Spinal Manipulative Therapy and Sports Performance Enhancement: A Systematic Review

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Abstract

Objective: The purpose of this study was to review the literature regarding the relationship between spinal manipulative therapy (SMT) and sports performance.
Methods: PubMed and Embase databases were searched for original studies published up to July 2016. Inclusion criteria were if SMT has been applied to athletes and if any sports performance–related outcome was measured.
Results: Of the 581 potential studies, 7 clinical trials were selected. Most studies had adequate quality (≥6/11) when assessed by the PEDro scale. None of those studies assessed performance at an event or competition. Four studies revealed improvement in a sports performance test after SMT. Meta-analysis could not be performed because of the wide differences in methodologies, design, and outcomes measured. Spinal manipulative therapy influences a wide range of neurophysiological parameters that could be associated with sports performance. Of the 3 studies where SMT did not improve test performance, 2 used SMT not for therapeutic correction of a dysfunctional vertebral joint but to an arbitrary previously set joint.
Conclusions: Although 4 of 7 studies showed that SMT improved sports performance tests, the evidence is still weak to support its use. Spinal manipulative therapy may be a promising approach for performance enhancement that should be investigated with more consistent methodologic designs. (J Manipulative Physiol Ther 2017;40:535-543)
Key Indexing Terms: *Musculoskeletal Manipulations; Athletic Performance; Sports; Athletes; Spine*

Introduction

The competitive nature of professional sports creates a constant demand for therapeutic options that could influence sports performance.[1,2] Most of the spinal manipulative therapy (SMT) studies in athletes are mainly focused on frequency of use, and the results are merely descriptive.[1,3-6] It is also easy to find anecdotal statements in which professionals or athletes claim that SMT increased performance. However, the majority of such reports are based on the opinion or background experience of these individuals and not on the result of specific scientific research designed for this purpose.[7-10]

Spinal manipulative therapy consists of a high-velocity, low-amplitude movement, applied at the paraphysiological space, just beyond the passive joint range of motion.[9] Several studies have evaluated its safety[11,12] and efficacy for the treatment of musculoskeletal disorders,[11] in short-term[12-17] as well as long-term results.[18,19] These and other studies indicate that SMT is considered a safe and effective approach for the treatment of biomechanical musculoskeletal disorders.[12,20-26] Different disciplines, such as chiropractic,[9,27-29] physiotherapy,[30] osteopathy,[31] and orthopedics,[32] use SMT as a therapeutic option in their practices.

Sports performance is defined as a combination of specific physical routines or procedures performed by someone who is trained or skilled in a physical activity and influenced by physiological, psychological, and sociocultural factors.[33] Interestingly, it is rare to find studies that evaluate treatment effects on athletes' real performance during a competitive event. Usually, researchers use laboratory or field tests that they believe to be directly associated with the event performance in spite of knowing that this relationship between test and event performance has not been adequately established thus far.[34]

Spinal manipulative therapy has been increasingly utilized in sports and has been shown to be a useful therapeutic strategy for biomechanical joint dysfunction,

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Paper submitted October 1, 2016; in revised form March 4, 2017; accepted March 14, 2017.
0161-4754

https://doi.org/10.1016/j.jmpt.2017.03.014

especially that involving the spine.[5,6,9,27] Several neurophysiological effects have been described,[35,36] but a unifying physiological mechanism is still not clear. Electromyographic activity is usually decreased in resting muscles after SMT[37-39] and increased at isometric contraction.[40] Corticospinal[41,42] excitability is usually increased, with some exceptions.[39] Increased muscle strength,[43,44] decreased muscle inhibition,[45] and muscle fatigue prevention were observed,[46] as were lower levels of proinflammatory cytokines[47] and pain sensation in humans[11,13-19,48-51] and animals.[52,53]

All these changes could interfere with sports performance, but there is still limited evidence to support SMT's ability to enhance sports performance. The aim of this study was to systematically review the scientific literature for clinical trials addressing this question.

Methods

Search Strategy

Two reviewers defined the search strategy and entered it independently in the PubMed and Embase databases, with no language or temporal restrictions, for the period up to July 2016. This review was not previously registered. Studies addressing any type of manipulative therapy in athletes were selected for full reading. The reviewers selected papers that specified SMT application and assessed its relationship to performance. The search strategy was composed of 3 interrelated main domains (Appendix A) and in accordance with the Cochrane library guidelines.[54,55]

The type of studies included was clinical trials that assessed the effects of SMT in any sports-related performance outcomes. The type of participants was active athletes from any sports modality. The term "athlete" was defined as an individual who is trained or skilled in a sports modality and is currently training or competing. The type of interventions included SMT administered to athletes, with comparison groups of sham, placebo, or controlled procedures. The type of outcomes was any factors that related to sports performance (outcomes based on PICOS strategy, as described in Appendix A), such as strength, muscle and physical resistance, speed, coordination, proprioception, and muscle and mental fatigue.

Study Selection

All titles or abstracts acquired through application of the search strategy and manual search were read. The papers were screened independently by 2 reviewers to assess whether inclusion criteria were met. The consensus was that studies would be fully read. Disagreements were resolved through the intervention of a third reviewer.

Quality Assessment

The PEDro scale was used to assess the quality of the selected studies.[56] Its validity and reliability have already been tested for the quality assessment of clinical trials.[57,58] The PEDro scale has been shown to be more appropriate for studies in which blinding is almost impossible because of intervention or disease characteristics, common to SMT or other physical interventions.[59] For each of the 11 criteria in the scale, 1 point was given if the criteria were fully met and 0 if not met. Studies that scored 6 or more were considered to be of adequate quality.

Results

Database research revealed 576 articles, and 5 additional articles were found through expert suggestions and manual search[60-64] (total of 581). After title and abstract evaluations, 12 papers were selected for full-text reading.[30,44,60-69] Five of these were excluded: 3 for not addressing SMT,[64,67,68] 1 for not assessing its effects on a sports performance variable,[30] and 1 for not addressing athletes.[62] The 7 remaining studies were included (Fig 1) and had their quality assessed through the PEDro scale.

Study Design

Selected studies were mostly parallel-randomized clinical trials, and 2 had a crossover design.[63,66] Shrier et al[66] analyzed 19 athletes from "sprint sports" and Olson et al[63] assessed 20 cyclists, and after the initial group randomized allocation, these findings were crossed between groups.[63,66] Sandell et al[60] randomized 17 middle distance runners, Costa et al[61] studied 43 golfers, Botelho and Andrade[44] studied 18 elite judokas, Humphries et al[65] studied 24 recreational basketball players, and Deutschmann et al[69] studied 40 soccer players.

All of these studies evaluated the effects of SMT on a specific sports-related performance test. Furthermore, they compared these outcome measures before and after the proposed interventions.

Quality Assessment

The quality of the selected studies was adequate ($\geq$6/11) by PEDro scale assessment, with the exception of the study by Deutschmann et al,[69] which was the only study that had a poor quality score (5/11). None of the studies had undergone quality assessment or had registered at the PEDro scale database. The methodologies were markedly different among all of these studies. No attempt had been made in these studies to standardize the methods or to measure similar outcomes.

Previous sample size calculations were not performed by any of the studies. Humphries et al[65] and Shrier et al[66] used placebo interventions that were not validated as placebo-effective approaches to SMT. None of the sham procedures was assessed for blinding efficacy.[44,63,69]

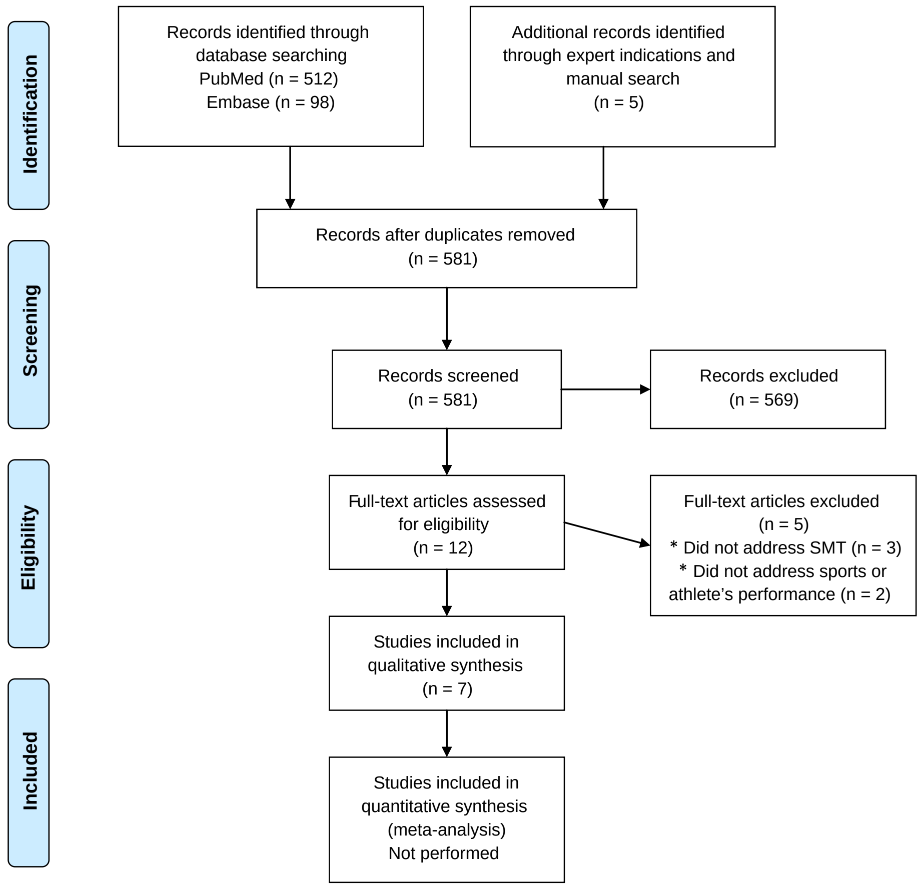

Fig 1. *Flowchart of the study selection procedure.* SMT, *spinal manipulative therapy.*

Tables 1 and 2 summarize the important quality aspects and the criteria not fulfilled by the PEDro scale assessment.

Outcome Measures

All studies had chosen different outcomes to be measured, with the exception of the studies by Humphries et al[65] and Botelho and Andrade,[44] which evaluated grip strength in athletes from different sports. However, despite the similar outcomes, in the study of Humphries et al,[65] SMT was not administered to treat a specific joint dysfunction previously determined by systematic clinical assessment. Therefore, a combined analysis from these studies' outcomes would be unfounded.

Botelho and Andrade[44] observed increased grip strength after SMT (10.53% right hand and 16.81% left hand, $P < .05$) was administered to clinically dysfunctional cervical vertebras of judokas. Humphries et al[65] found no differences in grip strength ($P = .710$) and free-throw accuracy ($P = .058$) after the "left posterior column of C5-6" was manipulated.

The studies by Humphries et al[65] and Olson et al[63] were the only ones where SMT was not applied to correct a dysfunctional segment, but to a previously arbitrarily set vertebral joint/segment (C5-6 in Humphries et al and L3 in Olson et al). Olson

Table 1. *Study Quality–Related Aspects*

Study	n	Sample Size Estimated?	Sport/Athlete Level	Sex	Number of Interventions	Validated Placebo
Shrier et al (2006)[66]	19	N	"Sprint sports"/Elite	M/F	1	N
Sandell et al (2008)[60]	17	N	Runners/Junior	M	3	N/A (Control)
Costa et al (2009)[61]	43	N	Golf/NI	M	4	N/A
Botelho and Andrade (2012)[44]	18	N	Judo/Elite	M/F	3	N/A (Sham)
Humphries et al (2013)[65]	24	N	Basketball/Recreational	M	1	N
Olson et al (2014)[63]	20	N	Cycling	M/F	1	N/A (Sham)
Deutschmann et al (2015)[69]	40	N	Soccer	M	1	N/A (Sham)

F, female; *M*, male; *n*, sample size; *N/A*, not applicable; *N*, no; *NI*, no information.

Table 2. *PEDro Scale Criteria That Were Not Fulfilled in the Studies*

Study	Concealed Allocation	Similar Groups at Baseline	Blinding of All Subjects	Blinding of All Therapists	Blinding of All Assessors	Final PEDro Score
Shrier et al (2006)[66]	No	Yes	No	No	No	7/11
Sandell et al (2008)[60]	Yes	No	No	No	Yes	8/11
Costa et al (2009)[61]	Yes	Yes	No	No	No	8/11
Botelho and Andrade (2012)[44]	Yes	Yes	No	No	Yes	9/11
Humphries et al (2013)[65]	Yes	Yes	No	No	No	8/11
Olson et al (2014)[63]	Yes	Yes	No	No	Yes	9/11
Deutschmann et al (2015)[69]	No	No	No	No	No	5/11

et al[63] evaluated hip flexibility (sit-and-reach test) ($P = .765$), 500 meters cycle ergometer sprint ($P = .877$), and exercise heart rate ($P = .944$), and found no differences among the groups.

The studies by Sandell et al[60] and Shrier et al[66] evaluated 2 different sports-related outcomes each, having in common running velocity. Shrier et al[66] evaluated jump height and 40 meters running velocity, whereas Sandell et al[60] evaluated speed in a 30-meter track and the ability to extend the hip. Both studies did not previously calculate the sample size and had large data variability and low statistical power. No changes were observed in running velocity, and Sandell et al[60] found increased hip extension ability (5.6 degrees; $P < .05$) in the treatment group.

Deutschmann et al[69] evaluated range of motion and soccer ball kicking speed after SMT was performed at the lumbar spine, sacroiliac joint, or a combination of both and found an increased kicking speed (average of 3.52 to 6.57 km/h, depending on group allocation; $P < .05$).

The study by Costa et al[61] was the only study that did not analyze SMT alone but SMT in conjunction with stretching. Two groups of golfers were compared for full-swing performance after stretching alone or after stretching combined with SMT. After the fourth weekly intervention, an increase in full-swing ball range was observed in the combined stretching and SMT group (16.9 m; $P < .05$).

It did not seem reasonable to perform meta-analysis compilation because of the discrepancies in outcome and intervention. The primary outcome results are detailed and summarized in Table 3.

Discussion

There is disagreement between sports professionals and athletes regarding SMT and its effect on sports performance.[7-10] An increasing number of studies on this theme have been performed, and the current review reveals a number of clinical trials assessing SMT effects in performance tests.[44,60,61,63,65,66,69]

Of the 7 included studies, 4 revealed improvements after SMT. Sandell et al[60] observed an increase in hip extension but no changes in running velocity after SMT. Costa et al[61] observed an increased full-swing range in golfers, Botelho

Table 3. *Selected Studies Main Results*

Study	n	Age in Years (SD)	Sport/Athlete Level	Sex M/F	Number of Interventions/Joints	Outcome Measure	Main Results
Shrier et al (2006)[66]	19	26 (±4)	"Sprint sports"/Elite	M/F	1/Thoracolumbar and tarsal	Jump height and 40-m run	No changes
Sandell et al (2008)[60]	17	17-20	Runners/Junior	M	3/Sacroiliac and hip	Hip extension and 30-m run	↑Hip extension; running velocity unchanged
Costa et al (2009)[61]	43	34.64 (±11.2)	Golf/NI	M	4/Full spine	Full-swing range	↑Full-swing
Botelho and Andrade (2012)[44]	18	20.28 (±3.2)[a]	Judo/Elite	M/F	3/Cervical	Grip strength	↑Strength
Humphries et al (2013)[65]	24	26.3 (±9.2)	Basketball/Recreational	M	1/Left C5-6 column	Grip strength and free-throw	No changes
Olson et al (2014)[63]	20	36.3 (±7.4)	Cycling/NI	M/F	1/L3	Hip flexibility and cycling sprint	No changes
Deutschmann (2015)[69]	40	23.4 (±3.4)	Soccer/Elite	M	1/Lumbar, sacroiliac	Range of motion and kicking speed	↑Kicking speed

F, female; *M*, male; *n*, sample size; *NI*, no information; *SD*, standard deviation.
[a] Data directly provided by author.

and Andrade[44] observed increased grip strength in Judokas, and Deutschmann et al[69] observed increased kicking speed after SMT in soccer players.

Shrier et al,[66] Humphries et al,[65] and Olson et al[63] found no differences in their measured outcomes. Humphries et al[65] and Olson et al[63] chose to not apply SMT as a therapy procedure to correct dysfunctional joint segments. Their protocol used previously determined joints regardless of clinical evaluation findings (left column of C5-6 used by Humphries et al, and L3 bilateral mammillary process used by Olson et al). Humphries et al[65] and Botelho and Andrade [44] assessed grip strength, and their contrasting results could be indicating that SMT produces different neurophysiological responses when applied for biomechanical joint dysfunction corrections[44] or when applied to a previously determined site.[65]

All selected studies evaluated individual performance on specific tests. However, sports performance itself, at an event, was not assessed by any of the studies.[44,60,61,63,65,66,69] Suitable study designs to investigate "real" sports performance, during a sporting event, has been shown to be very challenging and difficult to perform. Some common flaws are frequently found and contribute to the low quality of evidence in this area. One of the main limitations frequently observed is the inherent difficulty to have an appropriate sample size, especially when dealing with high performance athletes.[34]

Most of the researchers use performance tests to assess treatment efficacy, even if there is a lack of studies showing correlation between these tests and actual performance.[34] They usually choose routine tests performed by team staff to evaluate the athletes' physical performance, which is used to determine training routines and game team selection. These tests prioritize physical capacities, such as running velocity, jump height, strength, and others.[70]

Potential Mechanisms of SMT in Sports Performance

Afferent processing, modulation, and correspondent efferent response are part of the complex system responsible for motor control and physical performance. All included studies' outcomes should be influenced, to some extent, by those mechanisms; therefore, it is important to analyze current SMT neurophysiological evidence linked to them.

Several of the described neurophysiological effects of SMT[35-39,41-43,45,47-51,71] were observed in non-athletes, and there is still a lack of evidence to assume that these effects would also occur in athletes. However, Botelho and Andrade[44] found similar results as those observed in the non-athletic population, when assessing grip strength in judokas.

Proprioceptive afferents include Golgi tendon organs, muscle spindles, and other mechanoreceptors, such as Pacinian corpuscles and Ruffini endings. These specialized receptors are highly concentrated in axial and deep cervical muscles.[72,73] Vertebral joint dysfunctions are believed to generate central proprioceptive deficit input from those receptors, as there is impaired motion of the vertebrae.[74,75] Spinal manipulative therapy has an influence on such dysfunctions and has been shown to improve proprioceptive processing and motor control,[74-76] which could potentially influence sports performance.

Some experimental evidence further reinforces this idea. Haavik and Murphy[77] demonstrated that biomechanical dysfunction of cervical joints generates impaired perception of elbow joint position.[77] They also demonstrated that when cervical dysfunction is corrected by SMT, there is a subsequent improvement in the perception of elbow position. Such vertebral dysfunctions are believed to lead to a progressive state of maladaptive neuroplasticity, which could be responsible for impairment of joint proprioception.[35,77] The same authors also described other changes after the biomechanical dysfunctions of the spine were corrected by SMT. An increased ability of the central nervous system (CNS) to adequately integrate and suppress the response of 2 simultaneous peripheral nervous stimulations has been observed.[78] When SMT is applied after a motor training task, it changes the way the CNS responds to subsequent motor training tasks.[76]

Other neurophysiological findings showed decreased activity after SMT in resting paraspinal muscles on surface electromyography[37] and in H-reflex analysis.[38,39,71,79] This decreased muscle tonic activity can be one of the plausible causes associated to the increased hip extension observed by Sandell et al,[60] once the hip flexors muscles have been identified as the main limiting structures for hip extension. However, the effects of SMT on tonic muscle activity are still controversial[37-39,46,79,80] because data acquisition and analysis are quite different among studies.[81,82]

Additionally, after SMT, cortical motoneuron excitability changes were observed in studies with transcranial magnetic stimulation. Dishman et al[41,42] identified a transient increase in motor evoked potential (MEP) amplitude, which lasted up to 60 seconds after SMT.[41,42] This implies increased excitability of the corticomotor pathway after SMT and may justify the results of increased grip strength observed in judokas after SMT.[44] Fryer and Pearce[39] found a reduction in MEP. However, in their research protocol MEPs were evaluated only 10 minutes after lumbar SMT was applied.[39] These contrasting results suggest that the SMT effect is transient, and this needs to be further demonstrated.

CNS modulation through sensorimotor integration, combined with cortical motoneuron and spinal reflex excitability changes after SMT, should be the central mechanism associated with the increased full-swing in golfers,[61] the increased kicking speed in soccer players,[69] and the increased hip extension in runners.[60] These mechanisms should be related to the improved muscle strength observed in judokas[44] and in non-athletes.[43,45]

Limitations

One of the most important limitations of the present study was that a meta-analysis of the selected studies could not be performed. Those studies presented a wide range of methodologic designs and measured outcomes. Therefore, it was not plausible to perform a quantitative analysis (meta-analysis). The reviewers were not previously trained to use the PEDro scale.

Recommendations for Future Studies

Methodologic design quality is especially important when developing a clinical trial on SMT because of the inherent difficulty in patient blinding and in the creation of an effective placebo group.[28,83,84] Different guidelines, such as the guideline for nonpharmacologic treatment of the Equator group, are available to help improve study uniformity.[85] None of the selected studies reported using any guideline.

With regard to methodology design recommendations, we encourage a series of interventions in which outcomes are measured before and after each intervention. That would not only address the duration of the SMT effects but also show whether there is any cumulative effect from repeated SMT interventions.

Improvement of an isolated physical aspect, such as strength, does not necessarily mean enhancement of sports performance. Sports performance needs to be measured during a real sport event, when possible. The best way to assess it is in sports that objectively measure performance, such as swimming or track and field events. In those sports, time measured at a competition can accurately demonstrate if an athlete's performance is better or worse at that moment. However, team sports, such as soccer, basketball, and football, have multiple physical and mental variables that may influence team performance and, thus, the result of a match.

Individual sports with subjective performance definitions, such as dancing and gymnastics, and sports that are dependent on equipment, such as car racing, cycling, or shooting, or even sports that are dependent on animals, such as horse riding, are not ideal sports to properly assess the effects of SMT.

Developing adequate placebo models for hands-on therapies, such as SMT, is a challenging task. Similar models (sham manipulation) have had contrasting results in achieving[84] or not achieving[28] blinding in studies. Populations that are naive to treatment should have a higher potential of successful placebo models, such as the one proposed by Botelho and Andrade[44] (treating table drop mechanism). Other riskier and more costly options include short-duration anesthesia (propofol and remifentanil).[83]

Therefore, the ideal study design model would be a randomized clinical trial with a placebo/sham group, administered in modalities, such as track and field competitions or swimming, with more than one intervention. Measurements should be taken before and after interventions, and long-term follow-up is necessary. These models would properly address the duration and the accumulation of SMT effects and help discover an ideal number of interventions prior to a competitive event.

Additionally, cohort-type studies that evaluate treatment impact on lesion prevention, as performed by Brumm et al,[86] who analyzed the effects of osteopathic manipulative foot treatment on the incidence of stress fractures in cross-country athletes, are also encouraged. Lesion prevention is very important for the maintenance and improvement of athletes' performance.

Conclusions

Although most of the included studies (4 of 7) showed that SMT led to improved sports performance test results, the evidence is still weak to support its use with this aim. Therefore, despite the common contention of some athletes and sports-related professionals that SMT enhances sports performance, this review revealed that such a claim is not supported by current evidence. Spinal manipulative therapy may be a promising approach for performance enhancement, but it needs to be better and more deeply investigated.

Funding Sources and Conflicts of Interest

The first author (M.B.B.) received a scholarship for his master's program at the Federal University of Bahia, Brazil. No conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): M.B.B., B.A., A.F.B.
Design (planned the methods to generate the results): M.B.B., B.A., N.M., M.R., A.F.B.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): M.B.B., B.A., N.M., M.R., A.F.B.

Practical Applications

- Several observed neurophysiological effects of SMT suggest that it has a potential influence on sports performance.
- Some clinical trials assessed this relationship, but this theme is still new, and more investigations are needed.
- Important recommendations for future studies were made, with a focus on uniformity of study design and outcomes.

Data collection/processing (responsible for experiments, patient management, organization, or reporting data): M.B.B., B.A., N.M., M.R., A.F.B.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): M.B.B., B.A., N.M., M.R., A.F.B.
Literature search (performed the literature search): M.B.B., B.A., N.M., M.R., A.F.B.
Writing (responsible for writing a substantive part of the manuscript): M.B.B., B.A., N.M., M.R., A.F.B.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): M.B.B., B.A., N.M., M.R., A.F.B.

Appendix A. Search Strategy

athletes OR sports OR racquet sports OR snow sports OR sports medicine OR sports injuries OR track and field OR running OR martial arts OR swimming OR dancing OR weight lifting OR bobsled OR archery OR equestrian OR boxing OR soccer OR volleyball OR basketball OR golf OR baseball OR handball OR surf OR shotguns OR shooting OR hockey OR wrestling OR skating OR water sports OR gymnastics OR aviation OR off-road motor vehicles OR motor vehicles OR mountaineering OR car racing OR sumo OR football OR rugby OR kick boxing OR cricket OR race

AND athletic performance OR psychomotor performance OR performance-enhancing substances OR physical endurance OR muscle strength dynamometer OR muscle strength OR running OR proprioception OR plyometric exercise OR exercise OR fatigue OR muscle fatigue OR mental fatigue

AND spinal manipulation OR chiropractic manipulation OR musculoskeletal manipulations OR orthopedic manipulation OR osteopathic manipulation OR manipulative vertebral therapy

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