

Chiropractic treatment and the enhancement of sport performance: a narrative literature review

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A literature search and narrative review was carried out with the intent of determining the current level of knowledge regarding the chiropractic treatment of athletes for the purpose of sport performance enhancement. Of the fifty-nine relevant articles retrieved, only 7 articles of variable quality were obtained which specifically investigated/discussed chiropractic treatment and its involvement in sport performance enhancement. The role of the chiropractor in sport, unsubstantiated claims of performance enhancement, theories of how chiropractic treatment may influence sport performance, and the available evidence for the benefit of chiropractic treatment on sport performance are reviewed and discussed. Areas and directions for future studies are postulated. At this time there is insufficient evidence to convincingly support the notion that treatment provided by chiropractors can directly improve sport performance. (JCCA 2010; 54(4):210–221)

KEY WORDS: chiropractic, sport performance, athletic injury

Introduction

Can chiropractic care enhance sport performance? Do athletes treated by chiropractors obtain specific performance advantages from specific treatment techniques and/or objectives? When treating athletes, do chiropractors specifically intend or claim to improve an athlete's performance, or do chiropractors simply offer efficient and effective treatment for injured athletes, thus allowing a return to sport as soon as possible? These questions have

Une recherche de la documentation et des textes descriptifs fut menée dans le but de déterminer le niveau de connaissances sur le traitement chiropratique des athlètes afin de rehausser leurs performances sportives. Parmi les cinquante-neuf articles pertinents récupérés, seulement 7 articles de qualité variable abordaient le traitement chiropratique et son rôle dans l'amélioration des performances sportives. Le rôle du chiropraticien dans le sport, les prétentions non justifiées d'amélioration des performances, les théories sur la façon dont le traitement chiropratique peut influencer les performances sportives et la preuve disponible des bienfaits du traitement chiropratique sur les performances sportives sont analysés. Les aspects et la direction des futures études sont hypothétiques. En ce moment, il n'existe pas suffisamment de preuves pour soutenir avec conviction la notion selon laquelle le traitement prodigué par un chiropraticien peut améliorer directement les performances sportives. (JCCA 2010; 54(4):210–221)

MOTS CLÉS : chiropratique, performances sportives, blessure résultant de la pratique des sports

been asked infrequently in chiropractic and chiropractic related publications, and even less frequently have answers been postulated. However, it is not uncommon when reviewing chiropractic literature to come across information pertaining to chiropractors treating elite and/or amateur athletes for the purpose of improving or enhancing athletic performance.^{1–13} Such references typically represent the opinion or personal observation of an individual chiropractor treating an individual athlete or

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group of athletes.^{2-7,11,12} Although anecdotal information can be thought provoking, the deleterious consequences of scientifically unsubstantiated claims of chiropractic benefit hurt the profession more often than not.¹⁴ Uncritical empirical evidence and unsubstantiated claims of efficacy are frequently offered in marketing materials, professional and educational web sites, trade journals, and other public forums.¹⁴ As Keating comments, “chiropractors’ harshest critics continue to draw upon the chiropractic literature for ammunition to be used against the profession.”^{14(p.58)} This fact, commonly obscured by defensive comments of inter-professional persecution, would seem to be a direct result of our own profession’s actions. Thus, it seems imperative that claims of “athletic performance enhancement” by chiropractic treatment be substantiated or at the very least, clearly delineated according to the standards of evidence-informed health care. It is the aim of this narrative literature review to determine the extent of current information and evidence supporting the use of chiropractic care for the purpose of sport performance enhancement.

Methods

A literature search was carried out with the purpose of determining the current level of knowledge regarding the chiropractic treatment of athletes for the purpose of sport performance enhancement. A search, with no limiters or expanders, of the MEDLINE, CINAHL (Cumulative Index to Nursing and Allied Health Literature), AMED (Alternative Medicine), Alt HealthWatch (Alternative Health), Psychology & Behavioral Sciences Collection, The Cochrane Library, and ICL (Index to Chiropractic Literature) databases through to June 2010, was conducted using the following search terms and/or combinations of search terms: “chiropractic,” “manipulation,” “athletic injuries,” “sport,” “performance,” “performance enhancement,” “psychomotor performance,” “physical performance,” “performance measurement systems,” “treatment outcomes,” “sport specific training,” “sports medicine,” and “chiropractic assessment.” Reference lists from the obtained articles, in addition to appropriate textbooks, were manually searched to obtain additional literature sources. The inclusion criteria for article selection encompassed all studies and articles from both refereed and non-refereed literature sources determined by the author to be relevant to this literature review.

Results

The vast majority of searched citations were deemed unrelated to this review. Ultimately, fifty-nine sources were obtained to provide literature reference for this narrative review. Of the fifty-nine sources, only 7 peer-reviewed refereed articles of variable quality were obtained which specifically investigated/discussed chiropractic treatment and its involvement in sport performance enhancement.^{13,15-20}

Discussion

1. The role of the chiropractor in sport

It appears that there are many proposed roles for chiropractors within the sporting world. A commentary published by Stump in 2001, discussed the perceived role of chiropractors in sports health care, and stated that “chiropractic adjustment/manipulation of the spine and extremities comprise the greatest part of most sports chiropractic practices.”²¹ Referencing a survey study by the same author which investigated the use and role of sport chiropractors in the National Football League (NFL), Stump determined that other sport injury professionals, specifically certified athletic trainers in the NFL, perceive “a role for the sport chiropractor primarily as a spinal specialist treating low back and other musculoskeletal injuries.”^{21,24(p.4)} This perceived role of sport chiropractors being spine/musculoskeletal injury specialists is echoed in various chiropractic and non-chiropractic publications.²⁵⁻³¹ However, spine/musculoskeletal injury care is not the only suggested role for chiropractors in sport health care. The non-refereed literature makes reference to chiropractors acting, within the realm of sport health care, as emergency care providers, pre-participation examiners, and as sport injury specialists who are able to work and interact with coaches and other health professionals for the overall benefit of the athletes they treat.³⁰⁻³⁶ From that perspective some authors indirectly suggest that the role of a sport chiropractor is to facilitate an athlete’s performance by the early determination and prompt treatment of injury, and by working with coaches and other sport health professionals to identify and correct an athlete’s performance deficits when present.^{25,33,35-39} Kelsick (2004) offers the example of a pre-participation examination, and comments that “by correcting the deficiencies discovered in the examination,

athletic performance can be improved and the frustration level (of an athlete) decreased when the etiology of poor performance is unclear.”^{32(p.6)} This view of detecting and correcting impediments to performance is also offered in comments from Nook and Nook (1997), who state that in their opinion “the basis and definition of chiropractic emphasizes the correction of pathomechanics of the spinal and extremity joints restoring normal neurology and biomechanics.”^{25(p.138)} They comment further that “restoration of these pathomechanical faults in an athlete will reduce pain, decrease the severity of injury, and possibly enhance athletic performance.”^{25(p.138)} However, the opinion that the role of a sport chiropractor is to only affect performance ‘indirectly’ is not unanimous. Several authors in the non-refereed publications have suggested that the role of a chiropractor when treating athletes is to ‘directly’ improve performance via spinal manipulative therapy.^{1-5,7,11,12} Leonardi (1996) colourfully illustrates this view point by stating “where chiropractic truly excels is in its ability to actually improve performance, since it is through the full use of the nervous system that peak performance can be achieved.”^{2(p.94)} He states further that “chiropractic is the only form of care available to deliver subluxation free 100 percent nerve flow,” and that “peak performance is possibly only with chiropractic care.”^{2(p.95)}

Clearly, there is disagreement as to the specific role of the chiropractor within sports health care. However, a chiropractor practicing in Canada wishing to treat athletes would do well to practice within the chiropractic scope of practice of his or her jurisdiction. Although legislation is different from province to province and can be interpreted from different perspectives, the legal necessity of providing a diagnosis would suggest that the role of a chiropractor when treating athletes is in alignment with the opinions of Kelsick (2004), which is to indirectly facilitate an athlete’s performance by the early determination and prompt treatment of injury, by working with coaches and other sport health professionals to identify and correct an athlete’s performance deficit when present, and utilize best evidence therapies and treatment techniques to alleviate that deficit.³²

2. Unsubstantiated claims: pervasiveness within the non-refereed literature

Within the non-refereed literature it is not uncommon to

read proclamations regarding the efficacy of chiropractic treatment for the purpose of improving or augmenting an athlete’s performance or a component of an athlete’s sport performance such as strength, speed, balance, increased reaction and/or recovery times.^{1,5,11} In some instances, grand statements regarding the benefits of chiropractic care for athletes are reported. Rau in an opinion piece published in *Today’s Chiropractic* (2003) commented that “it is hard to imagine that chiropractors across the country have not said at least once, ‘if only I had a chance to adjust that player, they’d be right back on the field and wouldn’t have that problem again’.”^{12(p.57)} Lauro (1996), in a similar article, comments that “the chiropractor can become the most important health-care provider to the athlete because we can improve their performance, not just treat an injury,” and that “the correction of the subluxation is the key to improved health, performance, and life itself.”^{3(p.31)} Stone (2003) states that “it doesn’t matter what level of participation they are at, or whether they come to us “asymptomatic” or “healthy” or “normal,” they still can benefit from chiropractic care in order to optimize their health and maximize their performance.”^{11(p.64)} Leonardi (1996) commenting on his rationale and approach to treating athletes, as well as chiropractic’s ability to help athletes achieve peak athletic performance, states that “we can easily predict that peak performance is possible only with chiropractic care.”^{2(p.94)}

Other authors quote the athletes they treat as proof of the performance benefits of chiropractic. In a brief news clip, Cogan (2003) reported that “players innately recognize that chiropractic adjustments greatly increase their performance.”^{9(p.34)} In a similar article, Panter (2001) interviewed the chiropractor for the University of Tennessee Track and Field team, Dr. Michael Petty, on the topic of athletes under his care.⁷ Petty stated that “they (the athletes) were adjusted right before they competed, and all of a sudden they were hitting personal records.”^{7(p.52)}

Admittedly, experience and observation is an important component of clinical practice, and the communication between professionals about new treatment techniques and treatment outcomes is important for the continued improvement of therapy techniques. However, such treatment techniques and outcome observations should be published and communicated in the form of a formal case report, which allows for the observations and techniques to be interpreted in the context of the specific

patient characteristics, the health practitioner, the clinical setting, and therapy being utilized.²⁴ Bronfort, Haas, and Evans (2005) emphasize this point by stating that although the “personal experiences delivered by often charismatic leaders are interesting or even impressive, they do not represent scientific evidence to prove or disprove a therapy.”^{22(p.150)} The value placed on any published work regarding the efficacy of a treatment method or protocol should be determined by how well a study or investigation was performed.²²

Using an evidence-informed health care model, it would seem unwise for chiropractors to overtly state the benefits of chiropractic treatment for enhancing athletic performance without referencing quality evidence to support such claims. Perhaps the chiropractic profession would be better served if authors use qualifying phrases when reporting the anecdotal observation of athletic enhancement after chiropractic treatment. For example, it would be more accurate for authors to state that their observations of chiropractic treatment benefiting athlete performance, “tend to suggest,” or “may indicate,” that certain treatment techniques provided by chiropractors “may” indirectly affect performance in competitive athletes.

3. Theories of how chiropractic treatment may indirectly affect sport performance

Historically in chiropractic literature, spinal manipulative therapy (SMT) or “adjustment” is the primary intervention used for the treatment of diagnosed disorders related to the spine.²³ However, there remains debate as to the exact neurological, physiological, and mechanical mechanisms of benefit from “chiropractic adjustment/spinal manipulative therapy.”⁴⁰ Theories have typically involved concepts of nerve compression, neurological reflex, and/or endogenous mechanisms of pain relief.⁴⁰ A complete discussion of these theories is beyond the scope of this narrative review, however the most popular concepts of how SMT may potentially affect athlete sport performance are presented.

3.1 Spinal Manipulative Therapy

In 1986 Haldeman published a review on the topic of spinal manipulation in sports medicine.⁴¹ His review covered many areas including the definition of SMT, the proposed mechanisms of SMT, the evidence in support of SMT for

neck and back pain, and some of the various techniques of manipulation. Haldeman (1986) also commented on the proposed theories of how SMT was thought to benefit athlete performance.⁴¹ Considering that SMT is thought to correct restricted spinal motion, Haldeman (1986) contemplated the theory of how restricted spinal motion could potentially cause abnormal spinal mechanics and reflex muscular incoordination, which in turn could result in a reduced ability to maximize effort and thus disrupt the graceful, coordinated movement necessary in most sporting activities.⁴¹ This concept was repeated in a more recent review on the same topic by Prokop and Wieting (1996).⁴² These authors commented that the “global objective (of SMT) is to restore normal pain-free motion with the highest level of motor control and coordination in a state of postural balance to allow the athlete to perform at the highest level of his or her capacity.”^{42(p.915)} In both reviews the authors make reference to the fact that at the time of publication, the theories had not been validated or substantiated with quality research.^{41,42} Recently however, information on muscle inhibition/activation, muscle strength, motor reaction time, and motor training has shed light on the mechanisms of how SMT could perhaps indirectly affect athlete sport performance.^{43–51}

3.1.1 Reduction of muscle inhibition

Suter et al. (2000) investigated the effects of sacroiliac (SI) joint manipulative treatment on knee-extensor inhibition in patients with anterior knee pain (AKP).⁴³ Based on the clinical observation that patients suffering from AKP (also known as patellofemoral pain syndrome) often present with signs and/or symptoms of SI mechanical joint dysfunction, the investigators enrolled twenty-eight patients with symptoms of AKP into a randomized, controlled, double-blind study. The aim of this study was to assess whether conservative lower back treatment (SI joint manipulation) reduces knee-extensor muscle inhibition (MI). Results indicated that “after adjustment of the SI joint, MI was significantly decreased in the involved legs of the treatment group,” and there were “corresponding increases in knee-extensor moment and total electromyography (EMG) values, which did not reach statistical significance.”^{43(p.78)} Although the authors concede that the precise mechanisms by which their results may be explained are unknown, it is conceivable that SMT activates mechanoreceptors and proprioceptors from structures in

and around the SI joint. The altered afferent input arising from the stimulation of these receptors is thought to interrupt the pain-spasm cycle which results from conditions like AKP by changing the motor neuron excitability to the muscles acting on the knee joint. Suter et al. (2000) contend that the results of their study “point to the possible usefulness of spinal manipulation for the treatment (reduction) of lower limb MI.”^{43(p.80)}

In similar research, Suter and McMorland (2002) tested chronic neck pain patients to determine if they demonstrated inhibition in their elbow flexor muscles and if so, to determine if elbow flexor inhibition changes immediately following cervical spinal manipulation.⁴⁴ Results indicated that “cervical spine manipulation resulted in statistically significant immediate decrease in muscle inhibition on both sides (both biceps, left and right), while at the same time both elbow flexor force and the corresponding biceps EMG increased.”^{44(p.543)} The authors concluded that their findings “support the notion that chronic neck pain may have long-lasting effects on upper extremity muscle function,” and that “spinal manipulation may help to restore excitatory function of the upper extremity muscles such as the elbow flexors.”^{44(p.544)}

When athletes report symptoms of reduced muscular explosiveness and/or less than optimal function, perhaps muscular inhibition is the reason? If SMT can reduce muscular inhibition of major muscle groups such as the quadriceps, or to a single muscle like the biceps in patients experiencing knee and neck pain, could SMT help optimize muscle function in athletes prior to sporting events? Additional research is clearly warranted in this area before attempting an answer to this question.

3.1.2 Altered muscle electromyographic activity

Several investigations have been undertaken to look specifically at the before and after effects of SMT on the EMG activity of muscles.^{23,45,46} However, the results of these investigations have been mixed.²³ Studies have indicated both reductions and increases in EMG activity following SMT.^{23,46}

A recent descriptive study by DeVocht et al. (2005) examined the effect of SMT on EMG activity in the areas of localized tight muscle bundles of the low back.⁴⁶ Observing that “many chiropractors palpate for tight muscle bundles in the paraspinal musculature as one indication of where to apply SMT,” the authors hypothesized that it

was “reasonable to expect resting muscle activity, which can be monitored by EMG, to be abnormally high in the region of a tight muscle bundle.”^{46(p.465)} “If the presence of a tight muscle bundle is functionally associated with a spinal dysfunction that is correctable by SMT, it would consequently follow that the tight muscle bundle, and the associated higher EMG level, would diminish after the appropriate SMT.”^{46(p.466)} DeVocht et al. (2005) collected EMG activity from 16 low back pain subjects in 2 chiropractic offices before, during, and after SMT was delivered utilizing either Activator or Diversified manipulation protocols.⁴⁶ Similar to other investigations, this study found that muscle EMG activity can be increased or decreased following a single delivery of SMT.⁴⁶ However, the investigators determined that in the majority of cases (12 out of 16), SMT was followed immediately by a period of decreased paraspinal muscle EMG activity.⁴⁶

Could the subjective improvement of muscle function following SMT, by either an increase or decrease in muscle EMG activity/activation, be a mechanism to explain the clinical observation of improved sport performance in athletes receiving chiropractic SMT? It seems that no definitive answer can be postulated based on the literature currently available.

3.1.3 Muscle strength modulation

As discussed in the previous section, SMT is thought to either directly or indirectly result in the restoration of normal joint mechanics, physiology, and/or neurological integrity.²³ Many authors of chiropractic literature focus on the improvement of neurological integrity as the main component for the beneficial effects of the chiropractic adjustment or SMT.⁴⁹ Some of these authors have investigated the relationship between neurological activity and/or neurological health to muscle strength.^{23,43,45,47–49,52–56} Smith and Cox (2000) contend that “there are three broad determinants of a muscle’s ability to generate force: (1) neural factors, (2) muscular factors, and (3) biomechanics.”⁴⁹ In their review titled “Muscular Strength and Chiropractic: Theoretical Mechanisms and Health Implications,” they postulate that chiropractic adjustment or SMT can indeed affect all three of the factors that determine muscle strength.^{49(p.5)} In support of this postulation they offer many of the works previously mentioned in the current review, in addition to investigative work by Pollard and Ward (1996).

Pollard and Ward (1996) undertook an investigation into the strength change of the quadriceps femoris muscle group following a single manual manipulation of the L3/4 vertebral motion segment.⁴⁸ They enrolled 30 asymptomatic chiropractic college students, and randomly assigned them to either an experimental group or a control group. A single thrust was applied to the experimental subjects while in the basic lumbar roll position, and a sham thrust was applied to the control subjects. Results indicated that compared to pre-test values, the control group mean force score decreased by 2.04 Newton's following sham manipulation, whereas the experimental group experienced a group mean force score increase of 3.03 Newton's following manipulation of the L3/4 spinal motion segment. The difference between the control and experimental groups was determined to be statistically significant. The authors concluded that "in an asymptomatic student population a manipulation to the L3/4 motion segment resulted in a statistically significant short-term increase in quadriceps femoris muscle strength."^{48(p.143)} They further theorized that the 4.6% change post manipulation in the experimental group could have a potentially "beneficial impact on rehabilitation protocols and the performance of strength athletes."^{48(p.143)}

Contrasting the work of Pollard and Ward (1996) is an earlier investigation undertaken by Bonci and Ratliff (1990).⁴⁷ These authors (1990) investigated the strength modulation of the biceps brachii muscles immediately following a single manipulation of the C4/5 spinal motion segment.⁴⁷ Utilizing an experimental protocol similar to the work of Pollard and Ward (1996), Bonci and Ratliff (1990) manipulated 20 asymptomatic subjects and compared their strength results post manipulation with that of 5 non-manipulated control subjects. Bonci and Ratliff (1990) found no statistically significant change in muscle strength in the biceps brachii muscles following a single chiropractic manipulation to the C4/5 spinal motion segment. Although investigating the efficacy of muscle testing as a "prognostic parameter for spinal manipulation," it is interesting that in the introduction of their paper, Bonci and Ratliff (1990) hint towards a potential mechanism of how SMT may influence sport performance.^{47(p.15)} Under the premise that SMT may have an effect on the neural drive or functioning of muscles, and that during a given motor task, the pattern of fiber neurological recruitment can affect the performance of a motor task, Bonci and

Ratliff (1990) comment that "an impairment to voluntarily recruit motor units may result in a decreased maximal force output at the site of muscle exertion and/or an alteration in the ability to execute a motor program skillfully."^{47(p.15)} Perhaps optimizing neural drive to a muscle is an effect of SMT, which in turn can improve muscular strength and therefore sport/athletic performance?

Although the narrative review completed by Smith and Cox (2000), and the works of Pollard and Ward (1996), and Bonci and Ratliff (1990) offer some interesting theories and hypotheses regarding the potential affect of SMT on muscle strength, it would seem that due to the limited quantity and quality of the available research, no conclusive statement can yet be made as to whether SMT has an appreciable effect, positively or negatively, on muscle strength.⁴⁷⁻⁴⁹

3.1.4 Cognitive / motor reaction time and motor training improvement

Studies have investigated the relationship between cognitive/motor reaction times, motor task training, and the presence of cervical spine dysfunction.^{50,51,57} Kelly et al. (2000) measured reaction time (RT) on a mental task in subjects who were clinically determined to have upper cervical joint dysfunction.⁵⁷ The study subjects were randomly allocated into two different groups. An experimental group, which received a single upper cervical toggle adjustment and a control group, which did not receive an intervention other than laying on the adjustment table for 2 minutes. Kelly et al. (2000) found that RT decreased in both groups, but that this decrease in RT was significantly greater in the post adjustment group than in the control group. However, this study did not include a group with no evidence of upper cervical spine dysfunction, and therefore Kelly et al. (2000) could make no determination as to whether reaction times were normalized following a single upper cervical spine toggle adjustment.

Following the work of Kelly et al. (2000), Lersa et al. (2005) attempted to investigate the relationship between the number of sites of clinically determined cervical spine joint dysfunction and a range of RT measures of cognitive/motor processing.⁵⁰ Thirty subjects were assessed for the presence of cervical spine dysfunction. Utilizing a computer and computer keyboard, the subjects, following physical assessment, underwent three different RT measures involving a visual stimulus presented on the com-

puter screen and the response of a specified keyboard stroke. Lersa et al. (2005) determined that the presence of 2 or more sites of cervical spinal dysfunction “may be related to slower and/or less accurate performance on a range of RT tasks.”^{50(p.507)} However, like the study by Kelly et al. (2000) the study by Lersa et al. (2005) failed to include a control group of subjects with no evidence of cervical spine dysfunction, and thus the authors could not determine how their cervical spine dysfunction groups compared to non-dysfunction subjects.

More recently, Taylor and Murphy (2010) investigated the influence of spinal dysfunction and spinal manipulation on the response of the central nervous system to a motor training task.⁵¹ They recorded peripheral nerve somatosensory evoked potential ratios in 11 subjects before and after a 20-minute typing task and then again when the typing task was preceded with cervical spine manipulation.⁵¹ They determined that when a 20-minute typing task is preceded by SMT of dysfunctional cervical joints it results in altered sensorimotor integration as well as a change in the way the CNS responds to a functional task.⁵¹ Taylor and Murphy theorize that their results may help to explain the mechanisms responsible for the effective relief of pain and restoration of functional ability documented after spinal manipulation.⁵¹

If additional research projects indicate that SMT can actually improve cognitive/motor reaction time and/or motor task training, it could prove to be very important to athletes seeking to optimize their cognitive and motor skill sport performance.

4 Specific attempts at investigating chiropractic treatment effects on sports performance

The search strategy employed for this narrative review identified several peer-reviewed/refereed articles which specifically investigated chiropractic treatment and its involvement in sport performance enhancement.^{13,15-19}

Waters and Boone (1988) investigated the relationship between elements of spinal misalignment determined by chiropractic analysis and both static and dynamic balance during dance performance.¹⁷ A secondary aim of the study was to provide evidence for the efficacy of chiropractic spinal analysis to detect correctable spinal misalignments that would negatively effect a dancer’s performance, thus supporting the theory that the detection and elimination of spinal misalignment and/or dysfunction prior to an

athletic event can improve an athlete’s physical performance.¹⁷ In the six week study, Waters and Boone (1988) enrolled 14 experienced female dancers who performed a ten minute dance routine twice a week. Prior to, and following each dance performance, the subjects were analyzed for “leg length balance,” “pelvic torsion,” and the presence of a “cervical syndrome.” In spite of various methodological limitations and shortcomings including: the validity of their methods for spinal analysis, the content validity of the self-administered questionnaire, and the lack of discussion regarding inferential statistics to determine if their results were simply due to chance, Waters and Boone (1988) concluded that the results of their study “suggest that three elements of spinal misalignment: leg length imbalance, cervical syndrome, and pelvic torsion, play an important role in the specific and overall muscle balance in dancers.”^{17(p.57)} The authors theorized that their results suggest the “importance of eliminating the elements of spinal misalignment” prior to an athletic or physical performance.^{17(p.57)} However, Waters and Boone (1988) correctly conceded that future studies, with larger sample sizes, validated analysis techniques, and improved methodology are necessary to support their findings.¹⁷

Although not directly investigating the enhancement of sport performance via chiropractic care, Grimston et al. (1990) did obtain subjective reports of improved performance following a trial of chiropractic SMT combined with muscular rehabilitation for the treatment of dysfunctional sacroiliac (SI) joints in female runners.¹⁶ Utilizing the Gillet palpation tests, postural visualization, body weight distribution, radiographic analysis for lumbar-pelvic spinal asymmetry, and subjective reports of SI symptomology, subjects were allocated into either the SI dysfunction group (n = 18) or a control group (n = 4) based on the presence or absence of a chiropractic diagnosis of SI dysfunction. Results revealed that following 4 weeks of SMT, 83% of the SI group maintained or increased their training mileage, no subjects reported improvement in race times, and 82% of the SI group reported symptom reductions. Following 4 weeks of SMT and an additional 6 weeks of exercises, 100% of SI subjects reinstated or increased their training mileage, 5 SI subjects reported “personal record (PR)” times for 10km races and 2 SI subjects reported PR times for marathon races, and 100% of SI subjects reported subjective symptom reductions. No control sub-

jects reported improvements in race times and/or training capacities over the entire 10 week course of study. The authors concluded that “muscular rehabilitation programs prescribed in conjunction with prior chiropractic care, may provide an effective means of alleviating low back pain due to sacroiliac subluxation (dysfunction) in female runners.”^{16(p.7)} Grimston et al. (1990) did not comment on their performance improvement findings or the possibility that chiropractic care in conjunction with supervised muscle rehabilitation may potentially facilitate improved athletic performance in female runners.

Lauro and Mouch (1991) looked at measuring the effect of chiropractic care, specifically spinal manipulative therapy (SMT), on a group of asymptomatic athletes and their physical performance in a battery of eleven quantitative physical tests that were theorized to evaluate an athlete’s agility, balance, kinesthetic perception, power, and speed of reaction.¹³ The study separated the subjects into two groups: control (no manipulation) and experimental (manipulation). Results were examined by comparing the change in average score from baseline for the two groups across each of the eleven tests. The investigators called this measure the “Index of Average Athletic Ability Improvement (IAAAI).”¹³ After six weeks, the experimental group showed a 6.12% greater overall improvement in IAAAI score than the control group, and after twelve weeks, the experimental group showed statistically significant overall improvement ($p < .0005$) on all but three of the tests when compared to base line, but not in relation to the control group. Based on this, the investigators concluded that “it had been shown that there may be a potential for enhancing athletic ability through chiropractic treatment, when the goal of treatment is to diagnose and correct existing subluxation complexes, symptomatic or not.”^{13(p.87)} It is important to note that the control group was discontinued after the initial 6 six week study period, so the improvement seen in the experimental group at twelve weeks was not, and cannot be compared to the control group, nor can it be ruled out that the observed improvement was a result of task learning from repeated testing. Therefore, statistical significance between groups was not determined and clinical significance cannot be inferred; yet this study has often been cited as evidence of chiropractic’s positive effect on athlete performance.^{3,13,20}

Following the work of Grimston et al. (1990) and Lauro and Mouch (1991), Schwartzbauer et al. (1997) investi-

gated “the feasibility and sensitivity of detecting changes in physical and physiological measures in athletes before, during, and after a specified duration of chiropractic care.”^{15(p.2)} Twenty-eight male university baseball players (ages 19–23 years), undertaking the same training schedule and workout regimen, were randomly assigned to either a control group (no SMT) or chiropractic group (Palmer side posture cervical toggle-recoil thrust adjustment). Outcome measures included a vertical jump test, a specified landing broad jump test, a standard broad jump test, a muscle strength test, resting blood pressure and pulse rate, a treadmill cardio-stress test, and a visual count of nail-fold microcirculation. Measurement values were obtained at the beginning of the study, at 5 weeks and at 14 weeks duration of chiropractic care. Results indicated similar trends in both the control and chiropractic groups for all measures, thus there were no statistically significant differences between the 2 groups. Despite the fact that the study generated essentially no useful statistically or clinically significant results, the authors concluded that the “consistent trends of improvement in the group receiving adjustments compared to controls strongly suggests an association between the upper cervical chiropractic care administered in the present study and physical and physiological change.”^{15(p.7)} The authors failed to comment on the validity and reproducibility of their outcome measures, and the clinical importance of their measures in regards to the specific athletic performance skills necessary in the sport of baseball.

In 2006 Shrier et al., utilized a crossover study design with 19 elite sprint sport athletes to compare changes in jump height and running velocity with and without prevent high-velocity, low-amplitude (HVLA) manipulations applied from the thoracolumbar region to the mid-tarsal region depending on physical assessment findings.¹⁸ Outcome measures included countermovement jump (CMJ) height, electronic sprint time from a moving start for 40 meters, and perception of post intervention soreness. Results indicated a decrease in the CMJ for both the control and HVLA interventions, with qualitatively less decrease after manipulation, and sprint times improved with manipulation and worsened with the control, however the results were not statistically significant.¹⁸ The authors postulated that the direction and magnitude of the changes following HVLA manipulations were consistent with a clinically relevant performance enhance-

ment despite the lack of statistical significance, and after accounting for study limitations the authors concluded that their results suggest that both the potentially positive and negative effects of HVLA manipulations on athletic performance warrant further study.¹⁸

To this author's knowledge, the most recent study with a specific focus on chiropractic treatment and the enhancement of sport performance is by Costa et al., (2009) investigating the effect of SMT with stretching compared with stretching alone on full-swing performance in golfers.¹⁹ Experienced golfers with homogenous characteristics were randomized into 2 groups, stretching alone (n = 20) versus stretching and SMT (n = 23). Both groups underwent a standardized stretching program.¹⁹ Following stretching, the golfers would perform 3 trial full swing maneuvers, and then the SMT group subjects were evaluated for the presence of low-back, thoracic, and neck joint dysfunction.¹⁹ As determined from the chiropractic evaluation, spinal manipulation was performed.¹⁹ Then the golfers performed an additional 3 full swing maneuvers, the outcome distance was considered the average of the final 3 swings.¹⁹ The procedure was repeated once a week for 4 weeks.¹⁹ An improvement in full swing performance, as determined by average 3 shot distance, for the SMT group was observed on each treatment day, with statistical significance achieved on the fourth day.¹⁹ No statistical significance was obtained for the non-SMT group, and on the fourth day the non-SMT group experienced a decrease in performance.¹⁹ The authors acknowledged a variety of limitations including a small sample size and lack of control for subject activities outside of the study protocol.¹⁹ Costa et al., (2009) concluded that "SMT in association with muscle stretching seems to be associated with an improvement in golf players' full-swing performance when compared to muscle stretching alone."^{19(p.169)}

5. Future directions for research

Based on the articles reviewed for this publication, it would seem that the direction for future research in the area of chiropractic treatment and sports performance enhancement is quite simply - anywhere. Specifically, the chiropractic profession has only begun to investigate a few possibilities of "if" and maybe "how" chiropractic treatment has an effect on athlete performance. It would seem that a major difficulty inherent with the investiga-

tion of the effects of chiropractic treatment on athletic performance arises directly from the apparent confusion surrounding the definition of what constitutes a "chiropractic treatment."²⁰ There is very little information compiled to clearly express what interventions chiropractors utilize to potentially influence an athlete's performance, what aspects of performance they may or may not be intending to affect, or if for the majority of chiropractors, "performance enhancement" is an intended outcome of treatment at all.²⁰ Research on chiropractic and sports performance enhancement should perhaps begin by defining "how" rather than "that" chiropractors affect performance. Greenstein (1997) succinctly pointed out that "performance can be determined by a variety of factors, including but not limited to biomechanical, neurophysiologic, and psychological variables."^{20(p.285)} He asks "how does chiropractic fit into these variables and what, in this theme, would be the definition of chiropractic?"^{20(p.295)} Should the model of chiropractic care/treatment be limited to chiropractic adjusting or manipulative techniques?²⁰ Or is sports chiropractic a "multidisciplinary approach that applies spinal manipulative therapy, as well as soft-tissue techniques, physical therapy, rehabilitation, innovative training techniques, nutritional counseling, plyometrics, education on injury prevention, and more?"^{20(p.295)} Until there is greater understanding of the exact treatment interventions and objectives that chiropractors employ for the treatment of athletes, the ultimate goal of providing quantitative evidence in support of chiropractic athletic performance enhancement will remain elusive.

Another difficulty that must be overcome in order to legitimately research the effects of chiropractic treatment on athlete performance is the definition of "performance." How is "performance" and therefore "performance enhancement" defined from a chiropractic treatment perspective? Is it winning the race, lifting a heavier weight, scoring more points, or winning the game? Is performance related to individual athletic variables such as speed, strength, agility, or sport technique? Or is it simply the subjective report of improvement or injury recovery from a coach, trainer, or the individual athlete? These questions all need to be answered and put into a frame of reference prior to designing a particular research study. Conditions that quantify a given "sport performance" must be realized via a thorough investigation of the specific par-

ameters relevant to performance in the specific sport or discipline of interest. Tests must be developed or utilized that fully cover the sport-specific parameters, and allow for accurate classification and analysis of results.⁵⁸ In addition, the training or therapy intervention methods utilized to affect those parameters must be standardized and documented. Müller et al. (2000) supports this view by commenting that the quality of performance intervention research depends on the quality of the “performance diagnostics” or tests of performance.⁵⁹ In other words, before analysis of performance is undertaken, “performance indicators” or “performance parameters” need to be determined and defined, and then diagnostic tests of performance must be developed and validated.^{58,59} This is the challenge that faces chiropractors wishing to prove the efficacy of chiropractic treatment for sport performance enhancement.

Conclusion

This literature review sought to determine the extent of current information and evidence supporting the use of chiropractic care for the purpose of sport performance enhancement. Although many studies, ideas and theoretical frameworks have been postulated and discussed, it seems that at this time there is insufficient evidence to convincingly support the notion that treatment provided by chiropractors can directly and significantly improve athlete sport performance. The authors of the reviewed articles should be commended for their foundational work; collectively they represent the building blocks for continued and future research in this fascinating area of chiropractic. Additional research may or may not provide support towards a regular regimen of chiropractic treatment for competitive level athletes. Regardless of this, it would be prudent for the chiropractic profession to use qualifying phrases when reporting, via case studies, the anecdotal observation of athletic enhancement after chiropractic treatment. Until further research is undertaken it would be more accurate for authors to state that their observations of chiropractic treatment benefiting athlete performance, “tend to suggest,” or “may indicate,” that certain treatment techniques provided by chiropractors “may” indirectly affect performance in competitive athletes. It is sincerely hoped that the research in this area will continue, and that perhaps this review will stimulate new ideas and new directions for additional research.

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