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Spinal Manipulative Therapy Effects in Autonomic Regulation and Exercise Performance in Recreational Healthy Athletes

A Randomized Controlled Trial

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Study Design. A randomized, double blind, parallel groups, sham-controlled trial.
Objective. The aim of this study was to analyze the acute effects of spinal manipulative therapy (SMT) on performance and autonomic modulation.
Summary of Background Data. The use of SMT is progressively spreading from the clinical to the sporting context owing to its purported ergogenic effects. However, its effects remain unclear.
Methods. Thirty-seven male recreational athletes (aged 37±9 years) who had never received SMT were assigned to a sham (n¼19) or actual SMT group (n¼18). Study endpoints included autonomic modulation (heart rate variability), handgrip strength, jumping ability, and cycling performance [8-minute time trial (TT)]. Differences in custom effects between interventions were determined using magnitude-based inferences.
Results. A significant and very likely lower value of a marker of sympathetic modulation, the stress score, was observed in response to actual compared with sham SMT [P¼0.007; effect size (ES)¼-0.97]. A trend toward a significant and likely lower sympathetic:parasympathetic ratio (P¼0.055; ES¼-0.96) and a likely higher natural logarithm of the root-mean-square differences of successive heartbeat intervals [(LnRMSSD), P¼0.12; ES¼0.36] was also found with actual SMT. Moreover, a significantly lower mean power output was observed during the TT with actual compared with sham SMT (P¼0.035; ES¼-0.28). Nonsignificant (P>0.05) and unclear or likely trivial differences (ES<0.2) were found for the rest of endpoints, including handgrip strength, heart rate during the TT, and jump loss thereafter.
Conclusion. A single pre-exercise SMT session induced an acute shift toward parasympathetic dominance and slightly impaired performance in recreational healthy athletes.
Key words: athletes, chiropractic, cycling, endurance, fatigue, handgrip, heart rate variability, musculoskeletal manipulation, neural drive, sport, strength.
Level of Evidence: 2

Spinal manipulative therapy (SMT), defined as the application of high-velocity, low-amplitude manipulation to the spinal joints slightly beyond the passive range of joint motion, is widely used for the treatment of musculoskeletal conditions, such as acute and chronic low back or neck pain.[1–3] Its popularity is also growing in the sporting context owing to its purported benefits on athletic performance.

Recent studies have observed an increased corticospinal excitability and electromyographic activity after a single SMT session,[4,5] which could potentially result in muscle force improvements. However, the evidence regarding the performance effects of SMT is scarce and mixed, as indicated by a recent systematic review.[6] Some authors have found an increased muscle force after a single session of SMT,[4,5,7] but others have failed to find this effect,[8,9] and no benefits have been reported on performance during running or jumping exercises.[10,11]

The aim of this study was to analyze the effects of SMT on muscle strength and cycling performance in recreational healthy athletes, as well as on perceptual, heart rate (HR), and autonomic system measures.

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RANDOMIZED TRIAL

MATERIALS AND METHODS

Design

This study followed a randomized, double-blind (participant and assessor), parallel-group, placebo-controlled design (Figure 1). Subjects presented at the laboratory at approximately the same time of the day on two occasions separated by a minimum of 48 hours and a maximum of 1 week. The same tests were conducted in both testing sessions, but participants were submitted to the assigned group (sham or actual SMT) immediately before the second testing session. Randomization (simple randomization without stratification) was performed using a specific software (https://www.randomizer.org/).

Subjects

The present study was approved by the Ethics Committee of the University of Alcala´ (Spain). Participants were recruited from three different local triathlon and cycling clubs. In order to be eligible for the study, participants had to cycle at least 4 hours per week during the preceding 3 months, and have a cycling experience greater than 2 years. Exclusion criteria were having suffered an injury in the month before the study that precluded regular exercise practice; having suffered any type of spine injury before the study; and having previously received SMT. All the participants had the procedures explained and provided written informed consent.

Subjects were instructed to maintain their normal dietary pattern and to refrain from doing intense exercise and consuming ergogenic aids or stimulants 48 hours before each session.

Procedures

Participants in the actual SMT group were assessed through the activator method protocol (for specific details see [12]). SMT was performed with the Activator IV Adjusting Instrument (Activator Methods International, Phoenix, AZ) setting the force at level 1 for the high cervical spine (C1-C4), level 2 for the low cervical (C5-C7) and high thoracic spine (T1-T6), level 3 for the low thoracic spine (T7-T12), and level 4 for the lumbar spine and pelvis. This instrument offers an advantage for research studies compared to manual adjustments because the impulse duration (5 ms) and force pressure can be controlled and kept steady for all participants, whereas manual thrusts are variable. Segmental contact with this instrument is made with an 80-durometer rubber tip, 15mm in diameter, which permits localized thrusts to be applied to the spine.

Participants in the sham SMT group received a protocol identical to that described above, with the exception that a sham mechanical thrust (force set at level 0) was delivered to the targeted areas. In the force level 0, no excursion of the stylus occurs, but the instrument produces the same clicking sound as in the actual SMT condition. The same chiropractor performed both actual and sham treatments. After the second session, participants were asked whether they thought they had received actual or sham SMT.

Endpoints

Heart rate variability (HRV) was calculated from HR measurements taken at rest with a chest monitor (V800; Polar OY, Kempele, Finland) before the start of each testing session. The subject was lying supine and relaxed for 10 minutes, analyzing all R-R intervals during the last 5 minutes (Kubios HRV software; Kuopio, Finland). The natural logarithm of the root-mean-square differences of successive heartbeat intervals (LnRMSSD) was calculated as a measure of parasympathetic modulation. An analysis of the Poincare´-plot was also performed to calculate the stress score (SS), a measure of sympathetic modulation, and the sympathetic:parasympathetic ratio (S:PS), an indicator of autonomic balance.[13]

Handgrip strength was measured (Grip D T.K.K. 5401; Takei Scientific Instruments, Japan) after HRV assessment. Participants performed three maximal voluntary contractions with the dominant hand in a standing position, with the arm parallel to the body and without moving the wrist. The mean of the three measurements was analyzed.

After an initial standardized warm-up (consisting of 10 minutes of light cycling at a self-selected intensity and three 10-second sprints interspersed with 1-minute rests), participants performed an 8-minute time trial (TT) on a cycle ergometer (Cardgirus SNT Medical, Bikemarc, Barcelona, Spain). This test has previously proven reliable (intraclass correlation coefficient: 0.93) and valid to measure changes in fitness.[14] Subjects were encouraged to achieve the highest mean power output (PO) possible during the TT, and were allowed to change gears so as to maintain their preferred cadence.

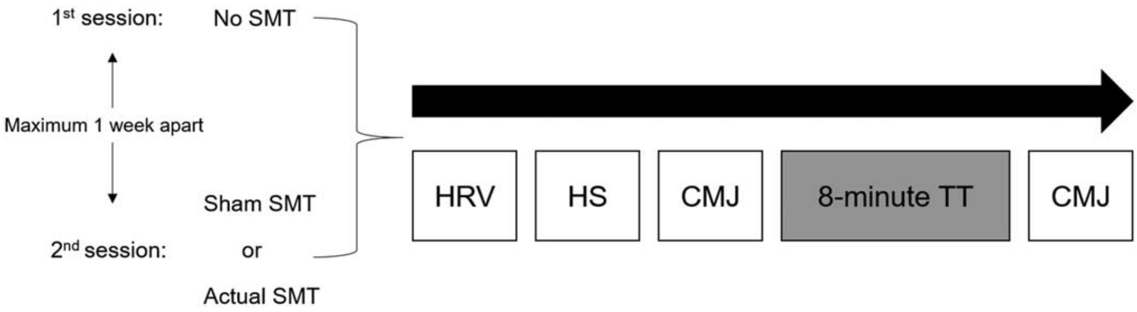

Figure 1. Schematic representation of the study design. CMJ indicates countermovement jump; HRV, heart rate variability; HS, handgrip strength; SMT, spinal manipulative therapy; TT, time trial.

Verbal encouragement was provided by the same researcher (blind assessor). We recorded mean values of PO and HR during the TT, and rate of perceived exertion [RPE, on a 1–10 scale (CR-10[15]) after it].

Jumping ability was assessed immediately before and after the TT. On each occasion, subjects performed three countermovement jumps (CMJs) and the height of each jump was calculated from flight time using a photoelectrical contact platform (OptoGait Version 1.9.9.0; Microgate, Bolzano, Italy). Participants were instructed to perform a downward movement to reach approximately 908 of knee flexion while maintaining their hands on the hips. They were also instructed not to flex their knees during the flight in order to avoid overestimation of the flight time. The relative loss in CMJ height (pre- vs. post-TT) was recorded as a marker of fatigue. The CMJ loss has previously proved to be a valid marker of fatigue.[16]

Statistical Analysis

The normal distribution (Shapiro-Wilk test) and homoscedasticity (Levene test) of the data were checked before any statistical treatment. Differences in proportions were analyzed with the Fisher exact test. Endpoints were analyzed by a two-way mixed analysis of variance (ANOVA) with time points (baseline and post-intervention) as the within-subject factor and intervention groups (actual or sham SMT) as the between-subject factor. A spreadsheet (pre-post parallel groups controlled trials.xls) was used to determine the standardized difference [effect size (ES)] and the chances of finding clinically meaningful differences in custom effects between groups.[17] ES values of 0.2, 0.6, 1.2, 2.0, and 4.0 were considered small, moderate, large, very large, and extremely large, respectively.[18] The chances of finding differences were assessed using magnitude-based inference and considered as follows: <1%, almost certainly not; 1% to 5%, very unlikely; 5% to 25%, unlikely; 25% to 75%, possible; 75% to 95%, likely; 95% to 99%, very likely; >99%, almost certain.[19] If the chances of having better and poorer results were both _5%, the difference was considered unclear.

RESULTS

The flow diagram of study participants is shown in Figure 2. The final study sample comprised 37 subjects (recreational triathletes or cyclists recruited from local clubs), who were assigned to receive either sham (n¼19) or actual SMT (n¼18). All data were normally distributed. No significant and trivial to small differences were found between groups in descriptive characteristics (Table 1).

The blinding protocol could be considered effective, as no significant differences (P¼0.402) were found between groups in the percentage of subjects who reported having received the sham (53% and 39% for the sham and actual SMT groups, respectively) or the actual SMT (47% and 61%). No adverse effects were reported during the study.

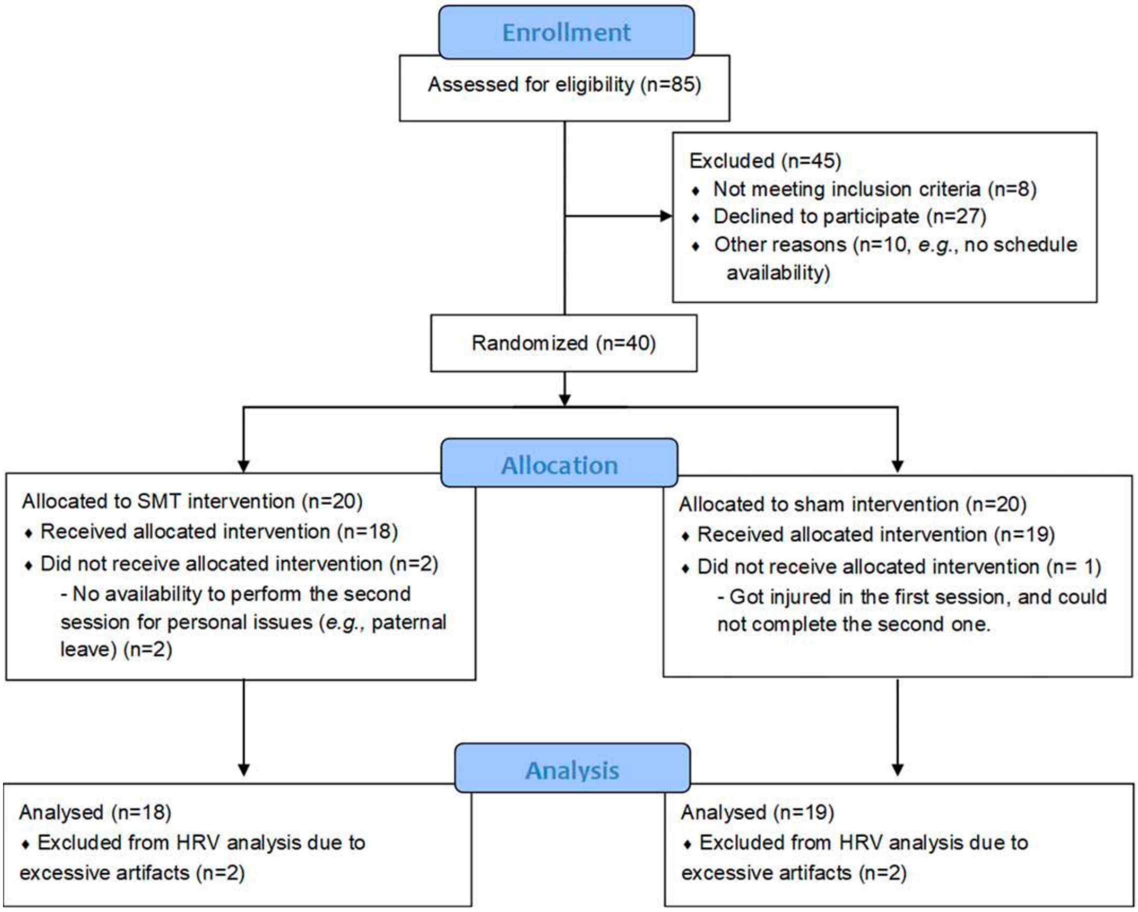

Figure 2. Flow diagram of study participants. HRV indicates heart rate variability; SMT, spinal manipulative therapy.

TABLE 1. Descriptive Data by Group

	Sham SMT (n = 19)	Actual SMT (n = 18)	*P*	ES
Age, yrs	38 ± 7	35 ± 10	0.244	0.34
Height, cm	177 ± 6	177 ± 5	0.654	0.00
Weight, kg	76 ± 7	72 ± 9	0.145	0.49
Body mass index, kg/m^2	24 ± 2	23 ± 3	0.138	0.39
Training volume, h/week	11 ± 4	10 ± 4	0.537	0.24

Data are mean ± SD. P values are obtained from the comparison between groups using unpaired Student t tests.
ES indicates effect size; SMT, spinal manipulative therapy.

The results of the endpoints for the sham and actual SMT groups are summarized in Table 2 and Figure 3. The HRV of two subjects in each group could not be analyzed due to excessive artifacts. A significant and very likely lower SS (P¼0.007; ES¼-0.97) was found in response to actual SMT compared with sham SMT. A trend for a significant and likely lower S:PS (P¼0.055; ES¼-0.96), and a likely higher LnRMSSD (P¼0.12; ES¼0.36) were observed with actual SMT. A significant and possibly lower PO during the TT was observed with actual SMT (P¼0.035; ES¼-0.28).
Nonsignificant and unclear or likely trivial differences were found for handgrip (P¼0.819; ES¼0.03), RPE (P¼0.962; ES¼-0.17) and HR during the TT (p¼0.364; ES¼-0.02), or CMJ loss thereafter (P¼0.527; ES¼-0.04).

DISCUSSION

The use of SMT is progressively spreading from the clinical to the sporting context owing to its purported beneficial effects on performance.[20] Our main finding is that a single SMT session before exercise induced a moderate parasympathetic dominance in recreational healthy cyclists along with a slight cycling performance impairment. In addition, it provided no benefits on muscle strength (as assessed with handgrip) or on the HR response to exercise.

TABLE 2. Effects of Spinal Manipulation Therapy (SMT) on Study Outcomes

	Sham SMT		Actual SMT		Group x Time *P*
	Pre	Post	Pre	Post	
Autonomic function					
LnRMSSD	3.8 ± 0.6	3.6 ± 0.6	3.9 ± 0.5	4.0 ± 0.5	0.121
SS	20 ± 8	26 ± 12	20 ± 9	18 ± 5	**0.007**
S:PS	0.9 ± 0.8	1.5 ± 1.5	0.7 ± 0.6	0.6 ± 0.5	0.055
Handgrip, kg	53 ± 8	52 ± 9	55 ± 10	55 ± 10	0.819
Time trial					
PO, W	246 ± 47	258 ± 45	268 ± 51	266 ± 47	**0.035**
HR, beats/min)	154 ± 18	157 ± 12	160 ± 16	160 ± 12	0.364
RPE	8.7 ± 0.8	8.9 ± 0.9	9.0 ± 1.0	9.2 ± 0.7	0.962
CMJ height loss (%)	2.3 ± 7.5	4.0 ± 7.9	2.8 ± 6.0	6.4 ± 6.2	0.527

Data are mean ± SD. Significant P values are in bold.

CMJ indicates counter movement jump; HR, heart rate; LnRMSSD, natural logarithm of root-mean-square differences between successive heartbeat intervals; PO, power output; RPE, rate of perceived exertion; S:PS, sympathetic:parasympathetic ratio; SS, stress score.

Several neurophysiological mechanisms have been proposed to support the potential clinical and performance benefits of SMT, notably its ability to alter central sensory processing (thereby increasing pain tolerance) and to improve motoneuron excitability.[21]Arecent study found an enhanced cortical drive after SMT in elite athletes, [4] which could support its potential ergogenic effect. However, the evidence for the effects of this technique on athletic performance is weak,[6,22] and in fact, our results suggest that pre-exercise SMT could be slightly detrimental to sport performance (at least in the analyzed study population, composed by healthy recreational athletes who had never received SMT).

Contrary to our results, some authors have found an increased muscle force after a single SMT session.[4,5,7] However, most studies have failed to find a performance benefit, which is in agreement with our results.[8–11] Although controversy exists regarding the potential of SMT for the improvement of strength on analytical movements such as handgrip, knee flexion/extension, or plantar flexion,[4,5,7–9] no benefits of SMT have been found during a running incremental exercise test,[10] a cycling sprint,[23] or other sport-specific actions such as jumping or sprinting.[11]

A small decrease in the PO during the TT was observed after SMT. This slight performance impairment could be related, at least partly, to the shift toward parasympathetic dominance elicited by SMT, as reflected by a lower SS and a trend for a lower S:PS ratio. Although increases in resting vagal-related HRV reflect an overall favorable adaptation to training loads, changes toward a sympathetic modulation in the days before competition have proven to precede optimal endurance performance.[24] Thus, it could be hypothesized that the excessive state of ''relaxation'' (i.e., increased parasympathetic activity) acutely induced by SMT could be actually detrimental to exercise performance.

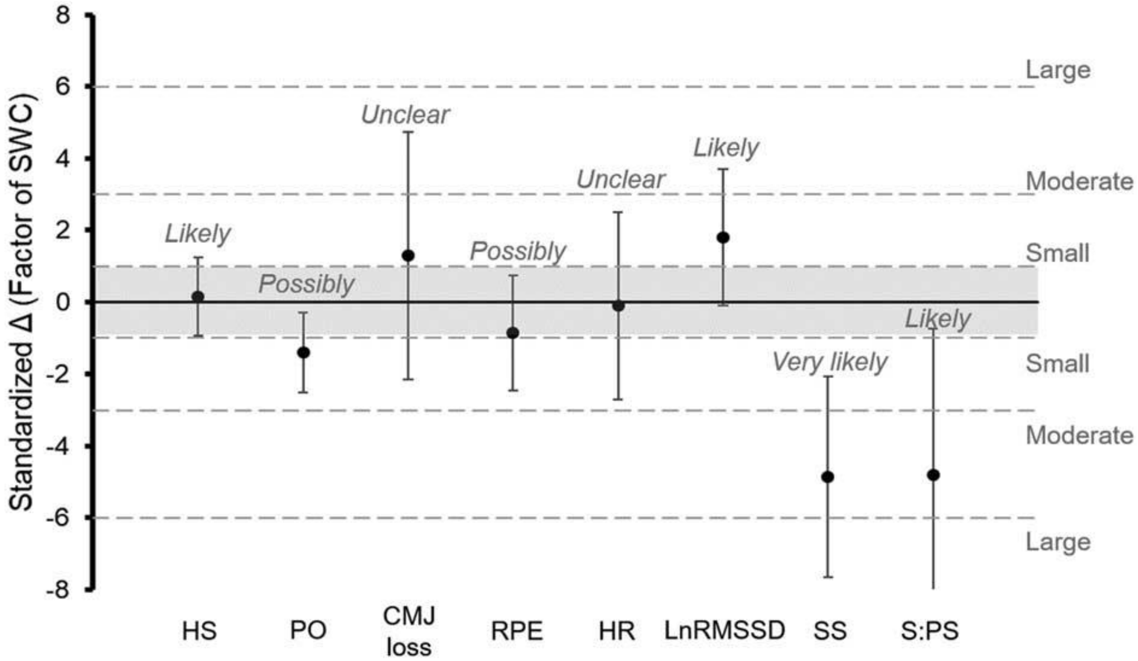

Figure 3. Standardized difference in custom effects between groups (actual-sham SMT). Differences are expressed as a factor of the smallest worthwhile change (SWC¼effect size of 0.2). Bars represent 90% confidence intervals. The chances of finding differences between groups are expressed using magnitude-based inference. CMJ indicates countermovement jump height; HR, heart rate; HS, handgrip strength; LnRMSSD, natural logarithm of root-mean-square differences between successive heartbeat intervals; PO, power output during the time trial; RPE, rate of perceived exertion; S:PS, sympathetic:parasympathetic ratio; SS, stress score.

Preliminary evidence suggests that changes in autonomic modulation as a consequence of SMT may depend on the segment mobilized, with cervical and thoracic manipulations increasing parasympathetic and sympathetic activity, respectively. [25] It is therefore possible that different results might have been found if only a thoracic manipulation had been performed. Moreover, a potentially beneficial effect of SMTinduced vagal modulation for enhancing exercise recovery cannot be ruled and should be addressed in future studies, as it could possibly counteract the marked parasympathetic suppression commonly observed after fatiguing exercise.[26,27] In summary, a single pre-exercise SMT session induced a moderate parasympathetic dominance and a slight impairment in the cycling performance of recreational athletes who had never received SMT.

Key Points

- Spinal manipulative therapy induced an acute shift toward parasympathetic dominance and slightly decreased cycling performance.
- Spinal manipulative therapy seems not to be an advisable pre-event ergogenic strategy.
- Studies analyzing a potentially beneficial effect of this strategy for the enhancement of exercise recovery are needed.

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