeric pain rating scale in the past 24 hours; and group 3 (history of LBP) currently had no symptoms but had experienced at least 1 episode of significant LBP in the past 2 years with symptoms that exceeded 3 days and that caused them to seek professional health care. The current LBP group was defined as being consistent with patients used in the development of the TBC system and clinical-decision algorithms.[3,11,13,16] Based on power analysis for the reliability of observations, using a total of 90 subjects allowed us to detect a kappa of at least 0.40 at 90% power. For individual groups of at least 32 subjects (no LBP, current LBP, history of LBP), we could detect a kappa of 0.50 at 80% power.[29] For the construct validity study, we used data from a prior study that collected the frequency of aberrant movements observed in patients with and without LBP to estimate subject numbers.[1] Using our frequency effect size of d = 0.80, α = .05, and 80% power, the a priori power analysis recommended a sample size of 21 per group (G*Power; http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3). Given the limitations of our prior study (single rater, not blinded to group, small sample size) and our desire to recruit subjects within each TBC subgroup,[3] we increased our sample size to 30 per group. Subjects were recruited consecutively at first and then as needed to fill each LBP group. Exclusion criteria consisted of (1) age under 25 or over 65 years; (2) clinical signs of systemic illness; (3) definitive neurologic signs, including weakness or numbness in the lower extremities; (4) previous spinal surgery; (5) diagnosed osteoporosis, stenosis, or inflammatory joint disease that interfered with upright stance; (6) pregnancy of greater than 4 months' gestation; and (7) any lower extremity condition that would potentially alter trunk movement in standing. Data were collected from October 6, 2008 to March 11, 2010.

Procedures

The Drexel University Institutional Review Board approved the study procedures. To maintain blinding, subjects were recruited by a physical therapist not involved in the observation portion of the study or treatment of patients at that clinic. Subjects were taken to a private examination room, asked for consent, and instructed in the study procedures. Following informed consent, all subjects completed a clinical intake form that provided demographic and background information about their history of LBP. Subjects wore clothing that allowed adequate visualization of the thoracic and lumbosacral spine. Five physical therapists with at least 5 years of experience (range, 5-25 years) in orthopaedic examination of the low back, including 2 certified orthopaedic clinical specialists, participated in the study. All therapists received 2 hours of training in the study procedures and a study manual with operational definitions of the aberrant movement patterns (**TABLE 1**). The training consisted of education about the clinical appearance of the aberrant movement patterns, trials of observation with patients not participating in the study, and comparison and discussion of results. Two physical therapists, who were chosen based on testing location and were blinded to group membership, performed the clinical observation of trunk movement. The 2 therapists simultaneously observed the subject perform 3 repetitions of trunk forward bending and return to upright. Each therapist's observations were recorded on a separate clinical observation of aberrant movement form (**APPENDIX**). No discussion was allowed between raters. Both therapists observed subjects for the presence of the following 3 aberrant movement patterns during both forward bending and return to standing: altered LPR, including Gowers' sign; deviation from sagittal plane (DEV); and judder/shake/instability catch (JUD). The painful arc of motion, described as an aberrant movement by Hicks et al,[17] was not included in the initial observations because of the blinding of the physical therapists.

Following completion of the observation of movement, subjects belonging to the current LBP group completed questionnaires and underwent a standardized physical therapy clinical examination by 1 of the authors (S.A.B.). Presence of a painful arc of motion was recorded at this time. The clinical information gathered on subjects in the current LBP group was used to assign each subject to a subgroup on the basis of the criteria outlined in the algorithm for the TBC system.[11] The reliability of the TBC system was previously determined.[10,11,13]

Data Analysis

Interrater Reliability Rater agreement for each type of aberrant movement pattern in each repetition was calculated to determine if the raters were observing the same aberrant motion at the same time. However, a patient is typically identified as having an aberrant movement pattern even if the pattern appears only once during multiple repetitions of movement testing. Therefore, in a second analysis, if the aberrant movement was observed at least once in any of the 3 repetitions, each subject was also rated as being positive for each type of aberrant movement. Per the clinical prediction rule developed by Hicks et al,[16] the different types of aberrant movements were collapsed within the current LBP group for comparison to other studies. Agreement between therapist raters was calculated with kappa statistics and 95% confidence intervals. The interpretation of kappa values was that suggested by Landis and Koch,[22] in which values of less than 0 indicate poor, from 0 to 0.20 slight, from 0.21 to 0.40 fair, from 0.41 to 0.60 moderate, from 0.61 to 0.80 substantial, and from 0.81 to 1.00 excellent or nearly perfect reliability. At least moderate agreement is required for observation of aberrant movements to be a useful clinical tool.

Hicks et al[17] found that for some of the aberrant movement patterns, the percentage agreement between observers was high but the kappa value was low, because the pattern had a very low prevalence. Specifically, the percentage agreement for observation of Gowers' sign was 98%, but the kappa was 0.00. Byrt et al[4] described a "prevalence effect" that can result in small kappa values when the prevalence of the phenomenon of interest is either very high or very low, even though agreement may be relatively high. They recommended using a formula for kappa that accounts for bias and prevalence: the prevalence-adjusted bias-adjusted kappa (PABAK).[4] A prevalence index tends to be high when the prevalence of the movement is very high or very low.[29] Therefore, bias and prevalence were calculated and, when the prevalence index was sufficiently high to affect the kappa, the PABAK was also determined.

Construct Validity Subjects were rated as positive for an aberrant movement type if the movement was observed at least once during the 3 repetitions. The ability to use each aberrant movement type to distinguish between groups was investigated using 3 separate chi-square analyses: no LBP versus current LBP, no LBP versus history of LBP, and history of LBP versus current LBP.

A second approach was to consider the frequency of observation of aberrant movements via an aberrant movement score (AMS), in which the number of different types of aberrant movements observed was totaled. This process allowed investigation into the possibility that the number of aberrant patterns observed was more informative than just the presence or absence of 1 type of aberrant pattern. In this case, each subject could have a maximum of 4 aberrant movement patterns: altered LPR, DEV, JUD, and painful arc of motion. The average AMS for each group was calculated and compared through the use of a 1-way analysis of variance, with the factor being LBP status and the 3 levels being current LBP, no LBP, and history of LBP. Tukey post hoc analysis was used as appropriate. All analyses were completed using SPSS Version 17 (SPSS Inc, Chicago, IL) and VassarStats (http://vassarstats.net/), with alpha levels set to .05 for all analyses.

RESULTS

Of the 102 participants in the study, 35 were in the no LBP group, 31 in the current LBP group, and

TABLE 3 SUBJECT DEMOGRAPHICS AND CLINICAL CHARACTERISTICS FOR EACH LBP GROUP*

	Current LBP	History of LBP	No LBP
Subjects, n	31	36	35
Gender (female), %	48%	50%	57%
Age, y	44.4 ± 12.3	41.1 ± 9.0	41.1 ± 9.0
Prior episodes, n	6 ± 3.9	6 ± 5.9	...
Time since last episode, mo	...	13 ± 14.2	...
Pain rating (0-10)	4 ± 2.6	...	...
Oswestry score (0-100 points)	28 ± 14.1	...	...
Time since symptom onset, wk	6 ± 4.2	...	...
Fear-avoidance beliefs score			
Physical activity subscale (0-30 points)	18 ± 7.2	...	...
Work subscale (0-66 points)	12 ± 9.9	...	...

Abbreviations: LBP, low back pain.
**Values are mean ± SD unless otherwise indicated.*

TABLE 4 MEAN ABERRANT MOVEMENT SCORE BY LBP GROUP*

Group	n	Aberrant Movement Score†
No LBP	35	0.8 ± 0.63 (0.58, 1.0)
History of LBP	36	1.3 ± 0.61 (1.1, 1.5)
Current LBP	31	2.5 ± 0.96 (2.1, 2.8)
TBC subgroups		
Specific exercise	7	2.7 ± 0.49 (2.3, 3.2)
Manipulation	4	2.0 ± 1.83 (−0.9, 4.9)
Stabilization	20	2.5 ± 0.89 (2.1, 2.9)

Abbreviations: LBP, low back pain; TBC, treatment-based classification.
**One-way analysis of variance of LBP groups: F_2 = 44.4, P<.001. Post hoc comparisons: no LBP to current LBP, P<.001; no LBP to history of LBP, P = .021; current LBP to history of LBP, P<.001.*
†Values are mean ± SD (95% confidence interval).

36 in the history of LBP group (**TABLE 3**). No significant difference in sex or mean age was found among the 3 groups. Using the classification algorithm for the TBC system previously detailed in the literature,[11] 31 subjects with current LBP were classified as follows: 7 specific exercise, 4 manipulation, and 20 stabilization. The small number of subjects in the current LBP group and the uneven numbers between subgroups prevented meaningful statistical analysis of subgroup data. The average AMS score was calculated to provide a description of the frequency of observed aberrant motion within each subgroup (**TABLE 4**).

Interrater Reliability

The ratings of 2 therapists were obtained in 91 of the 102 subjects. To retain potential subjects when only 1 therapist was available and to maintain the blinding of the available therapist, only 1 therapist rated the other 11 subjects. The 11 subjects (4 from the no LBP group, 5 from the current LBP group, and 2 from the history of LBP group) did not differ from other subjects in their respective groups. For the 91 subjects who were rated by 2 therapists, interrater agreement for each type of aberrant movement, separated by LBP group, is presented in **TABLE 5**. For the current LBP group, the kappa value was fair for JUD (κ = 0.35), substantial for DEV (κ = 0.68), and excellent for altered LPR (κ = 0.89). Using the clinical definition of observation of any 1 aberrant movement, the kappa value was substantial (κ = 0.65; 95% confidence interval: 0.00, 1.00) for the current LBP group (**TABLE 5**).

Construct Validity

We analyzed the construct validity using 2 different approaches: (1) each individual aberrant movement pattern and (2) the AMS. Because ratings by both therapists were not available for all subjects, the ratings of the senior therapist were used to determine whether a subject demonstrated aberrant movements (n = 102). Using the clinical approach, subjects were rated as being positive for an aberrant movement type if they demonstrated the aberrant movement at least once during the assessment. The frequency of each aberrant movement type per group is presented in **TABLE 6**.

The ability of each aberrant movement type to distinguish between groups for the 3 group combinations is presented in **TABLE 7**. According to chi-square analysis, significant associations were found for both DEV and JUD when comparing the current LBP group to the no LBP group. A significant association was also seen for JUD between the current LBP and the history of LBP groups, and for DEV between the history of LBP and no LBP groups.

The mean AMS calculated for each group is presented in **TABLE 4**. Although aberrant movement patterns appeared in all groups, a greater number of different types were seen in the current LBP group compared to the other 2 groups. A 1-way analysis of variance showed a significant difference between groups (F_2 = 44.4, P<.001). Post hoc analysis showed a significant difference (P<.001) between the current LBP and no LBP groups, as well as between the current LBP and history of LBP groups (P<.001) and the no LBP and history of LBP groups (P = .021).

TABLE 5 Interrater Reliability for Aberrant Movement Type*

Aberrant Movement Type	Agreement, %	Kappa Value†	Prevalence Index	Bias Index	PABAK†
Individual repetitions (n = 273 trials)					
Altered LPR	96	0.83 (0.73, 0.93)	0.73‡	0.03	0.92 (0.87, 0.97)
Sagittal DEV	80	0.60 (0.50, 0.69)	0.07	0.03	
Instability JUD	85	0.46 (0.31, 0.61)	0.66‡	0.10	0.69 (0.61, 0.78)
Any aberrant movement	80	0.53 (0.43, 0.64)	0.40	0.09	
Clinical (≥1 of 3 observations considered positive)					
No LBP (n = 35)					
LPR	100	1.00 (1.00, 1.00)	0.77	0.00	
DEV	80	0.61 (0.35, 0.87)	0.00	0.14	
JUD	94	0.84 (0.62, 1.00)	0.75‡	0.06	0.89 (0.73, 1.00)
Current LBP (n = 31)					
LPR	96	0.89 (0.69, 1.00)	0.43	0.04	
DEV	87	0.68 (0.34, 1.00)	0.43	0.04	
JUD	65	0.35 (0.00, 0.71)	0.22	0.35	
History of LBP (n = 36)					
LPR	94	0.77 (0.45, 1.00)	0.70‡	0.06	0.88 (0.72, 1.00)
DEV	91	0.72 (0.41, 1.00)	0.61	0.09	
JUD	94	0.80 (0.52, 1.00)	0.64	0.00	
Definition used by Hicks et al[16] in CPR					
No LBP (n = 35)					
Any aberrant pattern	89	0.72 (0.46, 0.98)	0.43	0.06	
Current LBP (n = 31)					
Any aberrant pattern	96	0.65 (0.00, 1.00)	0.87§	0.04	0.91 (0.75, 1.00)
History of LBP (n = 36)					
Any aberrant pattern	91	0.53 (0.02, 1.00)	0.39	0.10	
All groups combined					
Any aberrant pattern	91	0.68 (0.47, 0.89)	0.67§	0.02	0.82 (0.71, 0.94)

Abbreviations: CPR, clinical prediction rule; DEV, deviation from midline sagittal plane; JUD, instability catch/judder; LBP, low back pain; LPR, lumbopelvic rhythm; PABAK, prevalence-adjusted bias-adjusted kappa.
**Comparing single repetitions (n = 273), clinical definition per subject (n = 91), and clinical prediction rule for aberrant movement (n = 91).*
†Values in parentheses are 95% confidence interval.
‡High prevalence index due to a low prevalence of the movement being observed.
§High prevalence index due to a low prevalence of failing to see the movement.

DISCUSSION

This study was designed to investigate both the reliability and validity of the clinical observation of aberrant movements during forward bending in a manner that addressed the limitations of previous work in this area. Therefore, clinicians were blinded to subjects' LBP status during assessment of aberrant movement patterns and simultaneously observed trunk movements. The results of this study have helped to answer the following questions.

Can Clinicians Reliably Observe the Different Types of Aberrant Movement Patterns?

Clinicians independently observing the same aberrant pattern on the same repetition in a subject demonstrated moderate (κ = 0.46 for JUD) to excellent (κ = 0.83 for LPR) reliability (**TABLE 5**). Interrater reliability using the clinical definition of a positive aberrant movement type (aberrant movement observed at least once during several repetitions) was in the substantial-to-excellent range, with only 1 exception: JUD in the current LBP group was fair (κ = 0.35), which is lower than our hypothesized kappa value. On the basis of these results, JUD appears to be a difficult aberrant movement to detect in a patient who has current LBP. JUD was rarely observed in isolation in our subjects with current LBP, which might have made it more difficult to detect. The reliability of observing JUD may also be affected by pattern inconsistency or changing amplitude, or overshadowed by a more prominent aberrant movement. This aberrant pattern requires further investigation and may require re-

TABLE 6 Frequency of Aberrant Movement Type by LBP Group*

Aberrant Movement	No LBP (n = 35)	Current LBP (n = 31)	History of LBP (n = 36)
Altered LPR	4 (11)	9 (29)	8 (22)
Sagittal DEV	15 (43)	26 (84)	29 (81)
Instability JUD	9 (26)	20 (65)	9 (25)
Painful arc	0 (0)	24 (77)	0 (0)

Abbreviations: DEV, deviation from midline sagittal plane; JUD, instability catch/judder; LBP, low back pain; LPR, lumbopelvic rhythm.
**Values are n (%). This analysis uses the criterion of 1 observation out of 3 repetitions to establish the aberrant pattern as present on either forward bend or return.*

TABLE 7 Association Between Type of Aberrant Movement and Different LBP Groups

Group/Aberrant Movement	Chi-square Value	*P* Value
Current LBP versus no LBP		
Altered LPR	3.2	.07
Sagittal DEV	8.1	.004*
Instability JUD	10.0	.002*
Current LBP versus history of LBP		
Altered LPR	0.4	.52
Sagittal DEV	0.1	.75
Instability JUD	10.6	.001*
No LBP versus history of LBP		
Altered LPR	1.5	.23
Sagittal DEV	10.7	.001*
Instability JUD	0.1	.95

Abbreviations: DEV, deviation from midline sagittal plane; JUD, instability catch/judder; LBP, low back pain; LPR, lumbopelvic rhythm.
**Significant P value.*

finement of the clinical description and additional training of clinicians. Finally, the reliability of the operational definition of a positive aberrant movement per the clinical prediction rule[17] (observation of any 1 aberrant movement pattern at least once) ranged from moderate in the history of LBP group (κ = 0.53) to substantial in the current LBP group (κ = 0.65) and the no LBP group (κ = 0.72).

This study represents the most comprehensive look at aberrant patterns across different LBP groups. The moderate to excellent reliability for 2 raters observing the same aberrant pattern on the same repetition of movement demonstrates that trained and experienced therapists, using the present study's operational definitions of aberrant movement, are capable of recognizing these movement patterns. These findings, based on a clinical definition of aberrant movement (at least 1 observation) in a group of patients with current LBP, were similar to those of Hicks et al.[16] Those authors reported moderate (κ = 0.60) interrater reliability in this group, whereas the present study found the reliability to be substantial (κ = 0.65). The kappa values for the different types of aberrant movements in the present study were also higher than those reported by Hicks et al[17] (instability catch, κ = 0.25; altered LPR, κ = 0.16). The findings of the present study are more promising because 2 raters simultaneously observed each subject's trunk movements over several repetitions. Previous investigators[14,17,30] have studied reliability with subsequent examinations conducted by individual raters and an interval between evaluations ranging from 15 minutes to 2 weeks, which could have introduced additional sources of error based on the stability of symptoms or testing fatigue. We found that aberrant movements occurred inconsistently over multiple repetitions of trunk movement within the same session. This inconsistency might have been due to an actual variation in the patients' movement patterns, a change in the amplitude or severity of the aberrance that potentially fell under some threshold of the observer, or a shift in the examiner's focus to other aspects or patterns of movement during the examination. Therefore, simultaneous observations of trunk movement patterns may improve agreement, which was at least moderate for most of the types of aberrant movements.

The present study's operational definitions of aberrant motion types included aberrant motion observed in either direction (forward bending or return to standing). In addition, Gowers' sign was included in the altered LPR category, based on its reported low prevalence[17] and the effect of this compensation on the LBP pattern. Secondary to prevalence, we provided the prevalence and bias indices for our data. Though the bias indices for our observations were low and did not affect the kappa,[29] in several cases, the prevalence index was sufficiently high to affect the kappa (**TABLE 5**). For example, in the current LBP group, 30 of 31 subjects were positive for aberrant movements, which resulted in a prevalence index of 0.87 and a kappa of 0.65. Adjustments to the kappa using the PABAK statistic resulted in a kappa of 0.91 and changed the interrater reliability from substantial to excellent. We recognize the controversy over the use of the PABAK[29] and therefore provided both values.

With the exception of JUD in the current LBP group, the interrater reliability for detecting specific aberrant movement patterns was substantial to excellent. The results of this study suggest that the different types of aberrant movements can be detected with at least fair reliability by experienced physical therapists (more than 5 years) when assessing patients with current LBP. These findings justify further investigation of the potential diagnostic value of the different aberrant movement patterns.

Are Aberrant Movement Patterns Only Seen in Individuals With LBP?

We found that aberrant movement patterns may be seen in asymptomatic individuals, but a greater number of different types and a greater frequency of aberrant patterns are seen in subjects with current LBP. In addition, both DEV and JUD were significantly associated with the current LBP group compared to the no LBP group. While this information may not be diagnostically useful for the typical patient entering a practice with a primary complaint of LBP, the findings provide evidence for the association of aberrant movement patterns with current symptoms. To our knowledge, this is the first study designed to determine whether aberrant patterns are also observed in asymptomatic individuals with or without a history of LBP.

Subjects with a history of LBP also demonstrated more frequent aberrance, particularly DEV, than those without a history of LBP. This may indicate that some motor control or musculoskeletal impairment remains unresolved in this group. Unresolved impairments in those with recurrent LBP are supported by the recent work by Jones et al,[19,20] who demonstrated a pattern of trunk coactivation or stiffening and altered postural responses to perturbation in a group of subjects who were between episodes of LBP. These findings provide a factor that may be useful in identifying individuals with a history of LBP. Although further investigation would be required, aberrant movement patterns could be useful in identifying unresolved dysfunction or individuals who may be at risk for injury in jobs requiring frequent or high-demand lifting.

Our data indicate that simultaneous observation of aberrant movement patterns results in better interrater reliability and that the patterns are associated with LBP. The question that remains unanswered at this time is the diagnostic utility of specific aberrant patterns for subgrouping individuals with LBP. Given the small LBP sample and unequal subgroup sizes, no statistical analysis of the aberrant movement patterns between TBC subgroups was performed. However, across TBC subgroups, the similar frequency of observation of different aberrant movements, along with the high standard deviations and wide confidence intervals, suggests that the number of aberrant movement types may not be a separating factor. The number of aberrant movements observed in subjects belonging to our stabilization subgroup was comparable to that reported by Teyhen et al,[31] who also noted that subjects classified into the stabilization category had, on average, 2.5 aberrant movements. Interestingly, every subject in our current LBP group, with 1 exception, had at least 1 type of aberrant movement pattern observed by both raters. These findings may indicate that aberrant movements are common in subjects with acute/subacute, nonspecific LBP. The work of Stanton et al[30] brought to light the difficulty with single-subgroup classification using the TBC system, and the number of aberrant movement patterns may be one factor that creates this difficulty. Further study of the diagnostic value of different types or frequencies of aberrant patterns is necessary to determine any additional value of this factor for subgrouping.

Limitations

Our study has some limitations. The subjects were recruited from 2 outpatient physical therapy practices and the surrounding community, which limited our current LBP group to individuals with a symptom onset of less than 7 weeks and an age range of 25 to 65 years, and limited the raters to those with more than 5 years' experience evaluating and treating LBP. Therefore, the generalizability of the findings is limited to a subset of nonspecific LBP. Differences in subject anthropometrics (height, weight, and body mass index) between the groups might also have influenced observation of the spine movement patterns; however, we did not collect this information. Future studies should consider these limitations during study planning.

We recognize that clinicians are generally not blinded to their clients' primary complaint of pain; however, blinding the clinicians to subject group was necessary to limit bias in the construct validity study. We acknowledge that nonverbal aspects of pain behavior by the subject might have influenced the blinding. Following the study, we discussed the effectiveness of the blinding with the raters. They reported that blinding was maintained for most subjects. The behavior that appeared to tip them off as to subject group was extremely slow and guarded movements during the task.

In this study, the use of the TBC algorithm to subgroup LBP subjects could be problematic, because the variable studied is one of the criteria used to classify the subjects. However, if the first 3 steps of the classification algorithm by Fritz et al[11] are followed, the aberrant movement patterns are not considered for classification until after the specific exercise and manipulation subgroups have been identified. Therefore, subjects could be assigned to the specific exercise subgroup or the manipulation subgroup before the aberrant movements were considered. This approach should be considered carefully in future studies that assess the utility of specific aberrant motions in subgrouping patients with nonspecific LBP.

CONCLUSION

Our findings indicate that specific aberrant patterns can be detected with at least fair reliability and that observation of any aberrant pattern is substantially reliable in patients with current LBP during forward bending and return to standing, when viewed simultaneously by clinicians experienced in the assessment of LBP. Further, a strong relationship exists between current LBP and aberrant movement patterns, supporting the clinical assumption that aberrant movements are associated with current symptoms. Data from this study suggest that aberrant movement patterns are frequently seen in patients with acute/subacute, nonspecific LBP, and this may be one factor contributing to the difficulty of determining a single subgroup using the TBC system. However, this finding requires systematic investigation.

KEY POINTS

FINDINGS: Individual types of aberrant patterns occurring during trunk forward-bending movements can be detected with adequate interrater reliability. Although these patterns occur more frequently in patients with current LBP, they may occur in asymptomatic individuals.

IMPLICATIONS: Simultaneous observation of forward-bending movement patterns enhances interrater reliability, suggesting that these patterns may be inconsistent or change in amplitude when examination is repeated at a later time. The presence of forward-bending movement aberrance is associated with LBP.

CAUTION: The value of specific observed aberrant patterns in classifying patients into nonspecific LBP subgroups needs to be systematically investigated.

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APPENDIX

CLINICAL OBSERVATION OF ABERRANT MOVEMENT FORM

Instructions for the physical therapist observer: circle the appropriate descriptors (pattern, deviations, direction) in each category of movement during the subject's trunk forward bending and return. Comment as appropriate on consistency or specific regions of limitation of movement.

Subject #:____ Location:__________ Examiner: _____________
Date: __________Trial #:_____

Lumbopelvic Rhythm

Motion	Trial 1	Trial 2	Trial 3	Comments
Forward bend	Normal Abnormal	Normal Abnormal	Normal Abnormal	
Return	Normal Abnormal Gowers'	Normal Abnormal Gowers'	Normal Abnormal Gowers'	

Deviation From Sagittal Plane

Motion	Trial 1	Trial 2	Trial 3	Comments
Forward bend	Yes No Frontal Transverse Both Left Right First Second Third Pelvis Lumbar Thoracic	Yes No Frontal Transverse Both Left Right First Second Third Pelvis Lumbar Thoracic	Yes No Frontal Transverse Both Left Right First Second Third Pelvis Lumbar Thoracic	

APPENDIX

Motion	Trial 1	Trial 2	Trial 3	Comments
Return	Yes	Yes	Yes	
	No	No	No	
	Frontal	Frontal	Frontal	
	Transverse	Transverse	Transverse	
	Both	Both	Both	
	Left	Left	Left	
	Right	Right	Right	
	First	First	First	
	Second	Second	Second	
	Third	Third	Third	
	Pelvis	Pelvis	Pelvis	
	Lumbar	Lumbar	Lumbar	
	Thoracic	Thoracic	Thoracic	

Judder/Shake/Instability Catch

Motion	Trial 1	Trial 2	Trial 3	Comments
Forward bend	Yes	Yes	Yes	
	No	No	No	
	First	First	First	
	Second	Second	Second	
	Third	Third	Third	
	Pelvis	Pelvis	Pelvis	
	Lumbar	Lumbar	Lumbar	
	Thoracic	Thoracic	Thoracic	
Return	Yes	Yes	Yes	
	No	No	No	
	First	First	First	
	Second	Second	Second	
	Third	Third	Third	
	Pelvis	Pelvis	Pelvis	
	Lumbar	Lumbar	Lumbar	
	Thoracic	Thoracic	Thoracic	