Original studies

Thoracolumbar spinal manipulation and the immediate impact on exercise performance

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Abstract

Objective: The purpose of this study was to determine if thoracolumbar chiropractic manipulative therapy (CMT) had an immediate impact on exercise performance by measuring blood lactate concentration, exercise heart rate, and rating of perceived exertion during a treadmill-based graded exercise test (GXT).

Methods: Ten healthy, asymptomatic male and 10 female college students (age = 27.5 ± 3.7 years, height = 1.68 ± 0.09 m, body mass = 71.3 ± 11.6 kg; mean $\pm$ SD) were equally randomized into an AB:BA crossover study design. Ten participants were in the AB group, and 10 were in the BA group. The study involved 1 week of rest in between each of the 2 conditions: A (prone Diversified T12-L1 CMT) vs B (no CMT). Participants engaged in a treadmill GXT 5 minutes after each week's condition (A or B). Outcome measures were blood lactate concentration, exercise heart rate, and rating of perceived exertion monitored at the conclusion of each 3-minute stage of the GXT. The exercise test continued until the participant achieved greater than 8 mmol/L blood lactate, which correlates with maximal to near-maximal exercise effort. A dependent-samples *t* test was used to make comparisons between A and B conditions related to exercise performance.

Results: No statistically significant difference was shown among any exercise response dependent variables in this study.

Conclusions: The results of this research preliminarily suggest that CMT to T12-L1 does not immediately impact exercise performance during a treadmill-based GXT using healthy college students.

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Introduction

Many chiropractic doctors work with amateur and professional athletes on a daily basis. The use of chiropractic in sports is gaining increasing respect following the inclusion of chiropractic doctors in the 2007 World Ice Hockey championships,¹ 2010 Olympic Winter games,² and other sporting events. There is an abundance of non-peer-reviewed chiropractic literature purporting that chiropractic can improve exercise performance.³⁻⁵ The true impact chiropractic manipulative therapy (CMT) has on exercise performance, however, has been poorly studied and warrants further review.⁶⁻¹³ Some researchers have argued that most studies demonstrating that chiropractic improves exercise performance have been of questionable quality.¹⁴ As a result, this field warrants further review. Monitoring performance on an exercise test following CMT is one method to chronicle improvement in function. Blood lactate concentration (BLC), exercise heart rate, and rating of perceived exertion (RPE) are a few of many methods to monitor exercise performance during exercise testing that would be capable of testing the impact of CMT.¹⁵⁻¹⁹

Blood lactate is an important biomarker of cardiovascular exercise intensity. Skeletal muscle cells generate hydrogen and lactate ions that lower muscle pH during physically challenging exercise.²⁰⁻²² Muscle saturation with hydrogen ions in many studies has been associated with a reduced ability to generate force and is one of several processes that contribute to peripheral fatigue.^{23,24} The impact lactate ion accumulation has within muscle is less clear. As lactate ions build up in muscle cells, lactate will start to spill into the bloodstream.²⁵⁻²⁷ Lactate accumulation in the blood can be an indicator of exercise intensity because, at rest, it is tightly regulated near 1 ± 1 mmol/L.²⁸⁻⁴⁸ Interestingly, during exercise, the lactate that accumulates in the blood begins to cross over into the cerebrospinal fluid^{49,50} and is thought to contribute to central fatigue.⁵¹

Also during progressive incremental exercise, heart rate increases above baseline resting heart rate in relation to exercise intensity.⁵² The increase is initially driven by withdrawal of vagal parasympathetic suppression of the heart.^{53,54} This is followed by further concomitant vagal withdrawal and increased sympathetic stimulation through the cardiac plexus and release of epinephrine and norepinephrine from the adrenal medulla.⁵⁵⁻⁵⁷ The increase in the chronotropic and inotropic events of the heart that follow directly

raises baseline cardiac output as cardiac reserve is used. The heart rate will continue to increase to support exercise demands until an athlete attains his or her maximum heart rate and reach exhaustion.

The Borg RPE scale represents a 6 to 20 numeric scale that has been used in many studies to help quantify subjective participant perception of exercise intensity. Rating of perceived exertion has been linked to muscle force output,⁵⁸ exercise heart rate, and BLC.⁵⁹ During incrementally challenging exercise, RPE should gradually increase in relation to exercise intensity until a person reaches an RPE score of 20.

The purpose of this study was to quantify the impact thoracolumbar CMT had on immediate exercise performance by measuring BLC, exercise heart rate, and RPE during a treadmill-based graded exercise test (GXT).

Methods

This study was approved by the Texas Chiropractic College Research and Human Subjects Committees.

Study design and setting

This was a single-blind, randomized, controlled trial of the immediate impact thoracolumbar CMT had on exercise performance during a GXT. Twenty participants were randomly and equally assigned to 1 of 2 groups: AB (age = 27.0 ± 3.9 years, height = 1.69 ± 0.08 m, body mass = 68.6 ± 7.9 kg; mean $\pm$ SD) or BA (age = 27.9 ± 3.6 years, height = 1.67 ± 0.10 m, body mass = 74.1 ± 14.4 kg). The study involved 1 week of rest in between each of the 2 conditions: A (prone Diversified T12-L1 CMT) vs B (no CMT). Participants engaged in a treadmill GXT 5 minutes after each week's baseline condition (A or B). Outcome measures were BLC, exercise heart rate, and RPE recorded after 3-minute stages during a GXT as illustrated in Fig 1A and B. The test continued until the participant achieved greater than 8 mmol/L blood lactate, which correlates with maximal to near-maximal exercise effort. Each group, AB and BA, was composed of 5 men and 5 women. The laboratory room temperature was regulated as close as possible to 22°C.

Randomization and blinding

Group assignment was determined by drawing random slips of paper with group designation on

Fig 1. (A) Experimental design. (B) Treadmill-based GXT protocol.

them, AB vs BA, from a box just before baseline intervention. Before beginning the study, a male box and a female box were generated. Each box had 10 slips of paper in them (to provide 5 participants of each sex for each of the 2 study groups). The doctor providing the intervention drew the slips of paper to determine study participant group designation. By necessity, he was aware of which group the study participant belonged to. The graduate student research assistants taking all exercise outcome measurements, however, were blinded as to the study participant's group designation. This was performed by having them leave the laboratory room while the intervention or lack thereof took place.

Participants

Student volunteers were recruited with on-campus flyers and via word of mouth. All study applicants provided an informed written consent on college-approved documents. They were then screened against inclusion and exclusion criteria. Twenty apparently healthy individuals (range, 22-35 years of age) that met the inclusion/exclusion criteria participated in this 2-consecutive-week study (Fig 2, Table 1). One participant dropped out of the study because of the death of her father. During data collection, participants wore a Polar (Polar Electro Inc, Lake Success, NY) heart rate monitor strap across their chest. Trained research assistants aided the study participants in proper placement of the strap. Data collection for the 20 participants took place over the course of January to

April 2012 at approximately 5 study participants per week. This occurred between the hours of 3:00 PM and 6:00 PM. The intent of these constraints were to decrease the likelihood that seasonal or circadian (eg, related to cortisol daily cycle) rhythm changes in heart rate could act as covariates. Participants were given a study preparation handout of the exclusion criteria and reminded to avoid the following during both data collection days of the study: cardiovascular drugs of any kind; caffeine; alcohol; aspirin; tobacco; and

Fig 2. Screening, randomization, study dropout, and progression.

Table 1 Participant baseline attributes

	AB group	BA group
Sex		
Male	5	5
Female	5	5
Age (y)	27.0 ± 3.9	27.9 ± 3.6
Max HR	193.0 ± 3.9	192.1 ± 3.6
Body mass (kg)	68.6 ± 7.9	74.1 ± 14.4
Height (m)	1.69 ± 0.08	1.67 ± 0.10
Body mass index (kg/m ²)	24.0 ± 3.1	26.4 ± 3.1

Data listed as mean ± SD.

HR, heart rate.

exogenous nutritional supplements with niacin, magnesium, or potassium in them. In addition, they were also instructed verbally and in written form to not receive any outside source of CMT on the days of the study.

Inclusion/exclusion criteria

Inclusion criteria were as follows: (1) they reported no contraindication to thoracolumbar spine CMT, (2) between the ages of 20 and 35, (3) answering “no” to all exercise contraindication sections on a Physical Activity Readiness Questionnaire (PAR-Q), and (4) they provided their informed written consent. Study participants with any of the following were excluded from the study: (1) any surgery in the past year, (2) any broken bones in the past year, (3) reported cardiovascular drug use, (4) tobacco product use, (5) chronic obstructive pulmonary disease, (6) reported neurologic conditions (multiple sclerosis, myasthenia gravis, diabetes, etc), (7) reported cardiopulmonary conditions (asthma, congestive heart failure, emphysema, etc), (8) pregnancy, (9) rheumatoid arthritis, (10) Down syndrome, (11) Viagra (Pfizer Inc, Mission, KS) or Cialis (Eli Lilly, Indianapolis, IN) use, (12) known anemia, (13) kidney pathology, and (14) daily pain they rated greater than a 3 on a 1 to 10 visual analog scale.

Intervention

The intervention phase of the study was performed by a chiropractor with 10 years of experience. The intervention involved either prone double-thenar thoracolumbar manipulation or no manipulation. The CMT consisted of a high-velocity/low-amplitude force applied at the T12-L1 junction as described by Bergmann and Peterson.⁶⁰ Prone double-thenar CMT was chosen because it would likely impact both sides of the spine with one manipulation instead of using other tech-

niques that would require additional patient positioning (eg, side-posture manipulations to each side of the lumbar spine). No attempt to record an audible sound from CMT was made.

Manipulation studies have shown that, neurologically, manual manipulation appears to affect a few segments above and below the region manipulated.⁶¹ As a result, in this study design, manipulation at the thoracolumbar region was chosen with the intent of maximally impacting any nervous system branches to most of the lower limbs. The researchers theorized that, perhaps by increasing mechanical mobility at the lumbar region, the study participants might be able to perform better. Five minutes after receiving CMT or no intervention the study participants engaged in their GXT.

Assessments

Participants were all given a verbal description of the exercise test and what would be asked of them before testing to reduce anxiety during the test. All exercise performance measurements were taken at baseline and again at the conclusion of each 3-minute exercise test stage (Fig 1B). The treadmill-based exercise test began with a 4-minute warm-up at 3 mph on the FreeMotion TT30 treadmill (FreeMotion Fitness, Logan, UT). The treadmill used in this study was relatively new. It had been purchased the preceding year and had been rarely used in our research laboratory. The treadmill incline was 0° throughout the test. During the first stage of the GXT, the velocity was elevated to 5 mph. From this point forward, participants engaged in 3-minute exercise stages. At the conclusion of each stage, velocity was increased by 0.5 mph until the participant exceeded 8 mmol/L of blood lactate. For data analysis purposes, the researchers only compared data between groups at 5, 6, 7, and 8 mph.

Exercise heart rate, blood lactate, and RPE were chosen as outcome measures to track the study participants' capacity to engage in sustained strenuous exercise through a GXT. These variables are all effective markers of exercise performance difficulty that have been used in numerous exercise science studies in the past. Maximum oxygen consumption (VO₂max) was not measured during this exercise test because of the lack of a metabolic cart within our research laboratory. Testing on a treadmill, as opposed to a cycle ergometer, was chosen because it would likely be most applicable to the exercise habits of our study participants.

Exercise heart rate was measured using the RS 300X SD Polar heart rate monitor and chest strap. Study

Table 2 Summary of exercise response to thoracolumbar manipulation

Exercise variable	n	Difference between groups	95% Confidence interval		<i>t</i> test result
			Lower	Upper	
Velocity response					
No manip 4 mmol/L vel vs manip 4 mmol/L vel	20	0.1 mph	−0.2689	0.4589	.591
No manip 8 mmol/L vel vs manip 8 mmol/L vel	20	0.1 mph	−0.3602	0.5702	.642
Heart rate response					
No manip 4 mmol/L HR vs manip 4 mmol/L HR	20	2.9 bpm	−8.806	2.906	.305
No manip 8 mmol/L HR vs manip 8 mmol/L HR	20	4.8 bpm	−4.183	13.883	.275

Data listed as mean ± SD.

participants were not allowed to view the watch's display. This was done to reduce the chance of biofeedback acting as a covariate. Exercise heart rate can and was used as a measure of cardiovascular exercise intensity.²⁸⁻³⁰

Blood lactate was measured using the Lactate Plus Blood Lactate monitor (Nova Biomedical, Waltham, MA) and test strips. Universal safety precautions were used when taking finger-prick blood samples. Blood samples were taken from the right index finger tip using a disposable lancet. Before taking each sample, an alcohol pad was used to clean the sample location on the index finger. Blood lactate was measured as a marker of cardiovascular exercise intensity. The more hypoxic muscle cells become with strenuous exercise, the greater the quantity of lactate that will be measured in the bloodstream. As a result, blood lactate measurements are an important indicator of exercise intensity.²⁸⁻³⁰

Rating of perceived exertion was measured by having participants describe their exertion level in relation to a Borg RPE scale taped adjacent to the treadmill display panel. The Borg scale is a commonly used scale to measure subjective interpretation of exercise intensity.²⁸⁻³⁰ The intent of measuring this variable was to later compare it to objective study data (eg, heart rate and blood lactate) and see how well it correlates if statistically significant differences were found.

All exercise data were transcribed by hand by the blinded graduate student assistants to a form created for this study. Afterward, data were input into an Excel spreadsheet (Microsoft Office 2010; Microsoft, Redmond, WA) and later to SPSS (IBM, Armonk, NY) for further analysis.

Statistical analysis

Data were analyzed in SPSS version 19. Results were reported as mean ± standard deviation (SD) unless otherwise specified. Between-groups cardiovas-

cular dependent variables were compared using a paired-samples *t* test for CMT vs no CMT. Because we intended to use 8 *t* tests (Tables 2 and 3), we engaged in a Bonferroni adjustment. As a result, the α level of $P \leq .00625$ was considered statistically significant for all analysis.

Results

There was no statistically significant difference between participants in the CMT group vs the no-CMT group at baseline for heart rate, BL, or RPE. Sample data for one participant are demonstrated in Fig 3. There was no statistically significant difference found in response to CMT for any exercise variable measured throughout the GXT (Figs 4 and 5, Tables 2 and 3). This preliminarily indicates that thoracolumbar CMT appears to have minimal impact on exercise performance. However, one variable, RPE at 8 mph, was close to reaching statistical significance. Effect size was not calculated because of the lack of statistical significance of study dependent variables.

Discussion

Anatomically, the lumbar spine is poised to impact exercise performance of the lower limbs.^{62,63} Multiple nerves exiting at the lumbar spine innervate the muscles, tendons, and ligaments of the lower extremities. For this reason, it is feasible to suggest that CMT to the lumbar spine may increase spinal mechanical mobility and have some impact on gait. Often, the actions of CMT are not localized to a given spinal segment.⁶¹ Chiropractic manipulative therapy has been shown to affect multiple segments of the spine based on

Table 3 Comparison of RPE with and without thoracolumbar CMT

Velocity	n	No manip RPE	Manip RPE	95% Confidence interval		<i>t</i> test result
				Lower	Upper	
5 mph	20 (10 AB, 10 BA)	9.9 ± 1.7	9.6 ± 1.9	−0.490	1.090	.437
6 mph	20 (10 AB, 10 BA)	12.4 ± 2.4	12.3 ± 2.1	−0.466	0.666	.716
7 mph	13 (7 AB, 6 BA)	13.4 ± 2.3	13.5 ± 2.1	−0.541	0.441	.834
8 mph	8 (3 AB, 5 BA)	15.9 ± 2.9	14.9 ± 2.7	−0.066	0.866	.088

Data listed as mean ± SD.

surface electromyographic studies.⁶¹ As a result, CMT at the thoracolumbar junction was chosen as this study's intervention because of the greatest likelihood that it would affect multiple nerve roots in the region manipulated that could impact the lower limbs.

The objective of this study was to determine if thoracolumbar CMT significantly impacted variables of exercise performance during a treadmill-based GXT. Contrary to our hypothesis, no significant differences in exercise performance were demonstrated following thoracolumbar CMT. One theory as to why no change occurred is that CMT may have no mechanical impact on the spine that would augment exercise performance in reasonably healthy college-aged individuals. Another possible explanation is that the form of CMT we chose may not have significantly increased mobility enough throughout the complete lumbar spine to yield a noticeable benefit.

Interestingly, the RPE at 8 mph in the CMT group (14.9) compared with the no-CMT group (15.9) warrants further review. This occurrence in relation to the lower average exercise heart rate at 8 mmol/L BLC in the CMT group, 178.9 vs 183.7 beats per minute, exposes a possible trend. If the heart was being stressed less at higher exercise intensities in the CMT group, that could explain why study participants reported a lower RPE. Unfortunately, this relationship is weakened by the fact that only 8 study participants were able to run at this velocity out of our 20 participants. Follow-up studies should explore how VO₂max is impacted by lumbar CMT.

This article adds to the limited existing research attempting to elucidate any interaction that may exist between CMT and exercise performance.⁶⁴ Thus far, studies have been suggestive that CMT can increase respiratory function during exercise,⁶⁵ enhance hip

Fig 3. Sample study data to illustrate typical data trends. These data are from study participant 16.

extension while running,⁶⁶ possibly improve balance in older people,⁶⁷ alter jump height and 40-m sprint time,¹¹ and improve walking speed.⁶⁸

The findings of this experiment have led to multiple future directions of research. The following should be explored: (1) determine if manipulating other levels of the spine will demonstrate a clearer trend at modifying exercise performance than was shown in this study, and (2) determine the impact thoracolumbar CMT specifically has on maximal cardiovascular exercise output through a VO_2max test.

Limitations

This study only informs us as to the immediate impact spinal manipulation may have on exercise response. It is possible that a benefit may have been discovered with a longer study duration.

In addition, we only performed CMT at the thoracolumbar junction (T12-L1) once. It is possible that manipulating at higher or lower regions of the spine may have had a different impact. There may also be some form of dose-response relationship with manipulation and exercise performance that remains to be discovered.

One issue this study must accept is the limitation on external validity. The population we sampled was composed of chiropractic students who regularly receive spinal manipulation. It is possible that the general public may react differently than individuals who receive CMT often. Participants, however, were instructed to not receive CMT on the days of this study.

Furthermore, we cannot claim that the amount of force induced during CMT was always the same with

Fig 4. Velocity comparison between the 2 groups. Values are mean with SD error bars.

Fig 5. Exercise heart rate comparison between the groups. Values are mean with SD error bars.

all study participants. The experienced chiropractor performing all of the CMTs did, however, attempt to exert the same force each time.

In this study participants were not blinded. It is feasible that they, as chiropractic students, could have tried to perform better during the exercise test on the week that they were manipulated. As a countermeasure for this, we told all participants right before their exercise test that they had to perform their best on the GXT, as measured by their final blood lactate sample, and that, if they did not, we would not use their study data. After analysis of our data, no significant difference was found between study groups for any of the variables tested. As a result, this issue is inconsequential.

This study had a small sample size of 20 participants that were tested twice: 1 week with CMT and the other week without CMT. Perhaps with a larger sample size in accordance with a power analysis, a more distinct difference between CMT vs no CMT may have been seen.

Lastly, our participants were reasonably healthy and asymptomatic. The impact CMT may have had on patients with segmental back dysfunction or other health care issues may have yielded different findings.

Conclusions

The focus of this study was to help understand if thoracolumbar CMT could acutely improve exercise performance during a treadmill-based GXT. The results from this study preliminarily suggest that thoracolumbar CMT does not have an immediate impact on exercise performance during a GXT.

Funding sources and potential conflicts of interest

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