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A non-randomized clinical control trial of Harrison mirror image methods for correcting trunk list (lateral translations of the thoracic cage) in patients with chronic low back pain

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Abstract Spinal trunk list is a common occurrence in clinical practice, but few conservative methods of spinal rehabilitation have been reported. This study is a non-randomized clinical control trial of 63 consecutive retrospective subjects undergoing spinal rehabilitation and 23 prospective volunteer controls. All subjects presented with lateral thoracic-cage-translation posture (trunk list) and chronic low back pain. Initial and follow-up numerical pain rating scales (NRS) and AP lumbar radiographs were obtained after a mean of 11.5 weeks of care (average of 36 visits) for the treatment group and after a mean of 37.5 weeks for the control group. The radiographs were digitized and analyzed for a horizontal displacement of T12 from the second sacral tubercle, verticality of the lumbar spine at the sacral base, and any dextro/levo angle at mid-lumbar spine. Treatment subjects received the Harrison mirror image postural correction methods, which included an opposite trunk-list exercise and a new method of opposite trunk-list traction. Control subjects did not receive spinal rehabilitation therapy, but rather self-managed their back pain. For the treatment group, there were statistically significant improvements (approximately 50%) in all radiographic measurements and a decrease in pain intensity (NRS: 3.0 to 0.8). For the control group, no significant radiographic and NRS differences were found, except in trunk-list displacement of T12 to S1, worsened by 2.4 mm. Mirror image (opposite posture) postural corrective exercises and a new method of trunk-list traction resulted in 50% reduction in trunk list and were associated with nearly resolved pain intensity in this patient population. The findings warrant further study in the conservative treatment of chronic low back pain and spinal disorders.

Keywords Exercise · Posture · Rehabilitation · Spine · Traction · Trunk List

Introduction

Low back pain (LBP) is a common problem in the western world, with an enormous socioeconomic impact. It has been shown that 60–80% of the population will experience LBP in their lifetime [3, 8, 26, 27, 36]. Conservative management of chronic LBP has gained attention in an attempt to reduce costs and improve clinical outcomes of those suffering [58]. Compared with acute LBP, the prognosis for chronic LBP is less favorable [7, 56, 57].

It is common knowledge that the human spine as viewed in the frontal plane is normally straight [25, 32, 34, 51, 60]. However, on anteroposterior (AP) radiographic views, the presence of abnormal thoracic cage postures and their associated vertebral coupling patterns can lead to the appearance of a scoliosis. One such posture is trunk list [21]. Although not a traditional range of motion (axial rotation, lateral bending, flexion/extension), the lateral displacement of the human thoracic cage relative to the pelvis (trunk list) is a clinically common postural displacement [21]. However, the terminology describing this postural/spinal displacement in the literature is indistinct and confusing. For example, descriptions such as "lumbosacral list" [1], "trunk list" [33, 48, 44, 59], "sciatic spinal deformity" [37], "alternating lumbar scoliosis" [6, 49], "windswept spine" [20], and "side-gliding" [16] have all been utilized for the description of lateral thoracic-cage translation.

Within the literature, reports of lateral thoracic translations in patients with acute lumbar disc herniation are also common [16, 37, 48, 59]. However, this postural displacement can occur in LBP patients without disc herniation and in individuals without LBP [1, 33]. Due to the lack of adequate conservative methods to improve the frontal plane alignment of the lumbar spine in patients with the abnormal thoracic-cage translation, the current study was undertaken. The objective was to quantify clinical and postural changes via pretreatment–post-treatment AP lumbo-pelvic radiographic analyses in patients undergoing Harrison mirror image postural corrective methods [23]. It was hypothesized that these rehabilitative methods would cause tension on the thoracic and lumbar paraspinal soft tissues, thereby resulting in a reduction of adverse mechanical loading of the musculoskeletal system and subsequent clinical improvement through corrected frontal plane alignment of the lumbar spine.

Methods

Sixty-three consecutive patients with chronic LBP and lateral thoracic-translation posture (trunk list) received Harrison CBP (chiropractic biophysics) mirror image methods, including a new type of lateral translation lumbar traction. Since this study was designed to be conservative in methods, there were no other concurrent treatments provided (i.e., no medications or physiotherapy modalities). For this study, chronic low back pain was defined as symptoms of more than 3 months duration or more than one episode of recurrent low back pain. Subjects were included if they had chronic LBP, trunk list posture, and if their anteroposterior (AP) lumbo-pelvic radiograph depicted coupling patterns associated with lateral thoracic translation [21]. A prospective control group of 23 subjects, who had chronic LBP and trunk list posture, were volunteers who gave informed consent. The study was approved by a nonprofit institutional review board (CBP Nonprofit). All of the subjects were patients and/or volunteers at a spinal rehabilitation clinic center in Elko, Nevada.

The treatment subjects were composed of 34 males and 29 females, with an average age of 38.7 years ± 18.4 years, mean weight of 75.0 kg ± 22.7 kg, and mean height of 168.0 cm ± 17.3 cm. Pretreatment numerical rating scale (NRS) averaged 3.0 ± 2.1 (0 = no pain; 10 = bed ridden with severe pain). The average post-treatment NRS was 0.8 ± 0.9 at a mean of 11.5 weeks of treatment. The average number of treatments was 35.9 ± 7.3. The control group was composed of 17 males and 6 females, with an average age of 39.7 years ± 11.4 years, average weight of 85.7 kg ± 17.6 kg, and average height of 173.6 cm ± 9.1 cm. The pain scores for the control group were initially 3.9 ± 2.1 and 3.8 ± 2.1 at post evaluation after a mean of 37.4 weeks. Control subjects did not receive any spinal rehabilitative treatment and did not receive any medications or advice for their LBP symptoms.

Exclusion criteria were: (1) radicular signs and symptoms upon the application of lateral translation forces, (2) central canal stenosis, (3) compression fractures at any thoracic or lumbar level, (4) prior lumbar spine surgery, (5) moderate-to-severe degenerative changes in the intervertebral discs, vertebral bodies, articular facets, and/or spinal ligaments. Improvements in radiographic measurements were determined by comparing initial and follow-up (post-treatment) AP lumbo-pelvic radiographs, obtained at a mean of 11.5 (SD = 6.1) weeks). Treatment group data were compared to the control group's initial radiographic measurements and follow-up radiographic measurements at 37.4 weeks.

In addition to AP lumbo-pelvic radiographic measurements, all participants in both groups were clinically evaluated and completed a history that included (1) a pain drawing to elucidate the location, type of pain and to rule out possible radiculopathy [5], and (2) an NRS on which patients rated their perceived pain intensity from 0 (no pain) to 10 (bed ridden). This history was completed at the beginning and at follow-up.

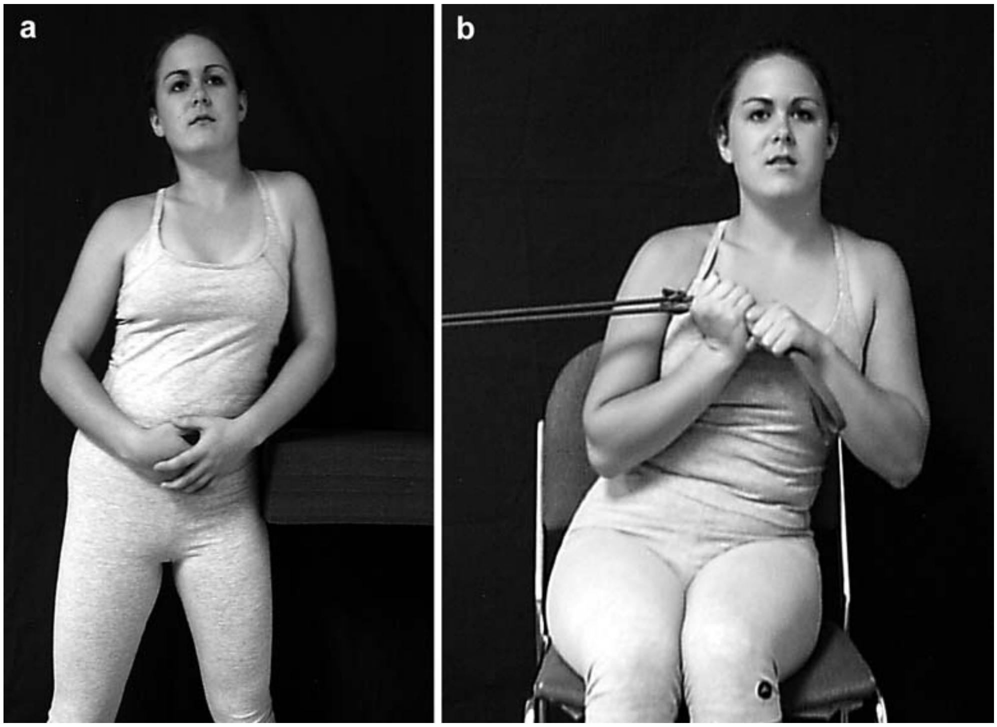

Fig. 1 Harrison mirror image trunk-list posture exercise. Harrison's mirror image postural exercises encompass all six degrees of freedom of the head, rib cage, and pelvis. For the specific posture of lateral translation of the thoracic cage compared with the pelvis (trunk list), the patient is instructed to translate his or her rib cage directly sideways, while keeping the shoulders as level as possible. This exercise can be done standing with a block between the pelvis and a wall **a** or sitting against bungee-cord resistance **b**

All 63 treatment-group subjects received the same treatment protocol. In the treatment group, high-velocity, low-amplitude (HVLA), side-posture lumbar-spinal manipulation was provided at each visit for pain relief for the initial 3 weeks of treatment and then discontinued. The treatment group then underwent CBP mirror image exercises (Fig. 1) and lateral translation traction treatment three to five times weekly for 10–12 weeks. Trunk-list traction time started at approximately 3 min and increased 1 min per session until reaching the goal of 20 min per session. The patients were informed to remain within their pain tolerance and were not encouraged to exert themselves beyond the limit of slight discomfort. This new type of lateral thoracic-cage-translation traction has been termed "Berry translation traction" (Dr. Bob Berry, Ithaca, New York) because of the lateral force providing a transverse load on the rib cage and lumbar spine while the pelvis is fixed (Fig. 2).

The AP lumbo-pelvic Ferguson view radiographs were obtained with subjects' pelvis centered against the cabinet with a standard tube distance of 101.6 cm (40 in.). A 14 in.x17 in. cassette was used with central ray in the plane of the sacral base angle in order to visualize the L5–S1 disc and L1–L5. Before exposure, subjects were asked to walk in place, nod their heads twice, and assume a comfortable resting position. This neutral resting posture has been shown to be highly repeatable [24].

The AP lumbo-pelvic radiographs were analyzed with a modified Risser-Ferguson method, which includes a lateral translation distance of T12 compared with the S2 tubercle (Tx), an angle at mid-lumbars (LD), an angle of the sacral base to horizontal (HB), and an angle of lateral bending of the lower lumbar vertebra compared with the sacral base (LS). This AP radiographic method has been reported to have inter-class and intra-class correlation coefficients in the high ranges with low standard errors of measurement (SEM $<2°$ for angles and SEM <2 mm for distances) [23]. Fig. 3 illustrates

Fig. 2 Berry translation traction. The subject is supine, with straps stabilizing the pelvis. The patient then has cross-straps on his or her ribcage, and the table is able to slide left or right, which translates the thorax in relation to the pelvis. The head can also be fixed and translated if a lateral head-translation posture is present. The patient is stressed to his or her tolerance, and the sustained-traction forces stretch the paraspinal tissues

Fig. 3 Radiographic method. On the anterior-to-posterior radiograph, a vertical line is drawn up from mid-S1. The amount of trunk list (lateral translation) is measured as the displacement of the centroid (Risser-Ferguson method) of T12 from this vertical line in millimeters (Tx). A line is drawn across the sacral base and compared with horizontal (HB angle). Best-fit lines are drawn through the centroids of T12 through L5. These lines create dextro or levo angles in the mid-lumbars (LD angle). The lower lumbar best-fit line (L3–L4–L5) creates a displacement from 90° at the sacral base (LS angle)

this radiographic method. All treatment subjects had the usual three-dimensional (3D) trunk-list posture and associated spinal-coupling patterns, as visualized on the 2D radiograph. This 2D projected spinal image was carefully analyzed and compared with the visual postural analysis. Besides radiographic measurements, the numerical rating scale values were compared between the two groups. To compare data between and within groups, two-sided, two-sample *t*-tests and two-sided paired *t*-tests were conducted with the Minitab software (Version 12, Minitab, State College, PA, USA, 1998). Analysis of covariance (ANCOVA, Table 1) was performed with S-Plus Version 6.2 (Insightful, Seattle, WA, 2003).

Results

Patients undergoing treatment, and control subjects, were closely matched for age, height, and initial pain scores, while differing in weight by approximately 10 kg (Table 1). No significant differences in patient demographics were noted between the two groups, with the exception of weight ($p = 0.006$). Since a difference in weight between the two groups was noted, an ANCOVA was performed with weight as a covariate. Comparing the control and treatment groups, the conclusions in Table 1 remain the same when controlling for weight. Additionally, treatment and control groups did not significantly differ in their ratios of males to females (Fisher's exact test, 2-sided p value = 0.14). Table 1 provides patient demographic information and pre-treatment-post-treatment NRS scores for the two groups. No significant differences in presenting NRS scores were observed between the treatment and control groups. In the control group, no significant difference was observed in NRS from initial to follow-up consultation. Significant improvements in NRS scores were observed for patients in the treatment group from the initial consultation to follow-up consultation ($p = 0.002$), and statistically significant differences in follow-up NRS scores were seen between the two groups ($p < 0.001$).

For the control group, pretreatment and post-treatment AP radiographic angles changed less than 1° for the difference of the means after 37.4 weeks of no treatment (Table 2). Using paired *t*-tests for equality of the means derived from radiographic analysis, there were no statistically significant differences in these three angles. Also for the control group, there was a slight increase (worsening) in trunk list (2.4 mm) measured as horizontal displacement of T12 to S1 (Table 2). This was statistically significant.

Table 1 Comparisons of subject characteristics in the control and treatment groups (*SD* standard deviation, *NRS* numerical rating scale for pain)

Variable	Control group, $n = 23$		Treatment, $n = 63$		P*
	Mean	SD	Mean	SD	
Age (years)	39.7	11.4	38.7	18.4	0.25
Height (cm)	173.6	9.1	168.0	17.3	0.88
Weight (kg)	85.7	17.6	75.0	22.7	Covariate
NRS‡-pretreatment	3.9	2.1	3.0	2.1	0.58
NRS‡ post-treatment	3.8	2.1	0.8	0.9	< 0.001

*Comparison of groups with ANCOVA, with weight as a covariate
‡NRS: 0 (= no symptoms, no limitations to daily living) to10 (= severe pain and bed ridden)

Table 2 Average AP lumbo-pelvic radiographic measurement comparisons in the control group ($n = 23$) for initial presentation and follow-up post X-ray at mean of 37.4 weeks (*SD* standard deviation)

Variable	Pre-X-ray Mean, SD	Post-X-ray Mean, SD	Change	$P^{\dagger}$
Tx^{T12-S2} (mm) ‡	7.2 ± 6.2	9.6 ± 7.3	−2.4	= 0.011
LD angle (°)‖	5.0 ± 2.0	4.7 ± 2.0	0.3	> 0.05
LS angle (°) +	2.9 ± 1.7	3.1 ± 2.1	−0.2	> 0.05
HB angle (°)*	2.8 ± 1.5	2.3 ± 1.4	0.5	> 0.05

†Two-sided paired *t*-test
‡Lateral distance of T12 from a vertical line through S2 tubercle (got worse at post X-ray)
‖ Lumbo-dorsal angle, formed at mid-lumbar spine by best-fit lines through centroids
+ Lumbo-sacral angle, formed by centroidal best-fit lines in lower lumbar as it intersects a line on the sacral base
*Horizontal base angle, formed by line on sacral base compared with horizontal

For the treatment group, the treatment duration was 11.5 weeks ± 6.1 weeks between the initial and follow-up evaluations. All treatment group radiographic measurements showed statistically significant improvement ($p < 0.0001$) to a more vertical (neutral) spine. There was an approximate 50% decrease in the trunk-list measurement of T12, compared with a vertical line up from S1 observed in the treatment group (Table 3).

Discussion

It is interesting to note the subjective clinical and objective radiographic improvements observed in the treatment group undergoing spinal rehabilitation. While the 23 control subjects had no significant changes in radiographic angle measurements (and a slight increase in trunk list) at follow-up, the 63 treatment subjects—who received Harrison mirror image trunk-list exercises and mirror image trunk-list traction—had a 50% reduction in radiographic measurements and significant improvements in numerical rating scale (NRS) for pain. These results support our initial hypothesis that these spinal rehabilitative measures resulted in clinically relevant postural improvements in this patient population. This report thus represents the first study reporting conservative rehabilitative methods that demonstrate improvements in abnormal trunk-list postures as measured on AP lumbo-pelvic radiographs.

Table 3 Average AP lumbo-pelvic radiographic measurement comparisons in the treatment group ($n = 63$) for initial presentation and follow-up post X-ray at mean of 11.5 weeks (*SD* standard deviation)

Variable	Pre-X-ray Mean, SD	Post-X-ray Mean, SD	Change	$P^{\dagger}$
Tx^{T12-S2} (mm) ‡	15.0 ± 5.9	7.3 ± 5.7	7.7	< 0.0001
LD angle (°)‖	6.0° ± 4.0°	4.3° ± 3.7°	1.7°	< 0.0001
LS angle (°) +	4.9° ± 3.6°	3.0° ± 3.0°	2.0°	< 0.0001
HB angle (°)*	1.8° ± 1.4°	1.0° ± 1.2°	0.8°	< 0.0001

†Two-sided paired *t*-test
‡Lateral distance of T12 from a vertical line through S2 tubercle (got worse at post X-ray)
‖ Lumbo-dorsal angle, formed at mid-lumbar spine by best-fit lines through centroids
+ Lumbo-sacral angle, formed by centroidal best-fit lines in lower lumbar as it intersects a line on the sacral base
*Horizontal base angle, formed by line on sacral base compared with the horizontal

Chronic LBP has been found to be associated with alterations in trunk-muscle activity [41]. Such muscular alterations are responsible for postures such as those observed in idiopathic and functional scoliosis, as well as trunk list [2, 15, 17, 35, 39, 47]. Muscular dysfunction in chronic LBP sufferers has included a more glycolytic (faster) profile of their trunk muscles, which is expected to render chronic LBP less resistant to fatigue [38]. In addition, investigation in scoliotic patients has observed a significantly lower proportion of type I (slow-twitch oxidative) fibers in the muscle on the concave side of the scoliotic curve [39]. Consequently, active conservative rehabilitative measures aimed at improving trunk-muscle function have focused upon muscular rehabilitation [40], although the typical glycolytic profile of the muscles of chronic LBP patients or back-muscle size has not been found to have changed in some rehabilitation programs [31]. Specific mirror image postural corrective exercises, as prescribed and carried out in the current study, aim to stretch muscles on the shortened side, while simultaneously strengthening muscles on the opposite side in an attempt to resume neutral posture where loads on the spinal tissues are normalized.

A possible limitation of the study may be the inherent projection-distortion errors in anterior-to-posterior radiographs. These AP projection distortions result primarily from the fact that the film-to-object distance changes in the AP radiograph, due to the normal physiologic thoracic kyphosis and lumbar lordosis [14, 13]. However, these magnifications are small on AP radiographs. A second limitation may be the use of multiple procedures on the patients. In addition to the opposite-trunk-list exercise and trunk-list traction, manual manipulation was provided in the first 3 weeks of care. Additionally, some patients received mirror image drop-table manipulations during the treatment period. Whereas the literature has shown that manipulation alone does not change the static position of the spine [22], no known studies have been performed to determine if combined exercise and translation traction will increase or decrease the amount of spinal correction. Further research is necessary to determine the effects of combined forms of exercise and traction on trunk-translation posture, pain, and function.

Further, the lack of a long-term follow up of the treatment group to document the stability of the improvements in pain and spinal alignment creates uncertainty. Future work should address this shortcoming. Similarly, the length of follow-up was three times greater in the control group as compared with the treatment group. We cannot rule out the possibility that controls might have had some success in pain reduction and reduction in spine displacement after some weeks but then lost this again. On the other hand, we believe that condition stability was shown in the control group, and in fact, the slight increase in their trunk displacement might indicate progression of the condition.

A final concern may arise in our use of non-antalgic cases only. The investigators excluded antalgic leans because it has been shown that these postures may be due to acute muscular spasms, which can cause pain. Thus, the antalgic patient often develops a fear-avoidance posture, which keeps the pain from returning. Additionally, these patients were excluded to ensure that the changes seen on the radiographs and in the NRS scores were not due to the pain reduction properties of spinal manipulation. Nonetheless, randomized clinical control trials are necessary to determine the effect of these protocols on both acute antalgic patients and those with chronic lateral-postural abnormalities and various pain syndromes.

It is clinically important to distinguish between scoliotic deformities and lateral thoracic translations (trunk list). None of the patients in this study had scoliosis of known origin or had been diagnosed with idiopathic scoliosis. The coupling patterns within the lumbar spine matched our treatment group's abnormal posture. The spinal deformity in scoliosis patients (large spinous process rotation) does not match the usual coupling patterns seen for trunk-list postures (minimal spinous rotation).

Measurement of lateral-translation postural and spinal abnormality has been quantified in different ways. Visually, it has been measured as a postural displacement, by McLean et al. [44], who suggested a simple plumb-line method in which the lateral displacement, in millimeters, of a surface marker on the spinous process of T12 compared with that of S1. Radiographic mensuration methods have also been used to analyze the projected spinal image on plain film AP lumbo-pelvic radiographs. Whereas Harrison et al. [21] used a horizontal displacement of T12 compared with a vertical line through S1, Arangio et al. [1], used an angle formed by the L2 vertebral body endplate to horizontal and a best-fit line through the lumbar spinous processes to vertical. In the current study, the radiographic line-drawing analysis was performed using the methodology described by Harrison et al. [21], which has been previously shown to be reliable [23].

Mechanically, trunk-list postural displacement would cause large compressive and shear stresses in the distal lumbosacral spine. Since the trunk is approximately 60% of body mass [12], a 200 lb. (90.7 kg) male with 1 in. (2.54 cm) of lateral trunk translation would have a minimum of 120 in. lbs. of increased load acting asymmetrically on the lumbosacral spine. However, due to the increased muscle effort required to stabilize abnormal postural displacements, the actual increase in load on the spine is much higher [19]. The presence of mechano-sensitive and nociceptive afferent fibers in spinal tissues (intervertebral disc, facet, ligaments, and muscles) [30, 42, 43, 46, 50]—and the subsequent neurophysiological research demonstrating the role of such afferent stimulation in pain production [9, 10, 11] and coordinated neuromuscular stabilization of the spine [28, 29, 52, 53, 54, 55]—provide a substantial theoretical framework supporting the rationale for goals of treatment regimens to include a reduction of stresses on spinal joints in spinal rehabilitation programs.

Normalizing posture and reducing musculoskeletal pain are obviously important goals of treatment for patients with chronic LBP. Conservative methods to restore or improve the normal position of the lumbar spine in the frontal plane, however, are rare. A thorough review of the literature located three studies utilizing lateral translation ("side-shift") exercises of the thorax in spinal rehabilitation [4, 18, 45]. Mehta and Morel [45] used lateral translation exercises to reduce the Cobb angle in scoliosis patients, where the shift direction was dictated by curve direction, not postural presentation. Similarly, in 44 subjects between 10–15 years of age whose Cobb angles measured 20–32°, Boer et al [4] used lateral-translation exercises dictated by the direction of the primary curve. Here, success was defined by lack of progression of the primary curve, and results were compared with a historical brace cohort. In another study using the McKenzie methodology, Gillan et al. [18] reported a reduction in trunk-list posture but not a reduction in pain. The current study's finding of a reduction in both trunk list and pain intensity is in contrast to Gillan et al. [18]. The difference in pain improvements herein might be due to two factors: (1) no radiographs were used by Gillan et al. [18] to identify the appropriate coupling pattern for the trunk-list posture, and (2) the use of initial spinal manipulative therapy in the current report.

Conclusion

Lumbar spinal manipulation followed by Harrison mirror image methods (lateral translation exercise and traction) were found to produce statistically significant and clinically significant reductions in pain and trunk-list posture, a finding not observed in the control group.

In fact, the control group's lateral thoracic translations were slightly worse at follow-up, possibly indicating progression of the disorder. Because these trunk-list postures are commonly associated with lumbar disc herniation and lower back pain, randomized controlled trials should be performed to evaluate the clinical significance of restoration of normal spinal-alignment biomechanics in chronic LBP pain subjects. Due to discrepancy between our study findings and a previous report, it is suggested that AP lumbo-pelvic radiographs and posture of the trunk should both be used as outcome measures in the treatment of the trunk-list deformity.

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