Immediate effects of lower cervical spine manipulation on handgrip strength and free-throw accuracy of asymptomatic basketball players: a pilot study

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Abstract

Objective: The purpose of this pilot study was to collect preliminary information for a study to determine the immediate effects of a single unilateral chiropractic manipulation to the lower cervical spine on handgrip strength and free-throw accuracy in asymptomatic male recreational basketball players.

Methods: For this study, 24 asymptomatic male recreational right-handed basketball players (age = 26.3 ± 9.2 years, height = 1.81 ± 0.07 m, body mass = 82.6 ± 10.4 kg [mean $\pm$ SD]) underwent baseline dominant handgrip isometric strength and free-throw accuracy testing in an indoor basketball court. They were then equally randomized to receive either (1) diversified left lower cervical spine chiropractic manipulative therapy (CMT) at C5/C6 or (2) placebo CMT at C5/C6 using an Activator adjusting instrument on zero force setting. Participants then underwent posttesting of isometric handgrip strength and free-throw accuracy. A paired-samples *t* test was used to make within-group pre to post comparisons and between-group pre to post comparisons.

Results: No statistically significant difference was shown between either of the 2 basketball performance variables measured in either group. Isometric handgrip strength marginally

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improved by 0.7 kg (mean) in the CMT group ($P = .710$). Free-throw accuracy increased by 13.2% in the CMT group ($P = .058$). The placebo CMT group performed the same or more poorly during their second test session.

Conclusions: The results of this preliminary study showed that a single lower cervical spine manipulation did not significantly impact basketball performance for this group of healthy asymptomatic participants. A slight increase in free-throw percentage was seen, which deserves further investigation. This pilot study demonstrates that a larger study to evaluate if CMT affects handgrip strength and free-throw accuracy is feasible.

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Introduction

In the competitive world of sports, there continues to be an interest in methods for improving athletic performance, especially treatment methods that avoid drugs or surgery. Many doctors of chiropractic work with athletes and are poised to impact their health and training.¹⁻⁴ Preliminarily, studies have suggested that chiropractic manipulation may improve the performance of football players,⁵ runners,⁶ and golfers.⁷ However, the true impact chiropractic manipulative therapy (CMT) has on exercise performance has been poorly studied and warrants further investigation.⁸⁻¹³

Some CMT studies have shown that manipulation may transiently increase volitional strength.¹⁴⁻¹⁶ If CMT has some capacity to make muscles stronger transiently, it could have a positive impact on sport performance, particularly with sports that require strong handgrip strength. Basketball is one such sport that requires handgrip strength for players to dunk, rebound, and engage in many other on-court tasks.

Research is suggestive that spinal manipulation may augment motor control. Preliminary research suggests maladaptive changes secondary to spinal dysfunction can result in reduced joint position sense.¹⁷ There are studies that show evidence that corrective spinal manipulation improves joint position sense¹⁷⁻¹⁹ and theories that corrective manipulation may help improve learning during motor tasks.¹⁸ If manipulation can improve an athlete's motor control capabilities, even transiently, then it may positively impact specific activities, such as free-throw performance among basketball players.

Spinal manipulation appears to induce muscle relaxation and diminish skeletal muscle reflexes transiently. Research has shown that, after spinal manipulation, there is a reduction in localized muscle tone and resting electromyography pattern^{20,21} and inhibitory effects on spinal reflexes.^{22,23} Performing free throws involves some measure of spring-loading during the backswing phase that would stimulate the

muscle spindle's reflexive activity. Any impact on the muscle spindle-associated reflex induced by CMT may have implications on the backswing component of attempting free throws.

There is some evidence that cervical manipulation has an effect on cortical function and cerebral glucose metabolism.^{18,24} Spinal manipulation has also been found to have an effect on primary afferents and invoke high-frequency discharges from "several types of dynamically-sensitive, mechanosensitive paraspinal primary afferent neurons."²⁵ Although these effects are not fully understood, it can be theorized that they may help to modulate muscle activity in terms of improvement in coordination and voluntary motor control.

Enhancing our understanding of how spinal manipulation can impact motor control patterns and skeletal muscle physiology is vital to determining if CMT is a viable ergogenic for athletes. Therefore, the purpose of this pilot study is to evaluate the feasibility of a study to measure the immediate effects of a single unilateral CMT to the lower cervical spine on handgrip strength and free-throw accuracy in asymptomatic recreational basketball players.

Methods

This study was approved by the Texas Chiropractic College Institutional Review Board. This study was not registered as a clinical trial given its status as a pilot study. Future randomized controlled trials following this pilot study will be registered in a clinical trial registry prior to their initiation.

Study design and setting

This was a pilot study of the immediate impact cervical spine CMT had on basketball performance. The study was designed to ensure the participants were blinded and randomly assigned to each treatment group (Fig 1). Twenty-four asymptomatic male recreational

Fig 1. Experimental design. *CMT*, chiropractic manipulative therapy.

basketball players participated in this research study. Participants tested their dominant handgrip isometric strength and performed 20 baseline free throws. The basketball players were then randomly and equally assigned to 1 of 2 groups (Table 1): CMT group or placebo CMT group. The CMT group underwent lower cervical spine manipulation on the left at C-5/C-6. The placebo CMT group underwent sham manipulation at the same level with an Activator device set at zero force setting. Following intervention, participants again engaged in measurements of isometric handgrip strength and free-throw accuracy. Free throws occurred on an NCAA regulation indoor basketball court.

Randomization and blinding

Group assignment (CMT group vs placebo CMT group) was determined through the use of a pregenerated randomization list. The graduate student research assistants recording handgrip strength and free-throw accuracy measurements were blinded as to the intervention. This was performed by having the intervention (manipulation or placebo manipulation) occur in an adjacent room out of the sight of the data recorders. The study participants were not informed if they received an actual manipulation vs placebo, although it is reasonable to suggest they noticed a physical difference.

Table 1 Participant baseline attributes

	CMT group	Placebo CMT group
Age (y)	26.3 ± 8.5	26.3 ± 10.0
Body mass (kg)	84.2 ± 8.5	81.0 ± 12.3
Height (m)	1.81 ± 0.06	1.81 ± 0.07
Body mass index (kg/m ²)	25.6 ± 4.8	24.8 ± 4.6
Baseline free-throw #	5.8 ± 1.1	6.1 ± 1.1

Data listed as mean ± SD.

CMT, chiropractic manipulative therapy.

Participants

Recreational basketball players were recruited with flyers and via word of mouth from local basketball gyms. All study applicants provided an informed written consent on college-approved documents. They were then screened against inclusion and exclusion criteria. As part of the inclusion criteria, they were required to pass a free-throw accuracy test. The test required each participant to successfully make 5 out of 10 free throws (Table 1). Ten participants were excluded from this study because they failed to pass the baseline free-throw accuracy inclusion test. Twenty-four apparently healthy individuals (range = 14-50 years of age) that met the inclusion/exclusion criteria participated in this study. Data collection for the participants took place over the course of 2 Saturdays between the hours of 9:00 AM and 3:00 PM.

Inclusion/exclusion criteria

Inclusion criteria were as follows: (1) they reported no contraindication to cervical spine CMT; (2) they were between the ages of 14 and 55; (3) they answered “no” to all exercise contraindication sections on a Physical Activity Readiness Questionnaire; (4) they provided their informed written consent; (5) they could not be a student or employee of our college; and (6) they passed a baseline free-throw accuracy test. Study participants with any of the following were excluded from the study: (1) they possessed a contraindication to cervical spine manipulation (neck surgery, known osteopenia, unstable neck fractures, multiple myeloma, osteomyelitis, primary bone tumor, Paget disease, cauda equina syndrome, spinal cord tumor, rheumatoid arthritis, ankylosing spondylitis, psoriatic arthritis, Reiter syndrome, Arnold-Chiari malformation, and/or unstable bleeding disorders);

(2) they received a spinal manipulation in the past 2 days; (3) they reported spinal instability, abnormal peripheral sensation, or blatant muscle weakness; (4) they reported injury to their shoulder, elbow, wrist, or hand that would preclude them from playing basketball; or (5) they reported daily pain rated greater than a 3 on a 0 to 10 numeric rating scale.

Assessments

Participants were all given a verbal description of what would be expected of them during the research study to reduce anxiety during the test. Isometric handgrip strength and free-throw accuracy were chosen as outcome measures to track basketball players' performance. Handgrip strength was tested before free throws throughout our study. Handgrip strength was chosen because of the importance of gripping the ball for dunking, lay-ups, defensive maneuvers, and other tasks that are intrinsic to basketball. Free-throw accuracy was chosen because of it is a fundamental skill in basketball.

Handgrip isometric strength was measured using the Baseline Hydraulic hand dynamometer (White Plains, NY). Measurements were taken with the elbow of the right limb at their side, bent to 90°. A graduate research assistant kept track of the force exerted by the participant in kilograms.

Prior to beginning the study, we purchased 10 Spalding Advanced 29.5" regulation NBA basketballs (Bowling Green, KY). Participants stood at the free-throw line and attempted 20 free throws during each test's iteration. Study participants did not have to retrieve any basketballs while attempting free throws. Two research assistants retrieved all balls for participants. A graduate research assistant kept track of all successful and failed free-throw attempts.

Then data were input into an Excel spreadsheet (Microsoft Office 2010; Microsoft, Redmond, WA) and later to SPSS (IBM, Armonk, NY) for further analysis.

Intervention

The intervention phase of the study was performed by a chiropractor with 20 years of experience. The intervention involved either a diversified manipulation to the left posterior column of C5-6 or the use of a placebo CMT at the same level. The cervical manipulation consisted of a high-velocity, low-amplitude force applied as described by Bergmann and Peterson.²⁶ No attempt to record an audible sound from

CMT was made. The participants in the placebo CMT group similarly had their neck rotated to the right just like the CMT group. Then the treating doctor placed the Activator adjusting instrument (Activator Methods International, Phoenix, AZ) over their left C5-6 posterior column. The Activator device was set to the zero force setting. The doctor then deployed the Activator device that makes a "click" noise. No therapeutic force was exerted on any vertebrae by this action.

Each participant's pre and post free-throw attempts were recorded and graphed. A negative change from pre to post attempts indicated a reduction in the number of free throws made from pre to post. A positive change indicated an increase in the number of free throws made from pre to post (Fig 3).

Manipulation studies have shown that, neurologically, manual manipulation appears to affect a few segments above and below the targeted segment to be manipulated.²⁷ As a result, in this study, we chose to manipulate C5-6 with the intent of maximally impacting any innervation to the upper limb. The coupled motion of the cervical spine suggests that, to open the intervertebral foramen on one side of the spine (eg, the right side), manipulation should occur on the left side.²⁶ This, in addition to the desire to keep our study's CMT standardized, was the reason why we chose to exclusively manipulate the left side of C5/C6.

Statistical analysis

Data were analyzed in SPSS version 19. Results were reported as mean $\pm$ standard deviation (SD) unless otherwise specified. Within-group dependent variables and baseline between group variables were compared using a paired-samples *t* test for the CMT group and placebo CMT group. The α level of $P \leq .05$ was considered statistically significant for all analyses.

Results

There was no statistically difference found between the CMT group and the placebo group. A marginal improvement was seen in isometric handgrip strength of 0.7 kg (mean) in the CMT group, $P = .710$ (Fig 2). This was followed by a 13.2% increase in free-throw accuracy in the CMT group, $P = .058$ (Fig 3). The placebo CMT group performed the same or worse in their postintervention data collection on both dependent variables. There was also no difference found

Fig 2. Within-group change (Δ) in right-handed isometric handgrip strength pre to post. Error bars illustrate SD (placebo CMT group = ± 1.67 ; CMT group = ± 1.65). Placebo CMT group 95% confidence interval (CI): -2.3 lower and $+3.3$ upper, t test = 0.699 . CMT group 95% CI: -4.5 lower and $+3.2$ upper, t test = 0.710 . CMT, chiropractic manipulative therapy.

between the groups when the baseline data were analyzed (Table 2). No adverse effects were reported.

This pilot study preliminarily indicates that unilateral lower cervical spine CMT among asymptomatic basketball players may have some small impact on free-throw accuracy. Effect size was not calculated because of the lack of statistical significance of study dependent variables. In follow-up studies, effect size should be calculated and a larger sample size used.

Discussion

This was the first study of its kind to measure the effects of CMT to the lower cervical spine on handgrip

Fig 3. Change (Δ) in successful free-throw attempts pre to post. Error bars illustrate SD (placebo CMT group = ± 0.57 ; CMT group = ± 0.02). Placebo CMT group 95% CI: -1.2 lower and $+3.2$ upper, t test = 0.339 . CMT group 95% CI: -2.9 lower and $+0.05$ upper, t test = 0.058 . CMT, chiropractic manipulative therapy.

Table 2 Between-group change (Δ) in baseline data

	CMT group	Placebo CMT group	P
Baseline free-throw test (#)	10.6 $\pm$ 2.8	12.3 $\pm$ 3.8	.237
Baseline handgrip test (kg)	43.8 $\pm$ 9.4	42.2 $\pm$ 11.2	.696
Post-free-throw test (#)	12.0 $\pm$ 2.9	11.3 $\pm$ 3.2	.553
Post-handgrip test (kg)	44.5 $\pm$ 11.0	41.7 $\pm$ 9.5	.507

Data listed as mean $\pm$ SD.

CMT, chiropractic manipulative therapy.

strength and free-throw accuracy in asymptomatic male recreational basketball players. These preliminary findings show that there was no statistically significant difference in performance between the CMT and placebo groups. Our findings also show that CMT did not reduce performance measures, and no adverse effects were reported for this study.

Other published studies have shown that CMT appeared to marginally improve performance in a sport-related motor task.^{7,17,19} In the research by Costa et al,⁷ they found that golf swing performance increased in response to CMT. Haavik and Murphy¹⁷ found in their study that elbow joint position sense increased post-CMT. Lastly, similar to the work of Haavik and Murphy, Enebo¹⁹ found that cervical spine CMT improved participant overall accuracy and movement variability during motor tasks. Our comparison of pre to post change in free-throw accuracy in our CMT group preliminarily demonstrates that some positive impact may have occurred because of CMT. The CMT group also had less variation in free-throw accuracy at baseline and at postintervention in comparison to the placebo group. Further studies to monitor these trends in asymptomatic and symptomatic participants should be pursued to determine if there is a statistically significant difference.

Contrary to similar studies, we saw minimal change in isometric handgrip strength that did not reach a statistically significant level.¹⁴⁻¹⁶

In the Judo article of Botelho and Andrade,¹⁴ they demonstrated an increase in handgrip strength in response to CMT; but this occurred over several weeks of care. More immediate improvements in strength were shown by Wang and Meadows¹⁶ as well as Hillermann et al.¹⁵ However, changes in strength post-CMT likely are short-lived, as what was shown by Wang and Meadows¹⁶ when participants returned to baseline strength within 20 minutes post-CMT.

Limitations

This study only informs us as to the immediate impact a single spinal manipulation may have on 2

markers of basketball player performance and does not measure long-term effects or effects on other performance measures. For example, we currently do not know how long any ergogenic impact on free-throw performance will last in response to CMT. It is also possible that, to show a CMT effect, more treatments are needed over time, such as using a longer-duration, multiple-treatment, multiweek study. It is also conceivable that other attributes of basketball player performance that we did not measure (eg, lay-ups, t-drills, star drills) could have been impacted by CMT to the cervical spine.

The population we sampled was composed of healthy recreational basketball players that did not report neck pain or present with cervical spine motion restriction. Thus, it is likely that athletes with neck pain or restricted spinal motion would react differently than the asymptomatic individuals in our study. If there is no pain or dysfunction, it might be expected that CMT would not have a large effect on performance.

This was a pilot study with a small sample size of 24 participants that were tested twice, pre- and postintervention. Engaging in a study following a power analysis would more clearly demonstrate a distinct basketball performance response difference between CMT vs placebo CMT.

Blinding is a potential issue. It is reasonable to suggest the participants may have noticed a physical difference between the true CMT and the sham CMT. The participants were allowed to participate in the study if they had received CMT to the cervical spine in the past. This was due to the challenges faced with recruitment of the study's participants. This poses a possible limitation on the ability to truly blind the participants; thus, it is possible it could have impacted the overall outcome of the study.

A final limitation of this study is the amount of player skill variability that may have existed. Although we included a baseline free-throw skill test, it would have been better to test competitive athletes on a team. Competitive athletes likely would demonstrate a higher and more consistent level of skill than recreational athletes.

Future studies

Future directions of research in this field should focus on spine restrictions among symptomatic athletes and the impact CMT may have on sport-specific accuracy. Future studies should include participants with neck pain or dysfunction, in addition to asymptomatic participants. As well, type of outcome

measures used to measure CMT should be considered. We recommend studies focusing on baseball pitchers' throwing velocity and accuracy, quarterback throwing velocity and accuracy, basketball free-throw attempts, or other sports that involve precision motor skills that can be quantified with some form of goal target.

Specifically for basketball, larger follow-up studies should use varsity-level basketball players or some other form of team-based criteria to help control for variation in the skill level of the participants. Future studies should also compare the impact we found with performing CMT at higher (upper cervical) as well as lower (C7/T1) regions of the cervical spine. In addition, long-term impact on basketball performance should be measured following repeated CMT over a course of weeks. This can be accomplished by administering the CMT once a week throughout an isolated season. The athlete's free-throw accuracy and grip strength could be monitored during the season to determine the repeated impact of CMT on sport performance. Follow-up clinical trials may help to provide a clearer picture of the true effects that CMT to the cervical spine has on specific skills associated with basketball players.

Conclusions

The results from this study preliminarily showed that a single cervical spine CMT did not significantly impact basketball performance for this group of healthy asymptomatic participants. There was a trend in increase in free-throw accuracy that deserves further investigation. This pilot study demonstrates that a larger study to evaluate if CMT affects handgrip strength and free-throw accuracy is feasible.

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