Evidence on the Ability of a Pneumatic Decompression Belt to Restore Spinal Height Following an Acute Bout of Exercise

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Abstract

Objective: The purpose of this study was to evaluate the ability of a pneumatic decompression belt to restore spinal height lost following an acute bout of exercise that induced compression.

Methods: This study implemented a test-retest repeated measures design in which twelve participants (male = 10, female = 2) age, 21.5 ± 1.0 years; height, 179.0 ± 7.70 cm; weight, 84.0 ±11.5 kg; were recruited from a university population and acted as their own control. All participants were healthy with no previous history of disabling back pain, and were frequent weight trainers. A stadiometer was used to measure spinal height at baseline, then following an acute bout of exercise and then again following the intervention (use of a pneumatic decompression belt for 20 minutes) or control (lying supine for 20 minutes). A 2-way repeated measures ANOVA was performed on the change in spinal height in order to evaluate differences between measurement phases and intervention conditions.

Results: The use of the decompression belt increased spinal height gain (4.3 ± 3.0 mm) significantly more than the control condition (1.8 ± 1.2 mm) following an acute bout of weightlifting exercises known to elicit high compressive loads on the lumbar spine.

Conclusion: The pneumatic decompression belt restored spinal height faster than a non-belt wearing condition in young healthy asymptomatic participants. (J Manipulative Physiol Ther 2016;39:304-310)

Key Indexing Terms: *Intervertebral Disc; Spine; Lumbar Vertebrae; Body Height, Load-bearing*

Diurnal variations in spinal height have been largely attributed to the intervertebral discs (IVDs) ability to imbibe fluid during periods of unloading, in which the osmotic pressure within the IVD is greater than the hydrostatic pressure from compressive loading; conversely fluid is expelled when the compressive loading exceeds the osmotic pressure of the disc.[1,2] Spinal height has been shown to decrease up to 19.3 mm (~1.1% of total stature) throughout an average day due to cumulative loading compressing the IVDs, causing fluid expulsion and thus decreasing disc height, namely, in the lumbar spine.[3–6] While the relationship between cumulative loading and spinal height is not straightforward, it has been suggested that loss of IVD height may be able to indicate the cumulative loading experienced by the spine due to various magnitudes and directions of loading.[5] Additionally, IVD height influences ligament length/slackness and thus range of motion (ROM). The interaction of ligament slackness and disc height (due to corresponding fluid levels) may serve to modulate the stiffness of the lumbar spine thereby influencing low back injury risk.

Several clinical practices exist (such as mechanical traction, spinal distraction and gravity inversion) that aim to unload and distract the lumbar spine in an attempt to increase IVD height and decompress the spine. While the efficacy of these treatments are debatable for low back pain, disc herniation and compression intolerant patients it appears that there is a variance in response with some reporting pain relief and others pain exacerbation.[7] The suggested mechanism of pain relief is via increased IVD height unloading the facet joints, relieving nerve root compression (in the intervertebral foramen) and reducing muscle spasms.[7,8] Previous works have investigated a range of treatments and postures in their ability to increase

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IVD height. Standard supine mechanical traction has shown an increase of 3.2 mm while aquatic vertical traction induced a IVD height increase of 5.0 mm.[9] Gravity inversion for 20 minutes increased spinal height by 5.2 mm following loading due to drop jumping,[10] while a gravitational traction device was recorded as causing overall stature changes of up to 31 mm.[9] Magnusson and colleagues suggested that 20 minutes of 20° hyperextension induced the greatest increase in spinal height and lasted for the longest period of time.[11] Several other postures such as prone extension, supine flexion and prolonged hyperextension have been shown to increase spinal height by 3.1 mm, 3.2 mm and 5.2 mm respectively.[6]

Stadiometry provides an inexpensive, convenient and non-invasive measure of spinal height, which has been proven to be both reliable and valid, albeit an indirect measure of IVD height.[3,12] Previous studies have used stadiometry to investigate IVDs response to cumulative and repetitive loading, prolonged unloading, posture, vibration, as well as spinal manipulation and other clinical treatments of low back pain.[3,5,6,12–15] Thus, stadiometry was used to measure changes in spine height in this study.

Given the use of such treatments, we were motivated to evaluate the ability of a pneumatic decompression belt to increase spinal height following an acute bout of exercise induced compressive loading. It was hypothesized that the use of a pneumatic decompression belt would restore spinal height significantly greater than a no-belt control condition.

Methods

Participants

Twelve participants (male = 10, female = 2) age, 21.5 ± 1.0 years; height, 179.0 ± 7.70 cm; weight, 84.0 ±11.5 kg; were recruited from a university population for this study. All participants were healthy with no previous history of disabling back pain, and were frequent weight trainers that were currently on a training regime that included exercises known to induce relatively large compressive loads on the lumbar spine. Participants signed an informed consent form, and the study was approved by the University of Waterloo Office for Research Ethics.

Experimental Design

A test-retest repeated measures design was implemented in which participants acted as their own control across intervention days, and over time within a given testing day. On both days, participants reported to the laboratory for height, weight and baseline spinal height measurements before going to the university gym to complete a typical weight training session in their training regime. Following the acute bout of exercise, they returned to the lab for post exercise spinal height measurements. On the control day, participants then lay supine for 20 minutes; while on the intervention day they wore a pneumatic decompression belt as they lay supine for 20 minutes. Following the control/intervention a final set of spinal height measurements were made. Figure 1 shows an illustration of the experimental protocol on a given testing day.

The order of control and intervention days were randomised. Each day was collected 7–9 days apart to ensure no lasting effects of the initial collection, with the same (or similar) exercise session on these days. The exercise sessions performed by the participants included exercises that are known to induce high compressive loads on the lumbar spine, such as compound lifts, loaded carries and other exercises requiring substantial core musculature activation. The details of each participants exercise sessions can be found in Appendix A. On both the control and intervention days, testing occurred at approximately the same time in an attempt to account for circadian variations in stature.

Stadiometer Protocol

The stadiometer protocol was replicated from previous works that included its use in measuring spinal height/stature. The stadiometer utilized a frame that was tilted 15° posteriorly to the vertical, and included four adjustable spine supports at the C4, T4, T8, and L3 levels in order to support, and control for, an individual's spine curvature. A separate head support was aligned with the occipital protuberance in order to control for anterior-posterior head position. Head tilt was controlled for (within a given testing day) via the use of goggles with a horizontal line marked at the eye level and a mirror (positioned approximately 40 cm from, and parallel to, the head support) with a horizontal line marked across the middle. Participants matched the line on the googles with that of the mirror in order to standardize head position for each set of measurements. Goggle position on the face was marked before baseline measurements were taken, to ensure that goggle placement was consistent within a testing day. Foot position was controlled for using a foot platform mounted perpendicular to the back rest (thus 15° superior to the horizontal) with lines dictating the position of the posterior and medial aspect of the heels. Adjustments to all experimental equipment was done so for the individual in advance of the baseline measurements, and remained in this position for the entirety of a given testing day. Figure 2 shows a participant in the stadiometer with the various control methods.

Participants entered the stadiometer and aligned themselves accordingly. Before each set of measurements were obtained, the participant stood for approximately 120 seconds in order for the heel pad to deform under load (as suggested by Foreman & Linge, 1989) and thus the recordings were not affected by this creep phenomenon.[16] A research assistant recorded the vertical position of the head with a digital spring-loaded linear caliper (accuracy ± 0.03 mm; resolution 0.01 mm) which was lowered onto the

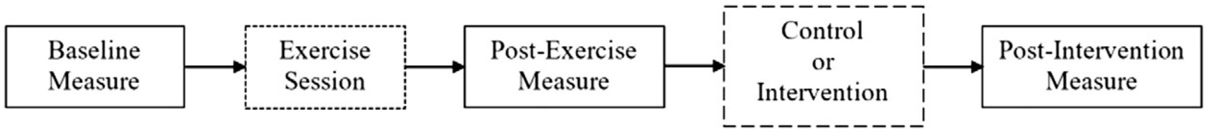

Fig 1. *Flowchart of protocol procedures.*

top of the participant's head. Since the vertical position of the head fluctuates with breathing, the participant inhaled and held their breath for 2 to 3 seconds. Over this period a range of values were observed, of which, the upper and lower were averaged to record a single value. Three values were recorded at each measurement stage, for which, the participants remained in the stadiometer the whole time so as to reduce variability in the recordings.[12]

Pneumatic Decompression Belt

The pneumatic decompression belt used in this study was Dr-Ho's® 'De-Stress Belt'. The belt was attached around the waist using adjustable Velcro straps, ensuring that the alignment markers were equally spaced from the center of the abdomen and the bottom of the belt on the lateral sides were placed slightly superior to the iliac crests (Fig 3A and C). Once firmly in place and tightly secured, the belt was fully inflated using a hand action pump attached to the valve of the belt. Air filled the plastic tubing within the belt in order to expand 3 inches vertically (Fig 3B and D). The belt aimed to lock the pelvis at the base of the lumbar spine (as it sits atop the iliac crests) and with inflation served to elevate the ribcage attached superiorly to the lumbar spine. Thus, the lumbar spine experienced tensile forces in an attempt to increase the height of the IVDs. Theoretically, the lumbar spine is lengthened and decompressed, causing an overall change in spinal height and stature.

Statistical Analysis

A two-way repeated measures ANOVA was performed on the change in spinal height in order to evaluate differences between measurement phases and intervention conditions on the participants (n = 12). Pairwise comparisons were made using Bonferroni adjustments for multiple comparisons, with significance set at the $P < .05$ level. When appropriate, post-hoc analyses were conducted in the form of paired t-tests in order to examine where differences within a factor existed.

Results

The use of the decompression belt increased spinal height (4.3 ± 3.0 mm) significantly more ($p<0.05$) than the control condition (1.8 ± 1.2 mm) following an acute bout of weightlifting exercises known to elicit high compressive loads on the lumbar spine (Fig 4). Change in spinal height from baseline to post-exercise was not significantly different between the control day (−2.78 ± 1.93 mm) and the intervention day (−4.04 ± 1.99 mm), thus the exercise exposure was considered to be similar over the days throughout the experiment.

A comparison between the changes in spinal height from baseline to post-intervention was made in order to evaluate the ability of the intervention to restore the spinal height lost to exercise. The use of the decompression belt restored, and exceeded, the baseline spinal height (0.3 ± 2.8 mm) while the control condition was unable to restore the baseline height (−0.9 ± 2.2 mm) (Fig 5). Thus, a significant interaction of belt and time was found, in which an increase in spinal height from post-exercise to post intervention was greater during the belt intervention than the control condition ($p<0.05$).

A trend emerged in which those with slimmer and taller physiques, and thus lower BMI scores, seemed to respond better to the belt intervention than those with larger BMI scores (Fig 6). The mean BMI score of all participants was 26.71 ± 2.6 kg/m^2; using this value, participants were split into high BMI (28.94 ± 0.9 kg/m^2) or low BMI (24.47 ± 1.7 kg/m^2) groups based on being above or below the overall group mean. All group means of BMI were calculated using values collected on both testing days. Although differences were non-significant, those in the low BMI group attained 2.16 mm more in spinal height than the high BMI group following the belt intervention, compared to a difference of only 0.50 mm following the control condition.

Discussion

The use of a pneumatic decompression belt for 20 minutes while lying supine following spine-compressing exercise increased spinal height significantly greater than the no belt condition. Thus, the hypothesis was confirmed that the belt restored spinal height following an acute bout of exercise-induced spine compression faster than the no-belt condition. In addition, the use of the decompression belt not only recovered the height lost to exercise, but actually exceeded the baseline measurement (Fig 5). The control condition, with no belt use, was unable to recover the spinal height lost due to exercise.

The amount of spinal height lost may be a consideration for interpretation. Boocock and colleagues (1988) noted

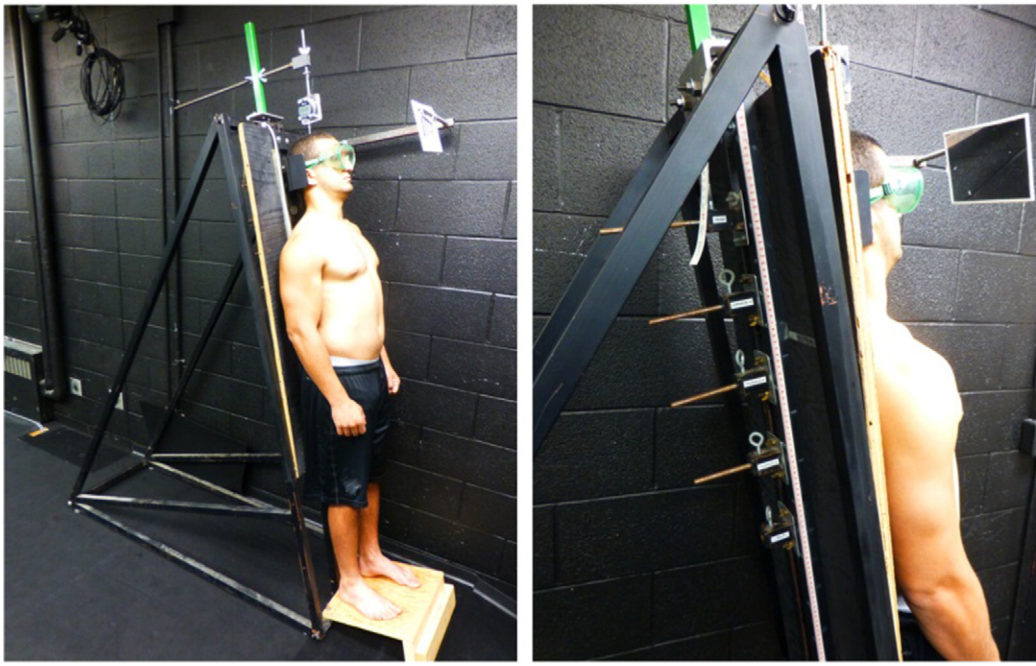

Fig 2. *A participant in the stadiometer. Spine curvature, head tilt and foot position are controlled for so as to decrease random measurement error.*

that more compressed IVDs recover at a greater rate compared to relatively less compressed discs.[17] Thus, the control condition may have eventually recovered all of the IVD height lost to exercise, but the time period given was unable to capture this phenomenon. The mean spinal height increase with use of the pneumatic decompression belt for all participants was 4.3 mm, this exceeds values reported for mechanical traction and supine flexion of 3.2 mm and 4.2 mm respectively.[9] However, values of spinal height increase from aquatic vertical traction (5.0 mm), gravity inversion (5.2 mm) and prolonged hyperextension (5.2 mm) exceed that measured here using the pneumatic decompression belt.[9,10,15] The no-belt control condition resulted in less increases in spinal height (1.8 mm) than reported designated postures such as prone extension (3.1 mm) and supine flexion (3.2 mm).[6] Obviously, the use of the decompression belt exceeded these reported values.

Further analysis was conducted which found a strong trend based on BMI scores and therefore physique. For example, those with slimmer and taller physiques, and thus lower BMI scores, seemed to respond better to the belt intervention than those with larger BMI scores. Curiously, those in the low BMI group attained 2.16 mm more in spinal height than the high BMI group following the belt intervention, compared to a difference of only 0.50 mm following the control condition. This trend suggests that the use of the decompression belt may lend itself best to those with suitable anthropometrics, body fat distribution and an optimal fit of the belt itself. This makes sense given that anecdotal evidence reported by participants in this study that some participants felt that the belt only served to move skin and subcutaneous fat, and that alone. Boocock et al. (1990) observed a negative correlation between an increase in spinal height and body weight during gravity inversion treatment, they suggested that heavier individuals may be unable to relax appropriately to allow alleviation of compressive forces.[10] Given the similar trend, it is also possible that differences in bony architecture that accompany increased body mass and/or BMI may influence the ability to lengthen the spine, irrespective of the treatment. Further, the belt may better "grab" the hips and ribcage of thinner people. However, as a counterpoint, Owens et al included women and men in their study that evaluated the ability of posture to alter spinal height, but given their results and variability in body frame, they concluded that sex and body parameters do not influence one's capacity to increase spinal height.[6] Further investigation into the relationship between body parameters and changes in spinal height is suggested given the observations in this study and the several conflicting conclusions in the literature.

The mechanism by which the belt increased spinal height was due to the traction force applied to the spine as the ribcage was lifted away from the pelvis during, and following, belt inflation. Traction has been documented to increase spinal height by reducing the hydrostatic load on

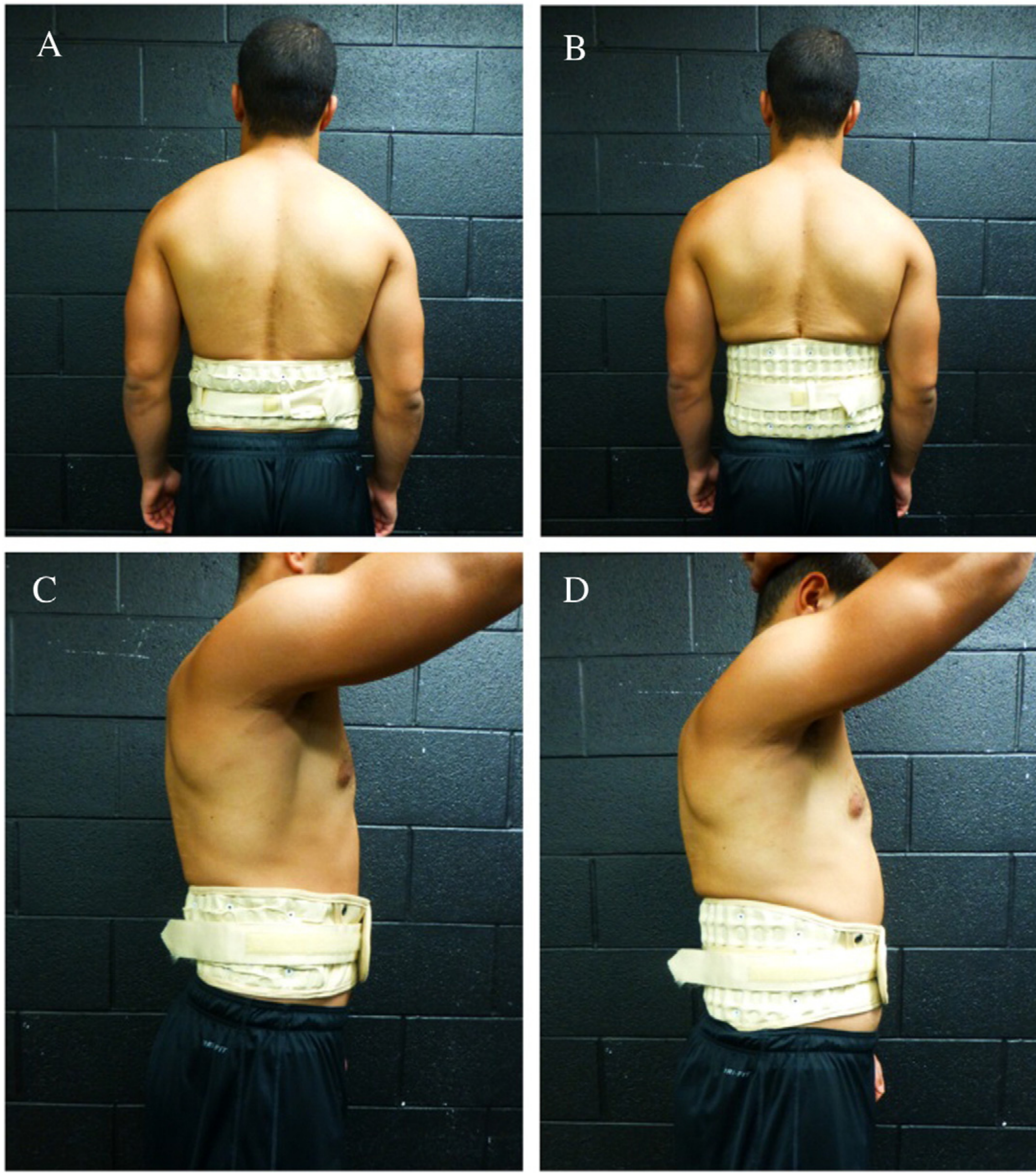

Fig 3. *A participant wearing the belt deflated (A and C), and then inflated (B and D) from a posterior and lateral view.*

the IVD and allowing fluids to cross the endplate driven by the osmotic pressure from the hydrophilic nucleus.[2,18,19] The concomitant intervertebral separation can reduce nerve impingement and mechanical friction. It has also been proposed that the application of traction force may modulate pain by increasing non-nociceptive input.[18,19] This study provides a proof of principle that the belt was able to apply sufficient traction force to assist a more rapid return of spinal height, compared to the control condition with no belt. This may help some patients with compression modulated pain, such as those with lumbar stenosis and low back pain patients with mechanically induced radicular pain. Given the aim and design of this study, with the inclusion of only healthy asymptomatic participants, the results may not be extended to the broad low back pain population nor should their clinical significance be explicitly stated at this time. Future research into the efficacy of such treatments for specific, diagnosed subsets of low back pain patients should be conducted to substantiate clinical relevance and appropriate applications for use.

While the focus of this study was on the ability to influence spinal height, it would be prudent at this time to consider treatment efficacy on a case by case basis. For example, substantiated contraindications exist which should be considered by the clinician before administering treatments and therapies aimed at increasing IVD height and overall spinal height. Notably, is the phenomenon in

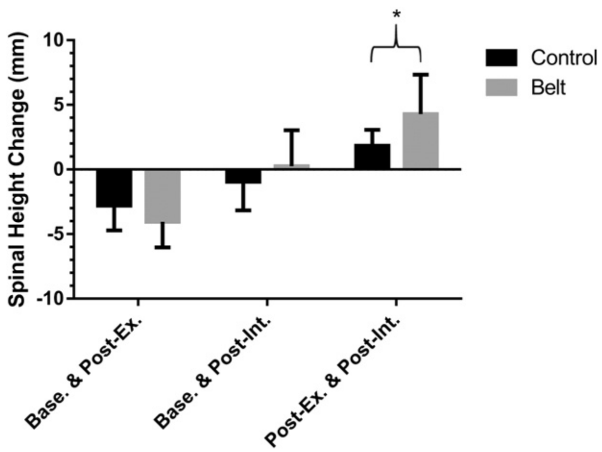

Fig 4. *Mean change in spinal height (mm) and standard deviations for the three measurement comparisons during the control and belt conditions. Note that a negative value means a loss in spinal height between the measurements, while a positive value means an increase.* Statistically significant at the P < .05 level.*

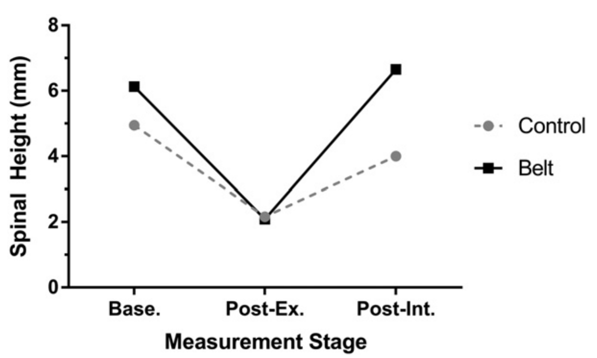

Fig 5. *Mean spinal height for the control and belt conditions at each measurement stage.*

which imbibed fluid causes disc annulus stresses during bending to increase by up to 300% and increase ligament stresses by up to 80 %.[1,20] The disc is most vulnerable to injury and failure following periods of unloading (such as when rising from bed) in which IVD height and fluid levels are at a maximum, compounded with compression, during flexion and axial twist of the lumbar spine.[3,21] Observations from our university clinic suggest that manually applied traction can either reduce, or increase, back discomfort.

Limitations of this study include those associated with the young, healthy, university students who comprised a convenience sample for this study. For example, age related losses of IVD height limits the extension of the results presented here to an older population. During each stage of measurement, three stadiometer recordings were taken which were considered sufficient. Additionally, every participant performed their own exercise protocol already established in their training regime, thus, variable degrees

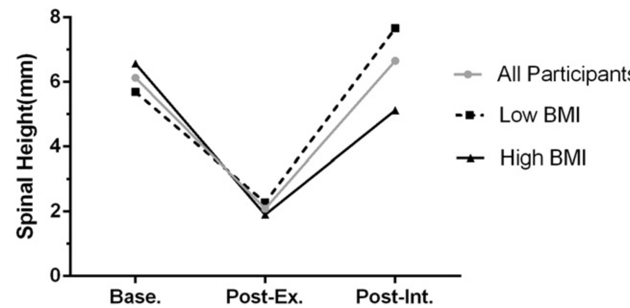

Fig 6. *Mean spinal height of the low BMI group, high BMI group and all group participants, across each stage of measurement. BMI, body mass index.*

of compression may have been induced due to exercise selection and magnitude of load being nonequivalent. However, this was unavoidable given differences in weight training capacity between individuals. Further, biological variability in both height losses and recovery, and the rate of recovery are recognized as part of the difference in response.

Given the results presented here and those in the literature, it appears that maximal increase in spinal height may be achieved when specific passive postures and external active forces are used in combination with one another. Specifically, a period of unloading via supine lying will relieve the spine of compressive forces due to body weight and gravity, with no tensile forces acting along the compressive axis of the lumbar spine. Meanwhile, laying supine with the decompression belt will unload the spine coupled with tensile forces along the compressive axis to amplify the magnitude of change in IVD height. The ability to recover spinal height following periods of compressive loading may be beneficial in alleviating pain symptoms for certain subgroups of low back pain patients. Future research should aim to elucidate these specific subsets of patients and understand the mechanism by which some may respond while others do not, in order to appropriately prescribe such an intervention.

Conclusion

The use of a pneumatic decompression belt following spine-compressing exercise was able to decompress the spine and increase IVD height to a greater extent than a control condition (no-belt), in young healthy asymptomatic participants. The spinal height lost to exercise was not only able to be recovered, but exceeded the baseline measurement with the use of the decompression belt. The magnitude of increased spinal height with the use of the decompression belt was similar to values reported for other common clinical treatments with the same objective.

Funding Sources and Conflicts of Interest

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Contributorship Information

Concept development (provided idea for the research): J.C., D.E., S.M.
Design (planned the methods to generate the results): J.C., D.E., S.M.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): J.C., S.M.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): J.C., D.E.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): J.C., D.E., S.M.
Literature search (performed the literature search): J.C., D.E.
Writing (responsible for writing a substantive part of the manuscript): J.C., D.E., S.M.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): J.C., S.M.

Practical Applications

- The use of a pneumatic decompression belt was able to restore spinal height.
- The magnitude of increased spinal height with belt use was similar to other clinical treatments.
- The use of a decompression belt may be beneficial in alleviating pain symptoms for appropriate patients.

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