



Research Article

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Novel Back Traction Training Device Increases Range of Motion and Increases Muscle Activation with Specific Activities of Daily Living



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Abstract

Background: As low back pain is a primary cause of musculoskeletal disability, inexpensive treatment strategies and devices are of utmost importance.

Purpose: To investigate a novel pelvic girdle-lower back traction device (PGLBT) with both acute and chronic training.

Methods: This crossover study design involved acute interventions (control and experimental: 3-sets of 60-seconds of PGLBT). After a 1-month control period, participants exerted moderate pressure (50-70% of maximal force) on the pelvic girdle with the PGLBT, 7-days per week (1-4 sets of 30-seconds) for 4-weeks. The Quebec Back Pain Disability Scale was completed at the start of each testing session. Pre- and post-testing measures for both the acute and chronic segments included sit and reach test, and supine straight leg raise test for range of motion, and neuromuscular efficiency (extent of electromyographic: (EMG) activity to perform an isometric box hold with 2.26 kg, box lifting task (4.5 kg), sit-to-stand-to-sit, and back extension endurance. Pain was assessed during the tasks with a visual analogue scale and pain pressure threshold ergometer.

Results: During the exercise tasks, there was significant, consistent training-related bilateral increases in upper erector spinae EMG activity, acute bilateral increases in lower erector spinae EMG activity, less back endurance fatigue, greater bilateral pain pressure threshold for upper and lower erector spinae muscles as well as decreases in the Quebec back pain scale and greater range of motion during the single leg test.

Conclusion: PGLBT training-induced reductions in pain permitted greater neuromuscular activation and increased range of motion.

Keywords: Low back pain; Electromyography; Back decompression; Endurance; Neuromuscular efficiency

Abbreviations: EMG: Electromyography; LBP: Low back pain; UES: upper (lumbar) erector spinae; LES: Lower (lumbar) erector spinae; MVIC: Maximal voluntary isometric contraction (MVIC); ASIS: Anterior superior iliac spine

Clinical Relevance: The reduction of pain with the pelvic girdle-low back pain traction device resulted in improved range of motion and back endurance and disinhibited prior pain-induced reductions in muscle activation (EMG) and thus may be used as an at-home rehabilitation treatment due to its ease of use, portability, and accessibility.

What Is Known about the Subject:

Low back pain (LBP) is one of the primary causes of global musculoskeletal disability. Although different exercises have been commonly used as treatments in reducing pain and disability with LBP, the effect size magnitudes are not large, and interventions have shown only moderate effects. Various devices and methods have attempted to relieve back pain, but none have consistently proven to be significantly effective and consistent in pain reduc-

tion. Therefore, it is essential to develop a non-invasive, portable, cost-effective, and user-friendly solution that can be used conveniently at home.

What this Study Adds to Existing Knowledge:

Reducing pain with the use of a pelvic girdle-low back traction device can enhance range of motion, back endurance and increase muscle activation in response to daily tasks.

Introduction

Low back pain (LBP) is one of the primary causes of global musculoskeletal disability (Green et al. 2018, Hurwitz et al. 2018 a,b) [1,2,3]. It adversely affects work attendance and productivity and is the most common cause of disability among individuals under the age of 45 years (Clinical Practice Guide 1994) [1]. Although there are many methods for diagnosing and addressing LBP, it is the most expensive industrial health and injury problem (Snook and Stover 1987) [4] imposing a huge burden on health-care systems (Pincus et al. 2010) [5]. Paradoxically, this surge in treatment methods has coincided with an increase in disability and the persistence of the condition (O'Sullivan et al. 2016) [5]. Despite improvements in understanding the contributing factors to LBP, there has been only moderate improvements in the alleviation of low back pain (van der Windt et al. 2008) [7]. LBP can induce both acute (periodic isolated episodes of pain) and chronic pain (van Dieën, Flor and Hodges 2017) [8] and dysfunction leading to potential long-term adverse consequences (Hodges 2011) [9]. LBP can negatively alter core and back muscle properties (i.e., force length relationship, atrophy), extent of muscle activation, stabilization (i.e., anticipation and ongoing core or trunk muscle activation in response to perturbations), kinematics (i.e., displacement, velocity, acceleration of movement), sensorimotor control (i.e., precision, force steadiness), and performance or function (i.e., force, power, endurance) (Biering-Sorensen 1984, Devecchi et al 2021, Enthoven et al. 2003, Laird et al. 2014, van Dieën et al. 2019) [10,11,12,13]. Reduced back endurance can be a predictor of both long-term back-related disability (Enthoven et al. 2003) [12] and the occurrence of first-time chronic low back pain (Biering-Sorensen 1984) [10]. Trunk muscle fatigue can exacerbate neuromuscular deficiencies, which can lead to back pain, unstable lumbar spine, and brief uncontrolled intervertebral movements (Granata and Gottipati 2008) [14]. LBP can inhibit voluntary muscle activation (van Dieën, Selen and Cholewicki 2003) [15], muscle reflexes (Radebold et al. 2000) [16], cortical sensory inputs from (Flor et al. 1997) [17] and motor outputs to (Tsao and Hodges 2011) [18] the trunk. For example, both an increase and a decrease of trunk muscle activation in individuals with LBP has been shown in the literature (van Dieën, Selen and Cholewicki 2003) [15]. With healthy individuals, an optimal control pattern is sought to achieve the task at a minimal energetic cost (van Dieën, Flor and Hodges 2017) [8]. However, studies have reported that the central nervous system can undergo plastic (semi-permanent) reorganization following musculoskeletal disorders (Roy et al. 2017) [19] resulting in suboptimal activation, stabilization, and motor control (van Dieën, Flor and Hodges 2017) [8]. More effective at home and at clinic treatments are needed to deal with these LBP-related health issues. Although different exercises have been commonly used as treatments in reducing pain and disability with LBP, the effect size magnitudes are not large (Saragiotto et al. 2016) [20] and interventions have shown only moderate effects (Chou and Huffman 2007) [21]. Various devices

and methods have attempted to relieve back pain, but none have consistently proven to be significantly effective and consistent in pain reduction. For example, Isner-Horobeti et al., (2016) [22] concluded that individuals suffering from disc herniation, and who underwent a course of lumbar traction (5 session per week for 2 weeks), experienced improved functionality, and enhanced overall well-being. Similarly, Unlu et al. (2008) [23] reported on the effectiveness of traction, ultrasound, and low-power laser therapies in managing patients with acute lumbar disc herniation. However, Thackeray et al. (2016) [24] suggested that there was no evidence that combining mechanical lumbar traction with an extension-oriented treatment offers superior results compared to extension-oriented exercises alone. In their research, Simmerman et al. (2011) [25] conducted two sessions of 15 minutes of loaded walking, followed by a choice between 15 minutes of a land-based supine position or 15 minutes of aquatic vertical traction. While the aquatic and land-based interventions resulted in noticeable increases in overall spinal height, the aquatic approach provided more significant pain relief among individuals experiencing low back pain [28]. Therefore, it is essential to develop a non-invasive, portable, cost-effective, and user-friendly solution that can be used conveniently at home. The objective was to examine acute and chronic (4-weeks of training) changes in pain perception, range of motion (ROM), back endurance, and lower back muscle electromyographic (EMG) activation during tasks of daily living after using a novel pelvic girdle-low back traction device.

Materials and Methods

Participants

Based on an "a priori" statistical power analysis (G*Power) to obtain an alpha of 0.05, moderate magnitude effect size of 0.5 with a power of 0.8 (non-centrality parameter: 14.0, Critical F: 3.982, actual power: 0.835), it was determined that a minimum of 14 participants was needed. In anticipation of dropouts, and an attempt to improve the statistical power and increase effect size changes, 25 male individuals were recruited. Inclusion criteria included individuals who experienced mild to moderate idiopathic LBP for a minimum of the last six months but were still able to perform typical activities of daily living. The definition of mild to moderate idiopathic LBP was based on subjective personal accounts with severe LBP considered as debilitating (inability to regularly perform activities of daily living) and thus exclusionary. Figure 1 (Consort flow diagram) illustrates that 21 participants were tested for acute responses (age: 42.4±14.7 years, weight: 86.6±15.2 kg, height: 174.3±6.15 cm) and 14 of these participants were tested after the 4-week washout control period and the subsequent 4-week training program (age: 41.6±15.8 years, weight: 88.3±15.9 kg, height: 173.7±5.85 cm). Four participants who initially volunteered decided not to attend for unknown reasons. The 7 participants who did not return for the traction training program after acute testing either did not respond to subsequent emails or cited scheduling difficulties for not continuing with the

training program. There were no injuries associated with the testing or training sessions. Before their laboratory visit, participants received instructions to refrain from engaging in intense physical activity within 24 hours before their participation. Additionally, they were instructed to abstain from alcohol consumption, smoking, and caffeine intake within 12 hours before their participation. Each participant completed the Physical Activity Readiness Questionnaire Plus (PAR-Q+ 2022) and read and signed the informed

consent form after receiving a brief explanation of the study and experimental procedures. Informed consent was obtained verbally and in written format from all subjects participating in the study. Ethical approval was acquired from the Institutional Committee for Ethics in Human Research at Memorial University of Newfoundland (Approval No: 20240943-HK) under the most recent version of the Helsinki Declaration.

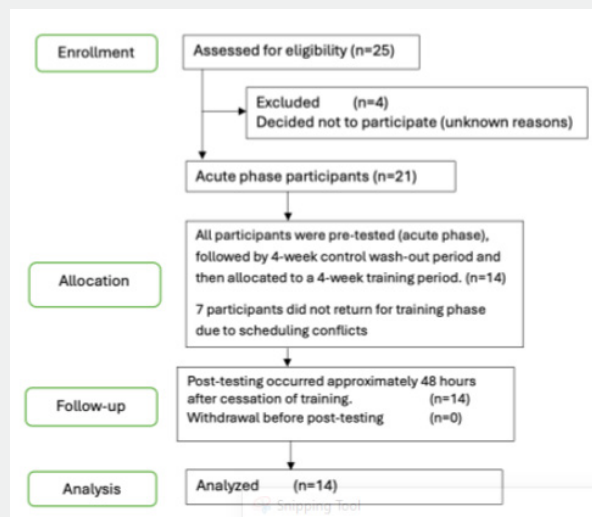


Figure 1: Consort flow program.

Experimental Design

After verbally agreeing to participate and signing the ethics forms, the participants went through an initial familiarization session with the traction device and the measurements (dependent variables). At their second and third sessions, they were tested in a randomized order for the acute effects of either the pelvic girdle – lower back traction device involving three sets of 60-seconds of self-applied traction with 60-second rest between sets or a control session (no intervention: rest for 6-minutes). Participants filled out the Quebec Back Pain Disability Scale questionnaire at the start of the testing sessions. During these two visits (acute responses), pre- and post-testing included physiological and practical measures such as ROM changes in lower back ROM (e.g., sit and reach test), and supine straight leg raise test ROM. Neuromuscular efficiency (the extent of muscle electromyographic: (EMG) activity as measured by the mean amplitude of the root mean square (RMS) EMG activity to sustain a relative load) was monitored during an isometric hold of a square plastic box (30 cm height x 30 cm width x 30 cm depth), with 2.26 kg (5 lbs.) weight dropped inside (researcher randomly determined when to drop the weight to reduce anticipation), during a dynamic box lifting task 4.5 kg (10 lbs.), sit-to-stand-to-sit task, and back extension endurance, [13] while pain was subjectively assessed with a visual analogue scale (0-100) and quantitatively by a pain pressure threshold ergometer (bilateral locations at T12-L1, and L5-S1). To

examine back traction training effects, participants underwent a control period of 4-weeks after the acute pelvic girdle – low back traction device and control testing sessions.

The control washout period was incorporated to ensure the acute testing sessions did not influence the subsequent training program and was used as the non-training control period. Regular activities of daily living were permitted during the control wash-out period, but no back traction or back strengthening training. None of the participants had been (within 6 months) participating in back traction or strengthening activities. Subsequently, a pre-training (fourth session) testing session was conducted with the same testing measures but with no acute back traction intervention (same as prior acute control session), 4-weeks after the acute testing sessions. Following this pre-training testing session, participants were provided with the traction device to train at home, adhering to a prescribed protocol emailed to them. Like the familiarization session, participants were again instructed and observed using the traction device after the pre-training testing. After 4-weeks of at-home training with the traction device, participants returned for their post-training testing session (fifth testing session). Participants were contacted weekly by email to inquire if there were any questions regarding training and to check on training adherence. The chronic (training) program began within 48 hours of the control acute testing session. Participants were asked to practice 7 days per week (for 4-weeks). Participants ex-

erted moderate pressure (subjective estimate of 50-70% of maximal pushing force with their arms on their pelvic girdle) with the traction device on the pelvic girdle for 1 set of 30-seconds in the first week, 2 sets in the second week, 3 sets in the third week, and

4 sets in the fourth week. Same testing measures as with the acute study session were implemented approximately 48 hours after the 4-week training program (Figures 2 and 3).

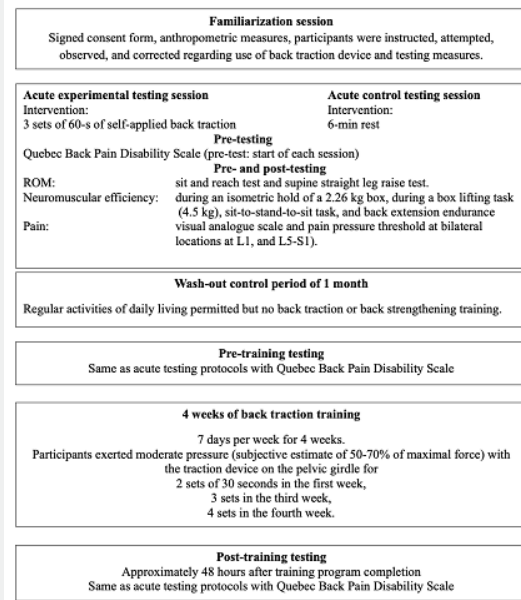


Figure 2: Experimental Design.



Figure 3: Pelvic girdle- lower back traction device.

Dependent Variables: Measures

Electromyography (EMG)

Upper (UES) and lower erector spinae (LES) EMG activity was monitored with each test. For electrode placement, self-adhesive

Ag/AgCl electrodes (Meditrace™ 130 ECG conductive adhesive electrodes) were utilized based on established protocols from SENIAM guidelines and previous studies from this laboratory (Hermens, Merlatti, and Freriks 1999, Kawamoto Aboodarda and Behm 2014) [26,27,28]. EMG electrodes were placed bilaterally

over the lower (lumbar) erector spinae (LES), 2 cm lateral to L5-S1 spinous processes and over the upper (lumbar) erector spinae (UES) 6 cm lateral to the T12-L1 spinous processes. The ground electrode placement was on the lateral epicondyle of the femur. Electrodes were placed in the same location for each participant using bony landmarks and careful palpation. The use of both skin marking (indelible ink) and measurement techniques enhanced the reliability of electrode placement. Thorough skin preparation included shaving body hair, removal of dead epithelial cells with an abrasive pad and finishing with cleansing with an isopropyl alcohol swab. To ensure an adequate signal-to-noise ratio, an inter-electrode impedance of $<5\text{ k}\Omega$ was obtained prior to testing. The EMG signal acquisition system (Biopac System Inc., DA 100: analog-digital converter MP150WSW; Holliston, Massachusetts) recorded all signals at a sampling rate of 2000 Hz. All EMG signals were filtered with a Blackman -61 dB band-pass filter between 10 and 500 Hz, amplified (bi-polar differential amplifier, input impedance = $2\text{ M}\Omega$, common mode rejection ratio $>110\text{ dB}$ min (50/60 Hz), gain $\times 1000$, noise $>5\text{ }\mu\text{V}$), and analog-to-digital converted (12 bit) for storage and analysis on a personal computer. The EMG baseline signal noise was monitored to remain below 0.05 mV. A commercially designed software program (AcqKnowledge III, Biopac Systems Inc.) was used for the establishment of signal parameters and for data analysis. The mean amplitude of the root mean square of the EMG signal was monitored. As raw EMG measures typically have lower inter-test reliability values and greater test to re-test variability than maximal voluntary isometric contraction (MVIC) force, the EMG values were then normalized to the highest MVIC value and reported as a percentage. For each testing session, the MVIC was performed by having the participants extend their backs against an unyielding resistance (isometric) while lying prone on a bench to perform a back extensor MVC (Biering Sorensen back endurance position) (Biering-Sorensen 1984) [10]. EMG signals during the first and last five seconds of the back endurance test were analyzed to assess the fatigue index (last 5-s RMS EMG / first 5-s RMS EMG) $\times 100$ of the erector spinae muscles during the intervention.

Sit-to-stand-to-sit

A commonly used functional test for activities of daily living is the sit-to-stand-sit test (Pourahmadi et al. 2018) [29]. Participants were seated on a typical wooden kitchen/dining room type chair with their arms relaxed and hanging by their thighs. Upon hearing the command "start," they stood up at a self-selected pace, maintained a normal standing position for 3 seconds, and then sat back down at their own pace. EMG activity was analyzed separately for the stand-up and sit-down components of this activity. This test has shown moderate to excellent intra-rater reliability for individuals with chronic LBP ($r=0.61 - 0.85$) (Pourahmadi et al. 2018) [29].

Modified Biering Sorensen Back Endurance Test

At the start of the test, participants lined up their pelvic anterior superior iliac spine (ASIS) with an edge of the plinth. Belts were used to strap participants over the hips and lower legs and participants supported their upper body by placing their hands on a chair. To start the test, the hands were removed from the chair and moved to clasp their fingers behind the head with elbows horizontally. Vigorous verbal encouragement was provided to the participants to hold that horizontal position (parallel to the floor) as long as possible. When the participant deviated from the horizontal position more than twice, the test was stopped, and the duration was recorded. This test has been reported to be a valid measure of back muscle fatigue (Coorevits et al., 2008, Pitcher, Behm, MacKinnon 2008) [30,31].

Pain Pressure Threshold (PPT):

The computer monitor was turned away from the participant, so they could not watch the force applied (thus reducing participant reactivity or anticipation). Participants were given a hand-held clicker and instructed to press the button when the sensation transitioned from a feeling of pressure to pain. The same verbal instructions were given to every participant in every session. The researcher pressed the tip of the algometer (1.3 cm^2) into the right and left LES at the L5-S1 location and the UES at the T12-L1 locations respectively at a constant rate of 5 N/s, following a running linear slope on the Tracker program (Tracker 5 JTECH- medical software, Midvale, UT). Right and left UES and LES testing was repeated twice and randomized with 30 seconds rest between tests. Forces at the onset of pain were recorded and analyzed.

Sit and Reach Test:

Although the sit and reach are commonly purported to be a test of the ROM of the lower back and hamstring muscles, Muyor et al. (2014) [32] indicated that the sit and reach is an appropriate measure of spine flexibility and pelvic tilt ROM but a less effective evaluation of the hamstrings' flexibility. For this sit and reach test, participants sat on a padded mat with their legs extended. Feet were situated 30.5 cm (12 inches) apart, with the soles of the feet placed against the measuring device. Participants reached forward with their arms and hands pushed in a small metal rectangle as far as possible while keeping their knees fully extended. Hands were placed over each other with palms pronated. This position was sustained for approximately two seconds. The test was repeated twice, and the greatest distance was recorded for analysis. Reliability has been reported to range from 0.91 to 0.99 (Ayala et al. 2012) [33].

Supine Straight Leg Raise Test:

Supine straight leg raises test attempts to measure hip flexion ROM and is highly affected by hamstrings extensibility. Inextensible hamstrings can contribute to LBP, by pulling on the pelvis, potentially causing a posterior pelvic tilt, limiting lumbar spine curvature, increasing pressure on the lower back and potentially

causing pain (Tikhile, Patil, and Jaiswal, 2024) [34]. Participants completed two supine single straight leg raise stretches to the point of maximal discomfort, which were held for 5-s with 10-s between each measurement of the dominant leg and non-dominant leg (randomized). A padded knee brace was placed around the knee to ensure the knee remained fully extended during the stretch. The researcher passively stretched the participant's leg (hip flexion) until the participant identified that the point of maximal discomfort was reached. The non-stretched leg was secured and kept extended with the researcher's other hand exerting pressure on the knee region. The maximal angle of the hip joint was measured and recorded using a digital goniometer with the axis of rotation at the femoral greater trochanter of the stretched legs. The intra-rater reliability of the supine straight leg raise test is reported as excellent with $r=0.85$ (Pesonen et al. 2021) [35].

Dynamic Box Lifting Task

Participants started in a standing position with knees and hips flexed so they could grasp the box from the seat of a chair (seat height: 50 cm). They held the handles of a square plastic box (30 cm height x 30 cm width x 30 cm depth) containing a 4.5 kg (10 lbs.) weight. They were instructed to lift the box, stand upright, and keep their elbows at a 90-degree angle while ensuring the box did not touch their body. Participants were required to maintain this position for 5 seconds. Reliability is reported to be strong with $r=0.76$ (Carstairs et al. 2016) [36].

Isometric boxes hold with weight drop

The isometric box hold task involved an isometric hold, during which a 2.26 kg (5 lbs.) weight was dropped from a height of 2 centimeters to inside the box (Gregory, Brown, and Callaghan 2008) [37]. The timing of the weight release (drop) was randomly allocated within a 15-second window. Participants were standing erect and instructed to close their eyes during the task to prevent anticipation of the weight drop. Nonetheless, EMG was monitored and analyzed 1 second prior to the weight drop (anticipation) and for 1 second after the drop (response). Participants maintained their elbows at a 90-degree angle, ensuring that neither their arms nor the box touched their body. Moderate reliability values of 0.62 have been reported for this sudden loading perturbation test (Santos et al. 2011) [38].

Intervention (Independent Variable)

A novel pelvic girdle – low back traction device (Figure 2) had the participants applying pressure with their arms on the device on the upper thighs while supine with hips at 90°. The participants placed their feet on a chair or platform to keep knees flexed and relaxed at approximately 90°. Participants exerted moderate pressure (subjective estimate of 50-70% of maximal force) with the traction device on the pelvic girdle. For the acute testing, self-applied back traction was applied for 3 sets of 60-s. With the at-home training sessions, back traction was applied for 2 sets of 30-seconds in the first week, 3 sets in the third week, and 4 sets in

the fourth week. Participants were informed to relax their trunk as much as possible during the exercise.

Statistical Analysis

Statistical analyses were calculated using SPSS software (Version 16.0, SPSS, Inc, Chicago, IL). This study employed a repeated measure within-subjects cross-over design. Normality (Kolmogorov–Smirnov) and homogeneity of variances (Levene) tests were conducted for all dependent variables. Modified Bonferroni post-hoc tests were conducted to detect significant differences. The effect size of each data was assessed by partial eta squared and considered as small ($\eta^2=0.01$), medium ($\eta^2=0.06$), or large effect ($\eta^2=0.14$). Pre- to post-intervention (or control) acute testing responses were analyzed with a 2-way repeated measures ANOVA (2×2) to determine the existence of significant muscle activation (EMG) differences between the 2 acute conditions (intervention and control) at 2 times (pre- and post-tests). Another 2-way repeated measures ANOVA (2×2) for chronic training was used to determine the existence of significant activation (EMG) differences between the 2 conditions (4-week training intervention and washout control) at 2 times. For the training intervention, data was compared between pre-training tests following the washout period and post-training tests. For the control washout period (repeated measures analysis of the same participants that subsequently trained), data was compared between the acute pre-test and pre-training measures. This comparison allowed researchers to determine which group of intervention or control elicited a greater relative activation of the two muscle groups in left and right side (UES and LES). The sample t-test was used to compare Quebec Back Pain Disability Scale of pre- and post-tests. Significance was defined as $p<0.05$.

Results

Whereas participants were asked to practice 7 days per week for 4 weeks, their personal training logs indicated an average compliance of 5.6 days per week.

Pain pressure threshold test (PPT)

A main effect between conditions was observed for PPT for right ($F=4.656$, $P=0.040$, $\eta^2=0.15$) and left ($F=6.263$, $P=0.019$, $\eta^2=0.19$) UES as well as right ($F=12.136$, $P=0.002$, $\eta^2=0.32$) and left ($F=5.620$, $P=0.025$, $\eta^2=0.18$) LES showing 24.25%, 22.00%, 44.01%, and 35.57%, greater PPT in the chronic intervention condition, respectively (higher PPT scores indicate greater pain tolerance). No main effects for time (pre- and post-tests), nor interaction effect for time*condition were observed for UES and LES PPT in right and left sides (Table 1).

Supine straight leg raises test (SLR)

A main effect between conditions was observed for SLR test of the right ($F=8.392$, $P=0.008$, $\eta^2=0.24$) and left leg ($F=22.53$, $P=0.001$, $\eta^2=0.46$), exhibiting 9.44%, and 13.26% greater ROM in the chronic intervention condition. Significant main effect for

time between pre-and post-tests in the right ($F=10.325$, $P=0.003$, $P\eta^2=0.28$) and left leg ($F=4.500$, $P=0.044$, $P\eta^2=0.15$) were found with 6.41% and 7.01% greater improvement in the post-test respectively. A significant time*condition interaction with the

right ($F=5.17$, $P=0.031$, $P\eta^2=0.17$) and left ($F=15.36$, $P=0.001$, $P\eta^2=0.37$) legs was also found (Table 2). SLR ROM increased from pre- to post-test in the intervention group by 7.9% and 10.1% with right and left legs respectively.

Table 1: Pain pressure threshold (PPT) test (values are mean $\pm$ SD kilograms).

				Pre-test right	Post-test right	Pre-test left	Post-test left
Pain	Intervention	Acute	UES	6.35±3.05	6.33±3.04	6.09±2.14	6.19±2.66
			LES	5.84±2.83	5.86±2.57	6.27±3.12	6.53±3.02
Pressure		Chronic	UES	6.35±3.05	7.89±2.62	6.09±2.14	7.43±3.59
			LES	5.84±2.83	8.41±3.70	6.27±3.12	8.50±4.61
Threshold	Control	Acute	UES	7.32±2.58	7.16±2.73	6.71±2.57	6.61±2.78
			LES	6.48±2.65	6.93±2.77	6.80±3.04	7.18±3.07
		Chronic	UES	7.32±2.58	8.17±1.50	6.71±2.57	7.60±1.44
			LES	6.48±2.65	7.64±2.03	6.80±3.04	7.29±1.48

Note: UES= Upper erector spinae, LES=lower erector spinae.

Table 2: Single leg raise (SLR) data of intervention and control groups in acute and chronic conditions (values are mean $\pm$ SD in degrees for range of motion (ROM)).

			Pre-test Right	Post-test Right	Pre-test Left	Post-test Left
Straight	Intervention	Acute	84.71 $\pm$ 17.38	90.14 $\pm$ 17.13	85.64 $\pm$ 16.01	91.64 $\pm$ 17.18
		Chronic	84.71 $\pm$ 17.38	92.71 $\pm$ 13.58*	85.64 $\pm$ 16.01	97.00 $\pm$ 14.98*
Leg	Control	Acute	92.57 $\pm$ 15.95	93.50 $\pm$ 14.34	95.28 $\pm$ 16.57	93.50 $\pm$ 17.35
		Chronic	84.71 $\pm$ 17.38	89.14 $\pm$ 13.95	85.64 $\pm$ 16.01	93.43 $\pm$ 16.72

Note: Shaded boxes indicate significant differences with the asterisks (*) illustrating training-related (pre- to post-tests) significant changes in range of motion (ROM).

Sit and reach (SR) test

interaction were detected (Table 3).

No significant main effects for condition, nor time*condition

Table 3: SR test data of intervention and control groups in acute and chronic conditions (values are mean $\pm$ SD cm).

			Pre-test	Post-test
Sit and Reach test	Intervention	Acute	15.00 $\pm$ 13.23	15.46 $\pm$ 12.65
		Chronic	15.00 $\pm$ 13.23	16.32 $\pm$ 11.84
	Control	Acute	16.00 $\pm$ 12.51	15.92 $\pm$ 13.33
		Chronic	16.00 $\pm$ 12.51	14.93 $\pm$ 12.76

Box lifting task

A main effect between conditions was observed for the box lifting task with right ($F=4.355$, $P=0.047$, $P\eta^2=0.14$), and left ($F=4.929$, $P=0.035$, $P\eta^2=0.16$) UES EMG activity as well as right LES muscle activity ($F=4.308$, $P=0.048$, $P\eta^2=0.14$) exhibiting

68.54%, 62.54% and 79.03% greater EMG activity with the chronic intervention condition, respectively. No main effect between pre- and post-tests, nor interaction effect for time*condition ($p>0.05$) was observed for right and left side UES and right LES muscle activity during the box lifting task (Table 4).

Table 4: Mean amplitude of the RMS EMG of intervention and control groups in acute and chronic conditions (values are mean $\pm$ SD percentages normalized (relative) to MVIC RMS EMG).

				Pre-test		Post-test	
				Right	Left	Right	Left
Box Lift	Intervention	Acute	UES	38.47 $\pm$ 14.78	44.35 $\pm$ 23.05	51.37 $\pm$ 21.39	45.84 $\pm$ 25.57
			LES	54.84 $\pm$ 22.96	60.37 $\pm$ 27.31	59.09 $\pm$ 27.14	62.73 $\pm$ 32.46

		Chronic	UES	38.47±14.78	44.35±23.05	64.84±41.26*	72.09±37.24*
			LES	54.84±22.96	60.37±27.31	98.18±42.78*	86.80±41.90*
		Acute	UES	54.84±33.80	51.10±32.59	52.04±35.93	51.14±40.52
			LES	59.23±36.26	62.20±48.88	59.41±43.08	60.40±38.58
	Control	Chronic	UES	54.84±33.80	51.10±32.59	57.54±31.54	51.45±23.97
			LES	59.23±36.26	62.20±48.88	51.31±29.69	55.07±36.55
		Acute	UES	56.32±30.32	63.21±38.04	56.50±29.54	65.17±40.34
			LES	61.60±32.70	77.65±44.73	69.62±39.31#	67.43±34.87#
Stand Up	Intervention	Chronic	UES	56.32±30.32	63.21±38.04	71.95±41.99*	90.64±59.19*
			LES	61.60±32.70	77.65±44.73	84.54±43.18	92.07±53.13
		Acute	UES	52.89±27.11	71.17±47.54	51.34±20.32	66.67±47.20
			LES	85.31±10.57	81.23±165.18	91.16±11.07	81.49±13.57
	Control	Chronic	UES	52.89±27.11	71.17±47.54	77.96±36.28	58.67±45.19
			LES	85.31±10.57	121.23±165.18	52.46±25.15	94.99±14.15
		Acute	UES	36.31±12.31	28.50±9.85	43.78±13.54	32.33±15.09
			LES	40.59±21.05	46.90±21.06	49.46±23.70	54.71±42.30#
Sit down	Intervention	Chronic	UES	36.31±12.31	28.50±9.85	43.23±9.11*	53.19±30.90*
			LES	40.59±21.05	46.90±21.06	67.82±35.43	114.22±77.84
		Acute	UES	35.47±18.31	36.33±22.36	32.75±18.48	66.67±47.21
			LES	68.48±86.95	75.84±10.62	56.05±70.67	64.72±89.65
	Control	Chronic	UES	35.47±18.31	36.33±22.36	51.29±23.85	34.06±18.29
			LES	68.48±86.95	75.84±10.62	43.77±18.11	63.65±34.36

Note: UES= Upper erector spinae, LES=lower erector spinae. Shaded boxes indicate significant differences with the asterisks (*) illustrating training-related significant increases in EMG, whereas the hashtag symbol (also known as a pound or number sign: #) highlights acute increases from pre- to post-test within a single session.

Sit-to-stand-to-sit test: Sit-down component

A main effect between conditions was observed for sit-down task with right ($F=6.635$, $P=0.016$, $\eta^2=0.20$) and left ($F=4.495$, $P=0.044$, $\eta^2=0.15$) UES EMG activity exhibiting 19.06%, and 86.63% greater UES activity in chronic intervention condition. Significant main effect for time ($F=5.085$, $P=0.033$, $\eta^2=0.16$) demonstrated a 14.27% increase from pre- to post-test in the acute condition for the left LES (Table 4). No significant interaction effect for time*condition were observed for UES and LES EMG activity in right and left sides during the stand-up task.

Sit-to-stand-to-sit: Stand-up component

A main effect between conditions was observed for stand-up task of right ($F=6.234$, $P=0.019$, $\eta^2=0.19$) and left ($F=50.733$, $P=0.001$, $\eta^2=0.66$) UES EMG activity exhibiting 27.75%, 43.39%, greater UES activity in chronic intervention condition. Significant main effect for time was revealed with the acute condition with right ($F=12.440$, $P=0.002$, $\eta^2=0.32$), and left ($F=13.847$, $P=0.001$, $\eta^2=0.35$) LES EMG showing 13.02% and 13.16% greater increases between pre- and post-test, respectively. A significant time*condition interaction ($F=10.565$, $P=0.003$, $\eta^2=0.29$) of the left leg LES EMG revealed that the intervention increased by 26.1% from pre- to post-test (Table 4).

Isometric box holding task

Anticipation condition

A main effect between conditions was observed for the anticipation of the dropping of the weight with the isometric box holding task with right ($F=8.086$, $P=0.009$, $\eta^2=0.24$) and left ($F=4.604$, $P=0.041$, $\eta^2=0.15$) UES EMG activity exhibiting 23.48% and 98.17% greater UES activity in chronic intervention condition, respectively. Significant main effect between pre-and post-test in the acute condition with right ($F=4.831$, $P=0.037$, $\eta^2=0.16$) and left ($F=4.747$, $P=0.039$, $\eta^2=0.15$) UES and right LES ($F=5.796$, $P=0.023$, $\eta^2=0.18$) demonstrated 20.77%, 27.83%, and 4.74% greater increases respectively (Table 5). No significant interaction effect for time*condition was observed for UES and LES EMG activity in right and left sides during anticipation condition (Table 5).

Response condition

The main effect between conditions was observed for isometric box holding task in response to dropping the weight in the box (response condition). Right UES EMG activity ($F=6.685$, $P=0.016$, $\eta^2=0.21$) exhibited 77.17%, greater UES activity in the chronic intervention condition. There were no significant main time effects between pre-and post-tests in the UES and LES. No signifi-

cant interaction effect for time*condition were observed for UES condition (Table 5). and LES muscle activity in right and left sides during the response

Table 5: Isometric box holding with anticipation and response to the dropping of the weight with intervention and control groups in acute and chronic conditions (values are mean±SD percentages normalized (relative) to MVIC RMS EMG).

				Pre-test		Post-test	
				Right	Left	Right	Left
Anticipation	Intervention	Acute	UES	11.37±9.02	10.91±3.23	13.73±9.93#	16.15±6.42#
			LES	17.23±7.07	16.97±10.13	16.45±7.07#	21.59±11.04
		Chronic	UES	11.37±9.02	10.91±3.23	14.04±14.33*	21.62±14.11*
			LES	17.23±7.07	16.97±10.13	24.80±24.64	24.23±19.17
	Control	Acute	UES	14.41±9.56	12.97±10.47	12.05±7.47	12.33±10.06
			LES	20.57±16.01	22.77±24.03	17.52±15.87	21.26±19.67
		Chronic	UES	14.41±9.56	12.97±10.47	22.72±15.85	11.95±1.72
			LES	20.57±16.01	22.77±24.03	21.67±2.59	22.53±2.85
Response	Intervention	Acute	UES	20.19±10.45	21.09±10.28	25.59±15.70	23.39±11.42
			LES	22.78±12.96	26.80±9.30	28.78±9.34	41.28±41.51
		Chronic	UES	20.19±10.45	21.09±10.28	35.77±22.30*	24.82±11.31
			LES	22.78±12.96	26.80±9.30	31.48±11.45	40.74±18.07
	Control	Acute	UES	21.43±11.67	23.59±15.11	22.39±13.06	23.69±16.32
			LES	27.91±20.40	33.61±27.78	26.20±18.37	32.75±21.95
		Chronic	UES	21.43±11.67	23.59±15.11	21.61±8.42	17.67±3.05
			LES	27.91±20.40	33.61±27.78	20.32±3.03	30.62±5.31

Note: UES= Upper erector spinae, LES=lower erector spinae. Shaded boxes indicate significant differences with the asterisks (*) illustrating training-related significant increases in EMG, whereas the hashtag symbol (also known as a pound or number sign: #) highlights acute increases from pre- to post-test within a single session.

Biering Sorensen back endurance test (Fatigue index)

A main effect between conditions was observed for the back endurance test with right ($F=4.618$, $P=0.041$, $P\eta^2=0.15$) and left

($F=19.414$, $P=0.001$, $P\eta^2=0.43$) UES EMG activity demonstrating 17.15%, and 6.91% lower fatigue-related decreases in UES EMG activity with the chronic intervention condition (Table 6).

Table 6: EMG fatigue index from back endurance test ((last 5 seconds/first 5 seconds) × 100).

				Right	Left
Back Endurance Test	Intervention	Acute	UES	102.77±21.14	101.91±18.10
			LES	88.64±9.83	88.45±15.00
		Chronic	UES	85.14±12.64*	94.87±21.91*
			LES	83.90±16.88	80.24±16.81
	Control	Acute	UES	95.70±14.57	97.39±19.79
			LES	83.08±12.76	80.08±13.46
		Chronic	UES	91.51±18.04	72.76±12.94
			LES	85.86±10.02	85.35±10.49

Note: UES=Upper erector spinae, LES=lower erector spinae. Shaded boxes indicate significant differences with the asterisks (*) illustrating training-related significant increases in EMG.

Table 6. EMG fatigue index from back endurance test (last 5 seconds/first 5 seconds) × 100)

Quebec Back Pain Disability Scale

A paired sample t-test showed 43.93% significantly lower pain disability between pre-training (26.93±15.57) and post-training testing (18.71±17.08) for Quebec Back Pain Disability Scale after

training ($t=2.21$, $P=0.046$). There was no significant change with the control washout period. A higher score denotes a more severe level of disability.

Discussion

The major findings of this study were that during the exercise tasks (tests), there was a) less pain sensitivity with chronic

training as evidenced by decreases in the Quebec back pain scale, b) training-related (chronic) increases in right and left UES EMG activity c) greater ROM during the single leg raise test and e) a lower EMG fatigue index (less muscle activation-related fatigue) with chronic training with the back endurance test. LBP can be attributed to a myriad of degenerative problems with vertebrae, and vertebral discs, with arthritic problems being very common (McGill 2002, Willie et al. 2017) [39,40]. These skeletal spinal deterioration issues may be attributed to structural damage to vertebrae and discs leading to instability (Cholewicki and McGill 1996) [41] as well as the loss of disc fluid with ageing that can decrease the distance between vertebrae (McGill 2002) [39]. Articular problems associated with LBP can affect motor planning and movement, (Hodges 2001) [42] cushioning or absorption of external forces (Hammill, Beazell, and Hart 2008) [43], alter trunk muscle recruitment, (Hodges and Richardson 1999) [44] as well as nerve root compression amongst other complications that can lead to chronic pain, altered reflex activity and function deficits (McGill 2002) [39]. These intervertebral articulations problems can also lead to the development of osteophytes, or bone spurs, which can press against the spinal cord or spinal nerve roots (McGill 2002) [39].

The objective of the acute and chronic application of the traction device was to promote decompression between vertebral joints, increasing intervertebral space to decrease associated pain and enhance function. Pain can impair muscle torque and rate of force development, adversely affect function, (Rice et al. 2019) [45] inhibit corticomotor excitability, (Rice et al. 2021, Canestri et al. 2021) [46,47] and decrease EMG activity and thus inhibit the ability to fully activate a muscle or muscle groups (Behm and St-Pierre 1997, Rice et al. 2021, Rutherford, Jones and Round 1990) [28,48,49]. Pain contributes to reduced activity and disuse (Rice et al. 2019) [44], which can chronically lead to decreases in muscle activation (EMG activity) (Behm 1993) [48]. Disuse studies have reported reductions in muscle activation (Yue et al. 1997) [50] when monitoring EMG, (Davies and McGrath 1982, Duchateau and Hainaut 1987) [51,52] reflex potentiation, (Sale et al. 1982) [53] and maximal firing rates (Duchateau and Hainaut 1987) [52]. Greater muscle inactivation has been reported in patients with joint pathologies (Rutherford, Jones and Newham 1986, Hurley, Jones and Newham 1994, McComas, Keresi and Quinlan 1983) [54,55,56]. Chronic intervertebral joint dysfunction can result in osteoarthritis contributing to inflammatory responses, (McGill 2002, Willie et al. 2017) [39,40] which in turn can induce muscle activation inhibition (DeAndrade, Grant and Dixon 1965, Wood, Ferrel and Baxendale 1988) [57,58]. Individuals experiencing LBP respond to trunk perturbations with altered responses (e.g., the isometric box hold with weight drop in the present study) (Gregory, Brown and Callaghan 2008) [59]. Thus, the finding of an improved Quebec back pain scale with the chronic training condition may have contributed to a disinhibition of EMG activity in response to some of the presented tasks in this study (e.g., stand-up task). While there was also a main effect for improvement in

PPT with training, main effects include both pre- and post-test scores and thus are not a strong indication of change for the traction trained condition. Increased back EMG activity could contribute to greater spinal stability during the selected tasks (Gregory, Brown and Callaghan 2008) [59].

The attenuation of pain found with the Quebec back pain scale may have also contributed to the enhanced ROM. A major mechanism underlying improvements in ROM is attributed to enhanced stretch (pain) tolerance (Behm et al. 2016, 2021 a, b, 2023, Magnusson et al. 1996) [60,61,62]. Hence, a reduction in chronic LBP with the decompression provided by the traction device would have permitted the participants to be guided (passive supine single leg raise test) through a greater ROM with less discomfort or pain. There was no significant change in the sit and reach test. The sit and reach test are influenced by both the lower back and hamstring muscles (Ayala et al. 2012) [33]. Hence, even if there was a traction effect on the lumbar vertebrae, the traction device may not have substantially affected hamstrings extensibility, limiting possible gains associated with the sit and reach test. Pain would also negatively affect muscle strength and the ability to sustain or endure exercise (Canestri et al. 2021, Rice et al. 2019, Graven-Nielsen 2022, Graven-Nielsen et al. 2002) [47,63,64] with the back endurance test, which demonstrated a lower EMG fatigue index (lower EMG decreases over time) with the chronic condition. Although not monitored in this study, there can also be pain-induced changes in muscle coordination, and co-contractions that can impede optimal functioning (Graven-Nielsen and Arendt-Nielsen 2008) [37] or in this study; restrict optimal UES and LES muscle activity during a back endurance task. EMG activity, particularly the median frequency slope values of thoracic vertebral muscles are moderately correlated with back endurance duration (Pitcher, Behm, and MacKinnon 2008) [31]. The pain attenuation may have led to improved muscle activation strategies enhancing neuromuscular efficiency during the back endurance task. With only 4 weeks of using the traction device, there were positive effects on muscle function (e.g., SLR ROM and back endurance fatigue index). St-Pierre et al. (1992) [28] reported that only minimal activity over 6 weeks was necessary for recovery of function with rehabilitation. Fuglsang-Frederiksen and Scheel (1978) [65] found that EMG activity following disuse returned to normal following 8 days of spontaneous recovery.

An additional mechanism for the increased ROM, lower back endurance EMG fatigue index and increased EMG activity with selected tasks might be exercise-induced hypoalgesia (EIH). It is ubiquitously reported that long-term exercise training provides pain relief in healthy, pain-free populations (Rice et al. 2019) [45]. However, EIH effects are more variable in chronic pain populations with decreases, no changes, and infrequently, increases with exercise (Rice et al. 2019) [45]. Although EIH is often reported with higher intensity aerobic exercise (60-75% of maximum aerobic capacity), (Koltyn 2002) [66] Koltyn et al. (2014) [67] demonstrated that EIH was apparent following low intensity isometric

contractions (25% of maximal voluntary isometric contraction (MVIC)) sustained for a relatively short duration (3-minutes). Rice et al. (2019) [45] in their review reported that EIH resistance exercise studies typically utilize isometric contractions at 10-30% of MVIC. There may be sex differences as men seem to need higher intensities of isometric contractions to induced EIH (Koltyn 2002) [66]. With chronic exercise (training), there is a significant positive correlation between exercise duration or frequency and the reduction of chronic pain (Polaski et al. 2019) [68]. In the present study, participants performed traction exercises for up to two minutes per day, seven days per week and were informed to push the traction device on their pelvis at a subjective estimate of 50-70% of their maximal force. However, while pain thresholds may be significantly elevated at 5 minutes after resistance exercise, the hypoalgesia effect returns to baseline levels approximately 15-minutes post-exercise (Koltyn 2002) [66]. Since there was no acute effect and in the chronic post-testing condition, there was no traction exercise, it is more likely that the chronic traction played a more significant role than EIH. Further research would be helpful to directly compare and determine whether the traction effect of the traction device was a major contributor to the decrease in LBP or was it simply the 4 weeks of the action (exercise) of contracting upper body musculature to push the device against the pelvic girdle promoting a chronic EIH effect. All studies have limitations. It can be difficult to recruit from a general population with chronic pain and ask them to exercise for 4 weeks and come in for five testing and familiarization sessions. Thus, a larger sample could possibly have strengthened statistical power. The training program was an unsupervised at-home program. Although the participants reported high compliance, supervised training programs typically elicit better results than unsupervised (Konrad et al. 2024) [69].

Conclusions

In conclusion, the reduction of pain with the pelvic girdle – low back traction device may have improved ROM and back endurance and disinhibited some prior pain-induced reductions in muscle activation (EMG). These improvements in function and activation may be attributed to a traction-induced decompression between vertebrae or might also be related to EIH with chronic traction applications. This novel device might be considered for an at-home rehabilitation treatment program due to its ease of use, portability, and accessibility.

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