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The effect of inversion traction on pain sensation, lumbar flexibility and trunk muscles strength in patients with chronic low back pain

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Abstract.
BACKGROUND: Effectiveness of inversion traction has been revealed in patients with chronic low back pain (CLBP), however, it is still unknown as to which angles of inversion traction positively affect patients with CLBP.
OBJECTIVE: To investigate the angle-effects of inversion traction on pain sensation, lumbar flexibility, and trunk muscles (flexors and extensors) strength in patients with CLBP after an 8 week treatment program.
METHODS: Forty-seven women suffering nonspecific CLBP for 23.00 ± 5.45 weeks were included prospectively and randomized into 3 groups: supine group (SG; $n = 15$), inversion $-30°$ group (I30G; $n = 18$), and inversion $-60°$ group (I60G; $n = 14$), respectively. Each group completed a 3-minute × 3-set inversion traction protocol at 0°, inverted $-30°$, or inverted $-60°$, respectively for 4 days a week during 8 weeks. The outcome measures included rating of pain using the visual analogue scale (VAS), flexibility of lumbosacral joint, and the isokinetic strength of the trunk flexors and extensors at 60°/s.
RESULTS: Pain was significantly improved after 8 weeks. The reductions observed in VAS scores were lower in the I60G compared with the changes in I30G and SG. Significant interaction effects were observed in trunk flexion and extension particularly in the I60G condition. There was also a significant increase in the extensor peak torque of the I60G.
CONCLUSIONS: Inversion traction at angle of $-60°$ reduced back pain or discomfort and improved lumbar flexibility and isokinetic trunk extensor strength in patients with CLBP following an 8 week program. Therefore, this treatment modality may be suitable for patient groups of similar CLBP phenomenology.

Keywords: Back pain, trunk flexor, trunk extensor, lumbar flexibility

1. Introduction

Low back pain (LBP), one of the most common musculoskeletal problems in modern society and is a highly prevalent and a very expensive health dilemma [1,2]. Hebert et al. [3] reported that 70–85%

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of the adult population will have experienced LBP at some point in life. Also, LBP is the most common cause of limitation in activity in those younger than 45 years of age, and that prevalence rates are shown to range 12–35%. In general, LBP is defined as pain localized between the 12^{th} rib and the inferior gluteal folds, with or without leg pain, and in 90% of cases it is nonspecific [4,5]. Other researchers concluded that it is best defined as a low level continuous or essentially continuous lumbar, sacral or lumbosacral spinal pain punctuated by exacerbations of pain and characterized as 'acute' [40,41]. Patients who experience this disability are limited in their daily living activities and may experience inappropriate neuromuscular adaptations to maintain and preserve functions such as walking, running, or other activities [6]. In addition, it is estimated that 80–90% of the patients will have recovered within 6 weeks, regardless of treatment [7]. However, 5–15% will develop chronic LBP (longer than 12 weeks) [8]. Chronic low back pain (CLBP) is more difficult to treat as treatment modalities and clinical outcomes vary [9, 10].

Generally, the passive modality of treatment for LBP in the acute-stage includes bed rest, hot pack, massage, and brace [11]. But resting longer than a week is basically contraindicated, because of disuse syndromes such as muscle weakness, osteoporosis, and soft tissue contracture. Moreover, the treatments for LBP in end-stage use spinal surgery or medication for pain relief. However, these therapies can potentially cause various side effects such as pain recurrence and myositis, inducing the physical deconditioning in patients with CLBP [11,12].

As a guide to functional restoration, therapeutic traction is widely accepted for management for CLBP [13–17]. The traction can be applied in many forms: motorized lumbar traction, autotraction, manual traction, or gravitational traction using an inversion device [18]. Especially, the former inversion traction was reported to provide the pelvic or lumbosacral joints stabilization and balanced trunk muscle strength [16,19,20]. deVries and Cailliet [21] demonstrated that gravity-facilitated traction produces significant intervertebral separation in the lumbar spine, concluding that gravity-facilitated traction may be an effective modality in the relief of LBP. Also, Cyriax [22] promoted traction not only for CLBP but also for lumbar disc lesions, theorizing that traction may produce negative pressure in the disc and thereby reduce disc herniations. Other investigators suggested that off-axis moments, such as flexion or extension, be added to axial traction to reduce back or leg pain [23–25].

Inversion traction is widely used for patients with CLBP in clinical fields as well as normal men without LBP in health promotion centers. However, although the functional role and effectiveness of inversion traction in patients with CLBP has been suggested, it is still unknown which angles of inversion traction positively affect patients with CLBP. Therefore, we investigated the effect of various angles of inversion traction on pain sensation, lumbar flexibility and trunk muscle strength in patients with CLBP.

2. Method

2.1. Subjects

The subjects were recruited on a voluntary basis from the Hanseo University Hospital. All of the volunteers complaining of back pain in everyday life for more than 12 weeks were checked by a specialist through X-ray, CT and MRI scans, and then diagnosed with LBP. After completing the clinical examinations, subjects were selected. The exclusion criteria were past or present neurological, hypertension, or cardiopulmonary diseases, chronic disease, and operation of LBP. We also excluded patients with abnormal ophthalmic artery pressure during inversion from this study. Finally, forty-seven women suffering nonspecific LBP for 23.0 ± 5.45 weeks were randomized into 3 groups: supine group (SG; $n = 15$), inversion $-30°$ group (I30G; $n = 18$), and inversion $-60°$ group (I60G; $n = 14$).

Prior to the study, the principal investigator explained all the procedures to the subjects in detail. All subjects signed an informed consent form approved by the Hanseo University of Health Science Human Studies Committee. We performed bioelectrical impedance analysis to measure weight, fat mass and muscle mass of subjects using InBody 320 Body Composition Analyzer (BioSpace, Seoul, Korea), and measured height using BMS 330 anthropometer (BioSpace, Seoul, Korea). The characteristics of subjects were shown in Table 1, and there were no significant differences in their anthropometric data. All subjects completed the study program without dropouts.

2.2. Experimental design

On the first day, participants were required to read and sign an informed consent form and to complete a self-assessed questionnaire designed to identify sub-

Table 1
Baseline descriptive physical characteristics by groups

	Supine group ($n = 15$)	Inversion $-30°$ group ($n = 18$)	Inversion $-60°$ group ($n = 14$)	P-value*
Age (years)	20.47 ± 0.52	20.67 ± 0.69	20.86 ± 0.66	0.259
Height (cm)	164.86 ± 3.66	164.55 ± 3.40	163.71 ± 3.45	0.660
Body weight (kg)	55.62 ± 3.43	57.13 ± 5.70	56.13 ± 6.95	0.726
Muscle mass (kg)	21.39 ± 0.95	21.49 ± 1.64	21.76 ± 1.82	0.819
Fat mass (kg)	15.94 ± 3.57	17.39 ± 3.76	15.89 ± 5.67	0.534
LBP duration (wk)	22.73 ± 4.45	23.94 ± 6.77	22.07 ± 4.65	0.622

All data represents mean ± standard deviation (SD). * P-values were derived from one way analysis of variance for normally distributed continuous variables and the Kruskal-Wallis non-parametric test in the case of fat mass.

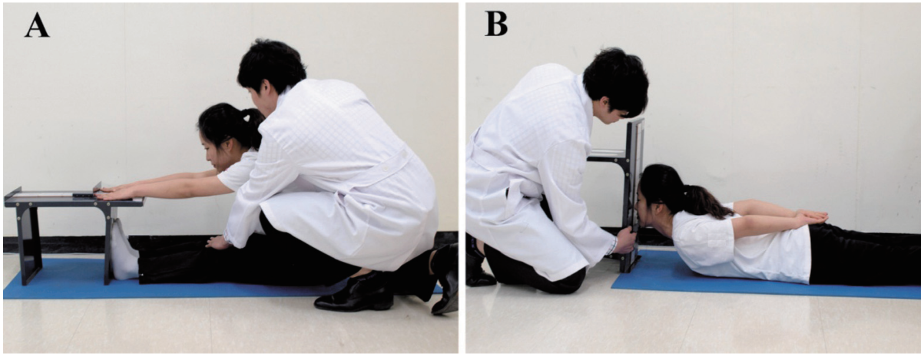

Fig. 1. Tests for lumar flexibilities: A and B represent trunk flexion and extenstion test, respectively. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/IES-130506)

jects with CLBP. One week later, subjects returned to the laboratory to complete baseline measurements including VAS, lumbar flexibility, and isokinetic trunk strength. All groups were instructed to invert with their inversion angles, respectively. In the follow-up post-treatment session the same tests were repeated.

2.3. *Outcome measures*

2.3.1. *Visual analogue scale*

The VAS is a self-reported pain assessment tool that requires the subject to place ∨ on a 10 cm long straight line with stops on each end. The left end means 'no pain' and the right end 'the worst pain' [26]. The scale can then be broken down into a length in millimeters and expressed numerically from 0 to 100 mm. The VAS has been widely used in various studies as a method of LBP measurement and shown to be valid and reproducible as well as a highly sensitive tool for assessing LBP [42].

2.3.2. *Lumbar flexibility*

Lumbar flexibility was assessed using trunk forward flexion and backward extension tests (Fig. 1). Before assessment, each subject performed a standardized warm-up consisting of 5 minutes of stretching exercise. The extent of trunk flexion and extension was measured by a flexibility meter, model TKK1859 (Takei Inc, Tokyo, Japan).

Trunk flexion was assessed using the sit and reach test. Subjects performed the test with the legs fully extended and knees relaxed. They were required to extend their arms as far as possible and hold at the furthest point for 2 sec. After completion of the trunk flexion test, all subjects were assessed by the trunk extension test. The position of subjects was prone with their hands clasped behind their head. Another examiner stabilized their ankles, instructed them to raise their back upward, and then recorded the point on the tester. Subjects were required to hold their position at the top for 2 sec.

2.3.3. *Isokinetic strength*

An isokinetic dynamometer (HUMAC®/NORM™ Testing and Rehabilitation System, CSMI, MA, US) was used for this study. All subjects were submitted to a stretching and warm-up program before the tests. Subjects were placed on a trunk extension/flexion modular component in a standing position (Fig. 2). After subjects had been transferred to the footplate of the trunk extension/flexion modular component, their heels were placed against the footplate heel cups. To

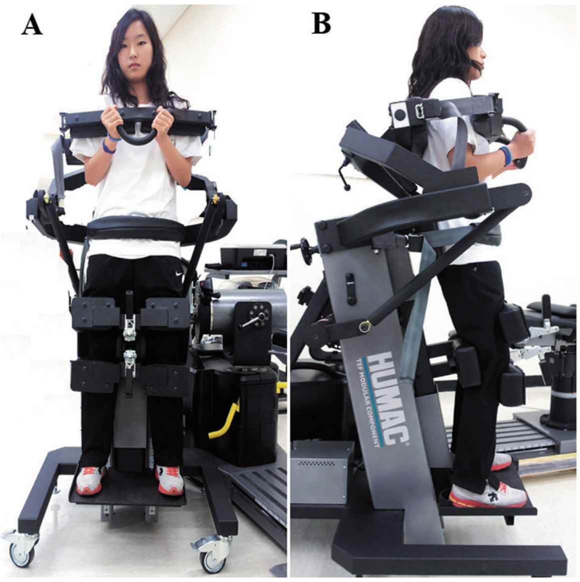

Fig. 2. Trunk extension/flexion modular component in a standing position. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/IES-130506)

align the patient's vertical axis with the NORM unit dynamometer axis, the footplate height was adjusted via the footplate switch until the rubber alignment pointer was approximately 3.5 cm below the top of the iliac crest; the intersection point of the midaxillary line and the lumbosacral junction. The pelvic belt was loosely fastened across the top of the anterior superior iliac spines. The popliteal pad height was adjusted to a position directly behind the patellae at the popliteal space. After the popliteal pad had been aligned, the thigh pad was positioned directly above the patellae and the locking lever was secured. After the thigh pad, the tibial pad was secured just below the patellae. The lower body was stabilized in a slightly bent-knee position (15° of knee flexion) by tibial, popliteal, and thigh pads. The subjects leaned against the sacral pad and were moved forward or back via the fore-after alignment wheel until the rubber alignment pointer was centered approximately to the axis of rotation. The pelvic belt was then tightened. The scapular pad was positioned across the center of the scapulae and locked in place. The chest pad was placed properly in a position that was parallel to the scapular pad and secured. The range of motion regarding extension/flexion was from approximately −15° to 95°. Subjects then performed 4 maximal warm-up repetitions and 5 maximal test repetitions at 60°/s. The rest time between warm-up and test at 60°/s was 30 sec. All tests were supervised by only one trained researcher. The results of isokinetic torques at 60°/s were analyzed by peak torque (PT) and peak torque % body weight (PTBW).

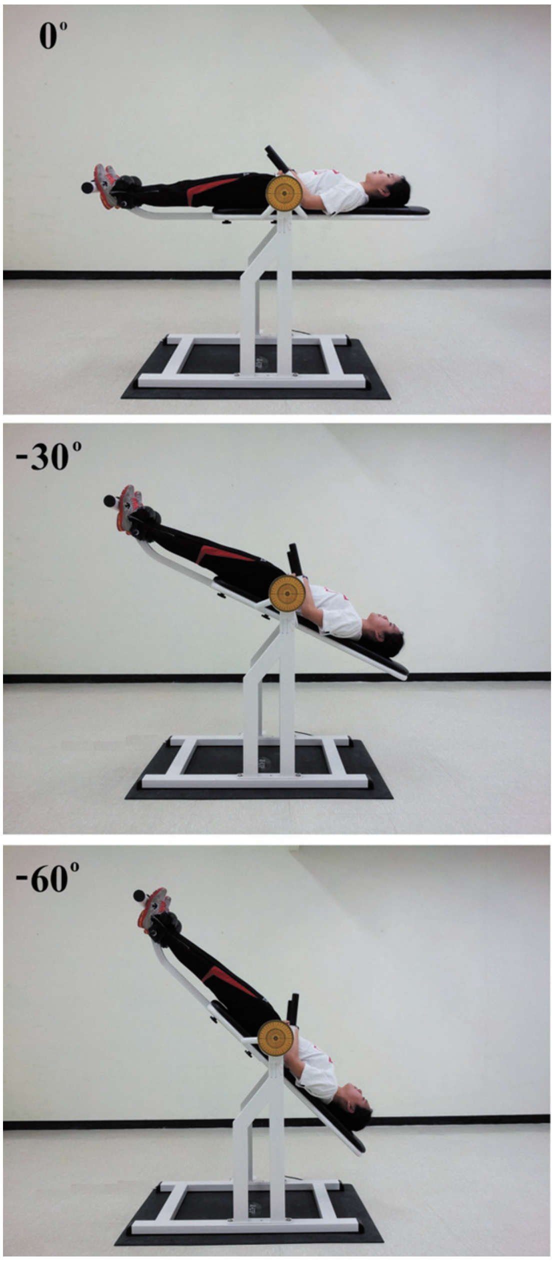

Fig. 3. Angles of inversion traction. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/IES-130506)

2.4. Inversion traction program

The subjects within the inversion groups were forced to be fastened on a motorized gravitational machine (MS-UP1, Medical Science Inc., Seoul, Korea) for

Table 2
Changes in anthropometric indices among groups

	Baseline	8 weeks	Δ%*	Interaction‡
Body weight (kg)				
Supine group	55.62 ± 3.43	55.23 ± 3.93	−0.74 ± 1.70	0.318
Inversion −30° group	57.13 ± 5.70	54.30 ± 10.85	−4.80 ± 16.31	
Inversion −60° group	56.13 ± 6.95	56.44 ± 6.40	0.69 ± 1.79	
P-value†			0.087	
Muscle mass (kg)				
Supine group	21.39 ± 0.95	21.14 ± 1.08	−1.18 ± 2.64^{c}	0.014
Inversion −30° group	21.49 ± 1.64	22.44 ± 3.29	4.19 ± 10.74^{b}	
Inversion −60° group	21.76 ± 1.82	23.64 ± 2.02	9.04 ± 10.30^{a}	
P-value†			0.001	
Fat mass (kg)				
Supine group	15.94 ± 3.57	16.08 ± 3.72	0.69 ± 2.85	0.382
Inversion −30° group	17.39 ± 3.76	17.72 ± 4.21	1.56 ± 4.09	
Inversion −60° group	15.89 ± 5.67	15.78 ± 4.96	0.87 ± 7.91	
P-value†			0.881	

All data represents mean ± standard deviation (SD). The statistical analysis performed was repeated measures analysis of variance. ‡Interaction means treatment × time effect. *{(8 weeks' variables − baseline' variables)/baseline' variables × 100}. †*P*-values were derived from one way analysis of variance for Δ%. Superscript letters(^{a,b,c}) indicate between-groups' differences derived by *post hoc* multiple comparisons using Bonferroni rule.

3 min × 3 repetitions 4 days a week for 8 weeks. The inversion angles were fixed at 0°, −30°, and −60°, respectively (Fig. 3). The rest time among inversion tractions was 5 min.

The inversion protocol used in this study referred was based on two studies. First, a gravity inversion time of over 5 min increased heart rate, systolic blood pressure, and arterial pressure whereas, an inversion time of 2.5–5 min did not produce these variations [27]. This resulted in choosing 3 min as target time. Likewise, gravity inversion angle of over −60° increased heart rate and systolic blood pressure [28] and therefore we decided to use −60° as the target angle. All tests were supervised by two trained researchers.

2.5. *Statistical analyses*

Statistical analysis was conducted with the SPSS statistical software (version 15.0; SPSS Inc, Chicago, IL). All data are reported as mean ± standard deviation (SD). Prior to comparison of measurements including VAS, lumbar flexibility, and isokinetic torque variables in 60°/s, the Kolmogorov-Smirnov test was used to determine the normality of distribution for the examined variables. Differences in baseline characteristics among the 3 groups of women were evaluated with one-way analysis of variance and with the Kruskal-Wallis test for normally and non-normally distributed variables, respectively. Repeated measures analysis of variance was used to evaluate the significance of the differences among groups at baseline and at the end of the 8-week intervention (treatment effect), the significance of the changes observed within each group (time effect), and the effect of treatment × time interaction. The between-group factor was the study groups (i.e. SG vs. I30G vs. I60G) and the within-group factor was the time-point of measurement. Meanwhile, we calculated the delta percent between times, (8 weeks' variables − baseline' variables)/baseline' variables × 100, for the differences among groups and then analyzed the differences by *post hoc* multiple comparisons using the Bonferroni rule. The significance level for all analyses was set a priori at $P \leqslant 0.05$.

3. Results

3.1. *Angle effects of inversion traction on anthropometric indices*

The baseline characteristics of the subjects with full data at baseline and follow-up examinations are summarized in Table 1. No between-group differences were observed in any of the characteristics indicating homogeneity in age, height, body weight, muscle mass, fat mass, and LBP duration.

Table 2 presents the values of anthropometric indices at baseline and at 8 weeks of intervention. With respect to the anthropometric indices, significant interaction effects were observed for muscle mass ($P = 0.014$), indicating a decrease in SG whereas significant

Table 3
Changes in visual analogue scale among groups

	Baseline	8 weeks	Δ%*	Interaction‡
Back pain				
Supine group	5.73 ± 1.53	3.73 ± 1.53	−32.03 ± 32.43[b]	0.012
Inversion −30° group	5.78 ± 1.52	2.22 ± 0.81	−59.42 ± 16.41[a]	
Inversion −60° group	5.57 ± 1.34	2.14 ± 0.66	−59.85 ± 16.46[a]	
P-value†			0.009	
Night pain				
Supine group	5.67 ± 1.35	3.87 ± 1.30	−29.59 ± 22.07[c]	0.013
Inversion −30° group	5.78 ± 2.37	2.22 ± 0.81	−50.79 ± 31.51[b]	
Inversion −60° group	5.57 ± 1.22	1.43 ± 0.76	−71.63 ± 20.81[a]	
P-value†			0.001	
Exercise				
Supine group	4.60 ± 1.55	4.40 ± 1.88	8.10 ± 65.98[c]	0.001
Inversion −30° group	5.11 ± 1.49	2.11 ± 1.32	−54.55 ± 34.17[a]	
Inversion −60° group	5.29 ± 1.07	1.71 ± 0.73	−67.45 ± 11.98[a]	
P-value†			0.001	
Drug relief				
Supine group	5.00 ± 1.36	3.47 ± 1.77	−19.21 ± 49.45[b]	0.004
Inversion −30° group	4.11 ± 2.19	3.11 ± 2.03	−18.65 ± 41.46[b]	
Inversion −60° group	5.00 ± 2.22	1.29 ± 0.47	−64.15 ± 29.44[a]	
P-value†			0.006	
Stiffness				
Supine group	5.00 ± 1.36	3.93 ± 1.79	−18.48 ± 39.44[c]	0.005
Inversion −30° group	4.56 ± 1.89	2.22 ± 0.94	−38.36 ± 40.83[b]	
Inversion −60° group	5.43 ± 1.22	1.86 ± 0.86	−66.09 ± 12.57[a]	
P-value†			0.004	
Walking freedom				
Supine group	5.00 ± 1.89	3.93 ± 2.05	−22.05 ± 37.56[c]	0.001
Inversion −30° group	4.33 ± 1.61	2.11 ± 0.90	−44.31 ± 29.36[b]	
Inversion −60° group	5.71 ± 1.44	1.57 ± 0.76	−70.41 ± 16.09[a]	
P-value†			0.001	
Walking discomfort				
Supine group	5.13 ± 1.51	4.13 ± 1.64	−9.11 ± 45.54[c]	0.002
Inversion −30° group	4.56 ± 1.62	2.78 ± 1.44	−29.37 ± 48.53[b]	
Inversion −60° group	5.71 ± 0.73	1.71 ± 0.91	−69.59 ± 16.63[a]	
P-value†			0.001	
Standing still				
Supine group	5.27 ± 1.91	4.40 ± 1.88	3.62 ± 70.69[b]	0.004
Inversion −30° group	4.89 ± 1.13	2.22 ± 0.94	−53.20 ± 18.38[a]	
Inversion −60° group	5.43 ± 1.09	2.14 ± 1.41	−60.92 ± 22.78[a]	
P-value†			0.003	
Twisting				
Supine group	5.20 ± 1.57	4.20 ± 1.93	−14.63 ± 37.40[c]	0.003
Inversion −30° group	5.00 ± 2.06	3.00 ± 1.28	−30.22 ± 37.84[b]	
Inversion −60° group	5.29 ± 1.07	1.71 ± 0.73	−66.77 ± 13.64[a]	
P-value†			0.001	
Hard chair				
Supine group	4.80 ± 2.04	4.60 ± 1.55	3.03 ± 29.04[b]	0.001
Inversion −30° group	5.33 ± 1.68	3.00 ± 1.28	−40.03 ± 27.73[a]	
Inversion −60° group	4.71 ± 1.33	2.29 ± 1.07	−49.39 ± 21.59[a]	
P-value†			0.001	
Soft chair				
Supine group	4.13 ± 1.64	3.27 ± 2.31	52.56 ± 263.67[c]	0.027
Inversion −30° group	3.67 ± 1.28	2.89 ± 1.13	−10.93 ± 49.22[b]	
Inversion −60° group	4.71 ± 1.54	1.86 ± 0.86	−60.54 ± 12.02[a]	
P-value†			0.002	

Table 3, continued

	Baseline	8 weeks	Δ%*	Interaction‡
Lying down				
Supine group	4.47 ± 1.55	4.13 ± 2.23	4.22 ± 60.60[c]	0.023
Inversion −30° group	4.67 ± 1.68	3.22 ± 1.17	−23.06 ± 31.46[b]	
Inversion −60° group	4.57 ± 1.22	2.00 ± 0.96	−50.44 ± 37.27[a]	
P-value†			0.031	
Handicap				
Supine group	4.60 ± 1.96	3.60 ± 2.10	−24.19 ± 33.04[b]	0.021
Inversion −30° group	4.22 ± 1.44	2.78 ± 1.06	−22.22 ± 52.24[b]	
Inversion −60° group	4.71 ± 1.20	1.86 ± 0.86	−55.82 ± 28.46[a]	
P-value†			0.028	
Work interference				
Supine group	4.53 ± 1.77	3.93 ± 1.67	−9.25 ± 36.29[b]	0.024
Inversion −30° group	4.22 ± 1.35	3.22 ± 1.44	−11.48 ± 51.98[b]	
Inversion −60° group	4.71 ± 1.33	2.29 ± 0.91	−48.91 ± 21.10[a]	
P-value†			0.006	
Work modification				
Supine group	4.47 ± 1.46	3.87 ± 1.41	−11.14 ± 26.93[b]	0.057
Inversion −30° group	4.11 ± 1.91	3.00 ± 1.37	−3.61 ± 71.36[b]	
Inversion −60° group	4.57 ± 1.09	2.14 ± 0.86	−51.43 ± 20.47[a]	
P-value†			0.011	

All data represents mean ± standard deviation (SD). The statistical analysis performed was repeated measures analysis of variance. ‡Interaction means treatment × time effect. *{(8 weeks' variables − baseline' variables)/baseline' variables × 100}. †*P*-values were derived from one way analysis of variance for Δ%. Superscript letters([a,b,c]) indicate between-groups' differences derived by *post hoc* multiple comparisons using Bonferroni rule.

increases in these variables were observed in I30G and I60G. However, the muscle mass increase in I60G was higher than that of I30G. After 8 weeks, there were significant differences of muscle mass change within the groups, and that in SG was the lowest ($P = 0.001$).

3.2. *Angle effects of inversion traction on VAS*

In order to assess the angle effects of inversion traction on the pain score using the VAS, the data from the VAS of the 3 groups were analyzed for differences in the pre- and post-exercise after 8 weeks (Table 3). Table 3 displays the changes observed in several VAS indices of the 3 groups. Significant interaction effects were observed for back pain ($P = 0.012$). Within the groups, a significant decrease was observed in I30G and I60G ($P = 0.009$). Such a result was similar to the other 14 items (i.e. night pain, exercise, drug relief etc.) namely, the decrease observed in the VAS indices of I60G was lower in I60G compared with the changes in I30G and SG after 8 weeks.

3.3. *Angle effects of inversion traction on lumbar flexibility*

Table 4 displays the changes observed in trunk flexion and extension of the 3 groups after 8 weeks. Significant interaction effects observed trunk flexion ($P = 0.001$) and extension ($P = 0.046$). Within the groups, a significant increase of trunk flexion was observed in I30G and I60G ($P = 0.001$). Such a result was similar to trunk extension ($P = 0.047$). That is to say, the increase of lumbar flexibility in I60G was found to be higher compared with the changes in I30G and SG after 8 weeks.

3.4. *Angle effects of inversion traction on isokinetic strength*

Table 5 summarizes the changes observed in the isokinetic torques at 60°/s. No significant interactions effects were observed in the flexor peak torque ($P = 0.926$) and flexor peak torque % body weight ($P = 0.871$). However, significant interaction effects were observed in the extensor peak torque ($P = 0.001$) and extensor peak torque % body weight ($P = 0.001$), respectively. Specifically, there was a significant increase observed in the extensor torques in I60G that was much greater than the changes observed in the two other groups.

4. Discussion

Inversion traction is commonly used for patients with CLBP in clinical fields and considered to be

Table 4
Changes in trunk flexion and extension among groups

	Baseline	8 weeks	Δ%*	Interaction‡
Trunk flexion (cm)				
Supine group	15.30 ± 3.09	14.40 ± 3.86	−6.33 ± 14.87[b]	0.001
Inversion −30° group	16.50 ± 6.58	18.17 ± 6.22	14.08 ± 23.21[a]	
Inversion −60° group	18.64 ± 3.17	21.79 ± 2.02	18.76 ± 13.98[a]	
P-value†			0.001	
Trunk extension (cm)				
Supine group	36.07 ± 4.91	37.80 ± 3.91	5.70 ± 10.76[b]	0.046
Inversion −30° group	40.50 ± 11.14	45.89 ± 9.26	19.54 ± 32.65[a]	
Inversion −60° group	40.14 ± 11.81	49.00 ± 4.44	29.99 ± 32.69[a]	
P-value†			0.047	

All data represents mean ± standard deviation (SD). The statistical analysis performed was repeated measures analysis of variance. ‡Interaction means treatment × time effect. *{(8 weeks' variables − baseline' variables)/baseline' variables × 100}. †*P*-values were derived from one way analysis of variance for Δ%. Superscript letters([a,b,c]) indicate between-groups' differences derived by *post hoc* multiple comparisons using Bonferroni rule.

Table 5
Changes in isokinetic torque of trunk at 60°/s among groups

	Baseline	8 weeks	Δ%*	Interaction‡
Flexor peak torque (Nm)				
Supine group	139.20 ± 18.51	135.67 ± 8.90	−0.99 ± 14.30	0.926
Inversion −30° group	145.89 ± 22.10	141.44 ± 21.58	−1.79 ± 15.55	
Inversion −60° group	143.14 ± 26.36	141.57 ± 19.59	0.42 ± 13.38	
P-value†			0.705	
Flexor peak torque % body weight				
Supine group	248.13 ± 37.76	241.80 ± 22.81	−0.92 ± 14.15	0.871
Inversion −30° group	257.78 ± 29.20	249.22 ± 19.88	−1.85 ± 15.67	
Inversion −60° group	257.43 ± 30.73	255.71 ± 30.28	0.32 ± 14.06	
P-value†			0.829	
Extensor peak torque (Nm)				
Supine group	108.60 ± 20.59	102.13 ± 3.74	−1.13 ± 27.70[c]	0.001
Inversion −30° group	123.78 ± 40.33	151.67 ± 25.19	31.99 ± 40.37[b]	
Inversion −60° group	124.57 ± 38.88	183.14 ± 34.25	52.68 ± 24.71[a]	
P-value†			0.001	
Extensor peak torque % body weight				
Supine group	210.00 ± 11.96	183.93 ± 11.54	−12.00 ± 9.22[c]	0.001
Inversion −30° group	218.56 ± 64.91	259.67 ± 63.01	23.97 ± 35.06[b]	
Inversion −60° group	223.71 ± 13.91	322.71 ± 13.91	54.72 ± 48.93[a]	
P-value†			0.001	

All data represents mean ± standard deviation (SD). The statistical analysis performed was repeated measures analysis of variance. ‡Interaction means treatment × time effect. *{(8 weeks' variables − baseline' variables)/baseline' variables × 100}. †*P*-values were derived from one way analysis of variance for Δ%. Superscript letters([a,b,c]) indicate between-groups' differences derived by *post hoc* multiple comparisons using Bonferroni rule.

effective in alleviating back pain [22–25]. Kane et al. [29] demonstrated that gravity-facilitated traction produces significant intervertebral separation in the lumbar spine, concluding that gravity-facilitated traction is an effective modality in the relief of back pain. Moreover, Dimberg and Ferraz-Nunes [30] reported that following treatment of inversion traction for 12 weeks, sick days from back pain was decreased by almost 33%. In addition, the average sick days lost to back pain fell by eight days per individual in the treated group. Recently, Guthrie et al. [31] also suggested that inversion protocol might provide pain relief, and reduce side effects such as nerve and skeletal muscle injuries, and infections.

In the present study, an 8-week inversion traction program significantly improved the poor VAS score imposed by CLBP, close to a perfect score. Specifically, both I30G and I60G significantly decreased the scores in VAS indices except a 'work modification' item. In addition, inversion traction in I30G and I60G significantly improved the lumbar flexibility and isokinetic torques at 60°/s. Within the groups, significant increases of trunk flexion and extension were also observed for I30G and I60G (Table 4). Flexibility is important to overall health and fitness as it allows a joint to move through its full range of motion. Improved flexibility can prevent back pain and injuries as well as maintain good posture and balance. In addition to decrease LBP it is important to maintain flexibility in the abdomen, legs, hips, and lower back. An inflexible lower back can lead to mobility problems and an increased amount of pressure carried in that area. According to the study of Johnson and Thomas [32], 60–80% of the U.S. population will experience lower back pain at some point in their life, due to lack of flexibility.

deVries and Cailliet [21] reported that the inversion devices can promote the flexibility [21]. Due to increased spacing in the joint, which can occur in response to traction, the muscles crossing that joint are pre-stretched, and experience greater lengthening compared to the equivalent joint angle while under no traction (lying down) or while being compressed (standing). Similar to previous studies, the results of this study also indicate that inversion traction played an important role in improving the lumbar flexibility altered in CLBP patients. Especially, I60G was more effective in increasing the lumbar flexibilities detected by trunk flexion and extension compared with I30G. Consequently, I60G is more effective in relieving the back pain in comparison with I30G (Tables 3 and 4).

We also measured trunk muscle strength isokinetically using the inversion tool [37]. In relation to CLBP, many studies reported that the trunk muscle strength is often decreased in patients with chronic lower back trouble [33,34]. Therefore, trunk strength in patients with lower back problems is measured for providing an index of how the back is functioning during or following rehabilitation [35]. In the present study, there were no significant interaction effects on the flexor peak torque (including flexor peak torque % body weight). However, there were significant interaction effects in the extensor peak torque (including extensor peak torque % body weight) at 60°/s. These results mean that an 8 week inversion traction at the angles of $-30°$ and $-60°$ significantly enhanced the extensor back muscle strength in patients with CLBP, compared with the SG. Especially, inversion traction of $-60°$ was more effective than the $-30°$ (Table 5).

Poor muscle mass is a detrimental factor in LBP. Muscles of the low back contribute in stabilizing and moving the trunk [38]. The amount of muscular activity influences the extent of stability at each segmental level it crosses. In the present study, an 8 week inversion traction at the angle of $-30°$ and $-60°$ was associated with increased muscle mass compared with SG. A decrease in muscle mass could be attributed to pain inhibition and consequently a disuse atrophy. Thus, by improving pain and flexibility, as well as by letting the muscles be mechanically expressed, the traction positions used in this study are able to enhance all of the measured variables. The important advantage of this traction mode is that it is safe and appropriate for most patients.

5. Conclusion

In the present study, an 8 week of inversion traction at the angle of $-30°$ and $-60°$ significantly improved VAS scores, trunk flexibility, trunk muscles strength and muscle mass. In particular, inversion traction at $-60°$ for 8 weeks seems to be an effective treatment for back pain or discomfort.

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