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Dr. Diana De Carvalho, DC, MSc, PhD Candidate

Dr. Diana De Carvalho
University of Waterloo

The CCA is delighted to announce that Dr. Diana De Carvalho has been named a recipient of the 2010 CCA Young Investigator Award.

This award recognizes young researchers working in the field of chiropractic and is given for a paper submitted for this competition that has not yet been published, or for a *recently* published paper. The investigator has not had his/her degree longer than two years before submitting the work.

Dr. De Carvalho has made very significant contributions to the chiropractic community. Among her many achievements to date, she recently published the research paper set out below which has had very high impact in the scientific literature. As the "lead author" in this high quality paper, Dr. De Carvalho has established herself as a very capable young researcher and clearly in a position to collaborate effectively with world class researchers.

Diana De Carvalho*, David Soave, Kim Ross, Jack Callaghan. Lumbar spine and pelvic posture between standing and sitting: a radiologic investigation including reliability and repeatability of the lumbar lordosis measure. J Manip Physiol Thera. 2010; V33(1):48–55.*

Dr. Diana De Carvalho DC, MSc, one of our profession's young researchers, has won the CIHR Doctoral Research Award for her study entitled:

> *"Effectiveness of a lumbar support in maintaining the lumbar lordosis in sitting: A radiographic comparison of initial and long-term effects on lumbar spine and pelvic posture during simulated prolonged driving".*

The award of $66,000 funds her PhD studies at the University of Waterloo. She is studying under the supervision of Dr. Jack P. Callaghan who currently holds the Canada Research Chair in Spine Biomechanics and Injury Prevention. Dr. De Carvalho's research goal is to examine the spine biomechanics and low back pain injury mechanisms associated with sitting. Specifically, she is interested in gender differences and spine posture responses to prolonged static conditions.

Congratulations to Dr. De Carvalho!

Dr. Cesar Hincapié, DC, PhD candidate

Dr. Cesar Hincapié
University of Toronto

The CCA is delighted to announce that Dr. Cesar Hincapié has been named as a recipient of the 2010 CCA Young Investigator Award.

This award recognizes young researchers working in the field of chiropractic and is given for a paper submitted for this competition that has not yet been published, or for a *recently* published paper. The investigator has not had his/her degree longer than two years before submitting the work.

Dr. Hincapié has raised the platform of the profession by his exemplary contributions to the chiropractic community.

In his recently published paper set out below, Dr. Hincapié is the "principal investigator" in a highly significant study that analyzes pain after traffic injuries.

Clearly, he represents one of rising stars in the scholarly community and demonstrates the creativity, knowledge and skills required in a young investigator to effectively collaborate in a trans-disciplinary global milieu.

***Hincapié CA**, Cassidy JD, Côté P, Carroll LJ, Guzmán J. Whiplash injury is more than neck pain: a population-based study of pain localization after traffic injury. In press, Journal of Occupational and Environmental Medicine, 2010.*

Dr. Cesar A. Hincapié DC, MHSc has been awarded the prestigious CIHR Fellowship Award in the Area of Knowledge Translation. The award comes with $165,000 and supports his PhD program. The project title is:

> *"An epidemiologic assessment of the risk for acute lumbar spine disc herniation from chiropractic care".*

In this CIHR Funding Competition, a total of 15 applications were received of which only one was approved for funding.

Dr. Hincapié is a PhD candidate in Epidemiology at the Dalla Lana School of Public Health, University of Toronto, a doctoral trainee in the Division of Health Care and Outcomes Research, at the Toronto Western Research Institute, University Health Network, and a research associate in the Artists' Health Centre Research Program, at the Toronto Western Hospital. His current research interests include the epidemiology of musculoskeletal disorders and injury. He is undertaking his doctoral training with Dr. David Cassidy and Dr. Pierre Côté, at the University Health Network.

Congratulations to Dr. Hincapié!

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

Andrew L. Miners, BPHE, BSc (Hons), CSCS, CK, DC, FCCSS(C)*

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

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

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 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 computer 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 subjects 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) investigated "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 significantly 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 pre-event 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 enhancement 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 investigation 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 parameters 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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Talocalcaneal coalition in a 15 year old female basketball player

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This case reports an adolescent athlete with activity related chronic bilateral dorsal foot pain and stiffness. A 15 year old competitive female basketball player presented to a chiropractor subsequent to an unsuccessful course of conservative treatment for posterior tibial dysfunction. The patient's plain films were incorrectly read as normal and a CT scan obtained by the radiologist called the findings bilateral osteoarthritis. The patient was awaiting a referral to a rheumatologist at the time of initial consultation with the chiropractor. Examination revealed limited subtalar mobility and review of the images revealed bilateral non-osseous talocalcaneal coalition. The patient was subsequently directed to a pediatric orthopedic surgeon and is scheduled for a resection of the coalition. Primary care practitioners should be aware of this uncommon, but not rare, variable clinical presentation as misdiagnosis and mismanagement could lead to suboptimal patient outcomes. To our knowledge this is the first case report of a patient with tarsal coalition published in chiropractic literature. In addition, this case is the first to report radiographic evidence of chronic mechanical stress to the second metatarsal associated with tarsal coalition.
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KEY WORDS: adolescent, tarsal coalition, talocalcaneal

Ce cas concerne une athlète adolescente souffrant de douleurs et de raideur chroniques à la région dorsale du pied bilatéral. Une joueuse de basketball de 15 ans se présenta chez un chiropraticien suite à une série de traitements conservateurs n'ayant pas réussi à guérir un dysfonctionnement tibial postérieur. Les radiographies de la patiente furent jugées normales à tort, et un tomodensitogramme obtenu par le radiologue ont démontré de l'arthrose bilatérale. La patiente attendait d'être recommandée à un rhumatologue au moment de sa première consultation avec le chiropraticien. Un examen a révélé une mobilité dans l'articulation sous-astragalienne, et un examen des radiographies révéla une synostose astragalocalcanéenne non osseuse bilatérale. La patiente fut envoyée à un chirurgien orthopédique pédiatrique, et doit subir une résection de la synostose. Les médecins de premier recours doivent savoir que cette présentation clinique variable peu courante, mais pas rare, constitue un mauvais diagnostic et peut entraîner des résultats sous-optimaux pour les patients. Selon nos connaissances, c'est la première fois où l'on fait état dans une publication sur la chiropratique d'un patient souffrant d'une synostose du tarse. En outre, c'est la première fois que radiographies démontrent un stress mécanique chronique au second métatarsien associé à la synostose du tarse.
(JCCA 2010; 54(4):222–228)

MOTS CLÉS : adolescente, synostose du tarse, astragalocalcanéenne

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Introduction

Congenital tarsal coalition is a diagnosis that is often overlooked in young patients who first present with foot and ankle pain.[1] Tarsal coalition is an abnormal fibrous, cartilaginous or osseous fusion of two or more tarsal bones.[2,3] The prevailing etiologic theory for congenital coalitions, is failure of complete segmentation of mesenchyme with the absence of normal joint formation.[3–5]

Approximately 50%–80% of cases of tarsal coalition are bilateral,[4,6] and more than 90% of coalitions are located between the calcaneus and the navicular or between the talus and calcaneus.[3,6] Calcaneonavicular and talocalcaneal coalitions have been reported to occur in approximately equal frequency,[6,7] however, recent investigations suggest that calcaneonavicular coaltions occur 3 times more frequently.[2,8]

The true prevalence of tarsal coalition in the general population is unknown. However, conservative estimates from x-ray diagnostic series' report a prevalence of approximately 1%.[1] A recent prospective analysis of 674 consecutive patients referred for ankle MRI's at the NYU Hospital for Joint Diseases demonstrated a 12% prevalence of tarsal coalition.[2] Thus the prevalence of tarsal coalition in clinical populations may in fact be much higher than is commonly reported.

According to the practice analysis of Chiropractic conducted in 2003 in the United States, lower extremity conditions contribute to 8.8% of the chief clinical complaints for which a patient seeks care from a chiropractor.[9] To our knowledge there have not been any cases of tarsal coalition published in chiropractic literature. The purpose of this diagnostic case report is to create awareness of an uncommon, but not rare, clinical condition that may present to chiropractors. This report details the complex diagnosis of bilateral non-osseous talocalcaneal coaltion in a 15 year old female with chronic bilateral activity-related dorsal foot pain and stiffness who was previously misdiagnosed and mismanaged.

Case Report

A 15 year-old female, competitive basketball player, consulted a chiropractor with a 2 year history of bilateral foot pain, worse on the left. Her chief complaint was a dull and achy pain across the dorsal aspect of the foot, in the region of the talus, but was poorly localized. An occasional sharp pain in the medial hindfoot with activity was also noted by the patient. A secondary complaint was bilateral stiffness with global ankle movement. The patient attributed her activity-related foot pain over the past few years to the "Active Ankle" braces she was required to wear by her team to prevent ankle sprains. The patient did not have a history of acute trauma.

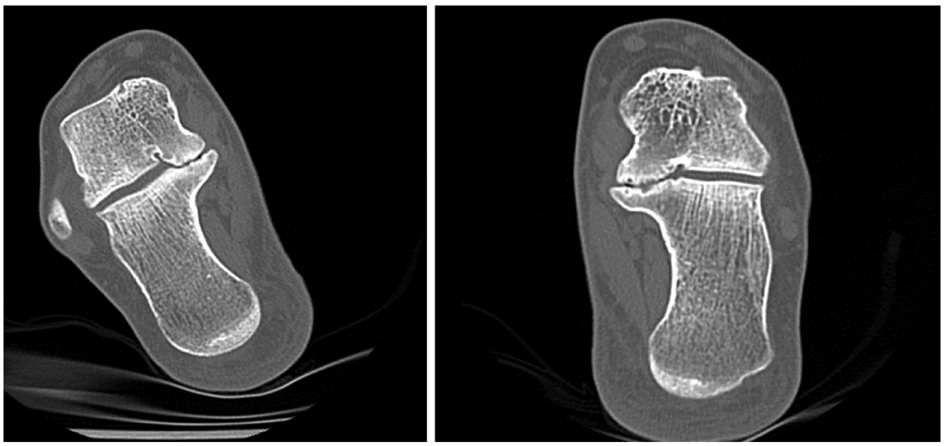
When she was 12 years of age she was prescribed custom fit orthotics to help manage bilateral activity related knee pain. At 13 years of age she experienced occasional bilateral dorsal foot pain after a lot of walking, which was alleviated initially by regularly wearing her orthotics.

The intensity of her symptoms rapidly increased in the previous five months as she was training 5 days per week, 2 times per day in preparation for a regional development basketball camp. She was also training for track and field during this period. The increase in dorsal foot pain forced her to leave the basketball camp and she has been unable to return to play.

At the time of her chiropractic consultation her medical care to date had included a recent visit to her family doctor. Plain films were taken of the left ankle, which were repeated two weeks later. Both sets of plain films were read as normal. A bone scan was subsequently ordered to investigate the possibility of metatarsal stress fractures. The bone scan was unremarkable in the region of the metatarsals, but showed abnormal focal uptake at the posterior and medial aspects of the talus bilaterally. A diagnosis of osteochondritis dessicans was suspected by the radiologist who subsequently recommended a CT scan of both ankles. The CT scan showed irregular articular contours, narrowed joint space and subchondral cysts with sclerosis in the middle subtalar joints in both ankles, worse on the left (Figure 1). The CT report impression was bilateral osteoarthritis and subsequently the family doctor referred the patient to a rheumatologist. The patient was awaiting consultation with a rheumatologist at the time of the initial chiropractic consultation.

Her medical care also included regular physiotherapy since being forced to stop playing basketball. The physiotherapist treated her for posterior tibial dysfunction. Treatment included soft tissue friction, ultrasound, wobble board exercises and strengthening exercises. The patient found the visits painful and they aggravated her condition, but she was encouraged to continue with the plan of management. This continued for approximately three months with no improvement in the foot and ankle

Figure 1 *Non enhanced coronal CT images of the right (image a) and left (image b) medial subtalar joint demonstrating small joint spaces with irregular articular contours, subchondral cyts and sclerosis, which appears more advanced on the left (image b). These findings were interpreted by the initial radiologist as bilateral osteoarthritis, but were eventually interpreted by a 2nd chiropractic radiologist as incomplete osseous talocalcaneal coalition.*



pain. She also consulted the MD who had made her last pair of orthotics, who prescribed and fitted the patient for a new pair.

Upon examination the patient had moderate pes planus and moderate rear foot valgus on static observation. She walked with mild bilateral forefoot abduction, but gait was otherwise unremarkable. Range of motion testing revealed bilaterally restricted dorsiflexion, inversion and eversion worse on the left side. Plantar flexion was full and pain free bilaterally. Passive inversion recreated her sharp pain posterior to the medial malleolus on the left. Motion palpation of the subtalar joint was significantly limited bilaterally, particularly in eversion. Resisted range of motion was full and pain free. Pain on palpation was non-specific, in the region of the talus bilaterally. Functional testing, including hopping on one foot, aggravated the patients' chief complaint of dorsal foot pain.

All existing imaging was requested from the patient. Upon reviewing the lateral view of the left foot plain films (Figure 2) an abnormal cortical confluence extending from the talus to the sustentaculum tali was observed by the chiropractor. This radiographic finding has been termed the "C" sign and is suggestive of talocalcaneal coalition. The bone scan and CT findings, previously reported, supported this differential as well.

The chiropractor sent these images to a chiropractic radiologist, who confirmed the suspicion of a C-sign along with non-visualization of the middle subtalar facet joint on the plain films. His interpretation of the plain films in combination with the bone scan and CT results confirmed the diagnosis of bilateral incomplete talocalcaneal coalition. Diffuse cortical thickening along the shaft of the 2nd metatarsal in the plain film AP view of the left foot was also noted at that time.

The chiropractor directed the patient to send the chiropractic radiologist's report and imaging directly to a hospital specializing in pediatric orthopedics. The orthopedic department agreed with the image findings and interpretation and subsequently scheduled a consultation with a pediatric orthopedic surgeon. The patient was advised of a 30% chance of satisfactory resolution of her symptoms with a below knee walking cast by the orthopedic surgeon. The cast was placed on the left leg for 6 weeks, then the right for 6 weeks. This treatment did not change the patient's symptoms and surgery was subsequently scheduled for the excision of the left talocalcaneal coalition. Surgery on the right foot is expected to follow 6 weeks later.

While waiting for the orthopedic consultation the patient received a cortisone injection in the left ankle. This treatment was self-directed. The treatment was not successful and was not repeated on the right ankle.

A second chiropractic consultation after the casting

Figure 2 *Plain film lateral view (image b) of the left foot demonstrates non-visualization of the middle subtalar joint and is associated with a "C" sign of the confluence of medial talar process and sustantaculum tali suggestive of talocalcaneal coalition. Diffuse cortical thickening is also detected in the AP view along the shaft of the 2nd metatarsal (image a).*

treatment for the left leg, revealed that as a child she always had "funny" gait, walking and running with toes out (which was described as a windmill effect). She would also refuse to walk long distances as child. Since the initial chiropractic consultation and left foot casting she was now starting to experience hindfoot pain localized to the region of the posterior calcaneus. Currently the patient is awaiting surgery.

Discussion

Coalitions are usually fibrous or cartilaginous at birth, but many begin to ossify in late childhood.[10] Therefore, the pathogenesis of tarsal coaltions is best viewed as a spectrum of pathology with progressive ossification representing increasing severity of the condition. Many individuals with tarsal coalition remain asymptomatic throughout their life.[4,11] It is suspected that biomechanical stress through physical activity may explain the progression of the spectrum of pathology. With repetitive microfracturing and remodelling the coaltion progressively becomes more osseous, resulting in increasing rigidity and evolving histological changes at the coalition site. This progressive ossification contributes to increasing pain sensitive structures at the coalition site, and also contributes to pain in joints surounding the coaltion due to biomechanical compensations. For example, increasing rigidity at the subtalar joint, results in dysfunctional shock absorption during gait and subsequently the transverse tarsal joint (calcaneocuboid and talonavicular joints) is forced to help dissipate these additional forces.[12] The patient in this case indicated that her left leg was her power generating take off foot for basketball. Her left leg was more symptomatic, had higher intensity of dorsal foot pain and more stiffness, and also demonstrated greater progression of ossification on CT. Future studies might consider investigating the role of leg dominance in the progression of tarsal coalition in athletes.

Patients with tarsal coalition most commonly present with hindfoot pain and stiffness.[6,13] The pain is generally reported in the region of the subtalar or talonavicular joint.[10] The patient in this case first presented with bilateral dorsal foot pain that was worse after activity. The pain was located in the region of the talus, but not specifically confined to the talonavicular joint. She also noted occasional sharp pain posterior to the medial malleolus that was recreated with passive inversion in the physical examination. She eventually started experiencing progressing hindfoot pain two years after the onset of dorsal foot pain on the more symptomatic left foot. The vague symptomatolgy in this case may have contributed the confusion and delay in an accurate diagnosis.

Limited hindfoot mobility, specifically subtalar inversion and eversion, is the most common physical examination finding in patients with talocalcaneal coalition.[13] The patient in this case reported subjective stiffness confirmed with observable limitation with these movements. Subtalar motion palpation also demonstrated limited, although not completely absent, mobility.

Patients may also present with a rigid planovalgus foot, also called peroneal spastic flatfoot, however this occurs in a minority of patients and not the majority as often cited in early publications on tarsal coalition.[3] Our patient did present with moderate bilateral pes planus and moderate rear foot valgus. A large case series by Takakura et al demonstrated that a bony prominence inferior and posterior to the medial malleolus may be palpated in cases of talocalcaneal coalition. These patients may also exhibit symptoms of tarsal tunnel syndrome, such as sensory disturbance in the sole of the foot and a positive tinel's test.[13] A bony prominence was not palpated in this case and the patient did not display symptoms of tarsal tunnel, however the sharp pain with inversion posterior to the medial malleolus may represent pain at the site of medial subtalar coalition. Our case emphasizes the importance of assessing the mobility of the subtalar joint in the physical examination.

The majority of symptomatic talocalcaneal coalition patients present clinically between 12 and 16 years of age.[3,6] Our patient first reported activity related bilateral knee pain at 12 years of age and a year later reported dorsal bilateral foot pain. By 15 years of age the intensity of dorsal foot pain forced her to minimize her activity level. Around this time she also started to note the progression of hindfoot pain.

Patients with tarsal coalition often present clinically after traumatic injury.[3,14] Ankle sprains have been reported by many authors as a common presenting complaint.[14,15] Mubarek et al also added fractures of the fifth metatarsal head and distal tibia as associated injuries in their series of 69 patients with tarsal coalition.[14] The patient in this case did not have a history of an acute traumatic injury but did have a recent history of left forefoot symptoms. Radiographs of the left foot demonstrated periosteal thickening in the second metatarsal suggestive of chronic mechanical stress. This radiographic finding has not been previously reported, to the authors' knowledge, in cases of tarsal coalition in athletes. The radiographic evidence of chronic bony adaptation is suspected by the authors to be related to the progressive biomechanical compensations secondary to the ossifying coalition. Studies that have measured plantar pressure in patients with tarsal coalition have noted excessive medial mid foot peak contact pressures with diminished peak contact pressures in the lateral forefoot and lateral rear foot compared to normal.[16,17] Excessive loading of the medial side of the mid foot and inadequate load distribution of the forefoot may have contributed to chronic stresses of the second metatarsal in this patient.

X-rays of the foot should be the first imaging modality selected for patients with suspected tarsal coalition.[10] Crim et al concluded that routine anterior-posterior and lateral x-rays are a sensitive screening test for both talocalcaneal and calcaneonavicular coalitions.[18] The review by Newman and Newberg and the study by Crim et al provide an excellent evaluation of the key radiographic signs practitioners should be looking for in cases of suspected tarsal coalition.[1,18] Crim et al determined that the most accurate radiographic signs for diagnosing talocalcaneal coalition are the C-sign and talar beaking visualized on lateral views of the foot.[18] Absent visibility of the subtalar facets (usually middle subtalar facet) and a dysmorphic sustentaculum tali are also helpful in diagnosing talocalcaneal coalition on a lateral x-ray of the foot, however the accuracy of these signs can be confounded by the direction of the x-ray beam.[18] The 15 year old patient in this case demonstrated a positive C-sign and absence of the middle subtalar facet on the lateral radiograph. This radiographic series was initially read as normal by the hospital radiologist, and highlights the importance of practitioners reading their patients films with awareness of these signs.

Axial and coronal CT images are considered the current imaging gold standard for diagnosing tarsal coalition. Many authors have speculated that MRI is more accurate at visualizing non-osseous coalitions. However, in a blinded prospective investigation Emery et al concluded although MRI has a high rate of agreement with CT, it is not superior in detecting non-osseous coalitions.[19] CT findings for complete tarsal coalition are the presence of an osseous bar between tarsal bones. The more common incomplete coalitions are demonstrated by articular narrowing with subchondral sclerosis or cystic changes[1,19], all of which were apparent in the middle subtalar facet of the case. Although these CT findings were all discussed in the initial report, the radiologist's interpretation of these findings resulted in delayed diagnosis.

Many authors believe symptom presentation correlates with the degree of progressive ossification.[3,8, 14] Our case supports this contention as more advanced CT findings were evident on the symptomatic foot. Clinical investigations quantifying imaging findings and degree of pain and disability would be helpful to determine this degree of correlation.

There is a lack of evidence for outcomes in conservatively managed cases of tarsal coalition. Expert opinion suggests that conservative measures may be adequate in less progressed cases of coalition, where symptoms are tolerable and non-disabling.[3,13,14] Conservative treatment options that have been proposed for symptom management are modifying activity level, cold compresses, NSAIDs and therapeutic modalities or a trial of care with supportive devices such as hard soled shoes, foot orthoses, ankle stabilizing orthoses or a short-leg cast.[3,13] The patient in this case successfully managed her initial dorsal foot symptoms with custom orthotics, but over time the orthotics aggravated her symptoms. Rigid boot casting was unsuccessful for symptom resolution in this case.

To our knowledge, there has been no discussion in the literature regarding the value or contraindications of specific manual therapies in cases of tarsal coalition. Limited hind foot mobility, commonly associated with tarsal coalition, may influence manual therapists to consider joint manipulation or other mobility enhancing techniques. It is our opinion that extremity manipulation of a joint directly affected by the coalition should be contraindicated. Although the biomechanical forces subjected to an extremity joint during a manual manipulation are unlikely to structurally damage a coalition, the intent of the manipulation should be questioned considering the joint is pathologically, and not functionally restricted. Manual therapy in joints surrounding the coalition may be of benefit considering the increased compensatory biomechanical stresses encountered. Exercise based treatments, such as those utilized in this case prior to accurate diagnosis, should also be contraindicated in symptomatic tarsal coalition as this may contribute to the progressive ossification of the coalition.

Surgical resection of the coalition has received the most attention in the literature, with orthopedic case series' reporting successful short term (mean post-surgical follow up of 1 to 5 years) outcomes ranging from 50–94% of cases.[14,20,21,22] Positive prognostic factors for surgical resection of a coalition include minimal joint space involvement (less than 50%), higher fibrous or cartilaginous content, non-skeletally mature patients, lack of secondary osteoarthritis changes and minimal rear foot valgus (less than 16 degrees).[20]

For young athletes who meet the criteria for positive surgical outcomes and wishing to continue to compete at a high level, surgical resection should be strongly considered. Patients who are candidates for surgical resection, but do not elect surgery are less likely to return to desired activity levels.[23,24] Mean duration to return to activity is approximately 10 weeks in those who elect surgical resection.[23]

The long term benefits and repercussions of surgical resection are relatively unknown. The longest available follow-up period post resection surgery in any case series is 10 years.[25] Those authors reported satisfactory results in eight patients with no deterioration of symptom relief, range of motion or progressive degenerative joint changes. Larger, prospective analyses are required to determine the long term effect of surgical resection.

Conclusion

Tarsal coalition is an often overlooked cause of pain in adolescents that present with foot pain. We report a diagnostic case of a competitive 15 year old basketball player who was eventually diagnosed with talocalcaneal coalition. Although tarsal coalition is an imaging based diagnosis that often results in orthopedic management, our case highlights the necessity for all primary care practitioners responsible for diagnosing and managing foot pain to be cognizant of the key diagnostic features of talocalcaneal coalition. In adolescent athletes, delayed diagnosis and inappropriate management may lead to decreased chance of return to competitive activity.

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Myositis ossificans traumatica of the deltoid ligament in a 34 year old recreational ice hockey player with a 15 year post-trauma follow-up: a case report and review of the literature

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Myositis ossificans traumatica is a relatively common injury associated with sports especially those involving contact. It continues to frustrate both athlete and health practitioner alike due to its continued lack of treatment options and a lengthy natural history. This case study chronicles the observation of a 34 year old recreational ice hockey player who presented 7 years post-trauma, was diagnosed with myositis ossificans traumatica and was followed up on 8 years later (15 years post-trauma). This case report is suspected to be the first published case study of its kind. The literature review outlines the various types of myositis ossificans, its incidence, pathogenesis, differential diagnoses including osteosarcoma, and the various methods/modalities reported in its treatment.
(JCCA 2010; 54(4):229–242)

KEY WORDS: myositis ossificans traumatica, heterotopic ossification, post-traumatic myositis ossificans, ice hockey, deltoid ligament

La myosite ossifiante traumatique est une blessure relativement courante liée à la pratique des sports, particulièrement les sports de contact. Elle continue de frustrer les athlètes et les professionnels de la santé en raison de l'absence d'options de traitement et du fait qu'elle existe depuis longtemps. Cette étude de cas raconte l'observation d'un joueur de hockey sur glace de ligue récréative de 34 ans qui reçut un diagnostic de myosite ossifiante traumatique après 7 ans, et qu'on examina ensuite 8 ans plus tard (15 ans après le traumatisme), Cette étude de cas est probablement la première en son genre. Une analyse de la documentation à ce sujet souligne les divers types de myosite ossifiante, sa fréquence, sa pathogénie, les différents diagnostics, notamment l'ostéosarcome, et les diverses méthodes/modalités signalées dans son traitement.
(JCCA 2010; 54(4):229–242)

MOTS CLÉS : myosite ossifiante traumatique, ossification hétéropique, myosite ossifiante post-traumatique, hockey sur glace, ligament deltoïde

Introduction

Myositis ossificans traumatica (MOT) is often defined as heterotopic, non-neoplastic proliferation of bone in an area previously exposed to trauma and hematoma.[1,2]

The most common areas that are affected by MOT are the quadriceps femoris, brachialis anticus, and the adductor muscles of the thigh[3] although it may occur anywhere. It can happen at any age, but occurs most frequently in adolescents and young athletes, with over half of the cases occurring in the third decade.[1,3] MOT is considered rare in children under 10 years of age[1] and males are more often affected than females.[3]

The incidence of MOT following quadriceps contusions is reported at varying percentages depending on the severity of the injury. Mild contusions have shown an incidence of MOT of 0–9%, moderate to severe 17–72% and recurrent contusion 100%.[4,5] Contusions of the thigh are generally graded according to the subsequent loss of range of motion at the knee joint. Contusions are graded as mild (active ROM greater than 90º), moderate (45–90º)

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Figure 1 *Photograph of patient's bilateral ankles. The arrow indicates the area of myositis ossificans traumatica of the left medial ankle.*

Figure 2 *Photograph of the patient's left medial ankle. The arrow indicates the area of myositis ossificans traumatica.*

and severe (less than 45º).[5] Arrington[6] grades thigh contusions as: mild – near normal ROM, local tenderness, no gait abnormality; moderate – swollen tender muscle, 75% ROM, antalgic gait; and severe – marked tenderness/swelling, 50% ROM with a severe limp. Muscle contusion injuries are second only to strain injuries as a major cause of morbidity in the modern athlete.[2]

This paper presents a case study of a 34 year old recreational ice hockey player who was diagnosed with MOT of the deltoid ligament of the ankle 7 years post-trauma and followed up on 8 years later (15 years post-trauma).

Case Report

History

A 34 year old recreational hockey player presented with an unusual bony lump just anterior and inferior to his left medial malleolus (see Figure 1 and 2). He reported that the lump had started following blocking a shot in a hockey game 7 years previously. He was able to finish the game and had partial weightbearing following the game. The foot became increasingly swollen and was treated with rest and ice. No radiographs were taken at the time of the initial injury. He reported that the lump had increased in size slowly over the next few years. Two years after the injury, he had returned to play competitive hockey and didn't recall any limitation although the lump had not resolved. Four years post injury, he began to notice the lump was larger and was becoming increasingly irritated from the direct pressure of tightening his skate laces. He was also getting sharp pain in his foot with pivoting while skating and noticed decreased range of motion especially in dorsiflexion. Seven years post-injury, he began to notice increased pain when turning around pylons while demonstrating drills as a hockey coach. Stopping, and backward skating had also become painful and pivoting was still difficult due to pain. He also noted increasing difficulty going up stairs and felt he had to lift his leg higher to get his foot flat on the next stair. At this point, he presented to the clinic for examination and possible imaging.

There was no history of recent infection, sudden unexplained weight loss or night pain. Systems review revealed a history of seasonal bronchitis but was otherwise unremarkable. Previous medical history revealed a previous right shoulder surgery for recurrent subluxation but no other major traumas or motor vehicle accidents. He did not report any previous injury to the left foot or ankle. Family history did not reveal anything relevant. He is an otherwise healthy individual who exercises regularly and

Figure 3 *Medial sagittal CT image of the left ankle 7 years post injury showing an irregular ossific density anteroinferior to the medial malleolus indicating myositis ossificans traumatica of the deltoid ligament. The white arrow indicates the area of ossification.*

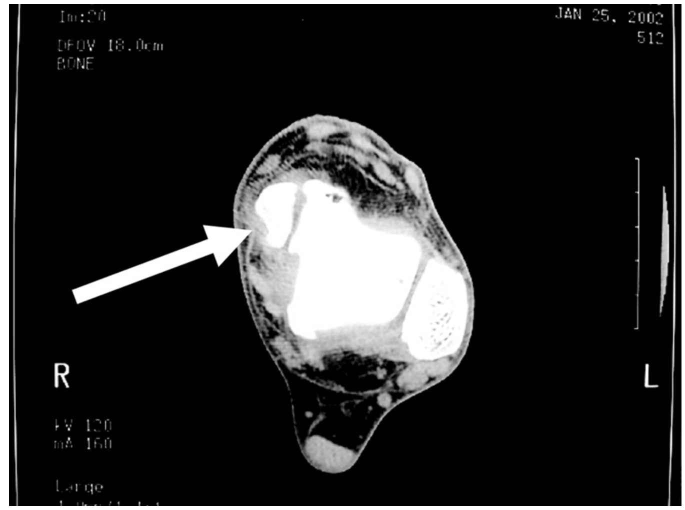

Figure 4 *Axial CT image of the left ankle 7 years post injury showing an irregular ossific density medial to the medial malleolus. The white arrow indicates the area of ossification.*

does not smoke. This patient is a factory worker and a part-time hockey coach.

He did not report any numbness or tingling in his foot or ankle.

Physical examination

Upon examination, the patient was able to ambulate normally. A visible prominence was noted anterior and inferior to the medial malleolus of his left foot. Active and passive range of motion revealed a decrease of 40% in dorsiflexion, inversion and eversion due to restriction not pain. Plantar flexion was decreased 10–20% due to soft tissue restrictions. (The patient felt he could go further but was tight and no bony end feel was noted.) Joint play of the midtarsal joints was within normal limits. Other ranges of motion were full and pain free. Strength was slightly decreased compared to the right side in all ranges but there was no pain. Palpation of the bony mass revealed some point tenderness but the foot and ankle were otherwise pain free. Radiographs and a CT were ordered for this patient at this point in the examination (see Figure 3–6) .

Diagnosis

The patient was subsequently diagnosed with myositis ossificans traumatica of the left deltoid ligament of the ankle.

Plan of management

The initial plan of management for this patient was to rule out any insidious diagnosis, including osteosarcoma, with the imaging. The diagnosis of osteosarcoma was unlikely due to the slow, progressive nature of the injury and its lack of pain but it was felt imaging was prudent in this case. Following the diagnosis, the patient was informed of the natural history of MOT and that there were few proven treatment options available at that time. Due to the relatively minor irritation experienced during hockey and activities of daily living the patient was not interested in surgery and decided to treat the area symptomatically with ice and rest as needed. A "wait and see" approach was taken with instructions that if the lump was increasing in size and/or pain that the patient was to return for further examination.

15 Year Follow-up

The patient, now 42 years old, was contacted to follow-up on his status. The patient reported that he felt there was little change in the size of the lesion on his left ankle. He still had similar restrictions with regard to his on-ice activities including quick pivoting and demonstrating drills and his activities of daily living including going up stairs. He felt these activities were difficult due to his decreased

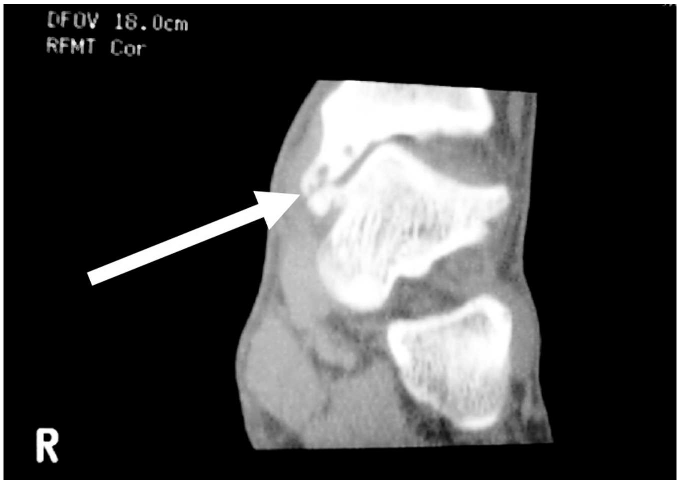

Figure 5 *Coronal CT image of the left ankle 7 years post injury showing an irregular ossific density anteroinferior to the medial malleolus. The white arrow indicates the area of ossification.*

ability to dorsiflex his ankle. The patient reported that he had learned to avoid certain aggravating activities because of the length of time of his injury. No follow-up physical exam was performed. Radiographic images were obtained at follow-up. The follow-up radiographs show that little change has occurred in the size of the MOT as visualized (see Figure 7 and 8).

Figure 6 *Radiograph left ankle AP view 7 years post injury showing an irregular ossific density inferior to the medial malleolus. The white arrow indicates the area of ossification.*

Discussion

Types of Myositis Ossificans

Heterotopic bone formation in soft tissue has historically been classified as myositis ossificans. Many authors now consider the term myositis ossificans to be a misnomer arguing that there is no inflammatory process and the condition may or may not involve bone or muscle tissue.[7,8] Myositis ossificans consists of three main types – congenital, idiopathic, and traumatic (see chart 1). Myositis ossificans traumatica (MOT) is also known in the literature by specific names given to MOT in specific areas of the body (see chart 2).[3,7,9,10] Arrington[6] classifies MOT into three types as does Mestan and Bassano (see chart 3).[10]

The pathogenesis of this injury remains unclear at this time. Some of the common theories include:[10]

1. transformation of muscle hematoma to bone;
2. hematoma calcification;
3. intramuscular bone formation from detached periosteal flaps;
4. osteoblast proliferation from periosteal rupture;
5. metaplasia of intramuscular connective tissue cells;
6. individual predisposition.

It is believed that blunt trauma to the extremity creates a compression wave travelling through soft-tissue crushing the deepest muscle against the bone. The force is transmitted through the fluid compartment of all of the layers of muscles but the damage usually occurs in the layer that is next to the bone.[5]

Figure 7 *Radiograph left ankle Oblique view 15 years post injury showing an irregular ossific density inferior to the medial malleolus. The black arrow indicates the area of ossification.*

Figure 8 *Radiograph left ankle AP view 15 years post injury showing an irregular ossific density inferior to the medial malleolus. The white arrow indicates the area of ossification.*

Wang[7] suggests that there are several steps following the injury to the tissue that leads to the development of MOT. There is cellular damage causing necrotic debris that is subsequently removed through the invasion of histiocytes. Fibroblasts from the endomysium then assail the injured cells and mesenchymal cells begin to proliferate. The fibroblasts and mesenchymal cells produce osteoid and chondroid tissue that lays down the groundwork for the formation of bone within the damaged tissue. This can occur as early as 4 to 5 days after the injury has occurred.

A particularly important aspect of MOT occurs at this

Chart 1 *Types of Myositis Ossificans*

1. Congenital[24]

- three inherited diseases that are characterized by heterotopic bone formation[24]
- these are: fibrousdysplasia ossificans progressive (FOP), progressive osseous heteroplasia (POH), and Albright's hereditary osteodystrophy (AHO)
- although rare, they should be included in children presenting with myositis ossificans of an idiopathic nature.

Fibrousdysplasia ossificans progressiva (FOP):

- also called "stone man disease" and myositis ossificans progressive
- first described in the late 17th century
- characterized by the formation of bone in tendons and muscles.
- manifests itself in childhood and is slowly progressive resulting in the formation of a "second skeleton" in patients.
- very uncommon occurring in approximately 1 in 2 million.

Progressive osseous heteroplasia (POH):

- first described by Kaplan in 1994
- originally thought to be atypical FOP
- in contrast to FOP, ossification begins in the dermis and spreads to the subcutaneous tissue and fascia with no skeletal abnormalities.
- POH is very rare and begins in childhood, similar to FOP.

Albright's hereditary osteodystrophy (AHO):

- manifests with a certain phenotypical presentation along with subcutaneous calcifications about the limb joints
- phenotypical features includes: short stature, a round facies, hypertelorism, and shortness of the 4th and 5th digits.
- mental retardation is also common in these patients.

2. Idiopathic

- controversy regarding the idiopathic nature of myositis ossificans and its naming.
- some authors use the term myositis ossificans circumscripta (MOC) to describe the heterotopic ossification of soft tissue of an idiopathic nature [25]
- other authors use MOC as synonymous with myositis ossificans traumatica[8, 16]
- has been reported following burns, tetanus, and polio and neurogenic injuries including spinal cord injuries, closed head injuries, central nervous system infections, and stroke[1,9]

3. Traumatic

- difficult to adequately research MOT due to its many synonyms.
- these include post-traumatic myositis ossificans, myositis ossificans circumscripta, pseudomalignant heterotopic ossification, pseudomalignant myositis ossificans, pseudomalignant osseous tumor of soft tissue, extraosseous localized non-neoplastic bone or cartilage formation[3]
- some radiologists consider the traumatic ossification of ligaments specifically to be called dystrophic calcification.
- dystrophic calcification is defined as "calcium salt deposits in the presence of normal calcium/ phosphorus metabolism involving tissues that do not physiologically calcify"[26] which may not adequately describe our case

Chart 2 *Specific Areas of MOT with Specific Names*[3,7,10,27,28]

"Rider's Bone", Prussian's Disease or "Saddle Tumor"	• found in the hip adductors in horseback riders and jockeys from the pressure of the saddle against upper/inner thigh. • described by Geschickter and Maseritz in 1938[27] as ossification in the thighs of cavalry men. Author's Note: the terms Prussian's Disease and saddle tumor were attributed to Ackerman[11] by Danchik et al.[3] but no mention of these terms were found when examining the Ackerman paper. A subsequent literature search of these terms did not reveal any articles on PubMed.
Pelligrini-Stieda Disease	• found in the medial collateral ligament of the knee. • first described by Pellegrini in 1905. Kohler reported a similar case in 1905 as well. Stieda, unaware of the previous works of Pellegrini or Kohler reported a similar case in 1907.[28] • most commonly found in football players.
"Rider's Bone"	• found near the attachment of the hamstrings at the ischial tuberosity. • Danchik et al.[3] suggests it is secondary to hypervascularity following an avulsion of the hamstrings • has also been called "Rider's Bone" due to the proclivity of this injury in horseback riders[3] • Common in sprinters, hurdlers and cheerleaders Author's Note: in checking Danchik's reference of Ackerman[11] no mention of "Rider's Bone" was found suggesting that the "Rider's Bone" mentioned may be similar to the aforementioned with "Prussian's Disease" and the ischial tuberosity injury as described is misnamed.
"Rifle Shoulder"	• found in the pectoralis major or anterior deltoid muscle due to the repeated kickback of a rifle or due to carrying the rifle on the shoulder. • most common in soldiers particularly the infantry. • described by Geschickter and Maseritz in 1938 [27] as the "rifle shoulders" of infantry men.
"Fencer's Bone"	• found in the brachialis anticus due to the overextension of the forearm[7] • most common in fencers and baseball pitchers.
"Dancer's Bone"	• found in the soleus muscle[7] Author's Note: a subsequent literature search of the terms "Fencer's Bone" and "Dancer's Bone" did not reveal any articles on PubMed.

Chart 3 *Classification of MOT*

Arrington Classification[6]		**Mestan and Bassano Classification**[10]	
1. stalk	there is a stalk attachment to the underlying bone	1. parosteal	the ossification is found near or against bone
2. periosteal	there is total continuity between the underlying bone and the heterotopic bone	2. periosteal	the periosteum is torn away from the underlying cortex due to the trauma. The resulting injury may have a sunburst appearance. Note: 60% of MOT's have a periosteal reaction secondary to the trauma.[12]
3. broad-based	is a large base of attachment to the underlying muscle	3. extraosseus	the heterotopic bone is found in the substance of the involved muscle

stage and is critical to the differentiation of MOT and osteosarcoma. The previously mentioned steps begin in the least damaged area moving toward the area of most damage. As a result, lamellar new bone is laid down in a centripetal pattern that is referred to as "the zonal phenomenon" (see Figure 9).[7,11]

Zonal phenomenon seems to be first mentioned by Ackerman in 1958.[11] He states, "I have been impressed by what I have designated as zone phenomena (inner, middle and outer zones)." He further states, "… they are well documented in examples of classic myositis ossificans, but no one has mentioned it, probably because the process is often recognized by typical histories and locations."[11]

Beginning in the second week to second month, bone is formed surrounding the area and then moves inward toward the site of injury giving layers of varying tissue activity. Moving inward, the outside layer is bone, the middle layer is an area of extensive osteoblastic and fibroblastic activity, and the central layer is an area of highly cellular tissue with a lot of cell differentiation and necrotic cells.[7,8] Osteosarcoma does not show this zonal phenomenon. The calcification seen with osteosarcoma begins in the central areas of the tumour. Unfortunately, if a biopsy

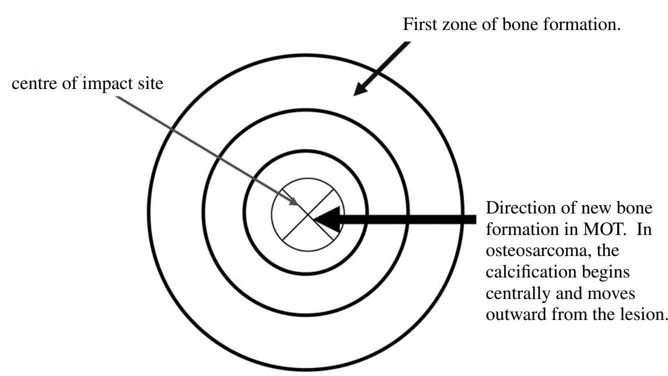

Figure 9 *The "Zonal Phenomenon" of MOT.*

of the area is done and the majority of the cells come from the middle and central layers, an incorrect diagnosis of osteosarcoma can been made and improper treatment has followed, including amputation.[3,12]

Typical Patient Presentation

A typical patient presentation includes a history of trauma to the affected area with increased difficulty in moving

Chart 4 *Myositis Ossificans Traumatica and Osteosarcoma*
A comparison of the two conditions includes the following:[23]

Myositis Ossificans Traumatica	Osteosarcoma
• history of trauma • found in the diaphysis • cortex usually intact even with a periosteal reaction • pain and mass decrease with time • activity-related pain • alkaline phosphatase levels often normal but can be elevated[2]	• no history of trauma (although trauma can occur in up to 40% of cases)[17] • found in the metaphysis • cortex often violated • pain and mass increase with time • night pain alkaline phosphatase levels elevated

and using the affected limb. In football, an opposing player's helmet to the thigh and in hockey and soccer, an opposing players knee to the thigh are common mechanisms of injury.[12] Trauma (direct and repetitive) is reported in 60–70% of the cases.[3] As previously mentioned the onset seems to be related to the severity of the injury.

In our case, the athlete reported a severe, yet common cause of trauma (blocking a shot). However, he did not feel it was severe enough to get a radiograph or seek treatment at the time of the injury.

A clinician should initially suspect the early stages of MOT if the pain, swelling and tenderness of the affected area has not responded to conservative management within the first 4–5 days.[12] This suspicion should increase further if the athlete reports that the symptoms have not improved significantly or have worsened within 10–14 days of the injury.[12]

A physical examination of an athlete suspected of having MOT begins with observation. If the injury is to the lower limb, particularly the thigh, an antalgic gait with limited weight bearing of the affected limb will often be noted as the athlete enters the treating room. The athlete will often have difficulty getting into the seated position due to an inability to flex the adjacent joints. A significant superficial hematoma is often noted with palpable tenseness of the affected area. However, a deep intramuscular hematoma may not produce visual signs of injury but should be suspected in cases of a severe blow to the limb.

Active, passive and resisted range of motion will be notably decreased in the affected limb with more severe injuries. In our case, the athlete's ankle range of motion was restricted but he was still able to function in his activities of daily living. While playing hockey, he reported that he was still able to play but certain movements while skating were difficult. Booth reports that muscle atrophy may be noted with persistent local tenderness and loss of range of motion.[12] There was no muscle atrophy noted in our case.

Beauchesne reported a case of MOT of the piriformis in a patient that fell down the stairs.[13] The patient presented with radicular symptoms of the lower limb including paresthesias and decreased sensation on the lateral border of the left foot as well as weakness in the left ankle. Our patient did not present with any lack or change in sensation.

Hyder reported a case of MOT of the tibialis anterior in a 31 year old man 14 years post injury.[14] The man presented with extreme limitation of ankle movements with some pain in the leg, especially with walking.

In another case report by Mestan and Bassano, a 54 year old man presented with acute pain localized to the middle aspect of his left lower leg after a log rolled onto it.[10] The patient was subsequently diagnosed with a fracture of a previous heterotopic bone formation secondary to a karate injury 32 years previously.

Booth identifies three important criteria to consider when diagnosing MOT.[12] These include:

1. a history of significant local injury;
2. clinical and radiological evidence of ossification within 2 months of the initial injury;

3. the location of the lesion in proximal limb areas more commonly associated with MOT including the brachialis anticus and quadriceps femoris.

Other reasonable differential diagnoses include:[8] extraosseous osteosarcoma, synovial osteosarcoma, osteochondroma, posttraumatic periostitis, osteomyelitis, and tumoral calcinosis. There have been cases of osteosarcoma that have developed from traumatic myositis ossificans but it is very rare.[1] Aboulafia reported a case of osteosarcoma arising from heterotopic ossification that occurred as a result of an electrical burn 10 years previous.[15] (Chart 3 provides a differential diagnoses between MOT and osteosarcoma).

There are several risk factors that have been identified in those athletes that have developed MOT. These are described in Table 1.

Treatment

Natural History

MOT is generally considered to be a self-limiting condition and can have spontaneous resolution.[1,3,16] Hamida reports that without treatment the radiological and clinical findings will have stabilized and/or resolved within 1.5 to 3 years following the onset of symptoms.[16] Danchik notes that within 4 to 6 months, the lesion has stabilized.[3] Full reabsorption can take place especially in lesions occurring within the muscle belly.[3] Lesions located near an origin or insertion of a muscle are less likely to reabsorb and may result in functional impairment.[3] Parikh reports that full reabsorption is more likely to occur in smaller upper extremity lesions compared to a larger lesion located in the lower extremity.[1] Le Roux noted that smaller upper extremity lesions were more likely to reabsorb except for those lesions occurring at the elbow.[8] There are several medical management options that are used for MOT. These are listed in Table 2.

Prevention

There is little to be done once the process of MOT has been initiated.[10,12] However, as a sport medicine clinician that may be responsible for the diagnosis and treatment of MOT in athletes, there are several areas in which the proper management of the risk factors may decrease the possibility of its onset. These include:

1. early consideration of MOT as a differential diagnosis and the proper management of the hematoma (see Post Injury Protocol);
2. protection of the athlete from recurrent injury to the area by restriction of return to play and the addition of extra padding when the athlete does return. Some authors recommend extra protection 3 to 6 months post injury;[17]
3. education of the athletes on the causes and consequences of MOT and the importance of early treatment in its possible prevention. This should occur after an injury and also prior to the season before serious contusions are likely to occur.

Fracture of the myositis ossificans is rare but has been reported.[10] Care should be taken to protect existing cases of MOT from fracture in those athletes that have returned to play and are at an increased risk of significant injury to the area.

Post Injury Protocol

Ryan investigated post injury protocols and the incidence of myositis in 117 contusions at West Point.[5] In a previous study done by Jackson and Feagin at West Point in 1973, early knee extension was emphasized.[4] In the 1991 study, early return of knee flexion was emphasized in an effort to reduce the disability and incidence of myositis ossificans.

Of the 117 contusions, 71 were mild, 38 were moderate and 8 were classified as severe. Their protocol consisted of 3 phases: Phase I – the limitation of hemorrhage with RICE. Weightbearing was to tolerance with crutches if necessary. The hip and knee were immobilized in flexion to pain tolerance as opposed to extension. The patient was advanced to the next phase when they were pain-free at rest and their thigh girth had stabilized; Phase II – the restoration of motion with emphasis on knee flexion and continued RICE as necessary. The patient was advanced to the next phase when their pain-free active knee range of motion was greater than 120˚ and their thigh girth was equal bilaterally; Phase III – functional rehabilitation emphasizing the return of strength and endurance with always pain free cycling, swimming, walking and jogging. The patient was advanced to full activities if they had full active range of motion, full squat, and all other activities were pain free. They were to wear extra thigh protection for 3 to 6 months for all contact sports. It is interesting to note that mild and

Table 1 *Risk Factors for developing MOT*[3,4,5]

1. Severity of the injury. Although MOT has occurred following relatively minor trauma or even repetitive microtrauma, the more severe the initial injury, the greater the likelihood of developing MOT.
2. Localized tenderness and swelling.
3. Knee flexion <120˚. In a study at West Point[5] no athlete with a contusion in which knee range of motion in flexion was greater than 120˚ developed MOT.
4. Re-injury during the recovery phase. Although having a small sample size, Jackson and Feagin[4] reported those athletes with recurrent contusions to the same area during recovery developed MOT in 100% of cases.
5. Delay in treatment >72 hours.
6. Improper management of the muscle contusion.[3] These include: i) massage, heat, ultrasound, whirlpool or specific analgesic liniments used in the initial stages of the injury recovery is applied to the area of hematoma; ii) soft tissue manipulation, passive exercises and active stretching of the contused area is performed too soon in the rehabilitation of the injury; iii) the athlete returns to competition too soon; iv) increased bleeding in the tissue secondary to hemophilia or anti-coagulant therapy. Author's Note: Danchik did not provide references for this list of improper management strategies and is therefore thought to be evidence based on the expert opinion of the authors.[3]

moderate quadriceps contusions were treated daily and severe contusions were treated twice daily.[5]

The results of this study showed that average disability time was reduced for moderate (19 versus 56 days) and severe (21 versus 72 days) contusions but increased for mild contusions (13 versus 7 days). The incidence of MOT occurring was 11 of 117 (9%) following contusions overall (mild contusion 3 of 71 (4%), moderate 7 of 38 (18%) and severe 1 of 8 (13%)). Compared to the 1973 study, there was a reduction in overall incidence from 20% to 9% and in severe contusions 72% to 13%.[4,5]

Extracorporeal Shock Wave

In a prospective study done by Buseli et al in 2010, three sessions of extracorporeal shock wave therapy was performed over a 6 week period occurring once every 2 weeks.[18] The shockwave was administered at 100 impulses per cm^2 of ossification at a medium power setting of 0.13 to 0.23 mJ/mm^2 in an effort to keep pain at a tolerable level. The shockwave treatments were started an average of 4 +/– 2.09 months after the trauma and treatment effectiveness evaluations were made at 1,2,3,6 and 12 months after the last treatment.

Table 2 *Medical Management of MOT*

Aspiration Booth[12] reported on a study done by Molloy and McGuirk in 1976.	• early aspiration of the hematoma with subsequent injection of steroids, lysosomal enzymes, and xylocaine. • able to return the majority of patients to full activity • intervention did not prevent the onset of MOT or the reabsorption of mature lesions. • efficacy in reducing the incidence of MOT is questionable.
Alendronate (Fosamax) Case report.[16] A 22 year old police officer and judoist presented following a period of intense training.	• started on Alendronate six months post presentation • six months later the symptoms had resolved although a smaller ossified mass was still present in the affected tissue. • larger trial necessary to rule out the effects of natural history of MOT
NSAIDs[17,23]	• Indomethacin (25 mg, 3 X/day for 6 weeks) suggested for prevention of heterotopic ossification post surgery. • Indomethacin and naproxen sodium are effective if used for 2 to 6 weeks but not effective with shorter-term usage. • NSAID therapy is especially endorsed following hip replacement surgery. • common side effects include the spectrum of gastrointestinal distress to bleeding ulcers and death, make their usage a less viable option.
Acetic acid iontophoresis Case report.[29] 16 year old male that developed MOT following a diving accident.	• 2% acetic acid solution was used with iontophoresis in an attempt to decrease the size and progression of the calcium formation. • treatment initiated 4 weeks post injury • consisted of iontophoresis, ultrasound and passive pain free ROM 3X/wk for 3 weeks. • after 3 week period, a follow-up radiograph showed a 98.9% decrease in the size of the mass • athlete regained full ROM and full, pain free ADL's. • a randomized control trial needed to rule out natural history. Author's Note: Iontophoresis involves the movement of an electrically charged substance (in this case acetic acid) through the skin using low electrical current. This is not to be confused with phonophoresis that involves the use of ultrasound.
Surgery[2,17]	• surgery may be necessary if the lesion has not resorbed and functional disability exists. • universally accepted that if surgery is performed, it is only after the lesion has reached osseous maturity as indicated on bone scan or radiograph. This usually occurs 6 to 12 months post-injury. • lesion is likely to reoccur if excised prior to osseous maturity and even in up to 67% of cases after maturity.

There was a complete clinical and functional resolution in 21 of the 24 athletes. Return to previous sport activity in these athletes occurred within the 12 months of follow-up. Interestingly, there were statistically significant improvements in range of motion and pain (visual analogue and Fischer algometer) but no significant difference in the size of the lesion with radiographic follow-up.

In our case, the athlete did not seek any assessment of the injury until 7 years post-trauma. Prior to that, he did not feel that his activities were restricted enough to seek assessment and/or treatment but now felt assessment was warranted.

Conclusions

The reporting of myositis ossificans traumatica (MOT) in the medical literature is, in general, a series of case reports that most commonly involve athletes but can range from injuries as a result of college fraternity hazing[19] to repetitive physical assault and battery found at autopsy[20] to subcutaneous injections[21] to falling down the stairs on the buttocks.[13] Previous MOT of the ankle in athletes has been reported as heterotopic ossification involving the interosseous membrane following a syndesmotic sprain in football players.[22] To our knowledge, the present case study is the first report of MOT involving the deltoid ligament of the ankle following blunt trauma from a hockey puck in a recreational ice hockey player.

MOT must be carefully examined and must be properly diagnosed due to its similarity in presentation to osteosarcoma.[10,17,23] An inappropriate diagnosis can lead to devastating results for the patient.

Until recently, there have been very few new approaches to the treatment of MOT other than prevention[10,12] and a proper post injury protocol[5]. Buselli et al have shown extracorporeal shock wave to have some real potential as a viable treatment option for athletes suffering from MOT.[18] More studies are needed in an effort to determine the most effective dose/response ratio for the use of shock wave in its treatment of MOT.

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A profile of 2008 Olympic Taekwondo competitors

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The purpose of this study was to identify the characteristics of Olympic medal winners (gold, silver, bronze) who competed in the 2008 Beijing Olympic Games and compare these characteristics to those who competed but did not earn medals. We have also descriptively analysed the 2008 data in comparison to the 2004 data (Kazemi et al., 2009), and 2000 data (Kazemi et al., 2006) and summarized changes that were identified. This study as well as the last two studies did not find any statistically significant differences between winners and non-winners with regards to average age, weight, height and BMI. There are, however, some trends that were observed. Female winners were slightly younger, shorter, with greater BMI's versus non-winners. There was a significant decrease in frequency of warnings from 2004 to 2008. Unlike 2004, the 2008 Olympic Taekwondo competitors used more defensive kicks to score. These suggest a shift from aggressive tactics to score to a more conservative one.
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KEY WORDS: Olympic, games, Taekwondo, profile, athlete

Cette étude avait pour objet de déterminer les caractéristiques des médaillés olympiques (or, argent, bronze) des Jeux de Pékin en 2008, et de les comparer à celles des athlètes qui ont compétitionné sans toutefois gagner de médailles. Nous avons analysé de façon descriptive les données de 2008 par rapport à celles de 2004 (Kazemi et autres, 2009) et de 2000 (Kazemi et autres, 2006), puis résumé les différences identifiées. Cette étude, ainsi que les deux dernières études, n'ont démontré aucune différence statisquement significative entre les gagnants et les autres athlètes relativement à l'âge moyen, au poids, à la taille et à l'indice de masse corporelle. Certaines tendances furent cependant observées. Les gagnantes étaient un peu plus jeunes, moins grandes, et leur IMC était supérieure par rapport aux autres athlètes. La fréquence des avertissements a beaucoup diminué entre 2004 et 2008. Contrairement à 2004, les compétiteurs de taekwondo aux Jeux de 2008 ont eu recours à plus de coups de pied défensifs pour marquer des points. Ils seraient donc passés des tactiques agressives à des tactiques plus conservatrices pour l'emporter.
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MOTS CLÉS : *Olympiques, jeux, taekwondo, profil, athlète*

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Introduction

Taekwondo, is one of many martial art forms originally developed over 120 centuries ago in Korea[1]. The words 'Taekwondo' translate as tae to hit using the foot, kwon to hit using the fist, and do referring to the art. This term directly translates into the art of kicking and punching. Being one of many martial art forms, Taekwondo is unique by the predominant use of powerful kicking techniques. In more recent times, Taekwondo has transformed from a Korean self-defence skill set during warfare to a recognized international sport.

Recently, research has specifically focused on the physiological attributes necessary to be successful. Markovic and Vucetic examined heart rate and blood lactate concentration in elite women Taekwondo and karate athletes.[2] They concluded that the physiological demand in Taekwondo fighting is much greater than the demand during training exercises and therefore suggest that training should focus on high intensity anaerobic conditioning. A study by Butios and Tasika recorded and analyzed heart rate and blood lactate levels of elite male Taekwondo athletes and found that the anaerobic capacity of competitors is the same, regardless of weight class and aerobic capacity.[3] This study further asserts the importance of anaerobic conditioning in elite Taekwondo competitors.

Studies evaluating body mass index in terms of speed, speed-endurance and flexibility show that successful Taekwondo competitors are leaner.[4] Kazemi et al. (2006) was the first to compare winners verses non-winners in the 2000 Olympic games with respect to weight, height, age, points obtained, warnings, deduction points, and defensive and offensive kicks and punches.[5] The results were not statistically significant but in a first attempt to analyze the profiles of winner's verses non-winners the study suggests that a trend can be seen with the winners. Specifically, winners tended to be younger in age, taller, with slightly lower body mass indexes than their respective weight category average.[5]

With the increase in popularity of Taekwondo as a sport, there has been a rise in interest in various areas of research, with injury rates being the most frequently investigated.[5,6,7] Kicking generates the most powerful strikes while keeping the greatest distance from the opponent, therefore it is not surprising that the lower limb has been found to be the most commonly injured body segment.[8, 9,10,11,12]

Variables such as height, weight, body-mass index (BMI), and VO2 max have been investigated in different sports. Defining physiological profiles have also been attempted in other sports such as freestyle wrestling,[13] and karate.[14] Heller et al. determined that the physiological profile of male and female taekwondo black belts consisted of very low body fat percentages, a high lean body mass, and above average results for muscle strength, flexibility, and anaerobic and aerobic capacities.[15] Toskovic et al. found that experienced and trained males and females were more athletically fit in terms of greater lower-body strength, better aerobic capacity, and greater flexibility when compared to novice males and females, even though the experienced competitors were older in age.[16]

In Taekwondo, competitors must be able to move with high velocity, speed, and power. A surplus of body mass can hinder this ability especially if this excess mass is in the form of fat which is metabolically inactive when compared to muscle. A study by Pieter et al. found that female athletes in Filipino combat sports have a higher sum of skin fold measurements in comparison to males.[7] Mengli assessed the differences in somatotype and body composition in female Taekwondo athletes at different competitive levels and concluded that elite female athletes are more mesomorphic and have less fat than collegiate female athletes in Taekwondo.[17] Similar findings that elite athletes possessed low body fat percentages along with increased lean body mass and high VO2 max were also described by Tosovic et al.[16] and Pieter et al.[7] In contrast, Melhim found no significant differences in either resting heart rate or aerobic power after training, however, he did find differences in anaerobic power and capacity.[18]

In 2009, Kazemi et al. examined the profile of the 2004 Taekwondo Olympic medalists to their non-winner counterparts.[19] They reported no statistically significant differences exist between winners and non-winners with respect to age, height, weight and gender.[19]

In Taekwondo, points can be obtained by using a foot technique: delivering a kick using any part of the foot below the ankle or a fist technique: delivering a punch using a tightly clenched fist to the torso. In 2003, rule changes introduced an increase in point value of head contacts in adult competition to 2-points, compared to a standard 1-point value for kicks to the torso as well as an additional point for an eight-count knockdown.[20] Winning by superiority is possible by two ways. One method

Table 1 *Demographic profiles of athletes (n = 128). Data are means (±SD).*

	Males		*Females*	
Characteristics	*Winners (n = 16)*	*Others (n = 48)*	*Winners (n = 16)*	*Others (n = 48)*
Age (yrs)	25.0 (3.53)	24.81 (4.31)	22.81 (2.80)	22.91 (4.52)
Height (m)	1.83 (.09)	1.79 (.08)	1.68 (.08)	1.70 (.06)
Weight (kg)	74.92 (14.65)	73.13 (12.41)	59.85 (9.44)	60.73 (8.65)
Body Mass Index	22.01 (2.64)	22.46 (2.35)	21.0 (2.36)	20.69 (1.92)

is termed "point gap," meaning if an opponent leads a match by a seven-point gap, the match is terminated and the leader wins by superiority. The second method of winning by superiority is by "point ceiling." Point ceiling is defined as a win by superiority by the competitor who first reaches a score of twelve points. If a winner cannot be decided after three rounds a fourth round is conducted. If neither competitor scores a point in the fourth round the winner shall be decided by superiority. Specifically, the opponent that has technically dominated the round through aggressive match management, the greatest number of techniques executed, the greatest use of advanced techniques both in difficulty and complexity and the better display of competition.

Penalties are considered as prohibited acts in Taekwondo. Two types of penalties exist: Kyong-go and Gam-jeom. A Kyong-go is a warning penalty and two Kyong-go's is counted as a gain of one point for the opponent. Gam-jeom is a deduction penalty and is counted as an additional point for the opposing contestant. [20]

The purpose of this study was to identify physiological attributes of winners (gold, silver and bronze medalists) verses non-winners who competed in the 2008 Olympic Games. We compared the results of this study to previous studies by the author to look for a trend of winner's verses non-winners. Results of this study allow Taekwondo coaches and competitors to practice evidence-based success in sport.

Methods

The data for this study was obtained from the official 2008 Olympic website, http://en.beijing2008.cn/ a public domain website. The information obtained from this website includes the following: participant's weight, height, date of birth, country, round report, points obtained, warnings (kyong-go, gam-jeom), deduction points, type of score (defensive kicks, offensive kicks, offensive and defensive punches), list of referee and judges with country origin.

T tests were used to compare winners versus non winners stratified by gender in terms of age, height, weight and BMI. Chi-squared testing was used to compare winners versus non winners for type of score as well as type of warning received after stratifying by gender and then weight class. Also, Chi-squared testing was used to compare 2008 results with the results from both the 2000 and 2004 Olympic games for differences in proportion of scores by defensive kicks and differences in proportions of penalties to warnings. Statistical analysis was conducted using the STATA version 10 software. Variables were coded and labelled prior to analysis.

Results

There were no significant differences found between winners and non-winners with respect to age, height, weight or BMI stratified by gender. Descriptive statistics for the sample according to age, height, weight, and BMI can be found in Table 1.

2008 data

No statistically significant association was found between success (winners versus non winners) and the distribution of type of score for either men or women. Furthermore, no significant association between success and type of warning was found for either men or women (i.e. type of warning received, kg or gj, was not dependent on whether the athlete was a winner or non-winner).

Table 2 *Techniques used to score.*

	Technique						
Weight Category	*Offensive Kick 1-pt*	*Offensive Kick 2-pt*	*Defensive Kick 1-pt*	*Defensive Kick 2-pt*	*Offensive Punch*	*Defensive Punch*	*Knock Down*
Males							
<58 kg	*33*	*5*	*42*	*0*	*0*	*1*	*0*
<68 kg	*39*	*2*	*49*	*1*	*0*	*0*	*0*
<80 kg	*40*	*4*	*55*	*3*	*0*	*1*	*1*
>80 kg	*50*	*6*	*63*	*1*	*0*	*0*	*0*
Total	*162*	*17*	*209*	*5*	*0*	*2*	*1*
Females							
<47 kg	*28*	*5*	*33*	*4*	*0*	*0*	*0*
<57 kg	*24*	*4*	*42*	*5*	*0*	*0*	*0*
<67 kg	*33*	*2*	*50*	*2*	*0*	*0*	*0*
>67 kg	*48*	*2*	*32*	*34*	*0*	*0*	*0*
Total	*133*	*13*	*157*	*45*	*0*	*0*	*0*

When analyzing the men's data stratified by weight class, no significant association was found between weight class and type of score. Among women, however, the type of score was found to be dependant upon weight class ($p = 0.033$). For the women, it was observed that the group with the highest proportion of one point offensive kicks versus other types of score was the >67kg weight class (58.5%) compared to the <67kg (38.8%), <57kg (34.3%) and <47kg (0.424).

For all athletes, offensive one and two point kicks accounted for approximately 39% of techniques used to score for male winners and 38% of techniques used to score for female winners.

Comparisons of 2008 to 2004 and 2000 data

A higher proportion of scores by defensive kicks was found among male competitors in 2008 (0.539, $n = 388$) versus 2004 (0.345, $n = 1018$) ($p < 0.0001$). For women the result was similar in 2008 (prop = 0.580, $n = 348$) and 2004 (prop = 0.392, $n = 684$), $p < 0.0001$). This is contrary to previous studies which recorded offensive kicks were the technique of choice to score among winners.

The proportion of penalties to warnings did not change significantly from 2004 to 2008 for men ($p = 0.34$) or women ($p = 0.34$). The frequency of warning for males decreased from 2004 (3.725 per match) to 2008 (1.276 per match) an approximate change of 65.7%. Deductions among males decreased by 58.1% from 2004 (1.413 per match) to 2008 (0.592).

Among women, there was a 20% decrease in warnings per match from 2004 (2.32) to 2008 (1.855). Regarding penalty deductions per match a decrease of 34.8% was seen from 2004 (0.747) to 2008 (0.487).

Discussion

Two previous studies investigated the profile of Olympic Taekwondo athletes that participated in the 2000 and 2004 Olympic Games.[5,19] This study as well as the last two studies did not find any statistically significant differences between winners and non-winners with regards to average age, weight, height and BMI. There are, however, some trends that were observed.

The average age of male winners was slightly more than that of non-winners. This trend is contrary to findings from the 2000 Olympic Taekwondo athletes but similar to the trend observed in 2004.[5,19] In the 2008 Olympics,

Table 3 *Types of Warnings Received*

Weight Category	Kyong-go (KG) # events	Kyong-go (KG) Average KG per match	Gam-jeom (GJ) # events	Gam-jeom (GJ) Average GJ per match
Males				
<58 kg	25	1.3	12	.64
<68 kg	26	1.36	11	.58
<80 kg	22	1.16	10	.52
>80 kg	24	1.26	12	.64
Total	*97*	*5.08*	*45*	*2.38*
Females				
<47 kg	38	2.0	11	.56
<57 kg	41	2.2	10	.52
<67 kg	28	1.46	7	.36
>67 kg	34	1.78	9	.46
Total	*141*	*7.44*	*37*	*1.9*

female winners were slightly younger than female non-winners. This was the same trend observed in the 2000 and 2004 Olympics.[5,19] This may suggest that younger female Taekwondo athletes have a better chance to succeed.

The average height of male winners was slightly more than non-winners, which corresponds well with previous studies. However, the average height of the female winners was slightly lower than that of non-winners, which is contrary to the female Taekwondo athletes in the 2000 and 2004 Olympic games.[5,19] This finding may relate to the fact that the difference in height for winners gave them a significant biomechanical advantage over their shorter competitors. Taller athletes have longer upper and lower limbs, which translates into longer levers providing them with greater ability to cover a larger area with less energy. It has been suggested that a certain somatotype (specifically, an ecto-mesotype) may have a better chance at excelling in competition.[8]

The male winners were slightly heavier than the male non-winners whereas the female winners were slightly lighter than their counterparts. This trend was different for the 2004 Olympic Taekwondo athletes where both male and female winners were slightly heavier than the non-winners.[19] The 2000 Olympic male and female Taekwondo winners were lighter than the non-winners.[5]

Body mass index (BMI) is a reliable indicator of calculating total body fat percentage related to morbidity and mortality.[21] Estimating body fat percentage by utilizing the calculated BMI has some disadvantages, as it may overestimate body fat in individuals who are of large muscular build, such as athletes. It may also underestimate body fat percentage in individuals who have lost muscle mass, such as the elderly.[21] The data from this study suggests that both male and female winners had lower average BMI's in comparison to non-winners. In general, these findings mirror those of Heller[15] who found that male and female Taekwondo black belts demonstrated extremely low estimated body fat percentages, and increased amounts of lean body mass. Elite female Taekwondo athletes were found to be more mesomorphic with less fat than collegiate female Taekwondo athletes.[22] Heller et al.[15] reported low adiposity for their male and female athletes. The 2008 male winners had a lower BMI compared to the male non-winners. This trend was also reported in the last two studies of Olympic Taekwondo athletes that participated in the 2000 and 2004 games.[5,19]

Contrary to the female winners in the 2000 and 2004 Olympics, the female 2008 Olympic Taekwondo winners had higher BMI than their non-winner counterparts.

Another accurate indicator of body-fat composition is to calculate the height-weight ratio. This method is more accurate in terms of taking into account the muscular build of an athlete. Future studies may find it beneficial to incorporate this measure of body-fat composition, as it may provide further insight into the somatotype of successful athletes in competition. This study chose to use the BMI measure in order to demonstrate a clearer comparison with the author's previous studies.[5,19]

As it was in the 2004 Olympics,[19] the 2008 Olympic Taekwondo competitors used kicks to score 100% of the techniques used to score. In the 2000 Olympic games[5] kicks were used to score 98% of the time. A chi-square test of difference in proportions show us that there is a significantly higher proportion of scores by defensive kicks among male competitors in 2008 (0.539) versus 2004 (0.345). For women the result was similar in 2008 (prop = 0.580) and 2004 (prop = 0.392). This is contrary to previous studies which recorded offensive kicks, was the technique of choice to score among winners. This may indicate a shift in scoring technique to more conservative tactics. The proportion of penalties to warnings did not change significantly from 2004 to 2008 for men ($p = 0.34$) or women ($p = 0.34$). The frequency of warning for males decreased from 2004 (3.725 per match) to 2008 (1.276 per match) an approximate change of 65.7%. Deductions among males decreased by 58.1% from 2004 (1.413 per match) to 2008 (0.592). Among women, there was a 20% decrease in warnings per match from 2004 (2.32) to 2008 (1.855). Regarding penalty deductions per match a decrease of 34.8% was seen from 2004 (0.747) to 2008 (0.487). The observed decreased in number of warnings and utilization of defensive technique to score in 2008 winners indicates a shift form aggressive tactics to more conservative one.

One of the limitations of this study is the assumption that the referees and judges were unbiased in their decision. A video analysis of each match to find proper scoring would shed light on how fair the referees and the judges were. Future research to look at the injuries and their relationship with winning as well video analysis of the kind of techniques i.e. round house kicks versus back kick etc. are recommended. A further limitation of our study is the utilization of BMI. Future studies should thrive to use height-weight ratio. Also, there is a paucity of research on relationships between injury pre and during competition and Taekwondo athlete performance and success. As such future studies should look into this relationship over extended periods of time.

Conclusions

Although not statistically significant, male winners were slightly older, taller, with lower BMIs versus non-winners. Female winners were slightly younger, shorter, with greater BMI's versus non-winners. There was a significant decrease in frequency of warnings from 2004 to 2008. Unlike 2004, the 2008 Olympic Taekwondo competitors used more defensive kicks to score. These suggest a shift from aggressive tactics to score to a more conservative one.

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Chiropractic utilization in BMX athletes at the UCI World Championships: a retrospective study

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Objective: *To examine paramedical (chiropractic, physiotherapy and massage therapy) utilization among high-level BMX athletes following sport-related injury at the 2007 UCI World Championships.*

Methods: *Retrospective analysis was conducted on a dataset from international male and female BMX athletes (n = 110) who sustained injury in training and competition at the 2007 BMX World Championships.*

Results: *Fifty percent of individuals aged 8–17 presented to a chiropractor versus 32% to physiotherapists and 18% to massage therapists. There was a significant difference in paramedical practitioner choice when comparing the sample across the different locations of injury. Specifically, the proportion of individuals presenting for treatment to chiropractors (84%) was much higher than to physiotherapists/massage therapists (16%) for spine or torso complaints.*

Conclusion: *Utilization of chiropractors by BMX athletes may be higher than utilization of other paramedical professionals as suggested by this study. Chiropractors appear to be the paramedical practitioner of choice in regards to spine and torso related complaints.*

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KEY WORDS: cycling, BMX, chiropractic, utilization, paramedical

Objectif : *Examiner le recours aux traitements paramédicaux (chiropratique, physiothérapie et massothérapie) par les athlètes BMX de haut niveau suite à une blessure liée à la pratique des sports lors des Championnats mondiaux UCI 2007.*

Méthodes : *L'analyse rétrospective fut menée relativement à un ensemble de données recueillies auprès d'athlètes BMX masculins et féminins (n = 110) ayant subi des blessures à l'entraînement et lors de compétitions dans le cadre des Championnats mondiaux BMX 2007.*

Résultats : *Cinquante pour cent des personnes âgées entre 8 et 17 ans ont consulté un chiropraticien, 32% ont consulté un physiothérapeute, et 18% ont consulté un massothérapeute. La différence dans le choix du professionnel paramédical était grande lorsqu'on comparait l'échantillon au type de blessure. La proportion de gens ayant consulté un chiropraticien (84%) était plus élevée que celle qui ont consulté un physiothérapeute/massothérapeute (16%) pour une douleur à l'épine dorsale ou au torse.*

Conclusion : *Les athlètes BMX ont tendance à faire davantage appel aux services des chiropraticiens qu'à ceux des autres professionnels paramédicaux comme le suggère cette étude. Le chiropraticien semble constituer le praticien de choix en cas de douleur à l'épine dorsale et au torse.*

(JCCA 2010; 54(4):250–256)

MOTS CLÉS : cyclisme, BMX, chiropratique, recours, paramédical

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Introduction

Bicycle motocross (BMX) has its origins in the late 1960s in California in the United States of America. Children and teenagers without the financial means to participate in the popular sport of motorized motocross instead built dirt tracks and raced bicycles around them. The participants also mimicked the motorized competitors by wearing motocross gear and clothing.[1]

The official start of BMX as a sport is considered to be in the early 1970s when a sanctioning body for BMX was founded in the United States.[1] By 1978, the sport was introduced on other continents such as Europe.[1]

The International BMX Federation was founded in 1981, and the first world championships were held in 1982.[1] BMX rapidly developed as a unique sporting entity, and later adopted codes of competition similar to cycling. In 1993, BMX was fully integrated into the Union Cycliste Internationale (UCI). There are over 75 nationally affiliated federations with official BMX programs recognized by the UCI.[1] BMX made its debut as an Olympic event in Beijing in 2008.

BMX races are held on circuits of around 350 metres, including jumps, banked corners and other obstacles (Figure 1). Eight riders compete in each heat (qualifying rounds, quarter finals, semi-finals, finals) with the top four qualifying for the next round.[1] Riders are divided into classes by age group and sex. The elite riders are divided by sex only.

The 2007 UCI BMX World Championships were held in Victoria, BC, Canada. The 2007 competition was the last World Championships prior to the 2008 Beijing Olympics, placing increased importance on the event. According to the International Cycling Union (UCI) the total number of entries for the 2007 World Championship event was 1954 riders/athletes from 39 countries.[1] This was a substantial increase from 1600+ competitors and 32 countries that UCI reported participated in the 2003 World Championships held in Perth, Australia.[1] The only other BMX event where participant numbers have been reported was authored by Brogger-Jensen et al[2] following the 1989 European BMX Championships, citing 976 participants.

UCI holds over 70 international BMX events on four continents annually.[1] Despite this, prior to the 2007 World Championships, statistics in regards to the amount or type of injuries seen by paramedical practitioners (chiropractic, physiotherapy and massage therapy) or medical practitioners (medical doctors and doctors of osteopathy) at a major BMX event have not been published.

Figure 1 *Computerized diagram of the 2007 UCI BMX World Championship track.*[1]

Despite the lack of published data, it is apparent that UCI perceives a need to provide both medical and paramedical services on a consistent basis to its high-level BMX athletes. In 2008, the UCI announced that it would be contracting medical services to Winning Medicine International of California (WMI).[1] WMI's mandate was "to provide comprehensive medical services at all 2008 UCI BMX events."[1,3] The WMI website[4] lists four medical practitioners (three medical doctors and one osteopath) and three paramedical practitioners (two chiropractors and one certified athletic trainer) on its medical staff. Despite being given the task of providing treatment and improving the safety of UCI BMX, no injury data is available from the UCI or WMI websites. The requirement for ongoing collection of data to improve safety and quality of treatment available to BMX athletes still needs to be satisfied. Such information would facilitate future medical and paramedical planning for major BMX events that are often held on various continents, with different health practitioners.

The following report was intended to provide information for paramedical services at future events. A separate report[4] on injuries seen by medical and first-aid at the Victoria 2007 World Championships has also been authored, but is unpublished. This data may be valuable at future major BMX events. There has been minimal information published regarding the health care utilization of BMX athletes with only one previous study.[2] The purpose of the present study was to examine the type of paramedical practitioners visited, specifically chiropractic utilization, following a sport-related injury among high-level BMX athletes.

Method

Ethical review approval from Canadian Memorial Chiropractic College (CMCC) was obtained to retrospectively analyze the data on November 25, 2009 (Certificate number: 0911X04).

A single group of subjects were included in this study. The sample population consisted of 110 male and female BMX athletes of all skill levels that presented to the paramedical services tent at the 2007 BMX World Championships following an injury at the event. A total of 110 subjects with an age range of 8 to 44 years, presenting with a total of 131 unique injuries were included in the study. Forty-five females and sixty-five males presented. In addition to a paramedical tent, a medical/first-aid tent was also present. Data from the medical/first-aid tent[4] is mentioned but was not included in this study.

As mentioned earlier, UCI does not have a standardized method for reporting injury data. However, the Chief Medical Officer at the 2007 World Championships required collection of injury data. Following the event, data were hand scored by the author from encounter forms. Injury tracking forms were adapted from the International Ski Federation (FIS)[5] to track injuries sustained by competitive level snowboarders. The validity, reliability and transferability of the FIS form to a BMX event have not been tested. The content of the BMX forms was created by consensus between the Chief Medical Officer, the event manager and the author prior to the event.

Both the medical and paramedical treatment tents were located conveniently within the competition venue adjacent to the national teams. All BMX athletes who presented to the paramedical tent had an injury form filled out to provide care for the athletes, consistent with British Columbia law. The forms were filled out by one of eight different paramedical practitioners that provided the treatment: four sports chiropractors (DC), two sports physiotherapists (PT), and two registered massage therapists (RMT). Each practitioner was trained by the author specifically to collect the following information for each athlete encounter and enter it on the modified FIS form:

1) Age
2) Sex
3) Country
4) Date of Injury (Only data for injuries sustained at the event were included).
5) Nature of injury/body part injured
6) Type of paramedical service provided

The form was discussed in detail with the athletes and written and verbal informed consent was obtained prior to its administration. Although the information was not initially collected for research purposes, participants were informed at the time of registration that data related to their participation in the event was being collected by UCI and may be included in future study. The data form did not include any identifying information and at the end of the event, the data forms were separated from treatment records to preserve confidentiality. The author was the only person who had possession of the injury and data collection forms. Only data for injuries sustained at the current event were included. Although chronic injuries not sustained at the event were also frequently seen and treated, they were not included in the analysis. Athletes seeking treatment from more than one practitioner, either medical or paramedical, were accounted for on the same data form but counted as separate encounters. Follow-up visits to the same type of practitioner for the same problem were counted as a single encounter to avoid artificially increasing the number of encounters.

Descriptive statistics of the anonymous sample were done at CMCC using proportions as well as means and standard deviations. Assessment of paramedical practitioner choice was done across the grouping variables through Chi-square testing. The standard for statistical significance was $p < 0.05$.

Results

The total number of documented paramedical encounters was 110 athletes out of 1954 total participants. Medical and paramedical encounters in total were 229 athletes out of 1954 participants, which represented 12% of all participants requiring medical or paramedical assistance from injuries sustained at the event. There is a high likeli-

Table 1 *Proportion of individuals presenting by age group*

Age Group	Chiropractic (n)	Physiotherapy (n)	Massage (n)	Total (n)
8–17	0.5 (11)	0.32 (7)	0.18 (4)	1.00 (22)
18–26	0.59 (37)	0.19 (12)	0.22 (14)	1.00 (63)
27–44	0.64 (16)	0.16 (4)	0.20 (5)	1.00 (25)
All	0.58 (64)	0.21 (23)	0.21 (23)	1.00 (110)

Table 2 *Proportion of individuals presenting by origin*

Location	Chiropractic (n)	Physiotherapy (n)	Massage (n)	Total (n)
NA	0.64 (41)	0.20 (13)	0.16 (10)	1.00 (64)
Europe	0.63 (5)	0.25 (2)	0.13 (1)	1.00 (8)
SA/CA	0.67 (12)	0.28 (5)	0.06 (1)	1.00 (18)
AUS/NZ	0.45 (9)	0.35 (7)	0.20 (4)	1.00 (20)
Total	0.61 (67)	0.25 (27)	0.15 (16)	1.00 (110)

hood that both medical and paramedical staff saw some athletes for the same injury. Younger athletes sought treatment under the guidance of a parent or guardian. Athletes specified the type of treatment they were seeking i.e.: "chiropractic," "massage" or "physio," and this eliminated the need for triage. Although there was some overlap in techniques used, chiropractors primarily utilized manipulation and mobilization, physiotherapists used mostly ultrasound, electrical modalities and stretching and the massage therapists utilized mostly effleurage to the soft tissues.

Fifty eight percent (n = 64) of those athletes seeing paramedical staff for treatment of an acute injury presented to a doctor of chiropractic. Twenty one percent of athletes (n = 23) presented to a physiotherapist, while 21% (n = 23) presented to a massage therapist. Of all initial encounters with paramedical staff, 41% were by female athletes and 59% were by male athletes. Although female athletes represented 41% of encounters, they represented only 20% of total participants, suggesting a much higher rate of injury in female BMX racers. Over three-quarters (76%) of the patients seen by the medical/first-aid staff were male. There was a full range of ages seen by paramedical staff. The youngest patient was 8 years old and the oldest was 44 years old. The median age of all paramedical patients was 21 years of age.

In regards to paramedical treatment, overall (See Table 1), a significantly larger proportion of individuals presented for chiropractic treatment (58%) compared with physiotherapy (21%; $X^2 = 31.96$, df = 2, $p < 0.0001$) and massage therapy (21%; $X^2 = 31.96$, df = 2, $p < 0.0001$).

Regarding age, the age groupings of 8–17, 18–26 and 27–44 (Table 1) were used. It was found that there was no significant difference in paramedical practitioner choice when comparing the sample across the different age groups (Table 1; $X^2 = 2.19$, df = 4, p = 0.701).

Fifty percent of individuals aged 8–17 presented to a chiropractor versus 32% to physiotherapists and 18% to massage therapists. This distribution of treatment choice was not significantly different from the age groups of 18–26 and 27–44.

Regarding origin of the athlete, the following groupings were used (Table 2): North America (NA), (Canada, United States of America); Europe (France, Germany, Netherlands); Central/South America (SA/CA), (Aruba, Brazil, Columbia, Ecuador, Venezuela) and Australia/New Zealand (AUS/NZ). It was found that there was no significant difference in paramedical practitioner choice when comparing the sample across the different locations of athlete origin (Table 2; $X^2 = 3.96$, df = 6, p = 0.683).

Sixty three – sixty seven percent of individuals from North America, South America and Europe presented to

Table 3 *Proportion of individuals presenting by location of injury*

Location of Injury	Chiropractic (n)	Physiotherapy/Massage (n)	Total (n)
Lower Limb	0.54 (15)	0.46 (13)	1.00 (28)
Spine / Torso	0.84 (47)	0.16 (9)	1.00 (56)
Upper Limb	0.53 (25)	0.47 (22)	1.00 (47)
All	0.66 (87)	0.34 (44)	1.00 (131)

a chiropractor for their injuries versus 45% of individuals from Australia and New Zealand. 20–35% of all athletes presented to physiotherapists and 6–20% of all athletes presented to massage therapists. Some countries provided their own medical services exclusively to their team members and their numbers are not included. American athletes accounted for 26% of all paramedical encounters (29/110), compared with Australian and Canadian athletes who accounted for 14% (15/110) and 32% (35/110), respectively.

Due to the small number of total presentations to a massage therapist by location of injury, the massage therapy and physiotherapy groups were combined into one group for the analysis.

Regarding location of injury, we used the following groupings (Table 3): Lower Limb (ankle, hip, knee, lower leg, thigh); Spine/Torso (back, lumbar, pelvis, ribs, neck); Upper Limb (clavicle, hands/fingers/thumb, shoulder, wrist). It was found that there was a significant difference in paramedical practitioner choice when comparing the sample across the different locations of injury (Table 3; $X^2 = 13.46$, df = 2, p = 0.001). This difference is seen when looking specifically at the proportion of individuals presenting for treatment for spine and torso related complaints. Eighty-four percent of individuals with spine or torso related complaints presented to chiropractors compared to 16% who presented to physiotherapists/massage therapists ($X^2 = 51.57$, df = 1, $p < 0.0001$). The comparisons between chiropractors and physiotherapists/massage therapists for proportions of individuals presenting with lower limb or upper limb complaints were not found to be significantly different (Table 3).

In the current study injuries to the torso and spine accounted for close to half the injuries seen by paramedical staff (43%). Upper limb injuries accounted for 36% of the injuries and lower extremity injuries accounted for 21% of injuries. On average, each athlete had 1.19 complaints. Some athletes also saw more than one provider per encounter and these athletes were recorded as seeing each provider as separate encounters. Only initial visits with each type of provider were recorded and total number of repeat visits was not studied. The majority of injuries were of a musculoskeletal nature, but almost all injuries also required First-aid (provided by both the paramedical practitioners and the medical staff) and wound care prior to assessment and treatment.

Discussion

This study is the first to investigate patterns of paramedical utilization of athletes at a large-scale BMX event. An electronic literature search using Pubmed and Biomed Central using cycling and BMX as keywords resulted in one relevant paper describing the 1989 European Championships.[2] The data collected covers a single World Championship in 2007. Given the high number of event registrants, and subsequent presentations at the paramedical tent, hopefully this study presents a clearer picture of paramedical utilization by BMX athletes in high-level competition.

The total number of documented medical/nursing/First-aid encounters during the 2007 World Championships was 119 athletes out of a total 1954 participants representing 6.2% of all athletes. This is similar to the 6.3% of BMX athletes sustaining injury at the 1989 European Championships.[2] When the 2007 medical and paramedical encounters are combined, 12% of participants were seen. This is much higher than the 6.3% of participants that were reported as injured at the 1989 European Championships, but without paramedical services provided in 1989, direct comparison is not possible.

Kazemi[6] has suggested that athletes desire a rapid recovery and may seek treatment from more than one practitioner to speed up the healing process. This insight may explain why multiple health professionals were consulted at the 2007 BMX Worlds. Other studies[7,8] suggest that athletes often use paramedical services in conjunction with medical services and observations from this study support this.

In regards to country of origin, Australia, Canada and the United States of America brought the largest number of athletes and therefore may have also resulted in the largest number of paramedical encounters. As well, athletes from these countries are also the most likely to be accustomed to using paramedical services at home, and may have been more comfortable requesting treatment as they did not have to overcome any language barriers to receive treatment as English was the primary language.

With their training and expertise in the area of musculoskeletal injuries, chiropractors and sports chiropractors in particular are well positioned to treat athletic injuries. Even so, little research has been conducted to examine the prevalence of chiropractic use in the treatment of sport-related injuries. Prior to this study, the relationships between age, location of injury, country of origin and choice of practitioner has not been adequately investigated. This study suggests that the utilization of doctors of chiropractic was twice that of other paramedical practitioners at the 2007 BMX Worlds. This difference might be explained by the presence of twice as many chiropractors (two) treating athletes compared to the other paramedical practitioners (one massage therapist and one physiotherapist) on one of the five days of competition. This is less likely because BMX athletes were freely given the ability to request any type of practitioner and athletes were not aware of the relative or absolute number of the different practitioners. On the other four days of competition, there was one chiropractor, one physiotherapist and one massage therapist present.

The ability to see paramedical providers free of charge may also result in an over reporting of injuries by athletes. Athletes may be more likely to seek treatment if services are provided free of charge. Paramedical visits accounting for 48% of the first injury encounters agrees with a study of paramedical usage by athletes in an American college where a rate of 56% was noted.[9]

There are limitations in the present study that should be addressed. The study could be strengthened with the use of a previously validated questionnaire or survey tool that could be peer-reviewed initially, and then subjected to testing at various events via a pilot study. The new questionnaire should be developed to take into account athlete use of multiple practitioners yet preserve confidentiality – perhaps using numbers off of the athlete's accreditation. There is no prior research regarding treatment preferences among BMX athletes, and this could be answered via a direct survey. Although the data collection of this study could have been strengthened, results from this study are a starting point to enhance future studies in this sport.

Retrospective surveys can be affected by poor recall and perception bias, but analysis of written data in this case may have controlled for this. Another study should be done regarding the demographic characteristics of high-level BMX competition participants to see if this study could be generalized to future BMX events of similar caliber. It is unknown if the population sampled here was similar in characteristics to that seen in other large-scale BMX events. Participants could also be surveyed in regards to the frequency and type of treatments they typically receive pre-mid-post competition.

The objective of this retrospective investigation was to identify trends in the paramedical utilization among BMX athletes. Paramedical practitioners with extensive BMX athlete contact should endeavor to further conduct utilization studies. There is a lack of information surrounding chiropractic utilization in the majority of sports. The results of this study are primarily descriptive. It provides some insight into paramedical utilization patterns among BMX athletes. Future studies should focus on developing a standardized form that can be tested. This paper was written with the intent of generating a database for decision-making or hypotheses for future study. Until now, the demographic tendencies of BMX athletes that use paramedical services have not been recorded.

Conclusions

This study suggests that at the 2007 BMX World Championships, paramedical utilization (n = 119) was almost equal to medical utilization (n = 110) among participants who sought treatment for injuries sustained at the event. With regards to the type of paramedical care utilized, chiropractors were used more than half the time for injuries to the upper limb, lower limb and up to 84% of the time for injuries to the spine or torso. There was no significant difference in paramedical practitioner choice due to the athlete's age or country or origin. The apparent popularity of chiropractic as treatment for injuries sustained at this event, suggests that its inclusion should continue at future high-level BMX competitions. This is especially true for treatment of spine and torso related complaints.

The data collected by this study encompasses BMX athletes of all ages and skill levels and thus it is believed that it represents the range of presentations that can be expected at a World Championship BMX event. However, comparing numbers of athletes participating at the BMX world championships in both 2007 and 2003 suggests an increase in riders participating in the sport at a high level.[1] Similar as is found in other sports, as the sport becomes increasingly popular and increasingly competitive, the potential for injuries may increase.[10] Without any attempt to determine the types of injuries seen, trends cannot be recognized. Analysis of injury trends may be used in education and injury prevention. The ongoing collection of standardized injury statistics of BMX athletes at competition is a worthy goal. Determining the validity, reliability and transferability of the FIS form for this purpose is also appropriate. This article could be used to better enable event planners to determine the type of injury care that ought to be provided for these kinds of events, by anticipating the preference of BMX athletes who are injured and the type of injuries they are most likely to sustain.

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Lunotriquetral instability in a climber – case report and review

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Wrist injuries and carpal instability may result from various sport-related acitivites. Lunotriquetral instability (LTI) is an infrequently recognized cause of wrist pain in athletes. The diagnosis of LTI through history and physical examination can be confirmed by Magnetic Resonance Arthrogram (MRA). This case report describes a case of clinically suspected LTI confirmed by MRA. Relevant literature on lunotriquetral injuries is discussed. Lunotriquetral joint injury can present itself and should be considered within a differential diagnosis of a wrist injury. The diagnosis of LTI through clinical history and physical examination can be confirmed by MRA. This case report demonstrates the importance of MRA in the accurate diagnosis and management of a patient with wrist pain.
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KEY WORDS: ligament, lunotriquetral, carpal instabilities, MR-Arthrogram, wrist

Les blessures au poignet et l'instabilité carpienne peuvent être causées par diverses activités sportives. L'instabilité luno-pyramidale (ILP) est une cause moins reconnue de douleur au poignet chez les athlètes. Le diagnostic de l'ILP par le biais d'examens et des antécédents médicaux peut être confirmé par un arthrogramme par résonance magnétique (ARM). Cette étude de cas décrit une ILP cliniquement soupçonnée et confirmée par l'ARM. La documentation pertinente sur les blessures luno-pyramidales fait l'objet d'une discussion. Une blessure luno-pyramidale aux articulations peut survenir, et doit faire l'objet d'un diagnostic différentiel d'une blessure au poignet. Le diagnostic d'ILP par le biais d'examens et des antécédents médicaux peut être confirmé par un arthrogramme par résonance magnétique (ARM). Cette étude de cas démontre l'importance d'un ARM pour énoncer un diagnostic exact et gérer un gérer souffrant d'une douleur au poignet.
(JCCA 2010; 54(4):257–263)

MOTS CLÉS : ligament, luno-pyramidal, instabilité carpienne, arthrogramme RM, poignet

Introduction

Carpal injuries and instability commonly result from high energy trauma and sports-related activities.[1] Two commonly affected complexes include the scapholunate and lunotriquetral joints. The stability of these joints depends on both the interosseous ligaments and extrinsic capsular elements.[2] Lunotriquetral (LT) injuries occur approximately one sixth as commonly as scapholuntate injuries.[1] The strongest region of the LT complex is on the palmar side.[2]

Isolated injury of the lunotriquetral ligament (LTL) complex and associated structures is an uncommon injury and poorly understood compared with the other proximal row carpal ligament injuries including scapholunate le-

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sions. The spectrum of injuries to the LTL ranges from isolated partial tears to frank dislocation and from dynamic to static lunotriquetral carpal instability (LTI).[3] Carpal instability has been recognized as the absence of proper skeletal and ligamentous support to keep the wrist stable during static or dynamic positions to external loads involved in pinching and grasping.[4]

An individual may develop a LTL injury by means of a post-traumatic incident, degenerative changes over time, a positive ulnar variance, a perilunate injury or a reverse perilunate injury.[5] These individuals will complain of pain on the ulnar side of the wrist.[3] The diagnosis may be difficult to establish because of the many possible causes of ulnar-sided wrist pain and these patients often present with normal radiographic appearance.[5]

This report reviews the relevant literature on LT injuries and adds one more case report to the literature where the diagnosis has been made clinically and was confirmed by MRA.

Case Report

A 32-year-old male competitive climber presented with left wrist pain. He reported that the injury occurred as he was bouldering at a level around 80% of his maximum capabilities at an indoor climbing gym. He stated that he was climbing overhanging terrain, his feet cut, causing him to swing out, which lead to forceful ulnar deviation. He felt a 'crunch' and a low-grade pain that lasted several minutes. The patient stated that immediately following the injury it felt as though something was out of place on the medial aspect of his wrist. He did not continue to climb after the incident. The patient did explain that he had been experiencing pain with activities of daily living such as squeezing dish soap on a sponge, rolling over in bed, and pulling back a shower curtain.

Physical examination did not reveal any swelling or bruising. The patient experienced mild tenderness on palpation of the medial side of the left wrist on both the dorsal and palmar side. The patient reported pain upon end range of pronation/supination. The patients grip was noticeably weakened and made worse when griped in combination with full pronation. Pain was sharp and discrete. He rated the pain 2–3 on a 10 point scale.

The patient was then referred to a Sports Medicine Physician for a second opinion and possibly imaging. The Physician was concerned with a possible tear of the patient's Triangular Fibrocartilage Complex (TFCC) and referred him for an investigative MR-Arthrogram (MRA). Due to the length of the waiting time for the scheduled MRA, the patient was scheduled for an MRI within a significantly shorter time-frame.

The results from the MRI showed no convincing injury of the TFCC. There was a small amount of marrow edema along the base of the ulnar styloid but no associated fracture. It was thought that this could reflect a small area of bone bruising. After receiving the results from the MRI, the patient still felt something was wrong and decided to go ahead with the MRA.

Under fluoroscopic guidance, a 22-gauge needle was inserted into the radiocarpal joint. Position was confirmed with injection of radiopaque contrast material. Following this, 3 cc of a dilute gadolinium solution was injected into the radiocarpal joint. The patient then proceeded to obtain the MRI.

The MR demonstrated extensive contrast in the midcarpal joint and carpometacarpal joints (Figure 1). There was evidence of tear of the lunotriquetral ligament with extension of contrast from the radiocarpal joint into the midcarpal joint along the dorsal aspect of the joint. The radiologist stated that there was ill-definition of both the dorsal and volar bands of the LTL with no associated diastases (Figure 2). The articular cartilage and the rest of the surrounding structures were within normal limits.

The patient was referred for an orthopaedic consult with a hand surgeon. The surgeon suggested that he stop all climbing and mountain biking. She recommended a thermoplastic moulded brace to be worn for 3–5 months. The surgeon mentioned that surgery was an option but felt that bracing is a less invasive treatment and should be attempted first since the surgery is fairly invasive with a long recovery period. The patient decided to abstain from all physical activity involving his left wrist and wore the thermoplastic moulded brace 5 days per week, regularly for 6 months.

After the completion of this time frame, the patient began climbing again at a slow, progressive rate. He was told to pay close attention to his pain levels and as long as there was no pain he could slowly increase his activity level. The patient stated that he started climbing once a week for 3 weeks, progressed to twice a week for 3 weeks and then three times for 3 weeks. One year after the incident, and 8 months after the start of the rehabilitation

Figure 1 *Fluoroscopic spot radiograph of the left wrist. This image was taken during the injection of contrast medium to localize the structure of interest. This image demonstrates extensive contrast from the radiocarpal joint into the midcarpal joint along the dorsal aspect of the joint (arrow).*

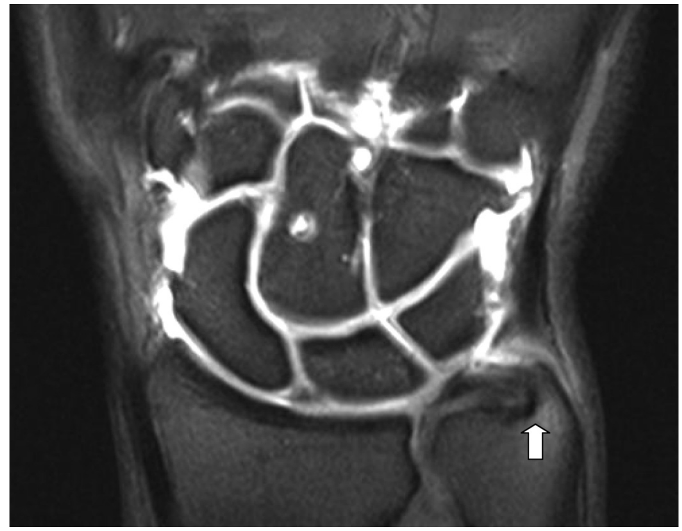

Figure 2 *Coronal T2-weighted MRI: The MR demonstrates increased signal intensity at the base of the ulnar styloid (arrow) and a large cyst in the capitate bone.*

process the patient stated that he was climbing at 75% of his pre-injury level. He also stated that he can still feel clicking in certain wrist postures. There is little pain during activity and he rates it less than 1 on a 10 point scale.

Discussion

Anatomy

The ligaments of the wrist are characterized as either extrinsic or intrinsic. An extrinsic ligament connects the radius to one or more carpal bones – a radiocarpal ligament. An intrinsic ligament interconnects two carpal bones together. Generally, the palmar extrinsic ligaments are more important than the dorsal extrinsic ligaments for carpal stability. The scapholunate and lunotriquetral ligaments are the most important intrinsic ligaments.[6]

There are three major palmar radiocarpal ligaments: the radioscaphocapitate ligament, the radiolunotriquetral ligament, and the short radiolunate ligament. The radiolunotriquetral ligament is the largest ligament of the wrist and originates just ulnar to the radioscaphocapitate ligament from the radial styloid process. It courses obliquely attaching to the lunate and triquetrum. The radioscaphocapitate and radiolunotriquetral ligaments are intracapsular as their volar surfaces are enveloped by the superficial fibrous portion of the joint capsule. They are also extrasynovial structures as their deep surfaces are enveloped by synovium.[6]

The proximal lunate and triquetrum is interconnected by the lunotriquetral ligament. It is a horseshoe-shaped structure that is uniformly thin and more lax in appearance than the scapholunate ligament. The central and proximal segments of the LTL are slim fibrocartilaginous structures with inadequate vascular supply.[7] The proximal margins of the scaphoid and lunate are connected by the scapholunate ligament. Its volar and dorsal portions are triangular and the middle portion of the ligament is thin and bandlike.[6]

Since the strongest region of the LT complex is on the palmar side it is important to stress this side of the wrist in an injured patient to determine if the critical restraining ligament of this joint has been compromised.[2]

Mechanism of Injury

The mechanism behind LT injuries is variable and can include a high-energy impaction after a traumatic incident (such as contact by falling on an outstretched hand).[5] The palmar portion of the LTL, dorsal radiocarpal ligament, and dorsal intercarpal ligament play the most significant roles in LT stability.[1] Volar midcarpal instability occurs when the lunate is no longer linked to the triquetrum. In this situation the lunate follows the scaphoid and angulates palmarly. As a result the capitate is displaced palmar to the radiometacarpal axis.[8]

Wrist instability can also develop from misalignment of a distal radius following fracture, which may produce relative length changes in the wrist ligaments leading to wrist instability.[9] In addition, dynamic wrist instability has been shown to result from an underlying ligament injury associated with wrist ganglions, lifting and twisting manoeuvres, overuse of the wrist, arthritis, positive ulnar variance, and perilunate or reverse perilunate injury.[9]

Signs and Symptoms

During the examination of a patient with a LTL tear will characteristically present with ulnar sided wrist pain or point tenderness over the LT interval.[3] Frequently, the patient will report symptoms of both generalized and focal pain, weak gripping abilities, and the inability to stabilize the wrist under load.[9] The instability during gripping actions will present itself while the wrist is positioned in dorsal flexion and ulnar-duction.[3]

Patients with dynamic patterns of midcarpal instability present with a wrist clunk when moving from radial to ulnar deviation but may be normal at rest. Instead of making a smooth synchronous transition during wrist movement the proximal carpal row will snap suddenly from a palmar flexed position to a dorsal flexed position.[10]

Orthopaedic Examination

Many individuals with carpal injuries and instability do not present with obvious clinical findings. Provocative manoeuvres to assess instability remain largely physician dependent and many of the tests proved to be more efficient at predicting the absence of injury than at predicting its presence.[11]

There are many commonly used stress tests for ruling out other wrist injuries including the Scaphoid Shift Test, Triquetroulnar Critical Test, Triangular Fibrocartilage Complex Stress Test, Midcarpal Stress Test and the Gripping Rotatory Impaction Test (GRIT) for TFCC tears.[15] Some of the commonly used stress tests for determining LTI include the Lunotriquetral Ballottment Test, Reagan Shuck test, Lunotriquetral Shear Test (Kleinman Shear Test), and the Linscheid Compression Test (Squeeze Test).[12]

Lunotriquetral ballottement is performed by compressing the triquetrum against the lunate. One hand is used to stabilize the wrist while the other thumb applies a radial force driving the triquetrum into the lunate.[12] This test has been shown to have a sensitivity of 64%, a specificity of 45%, a positive likelihood ratio of 1.2 and a negative likelihood ratio 0.80.[11] The *Regan Shuck test* involves one hand placed with the thumb and index on the triquetrum and pisiform while the other hand is placed on the lunate and radial wrist. The 2 hands are moved in opposite directions creating stress across the lunotriquetral joint.[12]

The Lunotriquetral Shear Test (Kleinman Shear Test) requires the clinician to grasp the pisiform and triquetrum. The contralateral thumb and index finger hold the lunate and radial carpus. The clinician will move the triquetrum while the lunate and the radial wrist remains stationary. The force transmitted across the LT joint is extremely precise and will cause a shift and pain in a patient with instability of the LT joint.[12]

The Linscheid Compression Test can also be referred to as the Squeeze Test. The clinician places their thumb on the ulnar border of the triquetrum and pushes in a radial direction. Compression force across the LT joint will elicit movement and/or pain in a patient with LT joint damage.[13]

Imaging for Lunotriquetral Injuries

Lunotriquetral instability is difficult to detect on radiographs and traditional MRI.[14] A wide range of sensitivities (40%–100%) and specificities (33%–100%) have been reported in the diagnosis of lunotriquetral ligament injuries using MRI.[8] For diagnosis, arthroscopic examination for LTI is the gold standard and most reliable.[3] However, recently multidetector computed tomography arthrography (MDCTA) and magnetic resonance arthrography (MRA) have become widely available and very useful in the detection of LTI.

CT-Arthrography (CTA) has been suggested for the assessment of SLL and LTL tears.[15] Schmid et al.[16] compared CTA to standard MRI for the evaluation of SLL and LTL tears. They found that CTA was superior to MR imaging in the detection of dorsal segment tears. Furthermore, CTA has ability to identify cartilage defects and thinning.[5] It has been suggested that CTA be used as the primary modality for the examination of intrinsic ligament tears.[17] Moser et al.[17] stated that the CTA sensitivities, specificities, and accuracies are similar or improved compared with MRA. They found that the sensitivity and specificity of MRI, MDCT arthrography, and MRA for tears of the SLL and LTL appeared equivalent for complete tears, but partial tears were significantly better visualized with MDCT arthrography.[18]

MRA combines the advantages of conventional MR imaging and arthrography by improving the visualization of small intra-articular abnormalities making lesions more conspicuous when they are outlined by contrast material in a distended joint space. Intra-articular injection of a contrast agent is generally performed under fluoroscopic guidance. The contrast agent will flow into both the scapholunate and lunotriquetral spaces. The intrinsic ligaments at the proximal margins of the scaphoid, lunate, and triquetral bones arrest the proximal flows of contrast, preventing communication with the radiocarpal compartment.[8] A solution of gadolinium diluted in a solution composed of saline, iodinated contrast material, and lidocaine is commonly used.[19]

The MRA modality allows for a confident assessment of ligament tears and potential diagnosis of associated abnormalities of cartilage, bone, and soft tissues.[17] Specific injuries to this area of the wrist which are detected through MRA include tears to the triangular fibrocartilage complex (TFCC), ulnar impaction syndrome, ulnar collateral ligament injury and instability of the scapholunate and lunotriquetral joint. The MRA is used to visualize disruption of the volar, dorsal and intrinsic carpal ligaments including the most crucial injuries to the interosseous scapholunate and lunotriquetral ligaments.[8] It has been suggested that direct MRA is equal to arthroscopy, but only an experienced radiologist who is familiar with this technique should perform this imaging.[14] However, the evaluation of ligamentous and TFCC injury must always begin with conventional radiographs.[17]

For MRA, this ligament will appear as linear in 37% and triangular in 63% of patients.[20] The signal intensity is homogeneous and low in the majority of patients and is distinguishable from a tear because it is not quite as bright as a fluid signal.[8] Disruption of the ligament is demonstrated on fat-suppressed T2-weighted images as a complete disruption or a discrete area of bright, linear signal intensity in a partial or complete tear.[8] It must be noted that even in advanced cases joint widening of the LT articulation is not usually evident. It is also important to note that the ligament tends to have a discontinuous appearance on MRA near the TFCC and it should not be mistaken for a tear.[8]

Treatment

Appropriate treatment requires assessment of the degree of instability and the chronicity of the injury. The methods for treatment of LTI of incomplete lesions without instability respond well to conservative, nonoperative treatments. Some of the most commonly used conservative therapies include immobilization/splinting, activity modification, strengthening exercises for grip and the wrist (isometric, isotonic, eccentric), peripheral joint mobilization, electrotherapy and corticosteroid injection.[1]

Surgery is sometimes necessary with complete ligament disruption. With a complete tear of the ligaments, LT joint reconstructions and stabilization is performed by tenodesis or arthrodesis.[3,5] Ulnar shortening may be required for individuals with problematic variances.[5] If the surgical approach is taken, after suturing the dorsal structures and skin, typically a high plaster cast reaching up above the elbow is applied for approximately 4 weeks, followed by application of a short plaster splint for another 2 weeks.[3]

Clinical Significance

The clinical significance of imaging findings of TFCC and ligament tears is controversial. Multiple studies have indicated that a large portion of asymptomatic wrists can present with communicating defects in the TFCC and intrinsic ligaments.[21] Several studies have verified defects in asymptomatic wrists as degenerative changes within the substance of the ligaments, as well as within the TFCC.[22–24] Therefore, a communicating defect of the ligaments or TFCC, through MRA, could present as an asymptomatic degenerative degradation within the wrist or as a symptomatic tear.

The clinical significance of a tear found through imaging on an asymptomatic wrist is complicated. Many people have several wrist injuries and therefore an asymptomatic wrist at the time of the examination cannot exclude that the wrist was previously damaged. Tears of different segments of the LTL have been shown to have varying clinical significance. The volar portion of LTL is the main contributors to stability of that joint consisting of closely packed collagen fibers.[25] The central portions of the LTL contributes little to stability as it is composed of a thin fibrocartilaginous membrane.[26] With increased age degenerative perforations in the middle segments of the LTL are commonly found and correlate poorly with patients' symptoms.[27]

Extrinsic ligaments between the radius, ulna, and carpal bones are important in maintaining carpal stability. The radiolunotriquetral ligament (RLTL) is one of the most important ligament complexes for carpal stability. The RLTL maintains the load transference and prevents ulnar translation.[28] If this ligament is damaged, it is more likely that there will be the need for treatment intervention.

Future studies should examine the clinical relevance of LT injuries in asymptomatic and symptomatic populations. It would be beneficial to observe the effects of conservative therapy, such as immobilization/splinting, activity modification, strengthening exercises for grip and the wrist, on these two populations and compare its effectiveness with surgery. It must be noted that this was only one case study demonstrating the diagnosis of a lunotriquetral ligament injury through fluoroscopy and MRI. It may be useful to support these findings with a lunotriquetral injury case series that can contrast differences found between various lunotriquetral injuries.

Conclusion

Carpal injuries and instability commonly results from high energy trauma sport-related activities.[1] Even though the scapholunate joint is more commonly affected, LT joint injury can present itself and should be considered within a differential diagnosis of a wrist injury. The diagnosis of LTI through clinical history and physical examination can be confirmed by MRA. This case report demonstrates the importance of MRA in the accurate diagnosis and management of a patient with wrist pain.

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Lunotriquetral instability in a climber – case report and review

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Wrist injuries and carpal instability may result from various sport-related acitivites. Lunotriquetral instability (LTI) is an infrequently recognized cause of wrist pain in athletes. The diagnosis of LTI through history and physical examination can be confirmed by Magnetic Resonance Arthrogram (MRA). This case report describes a case of clinically suspected LTI confirmed by MRA. Relevant literature on lunotriquetral injuries is discussed. Lunotriquetral joint injury can present itself and should be considered within a differential diagnosis of a wrist injury. The diagnosis of LTI through clinical history and physical examination can be confirmed by MRA. This case report demonstrates the importance of MRA in the accurate diagnosis and management of a patient with wrist pain.
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KEY WORDS: ligament, lunotriquetral, carpal instabilities, MR-Arthrogram, wrist

Les blessures au poignet et l'instabilité carpienne peuvent être causées par diverses activités sportives. L'instabilité luno-pyramidale (ILP) est une cause moins reconnue de douleur au poignet chez les athlètes. Le diagnostic de l'ILP par le biais d'examens et des antécédents médicaux peut être confirmé par un arthrogramme par résonance magnétique (ARM). Cette étude de cas décrit une ILP cliniquement soupçonnée et confirmée par l'ARM. La documentation pertinente sur les blessures luno-pyramidales fait l'objet d'une discussion. Une blessure luno-pyramidale aux articulations peut survenir, et doit faire l'objet d'un diagnostic différentiel d'une blessure au poignet. Le diagnostic d'ILP par le biais d'examens et des antécédents médicaux peut être confirmé par un arthrogramme par résonance magnétique (ARM). Cette étude de cas démontre l'importance d'un ARM pour énoncer un diagnostic exact et gérer un gérer souffrant d'une douleur au poignet.
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MOTS CLÉS : ligament, luno-pyramidal, instabilité carpienne, arthrogramme RM, poignet

Introduction

Carpal injuries and instability commonly result from high energy trauma and sports-related activities.[1] Two commonly affected complexes include the scapholunate and lunotriquetral joints. The stability of these joints depends on both the interosseous ligaments and extrinsic capsular elements.[2] Lunotriquetral (LT) injuries occur approximately one sixth as commonly as scapholuntate injuries.[1] The strongest region of the LT complex is on the palmar side.[2]

Isolated injury of the lunotriquetral ligament (LTL) complex and associated structures is an uncommon injury and poorly understood compared with the other proximal row carpal ligament injuries including scapholunate le-

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sions. The spectrum of injuries to the LTL ranges from isolated partial tears to frank dislocation and from dynamic to static lunotriquetral carpal instability (LTI).[3] Carpal instability has been recognized as the absence of proper skeletal and ligamentous support to keep the wrist stable during static or dynamic positions to external loads involved in pinching and grasping.[4]

An individual may develop a LTL injury by means of a post-traumatic incident, degenerative changes over time, a positive ulnar variance, a perilunate injury or a reverse perilunate injury.[5] These individuals will complain of pain on the ulnar side of the wrist.[3] The diagnosis may be difficult to establish because of the many possible causes of ulnar-sided wrist pain and these patients often present with normal radiographic appearance.[5]

This report reviews the relevant literature on LT injuries and adds one more case report to the literature where the diagnosis has been made clinically and was confirmed by MRA.

Case Report

A 32-year-old male competitive climber presented with left wrist pain. He reported that the injury occurred as he was bouldering at a level around 80% of his maximum capabilities at an indoor climbing gym. He stated that he was climbing overhanging terrain, his feet cut, causing him to swing out, which lead to forceful ulnar deviation. He felt a 'crunch' and a low-grade pain that lasted several minutes. The patient stated that immediately following the injury it felt as though something was out of place on the medial aspect of his wrist. He did not continue to climb after the incident. The patient did explain that he had been experiencing pain with activities of daily living such as squeezing dish soap on a sponge, rolling over in bed, and pulling back a shower curtain.

Physical examination did not reveal any swelling or bruising. The patient experienced mild tenderness on palpation of the medial side of the left wrist on both the dorsal and palmar side. The patient reported pain upon end range of pronation/supination. The patients grip was noticeably weakened and made worse when griped in combination with full pronation. Pain was sharp and discrete. He rated the pain 2–3 on a 10 point scale.

The patient was then referred to a Sports Medicine Physician for a second opinion and possibly imaging. The Physician was concerned with a possible tear of the patient's Triangular Fibrocartilage Complex (TFCC) and referred him for an investigative MR-Arthrogram (MRA). Due to the length of the waiting time for the scheduled MRA, the patient was scheduled for an MRI within a significantly shorter time-frame.

The results from the MRI showed no convincing injury of the TFCC. There was a small amount of marrow edema along the base of the ulnar styloid but no associated fracture. It was thought that this could reflect a small area of bone bruising. After receiving the results from the MRI, the patient still felt something was wrong and decided to go ahead with the MRA.

Under fluoroscopic guidance, a 22-gauge needle was inserted into the radiocarpal joint. Position was confirmed with injection of radiopaque contrast material. Following this, 3 cc of a dilute gadolinium solution was injected into the radiocarpal joint. The patient then proceeded to obtain the MRI.

The MR demonstrated extensive contrast in the midcarpal joint and carpometacarpal joints (Figure 1). There was evidence of tear of the lunotriquetral ligament with extension of contrast from the radiocarpal joint into the midcarpal joint along the dorsal aspect of the joint. The radiologist stated that there was ill-definition of both the dorsal and volar bands of the LTL with no associated diastases (Figure 2). The articular cartilage and the rest of the surrounding structures were within normal limits.

The patient was referred for an orthopaedic consult with a hand surgeon. The surgeon suggested that he stop all climbing and mountain biking. She recommended a thermoplastic moulded brace to be worn for 3–5 months. The surgeon mentioned that surgery was an option but felt that bracing is a less invasive treatment and should be attempted first since the surgery is fairly invasive with a long recovery period. The patient decided to abstain from all physical activity involving his left wrist and wore the thermoplastic moulded brace 5 days per week, regularly for 6 months.

After the completion of this time frame, the patient began climbing again at a slow, progressive rate. He was told to pay close attention to his pain levels and as long as there was no pain he could slowly increase his activity level. The patient stated that he started climbing once a week for 3 weeks, progressed to twice a week for 3 weeks and then three times for 3 weeks. One year after the incident, and 8 months after the start of the rehabilitation

Figure 1 *Fluoroscopic spot radiograph of the left wrist. This image was taken during the injection of contrast medium to localize the structure of interest. This image demonstrates extensive contrast from the radiocarpal joint into the midcarpal joint along the dorsal aspect of the joint (arrow).*

Figure 2 *Coronal T2-weighted MRI: The MR demonstrates increased signal intensity at the base of the ulnar styloid (arrow) and a large cyst in the capitate bone.*

process the patient stated that he was climbing at 75% of his pre-injury level. He also stated that he can still feel clicking in certain wrist postures. There is little pain during activity and he rates it less than 1 on a 10 point scale.

Discussion

Anatomy

The ligaments of the wrist are characterized as either extrinsic or intrinsic. An extrinsic ligament connects the radius to one or more carpal bones – a radiocarpal ligament. An intrinsic ligament interconnects two carpal bones together. Generally, the palmar extrinsic ligaments are more important than the dorsal extrinsic ligaments for carpal stability. The scapholunate and lunotriquetral ligaments are the most important intrinsic ligaments.[6]

There are three major palmar radiocarpal ligaments: the radioscaphocapitate ligament, the radiolunotriquetral ligament, and the short radiolunate ligament. The radiolunotriquetral ligament is the largest ligament of the wrist and originates just ulnar to the radioscaphocapitate ligament from the radial styloid process. It courses obliquely attaching to the lunate and triquetrum. The radioscaphocapitate and radiolunotriquetral ligaments are intracapsular as their volar surfaces are enveloped by the superficial fibrous portion of the joint capsule. They are also extrasynovial structures as their deep surfaces are enveloped by synovium.[6]

The proximal lunate and triquetrum is interconnected by the lunotriquetral ligament. It is a horseshoe-shaped structure that is uniformly thin and more lax in appearance than the scapholunate ligament. The central and proximal segments of the LTL are slim fibrocartilaginous structures with inadequate vascular supply.[7] The proximal margins of the scaphoid and lunate are connected by the scapholunate ligament. Its volar and dorsal portions are triangular and the middle portion of the ligament is thin and bandlike.[6]

Since the strongest region of the LT complex is on the palmar side it is important to stress this side of the wrist in an injured patient to determine if the critical restraining ligament of this joint has been compromised.[2]

Mechanism of Injury

The mechanism behind LT injuries is variable and can include a high-energy impaction after a traumatic incident (such as contact by falling on an outstretched hand).[5] The palmar portion of the LTL, dorsal radiocarpal ligament, and dorsal intercarpal ligament play the most significant roles in LT stability.[1] Volar midcarpal instability occurs when the lunate is no longer linked to the triquetrum. In this situation the lunate follows the scaphoid and angulates palmarly. As a result the capitate is displaced palmar to the radiometacarpal axis.[8]

Wrist instability can also develop from misalignment of a distal radius following fracture, which may produce relative length changes in the wrist ligaments leading to wrist instability.[9] In addition, dynamic wrist instability has been shown to result from an underlying ligament injury associated with wrist ganglions, lifting and twisting manoeuvres, overuse of the wrist, arthritis, positive ulnar variance, and perilunate or reverse perilunate injury.[9]

Signs and Symptoms

During the examination of a patient with a LTL tear will characteristically present with ulnar sided wrist pain or point tenderness over the LT interval.[3] Frequently, the patient will report symptoms of both generalized and focal pain, weak gripping abilities, and the inability to stabilize the wrist under load.[9] The instability during gripping actions will present itself while the wrist is positioned in dorsal flexion and ulnar-duction.[3]

Patients with dynamic patterns of midcarpal instability present with a wrist clunk when moving from radial to ulnar deviation but may be normal at rest. Instead of making a smooth synchronous transition during wrist movement the proximal carpal row will snap suddenly from a palmar flexed position to a dorsal flexed position.[10]

Orthopaedic Examination

Many individuals with carpal injuries and instability do not present with obvious clinical findings. Provocative manoeuvres to assess instability remain largely physician dependent and many of the tests proved to be more efficient at predicting the absence of injury than at predicting its presence.[11]

There are many commonly used stress tests for ruling out other wrist injuries including the Scaphoid Shift Test, Triquetroulnar Critical Test, Triangular Fibrocartilage Complex Stress Test, Midcarpal Stress Test and the Gripping Rotatory Impaction Test (GRIT) for TFCC tears.[15] Some of the commonly used stress tests for determining LTI include the Lunotriquetral Ballottment Test, Reagan Shuck test, Lunotriquetral Shear Test (Kleinman Shear Test), and the Linscheid Compression Test (Squeeze Test).[12]

Lunotriquetral ballottement is performed by compressing the triquetrum against the lunate. One hand is used to stabilize the wrist while the other thumb applies a radial force driving the triquetrum into the lunate.[12] This test has been shown to have a sensitivity of 64%, a specificity of 45%, a positive likelihood ratio of 1.2 and a negative likelihood ratio 0.80.[11] The *Regan Shuck test* involves one hand placed with the thumb and index on the triquetrum and pisiform while the other hand is placed on the lunate and radial wrist. The 2 hands are moved in opposite directions creating stress across the lunotriquetral joint.[12]

The Lunotriquetral Shear Test (Kleinman Shear Test) requires the clinician to grasp the pisiform and triquetrum. The contralateral thumb and index finger hold the lunate and radial carpus. The clinician will move the triquetrum while the lunate and the radial wrist remains stationary. The force transmitted across the LT joint is extremely precise and will cause a shift and pain in a patient with instability of the LT joint.[12]

The Linscheid Compression Test can also be referred to as the Squeeze Test. The clinician places their thumb on the ulnar border of the triquetrum and pushes in a radial direction. Compression force across the LT joint will elicit movement and/or pain in a patient with LT joint damage.[13]

Imaging for Lunotriquetral Injuries

Lunotriquetral instability is difficult to detect on radiographs and traditional MRI.[14] A wide range of sensitivities (40%–100%) and specificities (33%–100%) have been reported in the diagnosis of lunotriquetral ligament injuries using MRI.[8] For diagnosis, arthroscopic examination for LTI is the gold standard and most reliable.[3] However, recently multidetector computed tomography arthrography (MDCTA) and magnetic resonance arthrography (MRA) have become widely available and very useful in the detection of LTI.

CT-Arthrography (CTA) has been suggested for the assessment of SLL and LTL tears.[15] Schmid et al.[16] compared CTA to standard MRI for the evaluation of SLL and LTL tears. They found that CTA was superior to MR imaging in the detection of dorsal segment tears. Furthermore, CTA has ability to identify cartilage defects and thinning.[5] It has been suggested that CTA be used as the primary modality for the examination of intrinsic ligament tears.[17] Moser et al.[17] stated that the CTA sensitivities, specificities, and accuracies are similar or improved compared with MRA. They found that the sensitivity and specificity of MRI, MDCT arthrography, and MRA for tears of the SLL and LTL appeared equivalent for complete tears, but partial tears were significantly better visualized with MDCT arthrography.[18]

MRA combines the advantages of conventional MR imaging and arthrography by improving the visualization of small intra-articular abnormalities making lesions more conspicuous when they are outlined by contrast material in a distended joint space. Intra-articular injection of a contrast agent is generally performed under fluoroscopic guidance. The contrast agent will flow into both the scapholunate and lunotriquetral spaces. The intrinsic ligaments at the proximal margins of the scaphoid, lunate, and triquetral bones arrest the proximal flows of contrast, preventing communication with the radiocarpal compartment.[8] A solution of gadolinium diluted in a solution composed of saline, iodinated contrast material, and lidocaine is commonly used.[19]

The MRA modality allows for a confident assessment of ligament tears and potential diagnosis of associated abnormalities of cartilage, bone, and soft tissues.[17] Specific injuries to this area of the wrist which are detected through MRA include tears to the triangular fibrocartilage complex (TFCC), ulnar impaction syndrome, ulnar collateral ligament injury and instability of the scapholunate and lunotriquetral joint. The MRA is used to visualize disruption of the volar, dorsal and intrinsic carpal ligaments including the most crucial injuries to the interosseous scapholunate and lunotriquetral ligaments.[8] It has been suggested that direct MRA is equal to arthroscopy, but only an experienced radiologist who is familiar with this technique should perform this imaging.[14] However, the evaluation of ligamentous and TFCC injury must always begin with conventional radiographs.[17]

For MRA, this ligament will appear as linear in 37% and triangular in 63% of patients.[20] The signal intensity is homogeneous and low in the majority of patients and is distinguishable from a tear because it is not quite as bright as a fluid signal.[8] Disruption of the ligament is demonstrated on fat-suppressed T2-weighted images as a complete disruption or a discrete area of bright, linear signal intensity in a partial or complete tear.[8] It must be noted that even in advanced cases joint widening of the LT articulation is not usually evident. It is also important to note that the ligament tends to have a discontinuous appearance on MRA near the TFCC and it should not be mistaken for a tear.[8]

Treatment

Appropriate treatment requires assessment of the degree of instability and the chronicity of the injury. The methods for treatment of LTI of incomplete lesions without instability respond well to conservative, nonoperative treatments. Some of the most commonly used conservative therapies include immobilization/splinting, activity modification, strengthening exercises for grip and the wrist (isometric, isotonic, eccentric), peripheral joint mobilization, electrotherapy and corticosteroid injection.[1]

Surgery is sometimes necessary with complete ligament disruption. With a complete tear of the ligaments, LT joint reconstructions and stabilization is performed by tenodesis or arthrodesis.[3,5] Ulnar shortening may be required for individuals with problematic variances.[5] If the surgical approach is taken, after suturing the dorsal structures and skin, typically a high plaster cast reaching up above the elbow is applied for approximately 4 weeks, followed by application of a short plaster splint for another 2 weeks.[3]

Clinical Significance

The clinical significance of imaging findings of TFCC and ligament tears is controversial. Multiple studies have indicated that a large portion of asymptomatic wrists can present with communicating defects in the TFCC and intrinsic ligaments.[21] Several studies have verified defects in asymptomatic wrists as degenerative changes within the substance of the ligaments, as well as within the TFCC.[22–24] Therefore, a communicating defect of the ligaments or TFCC, through MRA, could present as an asymptomatic degenerative degradation within the wrist or as a symptomatic tear.

The clinical significance of a tear found through imaging on an asymptomatic wrist is complicated. Many people have several wrist injuries and therefore an asymptomatic wrist at the time of the examination cannot exclude that the wrist was previously damaged. Tears of different segments of the LTL have been shown to have varying clinical significance. The volar portion of LTL is the main contributors to stability of that joint consisting of closely packed collagen fibers.[25] The central portions of the LTL contributes little to stability as it is composed of a thin fibrocartilaginous membrane.[26] With increased age degenerative perforations in the middle segments of the LTL are commonly found and correlate poorly with patients' symptoms.[27]

Extrinsic ligaments between the radius, ulna, and carpal bones are important in maintaining carpal stability. The radiolunotriquetral ligament (RLTL) is one of the most important ligament complexes for carpal stability. The RLTL maintains the load transference and prevents ulnar translation.[28] If this ligament is damaged, it is more likely that there will be the need for treatment intervention.

Future studies should examine the clinical relevance of LT injuries in asymptomatic and symptomatic populations. It would be beneficial to observe the effects of conservative therapy, such as immobilization/splinting, activity modification, strengthening exercises for grip and the wrist, on these two populations and compare its effectiveness with surgery. It must be noted that this was only one case study demonstrating the diagnosis of a lunotriquetral ligament injury through fluoroscopy and MRI. It may be useful to support these findings with a lunotriquetral injury case series that can contrast differences found between various lunotriquetral injuries.

Conclusion

Carpal injuries and instability commonly results from high energy trauma sport-related activities.[1] Even though the scapholunate joint is more commonly affected, LT joint injury can present itself and should be considered within a differential diagnosis of a wrist injury. The diagnosis of LTI through clinical history and physical examination can be confirmed by MRA. This case report demonstrates the importance of MRA in the accurate diagnosis and management of a patient with wrist pain.

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Adductor tendinopathy in a hockey player with persistent groin pain: a case report

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Groin pain may stem from a variety of different causes. Adductor tendinopathy is a common but infrequently recognised cause of chronic groin pain especially in athletes. This case report describes a case of clinically suspected adductor tendinopathy in an amateur athlete confirmed by MRI (Magnetic Resonance Imaging). Relevant literature on musculotendinous injuries of the groin along with differential diagnosis for groin pain is discussed. There are several differential diagnoses for athletes that present with groin pain. Therefore, it is important to accurately diagnose the origin of groin pain as the plan of management is dependent of the specificity of the diagnosis. The diagnosis of adductor tendinopathy is made with a history of chronic groin pain along with pain/weakness during isometric adduction of the hip muscles. It is confirmed by MR imaging.
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KEY WORDS: adductor muscle, tendinopathy, MRI, groin pain, tenoperiosteal disease, enthesopathy, adductor strain

La douleur à l'aine peut être causée par différents facteurs. La tendinopathie adductrice est une cause courante mais rarement reconnue de douleur chronique à l'aine, particulièrement chez les athlètes. Cette étude de cas décrit une tendinopathie adductrice cliniquement soupçonnée chez un athlète amateur, puis confirmée par une imagerie par résonance magnétique (IRM). La documentation pertinente sur les blessures musculotendineuses de l'aine ainsi que le diagnostic différentiel des blessures de l'aine fait l'objet d'une discussion. Il existe plusieurs diagnostics différentiels pour les athlètes qui ont des douleurs à l'aine. Il est donc important de diagnostiquer avec exactitude l'origine des douleurs à l'aine, car le plan de gestion dépend de la spécificité du diagnostic. Le diagnostic de tendinopathie adductrice est prononcé lorsqu'il y a antécédents de douleur chronique à l'aine ainsi qu'une douleur/faiblesse durant l'adduction isométrique des muscles de la hanche. Le tout est confirmé par une imagerie RM.
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MOTS CLÉS : muscle adducteur, tendinopathie, IRM, douleur à l'aine, maladie ténopériostéale, enthésopathie, fouleur de l'adducteur

Introduction

Groin pain is a common problem found in many athletes.[1] Many athletes will present to clinicians with a history of groin pain that may be acute or chronic in nature, and may stem from a single traumatic event or repeated microtrauma to the region.[2] However, multiple pathologies may exist in individuals with chronic groin pain,[3] adding complexity to the diagnosis and management of these patients.[4] There are several common causes of groin pain. The groin pain may stem from the lumbar spine,

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sacroiliac joint, symphysis pubis stress, rectus abdominis tear, sports hernia, iliopsoas pathology or adductor musculotendinous pathology.[1,3,5]

The cases of groin pain in athletes that actually involve adductor muscle pathology can present in various forms. Adductor related groin pain can be due to muscle strain, tendinosis, tendinitis, paratenonitis, enthesopathy or a combination of the aforementioned (Table 1).[6] Therefore the specific diagnosis is crucial for the plan of management. Since the list of differential diagnoses for groin pain is large, MRI (Magnetic Resonance Imaging) is necessary to localize pathology and define its type.

There are several review articles examining groin and hip pain with associated adductor pathology.[2,3,7,8] There are articles examining adductor tears[9] and calcific tendinitis of the adductor magnus.[10] However, the case report literature is sparse in examining groin pain in athletes with a proven diagnosis of adductor tendinopathy through radiological evidence.[5,11,12]

Due to the complexity of groin pain in athletes and the difficulty to specifically diagnose the accurate pathological structure, it is important to have radiological evidence in combination with physical examination outcomes to appropriately manage these problematic patients. Delay in diagnosis and treatment may result in undesired complications and lost time from sport participation. The diagnosis of adductor tendinopathy through clinical history of chronic groin pain along with pain/weakness during isometric adduction of the hip muscles needs to be confirmed by advanced imaging to definitively exclude the many other possible anatomical structures that have been implicated in groin pain. This report reviews the relevant literature on adductor musculotendinous pathology, examines the common differential diagnosis for athletes with groin pain and adds one more case report to the literature where the diagnosis has been made clinically and was confirmed by MRI.

Case report

A 21 year old male previously competitive hockey player with persistent groin pain was referred for an MRI at our hospital. This athlete was competing recreationally and had symptoms of chronic pain in the region of the groin. The patient described his pain as localized to one specific region in the proximal portion of his left groin. Palpatory pin point tenderness was elicited at the proximal portion of the left groin at the tendinous insertion. A physical examination revealed pain and weakness of isometric adduction of the hip muscles. A clinical diagnosis of an adductor tendinopathy from repeated microtrauma and overuse was suspected and MR imaging was taken to confirm the diagnosis.

The MRI was performed on a Siemens 1.5 tesla scanner. Coronal T1 and coronal STIR in the plane of the body of the pubis, axial T1 and T2 fat saturation and sagittal gradient sequences were obtained.

The Axial T2 MRI, located at the level of the inferior body of the pubis at the adductor longus tendons, demonstrated an intense bright marrow signal within the body of the pubis bilaterally (Figure 1). This finding is suggestive of focal intense marrow edema at the attachment of the adductor longus tendons.

The Serial coronal T2 MRI, located at the level of the body of the pubis and the attachment of the adductor tendons, demonstrated an intense bright signal within the bone marrow of the body of the pubis bilaterally and the adductor longus tendon at its attachment to the body of the pubis (Figure 2). This finding is indicative of intense focal marrow edema and suggestive of adductor tendinopathy. The bright signal within the tendon is more obvious on the left side than the right.

Discussion

This case report demonstrates the diagnosis of adductor tendinopathy through a history of chronic groin pain, physical findings of pain/weakness during isometric adduction of the hip muscles, palpatory pin point tenderness and confirmed by MRI**.**

Chronic groin pain can develop from muscle strain, tendinosis, tendinitis, paratenonitis, enthesopathy or a combination of the aforementioned (Table 1).[6] Treatment for these conditions varies and therefore necessitates an aggressive early diagnosis to prevent undesired complications such as chronic groin pain and lost time from sport participation. Muscle strain, musculotendinous strain and tendinopathy disorders responds well to conservative rehabilitation therapy whereas enthesopathy, micro-tears at the tendon-periosteal junction, often progresses to prolonged, chronic groin pain.[13]

Pathology

The scientific literature for the sprain/strain injury process,

Table 1 *Classification of tendon and muscle injuries*[32,33]

Pathological Diagnosis	**Concept (Macroscopic Pathology)**	**Histological Appearance**
Tendinosis	Intratendinous degeneration (commonly caused by ageing, microtrauma and vascular compromise)	Collagen disorientation, disorganisation and fibre separation with an increase in mucoid ground substance, increased prominence of cells and vascular spaces with or without neovascularisation, and focal necrosis or calcification
Tendinitis/partial rupture	Symptomatic degeneration of the tendon with vascular disruption and inflammatory repair response	Degenerative changes as noted above with superimposed evidence of tear, including fibroblastic and myofibroblastic proliferation, haemorrhage and organising granulation tissue
Paratenonitis	"Inflammation" of the outer layer of the tendon (paratenon) alone, regardless of whether the paratenon is lined by synovium	Mucoid degeneration in the areolar tissue is seen. A scattered mild mononuclear infiltrate with or without focal fibrin deposition and fibrinous exudate is also seen
Paratenonitis with tendinosis	Paratenonitis associated with intratendinous degeneration	Degenerative changes as noted for tendinosis with mucoid degeneration with or without fibrosis and scattered inflammatory cells in the paratenon alveolar tissue
Enthesopathy	An inflammation or disease of an enthesis (the point at which a tendon joins to a bone)	Similar to tendinitis
Muscle Strain	An injury to a muscle in which the muscle fibers tear as a result of overstretching	*Destruction phase* – Rupture and ensuing necrosis of the myofibers, the formation of a hematoma between the ruptured muscle stumps, and the inflammatory cell reaction *Repair phase* – Phagocytosis of the necrotized tissue, the regeneration of the myofibers, the concomitant production of a connective tissue scar and capillary ingrowth *Remodeling phase* – Maturation of the regenerated myofibers, the contraction and reorganization of the scar tissue

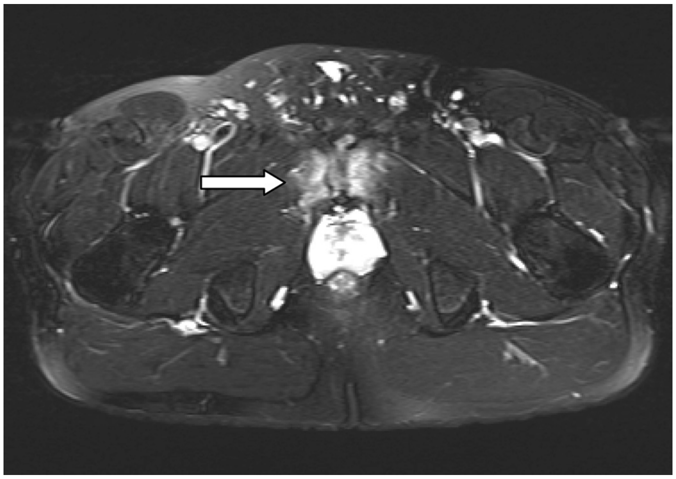

Figure 1 *Axial T2 fat suppressed images at the level of the inferior body of the pubis at the attachment of the adductor longus tendons; Note the intense bright marrow signal within the body of the pubis bilaterally suggestive of focal intense marrow edema at the attachment of the adductor longus tendons (arrow).*

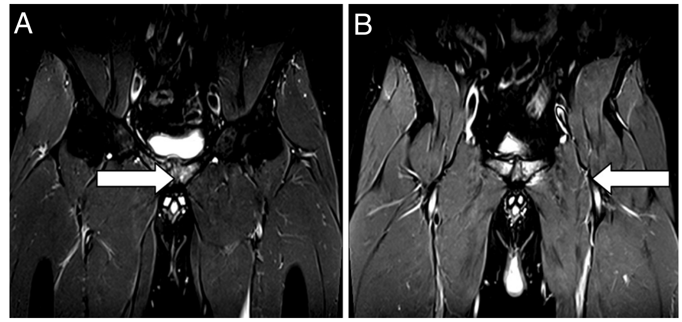

Figure 2 *A and B. Serial coronal T2 fat suppressed images at the level of the body of the pubis and the attachment of the adductor tendons; Note the intense bright signal within the bone marrow of the body of the pubis bilaterally (arrow). This is indicative of intense focal marrow edema. Also seen is high signal within the adductor longus tendon at its attachment to the body of the pubis suggestive of adductor tendinopathy. The bright signal within the tendon is more on the left side than the right (B).*

for a large proportion of groin injuries, has progressed from an inflammatory injury ("-itis") to a degenerative process ("-osis") with connective tissue degenerative change in the presence of a paucity of leukocytes.[14] C*onnective tissue insufficiency* is a term to describe the loss of tissue strength related to degenerative change, which results in loading and stimulation of relatively fixed-length pain mechanoreceptors.[15]

Enthopathy injuries stem from damage to the fibrocartilage enthesis between the tendon and periosteum as being the potential source of the problem.[13] Repair results in symphyseal sclerosis and irregularity, which is a secondary process rather than an active process, and that is why conventional radiographs and isotope bone scans can be inaccurate.

Mechanism of Injury

Groin injuries are common in sports that involve repeated kicking and rapid change of direction.[16] Some of the most prevalent sports include soccer, rugby, Australian Rules football, hockey and American football.[13,16] These conditions tend to relate to pathology with the symphysis pubis and/or surrounding soft tissues. However, these injuries are thought to develop secondary to mechanical stress forces through the anterior pelvis.[13] The combination of these forces along with inadequate abdominal strength or lack of flexibility can result in chronic damage to the pubic symphysis, enthesis, tendon, myotendinous junction and adductor muscles.

Clinical Symptoms and Examination

These athletes will present with chronic groin pain, hip stiffness and pain with active leg adduction. Enthesis disease tends to stem from the adductor longus and gracilis as they are positioned together at the symphysis.[13] The adductor brevis and magnus muscles arise more posterolaterally and are rarely implicated in chronic groin pain.[2]

Muscle strains tend to occur at the myotendinous junction. These injuries typically occur after a single traumatic event. However, tendinopathy injuries do not occur due to a single bout of trauma. They are simply an insidious onset of groin pain that is generally a result of overuse, progressive in nature and aggravated with sporting activity. Adductor tendinopathy should be suspected in cases of groin pain with localised tenderness, weakness and unilateral pain.[3] The patient may complain of groin, inner leg or lower abdomen pain with quick bursts of activity such as cutting, pivoting and skating.[2] In addition, compensatory mechanisms may result in symptoms extending to the rectus abdominis insertion and/or to the opposite groin.[2] There is increasing pain after activity and soreness the following day.

Intense physical activity, overloading the tendons and tendinous insertions, is needed to tease out the clinical symptoms and reproduce the patients' groin pain.[2] Pain can also be reproduced with adduction of the thigh against resistance and with passive stretching of the adductors.

Differential Diagnosis for Groin Pain

Some classify groin pain as adductor tendinopathy when isometric adduction is painful, pain caused by isometric contraction of hip muscles is not necessarily caused by an injury of adductor muscles or tendons.[17] However, athletes with groin pain can be extremely difficult to diagnose due to the several anatomical structures that have been implicated in exhibiting groin pain. The symptoms of groin pain in many patients have been found to stem from the sacro-iliac joint. For example, patients with pelvic girdle pain feel groin pain during isometric hip adduction.[18] Furthermore, studies have shown that these patients with groin pain can alleviate their pain wearing a pelvic belt.[1]

Patients with symphysis pubis stress injury (Commonly known as osteitis pubis. Osteitis pubis is frequently associated with infection, a finding notably absent among athletes with symphyseal stress injury[19]) tend to present with a history of increasing groin, pubic, or lower abdominal pain. These patients may have tenderness to palpation focally to the proximal adductor muscles, the symphysis pubis or the superior pubic ramus.[20] Both adductor originating injuries and symphysis pubis stress injuries have similarities in inciting mechanisms. Osteitis pubis often coexists with adductor related conditions and may be seen concurrently. Traction on the pubic ramus by the adductor muscles may lead directly to disruption of the fibrocartilaginous symphyseal disc.[21]

The osseous ring of the pelvis may be interrupted at the symphysis pubis and/or the left and/or right sacroiliac joints. Abnormal motion at one of these joints causes altered biomechanics with increased stress at the other two.[20] Clinicians that examine athletes that complain of groin pain should entertain the possibility of sacro-iliac joint dysfunction or symphysis pubis stress injuries.

Lumbar disc or facet joint abnormalities may result in radicular symptoms referred to the pelvis or groin. The ilioinguinal nerve originates from the T12 and L1 roots and the genitofemoral nerve originates from the L1 and L2 roots. Symptoms from these nerve roots may be provoked with slide or femoral nerve stretch tests.[17] In addition, research has shown that provocation of lumbar facet joints can have a distribution of pain provoked from L2 to L5.[22]

Bursitis, after direct blunt trauma or as the result of chronic irritation secondary to friction syndromes, can cause groin pain in many athlete. The groin pain can result from irritation to the bursa between the iliotibial tract and the greater trochanter, subgluteus minimus, medius and maximus bursae along with the sub-iliopsoas bursa.[23,24]

The iliopsoas can also be implicated in athletes with groin pain. Iliopsoas tendinosis or iliopsoas spasm can produce symptoms of groin pain and these pathologies are commonly seen in repetitive hip flexion sports or total hip replacement that has been caused by impingement of a malpositioned acetabular cup.[6]

Tears within the rectus abdominis and sports hernia are common causes of groin pain in many athletes.[25–27] Sports hernia is due to a posterior inguinal wall deficiency or Gilmore's groin. Posterior inguinal wall deficiency can result from tearing of the conjoint tendon and transversalis fascia which forms the posterior wall of the inguinal canal.[26] Gilmore's groin involves tears in the medial aspect of the external oblique aponeurosis which forms the anterior wall of the canal.[27]

Imaging

Radiological confirmation may require plain radiographs to exclude avulsion injury or heterotopic calcification.[28] Normal MRI of tendons show low signal intensity on all pulse sequences. Myxoid degeneration of tendons occurs with aging or from chronic overuse. On MR imaging, a degenerate tendon is normal or enlarged and has high signal intensity within the substance of the tendon on both T1W and any type of T2W sequences. The abnormal tendon is compatible with degeneration and micro tears, as they generally coexist.

MRI is also the imaging of choice for myotendinous strains. First-degree strains show hemorrhage at the myotendinous junction. There is also a feathery pattern of edema that runs from the myotendinous junction along the muscle fascicles. Second-degree strains will show a hematoma at the myotendinous junction along with increased fluid adjacent to the fascicles. Third-degree strains demonstrate complete disruption of the myotendinous unit.[29]

MRI for enthesopathy will show periostitis and adjacent marrow edema. The surrounding muscles will also demonstrate edema with thickening of the tendinous insertion of the adductor muscle.[13] Gadolinium enhancement of the adductor enthesis has been demonstrated to correlate with the symptomatic side.[13]

Treatment

Historically, conservative management may include cessation of physical activity, local anaesthetic/corticosteroid injection in addition to graduated strengthening of the core muscles, passive physical therapy modalities, anti-inflammatory drug medication, stretching exercises and prolotherapy.[2,7,30,31] Enthesopathy disorders of the adductor muscle group will sometimes require surgical repair.[20]

Treatment for muscle strains generally includes rest, ice, and compression. The goal of the treatment is to limit haemorrhaging and soft tissue swelling. Once the patient is pain free, progressive range-of-motion and strengthening exercises will begin.[17]

Conclusion

Groin pain in athletes may be acute or chronic in nature, may stem from a single traumatic event or repeated microtrauma and may arise from a variety of structures including muscle, tendon, ligament or joint. One of the most common causes of persistent groin pain in the athlete is adductor tendinopathy. The diagnosis of adductor tendinopathy through clinical history and physical examination can be confirmed by MR imaging. This case report demonstrates the importance of MR imaging in the accurate diagnosis of a patient with chronic groin pain.

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Chronic costochondritis in an adolescent competitive swimmer: a case report

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A search of the literature revealed that the torso sustains very few swimming injuries. Costochondritis is a poorly understood condition that presents as pain and tenderness on the costochondral or chondrosternal joints without swelling, and may result from increased pulling by adjoining muscles to this region of the chest wall. This case study describes the conservative treatment (spinal manipulative therapy, Active Release Techniques therapy, rehabilitative exercise, and clinical acupuncture) and positive outcome of anterior chest wall pain in a competitive swimmer diagnosed as chronic costochondritis.
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KEY WORDS: costochondritis, chondrosternal, swimming, adolescent

Une recherche dans la documentation révèle que la natation cause très peu de blessures au torse. Le syndrome de Tietze est une affection mal comprise dont les symptômes sont une douleur et une sensibilité aux articulations costales ou chondrosternales sans enflure, qui peuvent causer un étirement accru par les muscles adjacents de cette région de la paroi de la cage thoracique. Cette étude de cas décrit le traitement conservateur (thérapie manuelle de l'épine dorsale, techniques de relâchement actif, exercice de réhabilitation et acupuncture clinique) et les résultats positifs pour un nageur professionnel souffrant de douleur à la paroi thoracique antérieure qui avait reçu un diagnostic de syndrome de Tietze chronique.
(JCCA 2010; 54(4):271–275)

MOTS CLÉS : syndrome de Tietze, chondrosternal, natation, adolescent

Introduction

The risk of injury in any sport is governed by its nature and among other variables, such risk is inherent in the participation in competitive swimming. Most reported swimming injuries are classified as "minor" (i.e. bruises, lacerations, etc) and injuries are generally well distributed among all age groups. In particular, 3% of bodily injuries are sustained by the torso and those in the 13–14 year old age group constitute approximately 20% of all reported injuries.[1] Injuries to the chest wall and specifically the costochondral region in swimming have not yet been reported in the literature.

Costochondritis is a poorly understood, self-limiting[2] condition that is more common in women,[3] and generally presents as pain and tenderness on the costochondral or chondrosternal joints without swelling.[4] While the exact mechanism of this condition has yet to be defined, inflammation in this area is generally caused by an increase in pulling at this joint, likely from adjoining muscles to the rib or dysfunction at the costotransverse joints.[5]

We present a case study of a female competitive swimmer with anterior chest pain, diagnosed as chronic costochondritis, and managed conservatively. Treatment modalities consisted of high-velocity, low-amplitude

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(HVLA) spinal manipulation, soft tissue therapy including Active Release Techniques (A.R.T.), rehabilitation exercises, and clinical acupuncture.

Case

This 14-year-old female competitive swimmer presented for treatment of chronic anterior chest pain of almost two years duration. The pain was localized to the midline along the lower aspect of the sternum and was described as sharp and burning while swimming, and throbbing at rest. The pain intensity was reported to range from 6/10 during a regular swim practice, to 10/10 while performing sprints. When the pain was especially severe, she reported it limited her breathing. The pain was reported to have developed as a result of performing numerous consecutive push-ups during swim practice, approximately 21 months prior to presentation. She noted ongoing aggravation throughout the rest of the swim season (approximately six months) with relief during the summer months of the off-season (complete rest). No other relieving factors were revealed and the patient did not report receiving any prior physical therapy. However, the pain returned at the start of the next swim season, at which point she presented for care. In addition to swimming, the pain was reported to occur during dry-land training, including push-ups, seated rows, and medicine ball toss, and was said to be relieved with rest. She reported having to miss consecutive swim practices when the pain increased. Past medical history included gall-stones at four years of age, at which point she underwent laproscopic surgery. Her family history was unremarkable.

Examination revealed a fit-looking young woman with slight anterior head carriage, a depressed right shoulder, and an elevated right iliac crest, with bilateral pes planus. Active thoracic range of motion, performed in a seated position with the arms crossed in front of the chest, was full and pain-free in all directions. Kemp's test (active extension with rotation in a seated position) of the thoracic spine produced local pain along the spine in the mid-thoracic region when performed bilaterally as well as pain in the lower left sternum when performed on the right. Seated motion palpation[6] of the thoracic spine revealed local pain and restriction with lateral spinous process challenge from T3-T9, as well as local pain and restriction in the costovertebral joints bilaterally at T3-T4 and T6-T7 (worse on the right with posterior to anterior challenge). Anterior to posterior challenge of the third to six sternocostal joints was performed with the patient in a supine position with the patient's hands placed in between the clinician's hands and the patient's chest. Pain was noted locally on the left-hand side. Static palpation revealed pain and tightness in the thoracic erector spinae muscles bilaterally, the pectoralis major and minor bilaterally, and the third to seventh anterior intercostal muscles bilaterally. The left lower sternal pain was reproduced with pressing the palms of the hands together, as well as with resisted unilateral horizontal adduction. Upper limb sensory, motor, and reflex testing were unremarkable.

At the request of her physician, plain radiographs, MRI, and cardiac stress testing were performed but reported to be unremarkable. Swelling, heat, and erythema were absent ruling out a diagnosis of Tietze syndrome.[2] Additionally, in the absence of a palpable "slipped rib", such diagnosis was excluded.[2] As a result, the patient was diagnosed as suffering from chronic costochondritis with associated mechanical thoracic spine pain.

The patient undertook a course of conservative treatment for eight weeks at a frequency of two to three times per week for five weeks, followed by once per week for three weeks. The treatments consisted of manual sternocostal joint mobilizations, manual spinal manipulative therapy[7,8] of the thoracic spine[9,10] and costovertebral joints,[9,11] A.R.T.[12,14] therapy of the thoraco-humeral musculature (pectoralis major and minor), and scapular stabilization exercises (scapular retraction and push-up with plus).[14–18] As described in the instructional manual, A.R.T. is a tissue specific, manual manipulative therapy that takes a tissue from a shortened position to a fully lengthened position while the contact passes longitudinally along the soft tissue fibers and the lesion.[19]

The patient reported decreased frequency and intensity of her pain during regular swim practices with this treatment, but re-aggravation of her symptoms with intense swim practices. The patient chose not to rest from swimming, but agreed to refrain from dry-land training until the symptoms had resolved. While her symptoms had improved, recurrent re-aggravation prompted a course of acupuncture treatment (nine weeks following initial presentation). This modality was applied to the urinary bladder (12–15), large intestine (1–4), kidney (25–27), and conception vessel (19–21) meridians (Table 1), and performed for three weeks at a frequency of two times

Table 1 *Acupuncture points*

Meridian	Point	Description
Bladder Meridian (BL)	12	1.5 cun lateral to midline level with the spinous process of T2
	13	1.5 cun lateral to, and level with, the spinous process of T3
	14	1.5 cun lateral to midline level with the spinous process of T4
	15	1.5 cun lateral to, and level with, the spinous process of T5
Large Intestine Meridian (LI)	1	On radial side of index finger, 0.1 cun to corner of nail
	2	On radial side of index finger, distal to MCP joint
	3	On radial side of index finger, proximal to MCP joint
	4	Between 1st and 2nd metacarpal bones at midpoint of 2nd metacarpal bone
Kidney Meridian (KI)	25	2nd intercostal space 2 cun lateral to CV19
	26	1st intercostal space 2 cun lateral to CV 20
	27	In depression on lower border of clavicle 2 cun lateral to midline
Conception Vessel Meridian (CV)	19	On the midline level with the 2nd intercostal space
	20	On the midline level with the 1st intercostal space
	21	On the manubrium midline, 1 cun below CV22 (0.5 cun superior to the suprasternal notch, in the center of the depression)

* Cun = Measurement of one "body inch" utilized to locate acupuncture points and always taken from the patient's hand. 1 thumb = 1 cun

per week, in combination with ongoing soft tissue therapy and spinal manipulative therapy. The patient reported further improvement in her symptoms and although a follow-up was not performed at the commencement of the following season, she was able to complete the rest of her current season with little discomfort.

Discussion

As demonstrated in the present case, costochondritis commonly presents as a local,[2] sharp pain adjacent to the sternum and most often affects the second to fifth costal cartilages.[20,21] Often the result of repetitive physical activity,[22] movement of the chest and ribcage generally reproduces this pain,[23] and symptoms are usually elicited by pressure over one of the costochondral junctions of the sternum.[24] Crepitus during chest wall palpation is another common physical exam finding,[24] as well as costovertebral and costotransverse joint restrictions upon joint play assessment[25] and motion palpation[26,27] similar to that discovered in the current case.

Due to the location and nature of these complaints, the importance of ruling out cardiovascular conditions in patients presenting with such anterior chest pain cannot be understated.[28] Similarly, the evaluation of costovertebral joints is also imperative since they often may be the etiologic source of anterior chest pain as in cases of pseudo-angina.[11] While previously reported as self-limiting in nature that generally resolves within one year, usual medical management has generally consisted of relative rest for 4–6 weeks.[5]

Costochondritis has previously been reported to be diagnosed in 14–30% of patients with chest pain presenting to physicians[24,29] and, through their prospective analysis of 100 adolescent patients with chest pain, Pantell and Goodman reported that 31% of chest pain complaints appeared to be musculoskeletal in etiology.[24] The specific history of pain and discomfort resulting from both high intensity and high volume of training, as well as the presence of reproducible pain objective findings confirms the musculoskeletal nature of a costochondritis diagnosis in this patient with anterior chest wall pain.

Although rarely published in the sporting literature, this condition had previously been reported in a 21 year old collegiate volleyball player who presented with right anterior chest pain and mid-thoracic stiffness of 8 months duration.[9] This female athlete's pain was particularly made worse with volleyball and weightlifting (i.e. bench presses, bent flies, etc). In addition, this typically benign and self-limiting condition had also been described to likely occur in rowing sports due to the increased moment of rotation at the catch position[5] (when the oar / blade is placed in the water with the elbows in full extension and arms in horizontal adduction).[5] Specifically, combined adduction of the arm and ipsilateral rotation of the head may aggravate this position.[5] By comparison, since the pectoralis major provides the strongest contribution to initial and powerful humeral adduction, extension, and internal rotation of the early pull phase of the swim stroke,[30] the involvement of the structures within the thoraco-scapular-humeral joint complex in the act of swimming makes it plausible that a case of chronic costochondritis was present in this competitive and athletic patient.

While this condition has previously been reported as self-limiting in nature, various therapeutic approaches have been described in the management of costochondritis of musculoskeletal origin. Two cases, in particular, described a combination of manual therapy, modalities, and rehabilitative exercise. Hudes reported a low-tech rehabilitation protocol in the management of a 64 year old male patient with acute idiopathic onset of costochondritis.[15] This protocol utilized consisted of HVLA manipulation to the zygapophyseal joints of the thoracic spine, costotransverse, and costochondral joints, acupuncture, ischemic compression, cross-fibre friction massage, and cryotherapy. In particular, specific exercise prescription (low tech rehabilitation) was prescribed, and un-weighted supine arm pushes, wall push ups, full push ups, and plusses (end-range, closed-kinetic chain scapular protraction) were used.[15] Similarly, the therapeutic approaches involved in the management of a volleyball player included HVLA manipulation of costovertebral, costotransverse, and intervertebral zygapophyseal joints, instrument assisted soft-tissue mobilization applied directly to the costal cartilage, and Kinesiotaping of the fifth costal cartilage and along the third through sixth chondrosternal joints. Reassurance and exercise modification were also used in their management protocol.[9]

The following approaches were utilized in our competitive swimmer: mobilizations applied to affected sternocostal joints as well as HVLA spinal manipulative therapy of the symptomatic thoracic zygapophyseal and costovertebral joints. A.R.T. of the affected pectoralis major and minor, scapular stabilization exercises, and acupuncture treatment were also performed. It is recognized that this and those previously reported case reports cannot prove with certainty that the respective treatment protocols administered directly resulted in relief from pain, however, relief provided from the above approach rendered an outcome that differed from that of the preceding season as well as the previously reported self-limiting nature of costochondritis.[2] Case series and case-control studies comparing the above treatment protocol with other forms of management (e.g. relative rest) may therefore be the next logical progression for contribution of knowledge pertaining to costochondritis in the literature.

Summary

Although poorly understood, costochondritis is a musculoskeletal condition that should be included in the differential diagnosis of any person presenting with anterior chest wall pain. Conservative therapeutic approaches for this condition were utilized, and consisted of manual spinal manipulative and mobilization therapy, Active Release Techniques therapy, and rehabilitative exercise. Still, more studies are required to improve our understanding of costochondritis and certainly, the reporting of unique cases are strongly encouraged.

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Pudendal nerve entrapment in an Ironman athlete: a case report

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Objective: *To present the diagnostic and clinical features of pudendal nerve entrapment and create awareness amongst clinicians of this rare and painful condition.*

Clinical Features: *A 41-year old male ironman athlete complaining of insidious constant penis pain 12–24h after long distance cycling and pain after sexual intercourse. A diagnosis of "cyclist syndrome" also known as pudendal nerve entrapment was made.*

Intervention and outcome: *Patient was treated twice a week for four weeks using the soft tissue protocol described by Active Release Technique® to the obturator internus muscle. After two weeks of treatment his pain decreased to a 5/10 on the pain intensity scale and he began to cycle again. After four weeks of treatment his pain had decreased to 1/10 in intensity and he continued to cycle. At follow-up, approximately 8 weeks and 12 weeks later the patient communicated that his pain is resolved and he has began to train for Ironman Lake Placid 2010.*

Conclusion: *Pudendal nerve entrapment is a rare, painful condition and is often misdiagnosed due to the fact that the clinical manifestations can mimic other pathologies. It is important to be aware of the clinical*

Objectif : *Soumettre un diagnostic et des particularités cliniques de compression chronique du nerf honteux, et sensibiliser les médecins à cette affection rare et douloureuse.*

Particularités cliniques : *Un athlète masculine Ironman de 41 ans se plaint de douleur constante et insidieuse au pénis entre 12 et 24 heures après un long périple à vélo, et une douleur après avoir eu des relations sexuelles. Un diagnostic de « syndrome du cycliste », également connu sous le nom de compression chronique du nerf honteux, fut émis.*

Intervention et résultat : *Le patient fut traité deux fois par semaine pendant quatre semaines à l'aide du protocole du tissu mou décrit par Active Release Technique® sur le muscle obturateur interne. Après deux semaines de traitement, sa douleur avait diminué à 5/10 sur l'échelle d'intensité de la douleur, et il a recommencé à faire du vélo. Après quatre semaines de traitement, sa douleur avait diminué à 1/10 sur l'échelle d'intensité, et il a continué de faire du vélo. Lors du suivi, environ 8 et 12 semaines plus tard, le patient a affirmé que sa douleur avait disparu, et qu'il s'entraînait en vue de la compétition Ironman à Lake Placid en 2010.*

Conclusion : *La compression chronique du nerf honteux est une affection rare et douloureuse, souvent mal diagnostiquée en raison du fait que les manifestations cliniques ressemblent à autres pathologies. Il est important de connaître les*

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features to obtain appropriate diagnosis and treatment of this condition promptly.
(JCCA 2010; 54(4):276–281)

KEY WORDS: pudendal nerve, entrapment, neuralgia, obturator internus, pudendal canal, ART®

particularités cliniques pour émettre un diagnostic exact et traiter l'affection rapidement.
(JCCA 2010; 54(4):276–281)

MOTS CLÉS : nerf honteux, compression chronique, obturateur interne, canal honteux, ART®

Introduction

Pudendal neuralgia by pudendal nerve entrapment is described as severe, sharp pain along the course of the pudendal nerve.[1] Genital numbness and erectile dysfunction are two of the major symptoms and the prevalence has been reported to be 50–91% and 13–24% respectively. This can be caused by trauma, infection, tumour, child birth, iatrogenic injury, surgery and/ or microtrauma from cycling.[2] It has been reported that 7–8% of cyclists on long-distance multiday rides experience pudendal neuralgia.[3] Diagnosis of pudendal nerve entrapment is often delayed or misdiagnosed, causing people to suffer with this for 2–10 years.[4] It is important to understand the clinical presentation and diagnostic criteria to allow early diagnosis and appropriate treatment.

Case

A 41-year old male ironman athlete complained of insidious onset of constant penis pain and a dull ache in the perineum 12–24h after long distance cycling. His cycling training consisted of 6–11 hours per week, 3 days a week. The pain began in the beginning of September 2008 and by mid-September he was experiencing pain in the perineum after sexual intercourse and burning during urination. He visited with his medical doctor who diagnosed him with prostatitis and he was prescribed antibiotics for 30 days. He returned to his medical doctor who informed him that STDs were ruled out and he was told that the prostatitis was under control, however the pain was unchanged. At that time, the prostate was palpated for enlargement, an ultrasound was performed to examine the prostate and prostate serum antigen was measured. These tests proved to be normal. In early October he was referred to an urologist who prescribed him with another antibiotic for 30 days. By November 2008, the pain was rated 9/10 in intensity. He saw another urologist who explained that the infection and cycling caused inflammation of the pudendal nerve. At that point he was prescribed naproxen, 750 mg/day. He proceeded to see a sport medical doctor, who told him to experiment with new saddles for his bike. He completed the ironman in late November 2008 and ceased to ride from November 2008 to January 2009. With rest and the use of naproxen the pain intensity decreased to 5/10.

In January 2009, he began to cycle again. However, by February the pain increased to 7/10. For relief he would sit on a frozen water bottle placed in the perineal region and use a foam roller to massage his buttock region. He experimented with a new saddle and it seemed to provide relief. He competed in the ironman in July 2009 and discontinued to ride from July to September 2009 and the pain deceased to 3/10 in intensity. He began to cycle again in September to train for a half-ironman in late fall. The pain intensity increased to 9/10. At this point he was seen by a neurologist who diagnosed him with "cyclist syndrome" and he was prescribed naproxen, rest and to experiment with a new saddle.

In October 2009, he visited a chiropractor to receive treatment. Upon physical examination, hyperalgesia was found during palpation of the lesser sciatic notch and the obturator internus muscle. Palpation in this area reproduced the 9/10 pain in his penis and perineum and caused fasciculations in the surrounding buttock musculature. A working diagnosis of pudendal nerve entrapment was reached. He was treated twice a week for four weeks with only Active Release Technique (ART)® obturator internus muscle protocol. After the first treatment it seemed to aggravate the symptoms, however at two weeks of treatment his pain was decreased to a 5/10 and he began to cycle again. After four weeks of treatment his pain had decreased to 1/10 and he continued to cycle. Eight weeks later his pain after sexual intercourse and the pain in his penis and perineum resolved and he has begun to train for another ironman.

Discussion

Pudendal neuralgia, due to entrapment of the pudendal nerve (PN) has a varied clinical presentation and some suggest that is it due to the anatomical course of the nerve and the fact that the nerve is mixed. The PN arises from the roots of the sacral plexus S2-S4 where 20% consists of motor fibres, 50% are sensory fibres and the last 30% are autonomic.[5,6,7] The PN descends medially and caudal in relation to the trunk of the sciatic nerve.[5,6,7] From there it passes laterally and enters the gluteal region and then traverses the greater sciatic foramen.[5,6,7] Along its course the PN is accompanied by its artery (internal pudendal artery) and vein (internal pudendal vein). The pudendal bundle passes around the termination of the sacrospinous ligament just as it attaches onto the ischial spine.[5,6,7] The PN is now situated between the sacrospinous ligament ventrally and the sacrotuberous ligament dorsally. The PN travels into the perineal region via the lesser sciatic foramen, where it lies underneath the plane of the levator ani muscle.[5] From here it enters a duplication of the fascia of the obturator internus muscles and its medial aspect, which forms the pudendal canal.[5] It is at this location where the PN divides into its three terminal branches: inferior rectal nerve, perineal nerve and the dorsal nerve to the penis/clitoris.[5]

The inferior rectal nerve supplies the integument around the anus, provides sensation to the distal aspect of the anal canal and to the perianal skin.[5,8] It also provides motor innervation to the external anal sphincter.[5,8] The perineal nerve supplies motor innervations to the pelvic floor muscles (transverse perineal muscles, bulbospongiosus, ischiocavernosus, sphincter urethra and the levator ani muscles).[5,8] The sensory braches of the perineal nerve supply the perineum and the ipsilateral posterior surface of the labia majora. Finally, the dorsal nerve of the penis /clitoris is the most superficial branch found at the level of the pubic symphysis.[5,8] This nerve carries afferent sensory information from the clitoris/penis.[5,8]

The anatomical course of the PN has great implications regarding the potential sites for its entrapment. The following are areas in which the PN can become entrapped leading to injury and symptoms of pudendal neuralgia: the zone at the ischial spine, the zone between the sacrospinous and sacrotuberous ligaments, the falciform process (formed by the dense fanning out bands of the medial portion of the sacrotuberous ligament as it attaches to the ischial tuberosity), the zone between the levator ani and obturator internus muscle, within the pudendal canal and lastly compression from the piriformis muscle (Figure 1).[1,5,6,9] A new entrapment site was proposed, which described a distinct narrow osteofibrous canal measuring 3cm long found in all 10 male dissected cadavers.[7] This canal was bordered by the pubic symphysis dorsal-cranially, the inferior pubic ramus and suspensory ligament laterally and the corpus covernosum medially.[7] The dorsal nerve to the penis was found to travel in this canal and thought to be a potential site for entrapment.[7]

Figure 1 *Right arrow: piriformis; left arrow: pudental nerve.* Image courtesy and copyright Primal Pictures Ltd.

The exact pathophysiology of pudendal nerve entrapment is not completely understood, however there are proposed theories. Neuronal insult can be caused by stretching or compression of the nerve, which may lead to ischemic neuropathy due to transient hypoxemia of the PN.[2] This can result in changes to the intraneural microcirculation and fibre structure, such as fibrosis and or inflammation, leading to impairment of axonal transport of the PN.[2] During cycling, repetitive impacts generate extreme perineal pressure leading to increased friction in the pudendal canal and compression from the surrounding muscular (levator ani, obtruator internus,and piriformis) and ligaments structures (sacrospinous and sacrotuberous).[2,10,11] This constant pressure can lead to loss of gliding of the PN putting it at risk for entrapment.[2,10,11] Also, the biomechanical position adapted while cycling, forward lean posture with arms on the aerobars of the bike, further increases the compression in the perineal region due to pressure from the nose of the saddle.[2,10,11] This chronic perineal microtrauma results in the pathophysiological changes mentioned above.[2]

As mentioned previously, the clinical presentation of pudendal neuralgia is varied due to the fact that the PN is a mixed nerve and has numerous potential entrapment sites creating diverse symptomatology depending on the location of compression. Patients will experience remitting and relapsing neuropathic pain in the distribution of the PN often described as burning, tearing, stabbing, lightning-like, sharp, electrical, and shooting.[6] Genital numbness, the most common symptom with a prevalence of 50–91% in bicyclists, is often the first sign and may be considered a warning sign to clinicians.[10,12] Erectile dysfunction is often associated with pudendal nerve entrapment having a prevalence of 13–24% in bicyclists.[10] Pain and paresthesia, which often begin in one location and spread, may extend as far as the groin, inner leg, buttock, and abdomen.[5] Patients may also experience hyperesthesia and allodynia so intense that they avoid wearing certain clothing that may irritate the area.[5,6] Pudendal neuralgia presents most commonly as unilateral, but in certain instances may be bilateral.[5,6,13] The symptoms are usually aggravated by sitting or cycling and absent or relieved by standing, recumbent position and sitting on a toilet seat.[8]

The physical examination findings of patients suffering from PN entrapment are less concrete. Pain may be elicited during application of pressure on the PN at the ischial spine and palpation inferio-medially to the sciatic notch.[6,14] The most common finding is tenderness with direct palpation of the obturator internus muscle.[4] The symptoms may be worsened by performing passive internal and external rotation of the hip and resisted abduction and adduction of the hip flexed to 90 degrees.[4]

There is no widely confirmatory test available to diagnose pudendal neuralgia explaining why it is often misdiagnosed or delayed.[8] It has been reported that proper diagnosis can take anywhere from 2–10 years.[4] Pudendal neuralgia is a diagnosis of exclusion, therefore all other causes of the symptoms must be ruled out. However, diagnostic criteria for pudendal neuralgia was established and validated by a multidisciplinary working party in Nantes, France and by members of the Francophone Perineal Electrophysiology club in 2008.[15] The criteria are broken down into four diagnostic domains (Table 1).

Following diagnosis of pudendal neuralgia by PN entrapment, treatment usually involves a course of conservative medical care management. Practitioners may begin by prescribing anti-inflammatory and or nerve pain medications. Patients may opt to have a pudendal nerve block with or without the addition of steroids, which have the potential to relieve the symptoms for a longer period of time.[5] Surgical decompression of the PN may be an option for those who encounter only temporary relief with a nerve block.[5,9,14] There are three different approaches and these include: transperineal, transgluteal, and via the ischio-rectal fossa.[5,14] Working in collaboration with medical management, there are several recommendations regarding cycling that one may choose to implement to reduce the symptoms. These include: stretches, short-term cessation of cycling (3–10 days), weight loss, wider saddle, absent or flexible nose on the saddle, tilt the saddle slightly downward, use of a gel saddle, change body posture to a more upright position, rise out of the saddle for 20–30 seconds every 20 minutes, take breaks during long rides and ensure that the bike has been properly fitted.[1,2,3,10,13,16]

In the case presented the chiropractor treated the patient using Active Release Technique (ART)®, which is described as a hands-on touch and case-management system that allows a practitioner to diagnose and treat soft-tissue injuries.[17] It is performed by contacting the effected muscle, applying a tension and asking the patient to actively contract/shorten the muscle followed by actively stretching/tensioning the muscle.[17] The ART® protocol for obturator internus treatment is described as follows. The patient is to begin in the side lying position, involved side up, and the hip in the anatomical position or abducted. The practitioner then places their contact on the distal portion of the muscle and draws tension medially. The practitioner must maintain or increase tension and move the hip into flexion, adduction and external rotation (an assistant may be used to externally rotate the hip).[17] This procedure is conducted several times along

Table 1 *Summarized from Labat et al 2008, Diagnostic Criteria for Pudendal neuralgia by Pudendal Nerve entrapment (Nantes Criteria)*

Essential Diagnostic Criteria	Complementary Diagnostic Criteria	Exclusion Criteria	Associated Signs Not Excluded the Diagnosis
Pain in the territory of the PN	Neuropathic pain	Exclusively coccygeal, gluteal, pubic or hypogastric pain	Buttock pain on sitting
Pain predominately with sitting	Allodynia or hyperpathia	Pruritus	Referred sciatic pain
Pain with no objective sensory impairment	Rectal or vaginal foreign body sensation	Paroxysmal pain	Pain referred to the medial aspect of the thigh
Pain relieved by diagnostic nerve block	Pain worsening during the day	Imaging abnormalities able to account for the pain	Urinary frequency or full bladder
Pain does not wake the patient at night	Predominately unilateral		Pain after ejaculation
	Pain triggered by defecation		Dyspareunia and or pain post-coitus
	Presence of exquisite tenderness on palpation of the ischial spine		Erectile dysfunction
	Clinical neurophysiology findings of motor latency		Normal clinical neurophysiology test

the muscle until the practitioner subjectively determines that the tissue is moving properly and the adhesions are no longer palpated.[17]

To date there is no research describing the therapeutic effect ART® has on muscle injury. Contemporary soft tissue literature has been focusing on the role of fascia. Fascia is dense irregular connective tissue that allows for continuity throughout the body.[18,19,20,21] Not only does it envelop muscles, fascicles, fibers, tendons, but it penetrates and surrounds organs, bones and nerves.[18,19,20,21,22] Fascia is primarily composed of fibroblasts, mast cells and macrophages while the extracellular matrix is made up of ground substances (dense gel), collagen and elastin fibers.[18,19,20,21,22] Contractile cells have also been identified in fascia and have been termed myofibroblasts.[20,21,22,23,24,25,26] Ruffini organs, a type of mechanoreceptor found in fascia, have been shown to respond to deep pressure.[23,24,27,28] Once ruffini organs are stimulated, altered input is transmitted to the central nervous system, which changes the signal received by the motor unit creating tonus change in the muscle.[23,24, 27,28] Perhaps this is an explanation for the therapeutic effect of ART®, since the protocol involves the practitioner applying pressure to the muscle. Another proposed mechanism rationalizing the role of ART® can be extrapolated from the work of Cottingham in 1985 and Schleip in 2003.[20,21,22,29] Golgi receptors, which are a sensory ending, are traditionally found in tendons, but are also found in the muscular portion of the myotendinous junction, ligaments, capsules, fascia and aponeuroses.[29] Golgi receptors are arranged in series in fascia and have been found to respond to muscular contraction/tension.[20,21,22,30] Afferent signals sent from golgi receptors in response to contraction/tension, reach interneurons in the spinal cord, which, in turn, have an inhibitory effect on alpha-motor neurons thereby relaxing muscle.[20,21,27,30] Perhaps ART® stimulates the golgi receptors since the protocol involves the patient actively shortening/contracting followed by actively stretching/

tensioning the muscle. It should be noted that the suggested explanations regarding the mechanism of ART® are theories and more research is needed in the future to fully understand the mechanism.

Conclusion

Pudendal neuralgia by pudendal nerve entrapment is a rare diagnosis, but it is one that causes extreme pain and limitation in suffering individuals. Patients may be enduring this injury for 2–10 years before the diagnosis is made and finally receive appropriate treatment. Pudendal neuralgia has a varied clinical presentation due to its intricate anatomical structure, which may confuse practitioners. Therefore, it is important to be aware of this condition to avoid delayed and/or misdiagnosis and provide prompt treatment.

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A survey of Fellows in the College of Chiropractic Sports Sciences (Canada): their intervention practices and intended therapeutic outcomes when treating athletes

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Objective: *To compile baseline data regarding the treatment practices and therapeutic outcomes that fellows of the College of Chiropractic Sports Sciences Canada (CCSS(C)) strive for when treating athletes.*

Design: *Cross-sectional self-report mail out survey of CCSS(C) fellows.*

Participants: *Current registered fellows of the CCSS(C) as determined by the College at the time of survey distribution.*

Results: *The majority of questioned fellows believe that they can cause direct and specific improvements in an athlete's sport performance. The most commonly utilized therapeutic intervention was spinal joint manipulation/mobilization. The most anticipated outcomes following the treatment of athletes with the goal of affecting athletic performance were "changing or improving aberrant body mechanics," "restoring or improving aberrant muscle function," and "improving joint function or reducing joint dysfunction."*

Conclusion: *The majority of respondent fellows of the CCSS(C) believe their therapy to be effective in enhancing an athlete's sport performance.*

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KEY WORDS: Sport Sciences, fellows, performance, manipulation

Objectif : *Compiler des données de base concernant les méthodes de traitement et les résultats thérapeutiques que les membres du Collège chiropratique des sciences de sports (Canada) (CCSS(C)) cherchent à mettre en pratique au moment de traiter les athlètes.*

Processus : *Sondage transversal d'auto-évaluation par la poste des membres du (CCSS(C)).*

Participants : *Membres actuels du (CCSS(C)), selon le Collège au moment de l'envoi du sondage.*

Résultats : *La majorité des membres interrogés croient être en mesure d'améliorer de façon directe et particulière le rendement d'un athlète. L'intervention thérapeutique la plus couramment utilisée était la manipulation/mobilisation vertébrale. Les résultats espérés suite au traitement destiné à améliorer le rendement des athlètes étaient de « modifier ou améliorer la mécanique corporelle aberrante », « restituer ou améliorer la fonction musculaire aberrante », et « améliorer la fonction des articulations ou réduire la dysfonction des articulations ».*

Conclusion : *La majorité des répondants du CCSS(C) croient que leur thérapie permet d'améliorer le rendement d'un athlète.*

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MOTS CLÉS : sciences de sports, membres, performance, manipulation

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Introduction

It is not uncommon when reviewing chiropractic literature to come across information identifying improvement or enhancement of athletic performance through chiropractic treatment.[1–9] Such references typically represent the opinion or personal observation of an individual chiropractor treating an individual athlete or group of athletes.[1–8] According to standards of evidence-based health care, it is imperative that claims of "athletic performance enhancement" by chiropractic treatment be substantiated or at the very least, clearly delineated.

To date, no investigations have been published in the peer reviewed literature to solidly support the idea that treatment provided by chiropractors can singularly enhance or improve an individual athlete's sport performance.[10] Attempts have been made, but such studies were of questionable methodology and resulted in dubious conclusions.[9–15]

A major difficulty inherent with the investigation of the effects of chiropractic treatment on athletic performance arises directly from the apparent confusion surrounding the definition of what constitutes a "chiropractic treatment."[10] 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.[10] Research on chiropractic and sports performance enhancement should perhaps begin by defining "how" rather than "that" chiropractors affect performance.

In Canada, fellows of the College of Chiropractic Sports Sciences, or FCCSS(C)'s, represent the expert standard for the chiropractic treatment of athletes.[16] The College of Chiropractic Sports Sciences (Canada), or CCSS(C), is a recognized specialty college under the regulation of the Canadian Federation of Chiropractic Regulatory and Educational Accrediting Boards (CFCREAB), and is the governing and organizing body that coordinates the involvement of the chiropractic profession with amateur and professional athletic and sport organizations.[16] The CCSS(C) "maintains and encourages the highest standards and morals of practice within sports chiropractic, and strives to standardize the chiropractic approach in the evaluation, treatment and rehabilitation of sports related conditions."[16] Even though fellows of the CCSS(C) equate to the expert standard, very little is known about this specialized subset of chiropractors in Canada. Do fellows of the CCSS(C) believe chiropractic treatment enhances athletic performance? Before designing quantitative studies in the attempt to prove that chiropractic treatment enhances athletic performance, the chiropractic profession needs to answer two basic questions. What are the intended outcomes when chiropractors treat athletes, and what interventions do they use to affect those outcomes? It was therefore the purpose of this study to compile such data from fellows of the College of Chiropractic Sports Sciences (Canada).

Methods

Study design

This research was approved by the Canadian Memorial Chiropractic College Research Ethics Board. The design consisted of a cross-sectional self-report mail out survey of registered CCSS(C) fellows. The questionnaire format was determined by the research team and following several content expert draft reviews the final questionnaire was produced. Eligible participants consisted of Canadian chiropractors who were active in practice and who were current registered fellows of the CCSS(C), as determined by the College of Chiropractic Sports Sciences (Canada) for the year 2006/2007. Permission was obtained from the CCSS(C) to include the research questionnaire in the CCSS(C) annual membership mail out. Fellows were given an introduction cover letter describing the investigations concept and purpose. No deception was used. Fellows voluntarily completing and anonymously returning the survey were considered to have provided passive consent to participate. Following conclusion of the study all completed surveys were destroyed.

Results

Response rate

Of the 54 sport fellows receiving the research questionnaire, 37 returned fully completed questionnaires. Thus, 68.5% of fellows who received the research questionnaire participated as respondents.

For the purposes of this investigation an athlete was defined as one who is trained to compete in sport or games

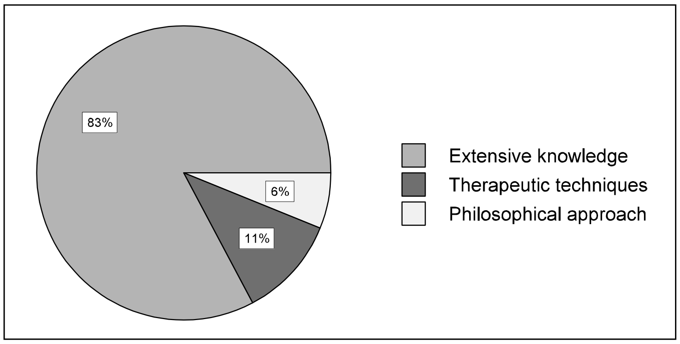

Figure 1 *Defining Features of Sports Specialist Chiropractors (n = 37)*

requiring physical strength, agility, or stamina. The sport specialists questioned for this investigation most commonly reported treating athletes on a daily basis (49%) to at least 2 to 6 athletes per week (41%). Only 5% of fellows reported that they treated athletes exclusively or alternatively, less than once a week, and none of the respondent fellows reported that they never treat athletes. When asked, "What percentage of your practice is composed of treating athletes?" the majority of fellows (60%) reported that a range of 0–25% of their practice was composed of treating athletes. As a group, the respondent fellows reported that they treat or have treated all levels of athletes; however the calibre of athlete that they treated was most commonly a recreational or "weekend warrior" level of athlete (55%). Twenty two percent of respondents stated that they most commonly treated high level amateur (provincial or national) or professional athletes.

All of the respondent fellows reported that they feel that inter-health professional relationships are important in the treatment of athletes, and all stated that they strive to practice evidence based care (EBC). All of the questioned fellows endeavour to keep up-to-date on current medical and chiropractic literature, and 95% subscribe to, or have access to peer reviewed sports medicine journals (online or hard copy). Figure 1 highlights the respondent's opinion regarding the definition of sports specialist chiropractors. Seventy percent of questioned fellows felt that "a chiropractor must be a fellow of the CCSS(C) to be considered fully qualified to work with a professional sports team, or at a major sporting event;" whereas 22% "disagreed" and 8% were "unsure."

Opinions regarding chiropractic care and athletes

Table 1 summarizes the respondents' answers to questions on chiropractic care and athletes in general. One hundred percent of sports sciences fellows felt that "chiropractic care can be very effective for athletes with musculoskeletal type injuries," and that "chiropractic care should always be included in the core medical team of major sporting events." To the statement, "maintenance chiropractic care can reduce sport related injuries," when "maintenance care" is defined as a pre-determined interval of spinal manipulative and/or adjunctive therapy for an asymptomatic or near asymptomatic patient," 73% "agreed," 3% "disagreed," and 24% responded that they were "unsure." Asymptomatic was defined as a patient having no overt symptoms/indications of a diagnosable disease, condition, or injury (i.e. apparently healthy).

Opinions regarding the treatment of athletes

When prompted with the statement, "I only treat athletes when they have a self-reported physical complaint (pain and/or dysfunction) or injury," only 24% stated "yes" or that they "agreed," but 76% stated "no" or that they "disagreed." Likewise, 30% "agreed" to the statement "I only adjust athletes when they have a self-reported physical complaint (pain and/or dysfunction) or injury," and 70% "disagreed." Seventy three percent of fellows said that "yes" they do "treat asymptomatic athletes with the specific goal of enhancing sport performance," and 27% said that "no" they do not. Additionally, 97% of respondent fellows felt that "by utilizing specific treatment techniques they could affect specific treatment outcomes that may *indirectly* enhance athletic performance"; whereas 76% felt that "by utilizing specific treatment techniques they could cause *direct and specific* improvements in an athlete's sports performance." In relation to the above statements, 84% of respondents stated that they "have witnessed an apparently asymptomatic athlete experience performance enhancement immediately after spinal manipulative therapy (SMT) and/or adjunctive therapy."

Opinions regarding what constitutes a chiropractic treatment

The opinions of respondent fellows on what they consider to be an acceptable component of a chiropractic treatment is summarized in Table 2. Of the 37 respondent fellows, 95% felt that "chiropractic treatment involves more than

Table 1 *Opinions Regarding Chiropractic Care and Athletes (n = 37)*

Statement	Agreed	Disagreed	Unsure
Chiropractic care is important for all athletes	81%	8%	11%
Maintenance chiropractic care can reduce sport related injuries	73%	3%	24%
Chiropractic consultation when athlete's performance is suffering	81%	3%	13%

Table 2 *Opinions Regarding What Constitutes a Chiropractic Treatment (n = 37)*

Question	Response Option	Frequency Count (%)
Which of the following do you consider an acceptable component of a chiropractic treatment? Mark all that apply.	Spinal joint manipulation / mobilization	37 (100)
	Extremity joint manipulation / mobilization	37 (100)
	Specific soft tissue therapy	37 (100)
	Acupuncture	22 (59)
	Nutritional advice or prescription	33 (89)
	Exercise prescription (general health improvement)	36 (97)
	Rehab prescription (injury recovery)	36 (97)
	Physical modalities (Ultrasound, IFC, etc.)	32 (86)
	Sport specific training advice (exercise designed to enhance sport performance)	32 (86)
	Lifestyle counselling	36 (97)
	Additional care, health professional referral	37 (100)

a chiropractic adjustment"; therefore 5% felt that a chiropractic treatment only involves a chiropractic adjustment.

It was hypothesized that a large number of respondents would consider "soft tissue therapy" to be an acceptable component of a chiropractic treatment. Consequently, fellows were asked to comment on which, if any, of the popular named or specific protocol soft tissue or myoneural treatment techniques they were certified to utilize. One hundred percent of the respondent fellows considered "specific soft tissue therapy" to be an acceptable component of a chiropractic treatment (Table 2) and of the named or specific protocol soft tissue or myoneural treatment techniques, Active Release Techniques® (ART®) and acupuncture were the most popular as depicted in Figure 2.

Interventions utilized to affect athletic performance (directly or indirectly)

Table 3 and Table 4 summarize the respondents' answers to questions on the treatment interventions utilized when treating athletes for the (direct or indirect) goal of affecting performance. The most popular intervention utilized to affect performance was spinal joint manipulation/mobilization (92%) followed closely by extremity joint manipulation/mobilization (89%). These two interventions were also perceived to be the most effective for affecting

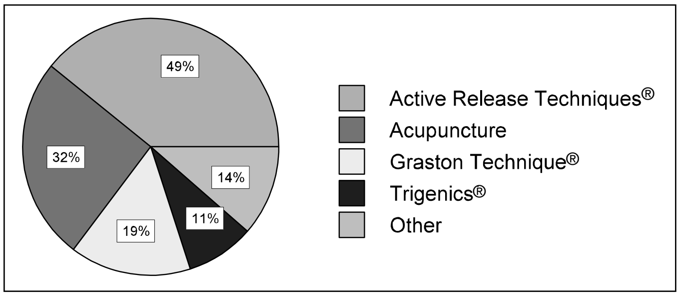

Figure 2 *Utilization of Named Soft Tissue Treatment Techniques (n = 37)*

athlete sport and performance (directly or indirectly) see Table 4.

Anticipated treatment outcomes

Table 5 summarizes the opinions of sport fellows in regards to their intended/anticipated outcomes following the treatment of athletes with the (direct or indirect) goal of affecting performance. For the purposes of the questionnaire, the term subluxation was defined as a complex of functional and/or structural and/or pathological articular changes that compromise neural integrity and may influence organ system function and general health.

The sports fellows were also asked to comment on what they utilized to evaluate their intended treatment outcomes. The results indicated that they all typically use a variety of methods to assess treatment outcomes as shown in Table 6.

Discussion

This study sought to gain insights into the intervention practices and therapeutic outcomes fellows of the College of Chiropractic Sports Sciences (Canada) strive for when treating athletes. Pursuant to this objective, approximately 68.5% of the contacted registered fellows of the CCSS(C) provided their thoughts and opinions on the chiropractic treatment of athletes. As such, it can be reasonably stated that the results of this qualitative investigation accurately reflect the collective opinions of the respondent chiropractic sports specialists in Canada.

The consensus (81%) in regards to chiropractic care and athletes was that chiropractic care is important for all athletes. There was complete agreement (100%) that chiropractic is very effective for athletes with musculoskeletal type injuries and that chiropractic care should always be included in the core medical team at major sporting events. Of interest, is the fact that the majority of respondent fellows stated that maintenance chiropractic care can reduce sport related injuries (73% agreement) and that a chiropractor should be consulted if an uninjured (apparently healthy) athlete's physical performance is suffering (81% agreement). The perspective that a chiropractor can 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 is not new.[17,18] 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."[17] 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."[8] 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."[8] Although several studies have sought to prove the performance enhancing effects of chiropractic treatment, the evidence to date would be considered inconclusive at best.[9–15]

The two most recent studies dealing directly with the concept of chiropractic treatment and the enhancement of sport performance are by Shrier et al., (2006) and Costa et al., (2009).[14,15] Shrier et al., (2006) utilized a crossover study design with 19 elite sprint sport athletes to compare changes in jump height and running velocity with and without pre-event high-velocity, low-amplitude (HVLA) manipulations applied as indicated from the thoracolumbar region to the mid-tarsal region.[14] Results indicated a decrease in jump height 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.[14] Costa et al., (2009) investigated the effect of spinal manipulative therapy with stretching compared to stretching alone on full-swing per-

Table 3 *Opinions Regarding the Treatment Interventions Utilized to Affect Performance (n = 37)*

Question	Response Option	Frequency Count (%)
When treating athletes with the (direct or indirect) goal of affecting performance, what treatment interventions would you potentially utilize? Mark all that apply.	None. I do not treat athletes with the intent to specifically affect performance.	3 (8)
	Spinal joint manipulation / mobilization	34 (92)
	Extremity joint manipulation / mobilization	33 (89)
	Manual soft tissue therapy (myofascial release, trigger point, cross friction, etc.)	31 (84)
	Active Release Techniques®	20 (54)
	Trigenics®	4 (11)
	Graston Technique®	7 (19)
	Acupuncture	12 (32)
	Nutritional advice or prescription	24 (65)
	Exercise prescription	32 (86)
	Rehab prescription	30 (81)
	Physical modalities (Ultrasound, IFC, etc.)	27 (73)
	Sport specific training advice	32 (86)
	Lifestyle counselling	26 (70)
	Additional care, health professional referral	26 (70)

formance in golfers.[15] An improvement in full swing performance for the SMT group was observed however not for the non-SMT group.[15] 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."[15(p.169)]

It seems that the majority (76%) of questioned sports fellows do in fact believe that by utilizing specific treatment techniques they can cause direct and specific improvements in an athlete's sport performance. This suggests that a majority of Canadian sport injury specialists believe that by performing some form of specific treatment on an athlete, they can cause an immediate improvement in that athlete's level of sport performance. In fact, 73% of questioned fellows stated that they treat asymptomatic athletes with the specific goal of enhancing sport performance, and that many of the respondent fellows treat and adjust athletes without a self-reported physical complaint (pain and/or dysfunction) or injury. A good example of this premise lies within the previously mentioned work by Costa et al., (2009).[15]

There was almost complete agreement (97%) that by utilizing specific treatment techniques chiropractors could affect treatment outcomes that may indirectly enhance athletic performance. This suggests that most sports specialist chiropractors believe that they can perhaps affect performance indirectly by striving for specific treatment outcomes which may include (as this study has identified); changing or improving aberrant body mechanics, restoring or improving aberrant muscle function, and improving joint function or reducing joint dysfunction. In addition to this, 84% of the respondent fellows stated that they had witnessed an apparently asymptomatic athlete experience performance enhancement immediately after spinal manipulative therapy and/or an adjunctive chiropractic therapy.

In terms of specific treatment interventions utilized by sports fellows to affect athlete sport performance either directly or indirectly, the results of this study indicate that

Table 4 *Opinions Regarding the Perceived Effectiveness of Treatment Interventions Utilized to Affect Performance (n = 29*)*

Question	Response Option	Ranking 1 to 3 Frequency Count (%)		
		#1	**#2**	**#3**
When treating athletes with the (direct or indirect) goal of affecting performance, what **3** treatment interventions do you most commonly utilize? Rate each of your 3 responses from 1 to 3 in terms of their perceived effectiveness. 1 = Most effective 2 = Second most effective 3 = Third most effective	I do not treat athletes with the intent to specifically affect performance.	3 (10)	0 (0)	0 (0)
	Spinal joint manipulation / mobilization	15 (52)	7 (24)	2 (7)
	Extremity joint manipulation / mobilization	2 (7)	5 (17)	5 (17)
	Manual soft tissue therapy (myofascial release, trigger point, cross friction, etc.)	1 (3)	6 (21)	4 (14)
	Active Release Techniques®	5 (17)	3 (10)	4 (14)
	Trigenics®	1 (3)	1 (3)	1 (3)
	Graston Technique®	0 (0)	0 (0)	0 (0)
	Acupuncture	0 (0)	0 (0)	1 (3)
	Nutritional advice or prescription	0 (0)	0 (0)	0 (0)
	Exercise prescription	1 (3)	2 (7)	7 (24)
	Rehab prescription	1 (3)	0 (0)	1 (3)
	Physical modalities (Ultrasound, IFC, etc.)	0 (0)	1 (3)	2 (7)
	Sport specific training advice	0 (0)	0 (0)	1 (3)
	Lifestyle counselling	0 (0)	0 (0)	0 (0)
	Additional care, health professional referral	0 (0)	0 (0)	0 (0)

* Note: Eight respondents of the 37 returned questionnaires did not respond to the question according to instructions. Therefore percentage calculations represent n = 29.

the most commonly utilized interventions are spinal joint manipulation/mobilization (92% utilization), followed closely by extremity joint manipulation/mobilization (89% utilization), exercise prescription (86% utilization), sport specific training advice (86% utilization), manual soft tissue therapies (non-specified) (84% utilization), and rehab prescription (81% utilization). Questioned fellows perceived that spinal joint manipulation/mobilization was the most effective (52% selected) intervention to produce an effect on athlete sport performance. However, they also considered spinal joint manipulation/mobilization to be the second most effective intervention (24% selected), meaning that some of the respondent fellows selected one of the other intervention options as the most effective intervention. When this occurred, Active Release Techniques® or ART® was chosen as the second most selected preference for the number one most effective intervention to affect athlete sport performance. The third most effective intervention to affect sport performance was considered to be exercise prescription (24% selected). The most common specific interventions selected by the respondent fellows as never or hardly ever utilized to affect sport performance were Trigenics® (69% selected), Graston Technique® (69% selected), and acupuncture (58% selected). However, just as the opinions regarding the perceived most effective interventions

Table 5 *Opinions Regarding Anticipated Treatment Outcomes (n = 37)*

Treatment Outcomes	Popularity
Changing or improving aberrant body mechanics	89%
Restoring or improving aberrant muscle function	89%
Improving joint function or reducing joint dysfunction	89%
Restoring an injured tissue or area efficiently and effectively	84%
Improving spinal health and neural function	59%
Removing Subluxations	49%

Table 6 *Outcome Measures Utilized to Evaluate Intended Treatment Outcomes (n = 37)*

Outcome Measures	Frequency Count (%)
Observation	36 (97)
Soft tissue palpation	32 (86)
Range of motion	34 (92)
Muscle testing	32 (86)
Diagnostic testing (neurological exam, orthopaedic tests, imaging, etc.)	28 (76)
Subjective improvement	31 (84)
Pain scale	24 (65)
Before / after comparison	27 (73)
Site specific function/pain scale/ questionnaire (i.e. NDI, ODI, Shoulder disability index, etc.)	23 (62)
Other*	7 (19)

* Other Methods Offered: Competition outcomes (i.e. higher, stronger, faster, etc.), Performance Indicators (i.e. time, distance, skill performance, etc.), Motion palpation, Surface EMG and thermography

should not be interpreted as proof of their clinical efficacy, the opinions regarding never or hardly ever utilized interventions should not be interpreted as an indication of their lack of efficacy. Indeed, Trigenics® and Graston Technique® are the two least utilized named or specific protocol soft tissue/myoneural treatment techniques used by sports fellows. It is possible that their lack of use to affect performance may simply be a reflection of their less common utilization in general or limited exposure to practicing sports fellows. On the other hand, the high utilization and perceived effectiveness of ART® in the treatment of athletes with the goal of affecting performance is common place for fellows of CCSS(C). Interestingly, and as with most techniques, research on the effectiveness of ART® for enhancing sport performance remains untested.

When fellows of the CCSS(C) treat athletes with the goal of affecting sport performance, they most commonly anticipate that their specific treatment interventions (likely those described above) will produce a "change in or an improvement in aberrant body mechanics" (53% selected), or a "restoration or improvement in aberrant muscle function" (53% selected); which may include the removal of adhesions, the removal of scar tissue, and/or the facilitation of relative movement between muscles or muscle groups. Alternatively they may be anticipating the 'improvement of joint function" or conversely the "reduction of joint dysfunction" (53% selected). Other outcomes that CCSS(C) fellows commonly anticipate included; "restoring an injured tissue or area efficiently and effectively" and "restoring or improving aberrant muscle firing patterns," which included the improvement of neural muscular control and the reduction/removal of neural inhibition.The least commonly anticipated chiropractic treatment outcomes when treating athletes with the goal of affecting sport performance were "removing subluxations" (6% selected), "improving spinal health and neural function" (3% selected), and "reducing the risk of injury" (3% selected). Perhaps the reason that "removing subluxations" and "improving spinal health and neural function" are not the more popular intended outcomes of chiropractic treatment is a reflection of the movement away from the traditional subluxation model of chiropractic and the movement towards an evidence based health care model. The evidence based model of chiropractic is the model that is currently being taught in Canadian chiropractic educational institutions.[19] It is interesting to note that all of the above mentioned chiropractic treatment outcomes, and others, have been investigated and/or discussed within the chiropractic literature.[20–50] However, discussion of the evidence behind each of these anticipated treatment outcomes is beyond the scope of this paper.

Limitations

Despite the fact that the study successfully contacted 68.5% of the currently registered fellows of the CCSS(C) for the year 2006/2007, it is possible that it may have failed to accurately capture the collective opinions of chiropractic sport injury specialists in Canada. The 31.5% of fellows either not contacted, or who opted not to participate in the study, may have possessed significantly different opinions than those captured in this investigation. However, we hypothesize that this is unlikely. Canadian sports fellows are required to complete very specific education and training requirements, and homogeneous training most typically leads to homogenous behaviours and attitudes.[16]

In addition, the length of time necessary to properly respond to our questionnaire may have been a factor which limited our response rate.

Recommendations

Clearly, more research on chiropractic treatment and sport performance enhancement is required. This inventory of the opinions of fellows of the College of Chiropractic Sports Sciences (Canada) on the intended outcomes when chiropractors treat athletes, and what interventions they utilize to affect those outcomes, can be used as a starting point for focusing further research in this area, including: 1) Quantifying the dosage of treatment interventions to affect performance; 2) Quantifying the efficacy of the proposed treatment interventions to affect athlete performance; 3) Determine the relationship of anticipated treatment outcomes to sport performance enhancement; and, 4) Develop quality performance diagnostics and tests of performance that correlate with the anticipated outcomes of the chiropractic treatment of athletes. 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.[52] 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.[51,52]

Conclusion

It seems that the majority of respondent sports fellows do in fact believe that by utilizing specific treatment techniques they can cause direct and specific improvements in an athlete's sport performance. In fact, 73% of questioned fellows stated that they treat asymptomatic athletes with the specific goal of enhancing sport performance. According to Canadian chiropractic sports specialists, a "chiropractic treatment" would appropriately consist of some combination of spinal or extremity joint manipulation/mobilization, specific soft tissue therapy, exercise/rehabilitation/sport specific training prescription, and when necessary, a referral to an additional health professional. Questioned fellows perceived that spinal joint manipulation/mobilization was the most effective intervention to produce an affect on athlete sport performance. The most anticipated outcomes following the specific treatment of athletes with the goal of affecting athletic performance were "changing or improving aberrant body mechanics," "restoring or improving aberrant muscle function," and "improving joint function or reducing joint dysfunction." It is recognized that the above findings do not represent proof of chiropractic treatment improving athlete sport performance; they only represent the consensus opinion of the respondent fellows of the College of Chiropractic Sports Sciences (Canada).

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Posterior tibialis tendonopathy in an adolescent soccer player: a case report

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Objective: *Detail the progress of an adolescent soccer player with right-sided chronic medial foot pain due to striking an opponent's leg while kicking the ball. The patient underwent diagnostic ultrasound and a conservative treatment plan.*

Clinical Features: *The most important features were hindfoot varus, forefoot abduction, flatfoot deformity, and inability to single leg heel raise due to pain. Conventional treatment was aimed at decreasing hypertonicity and improving function of the posterior tibialis muscle and tendon.*

Intervention and Outcome: *Conservative treatment approach utilized soft tissue therapy in the form of Active Release Technique®, and eccentric exercises designed to focus on the posterior tibial muscle and lower limb stability. Outcome measures included subjective pain ratings, and resisted muscle testing.*

Conclusion: *A patient with posterior tibialis tendonopathy due to injury while playing soccer was relieved of his pain after 4 treatments over 4 weeks of soft tissue therapy and rehabilitative exercises focusing on the lower limb, specifically the posterior tibialis muscle.*
(JCCA 2010; 54(4):293–300)

KEY WORDS: foot, adolescent, soccer, injury, tendonopathy

Objectif : *Détailler la progression d'un joueur de soccer adolescent souffrant d'une douleur chronique interne au pied après avoir frappé un adversaire en donnant un coup de pied sur le ballon. Le patient a subi une ultrasonoscopie et un traitement conservateur.*

Particularités cliniques : *Les plus importantes particularités étaient le varus de l'arrière-pied, l'adduction de l'avant-pied, la difformité du pied plat, et l'incapacité de soulever le talon en raison de la douleur. Le traitement conventionnel avait pour but de diminuer l'hypertonicité et d'améliorer la fonction du tendon du muscle tibial postérieur.*

Intervention et résultat : *Le traitement conservateur comprenait la thérapie des tissus mous sous la forme d'Active Release Technique®, et des exercices excentriques axés sur le muscle tibial postérieur et la stabilité du membre inférieur. La liste des indicateurs de résultats comprenait l'évaluation subjective de la douleur et le test du muscle contrarié.*

Conclusion : *Un patient souffrant de tendonopathie tibiale postérieure suite à une blessure subie en jouant au soccer fut soulagé de sa douleur après 4 traitements durant 4 semaines de thérapie des tissus mous et d'exercices de réhabilitation axés sur le membre inférieur, particulièrement le muscle tibial postérieur.*
(JCCA 2010; 54(4):293–300)

MOTS CLÉS : pied, adolescent, soccer, blessure, tendonopathie

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Introduction

Injuries are an unfortunate part of any sporting activity and soccer is no exception. Due to the nature of the sport the majority of soccer injuries occur in the lower limb, especially the ankle.[1,2] It should come as no surprise that lower limb injuries are a common complaint that present to a chiropractic sports clinic. Injuries in soccer typically occur because of tackling, being tackled, running, shooting, twisting and turning, jumping and landing.[2] A suggested reason for the higher incidences of ankle injuries is its close approximation to the ball, which is the main object of control in the sport. The chances of sustaining an ankle injury are highest when a player is tackling, shooting, or dribbling.[2] Risk factors for soccer related injuries include age, gender, skill level, environment, and surface type.[1] Epidemiological evidence indicates that approximately 10–15 injuries occur in soccer per 1000 playing hours.[1] Older age players appear to be more prone to injury than younger ones, as do higher skill level athletes.[2] Environment can also play a role in increased incidence, as playing indoors or on artificial turf has been linked with an increase in injury. Males are more susceptible to ankle injuries while it is reported that knees are the most frequent injury for females.[2]

Avulsion injuries for soccer players are rare. They can present as groin pain from a sports hernia (tear of the abdominal muscles attachments to the pubic tubercle), or rectus femoris injury (tear of proximal attachment from the anterior inferior iliac spine avulsion).[3,4] In younger athletes consideration must also be given to apophyseal injuries. These injuries typically occur between 8 and 15 years of age and are associated with skeletal immaturity, muscle-tendon imbalance, and repetitive microtrauma. Common apophyseal injuries in young athletes include Osgood-Schlatter disease (tibial tuberosity), Sever's disease (posterior calcaneus), Sindig-Larsen-Johansson syndrome (inferior patella), and medial epicondylitis (medial humeral epicondyle).[5] Navicular fractures can also occur in athletes though they are far less common in soccer players.[6,7] As well to-date there have been few avulsion injuries reported with the navicular bone (main distal attachment site of the posterior tibialis muscle) and not a single navicular apophsyeal injury in a young athlete.[8,9]

A common tendon injury associated with soccer however is the posterior tibial tendon (PTT).[1] The prevalence of PPT dysfunction in the general population is approximately 3.3% and often results in adult acquired flatfoot deformity.[10] In soccer athletes injuries to this tendon result from repetitive kicking of the ball. During a ball strike the ankle is forced into excessive plantar-flexion and the foot into extreme pronation. Consequently the PTT can become irritated due to friction against the medial malleolus and subject to a number of pathological changes such as avulsion, longitudinal tear, or rupture of the mid tendon substance.[1,11] The medial malleolus acts to change the direction of pull by the tendon. This is believed to cause increased stress on the tendon as ruptures typically occur in this location.[12]

The mechanism of injury is theorized to be a degenerative process of the PTT caused by decreased blood supply. This then results in a tendon dysfunction with possible rupture and gradual collapse of the medial longitudinal arch of the foot. Other common findings associated with PTT dysfunction include hindfoot valgus deformity and forefoot abduction. Mechanically the PTT is stressed during gait immediately after heel strike as the hindfoot moves from eversion into inversion. As the angulation of the hindfoot increases the forefoot compensates by progressively moving into an abducted position. Cutting sports such as soccer are known to place increased stress on the PTT.[13,14] Additionally, as the PTT becomes dysfunctional there is an imbalance with its antagonist muscle the fibularis brevis. The dominating unopposed action of the fibularis brevis also contributes to the deformities mentioned above (medial longitudinal arch collapse, hindfoot valgus, and forefoot abduction).[15,16] Finally, the presence of a prominent navicular tuberosity or an accessory navicular have been linked to PTT tears. Again the proposed mechanism of injury is chronic irritation of the tendon. However, the location of the tear is now at the navicular insertion, not at the level of the medial malleolus.[17]

The purpose of this case report was to describe an adolescent soccer player who experienced medial foot pain after attempting to strike the ball. The patient underwent a simple non-invasive chiropractic treatment plan using manual soft tissue procedures and rehabilitative training on the lower limb musculature.

Case Report

This case report involves a 14-year old male competitive soccer player who developed right medial foot pain after striking an opponent in the leg while trying to kick the

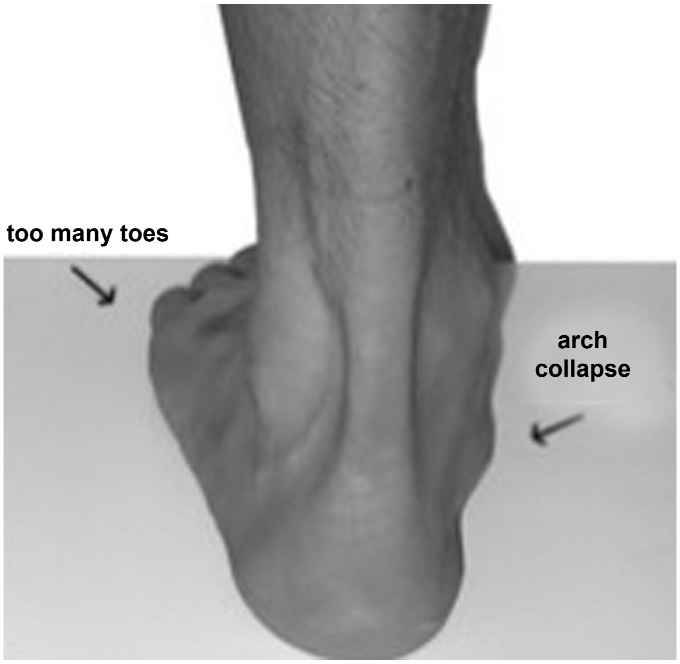

Figure 1 *Posterior view of foot and ankle showing "too many toes" sign and pes planus via collapse of the medial longitudinal arch.*

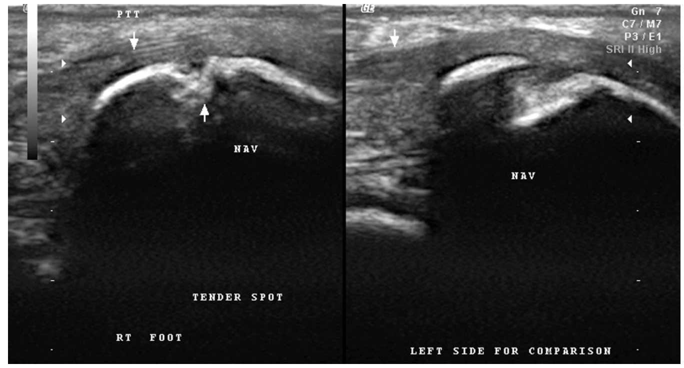

Figure 2 *Diagnostic ultrasound results showing thickening of the right tibialis posterior tendon at the navicular insertion and irregularity of the bone at the right navicular tuberosity.*

ball. The initial incident occurred 4 months prior to the patient's first visit. He recalls the injury as a direct impact of his right medial foot against the opponent's leg. This created a forced external rotation of the foot on the tibia. The athlete reported immediate pain and swelling of the medial foot and ankle. He had to be helped off of the field and was unable to return to play for the remainder of the game. The next day the subject saw a sports medical doctor who diagnosed him with a "bone bruise" and told the patient to rest for 4 to 6 weeks. No imaging was ordered at this time. After 6 weeks the patient reports that he was pain free with his activities of daily living. However, when he attempted to return to sport he was unable to continue due to sharp pain in his right medial foot. Jumping and landing particularly exacerbated his pain, which he rated as 8/10 on a Visual Analog Scale (VAS). Running was reported as normal. It was not until 4 months after his initial injury that the patient presented to a chiropractic sports clinic for treatment. The patient reported no previous history of injury and a systems review was unremarkable.

On physical examination postural observation of the subject revealed pes planus of his right foot when viewed from the front and "too many toes" sign when observed from behind (Figure 1). Moderate pronation of the right foot was also observed with gait analysis. Palpation reproduced pain over the right navicular tuberosity, which appeared to be mildly swollen. Orthopedic testing found ankle range of motion to be normal and tuning fork test over the navicular to be negative. Hop test was positive due to pain on the right side. Functional testing also reproduced weakness due to pain (6/10 VAS score) with single leg heel raises. One legged squat revealed severe foot pronation, internal femoral and tibial rotation, and valgus knee deviation on the right side. Muscle testing of the posterior tibialis found weakness with resisted foot inversion (Score of 4/5 due to pain).

The patient was diagnosed with a suspected posterior tibialis tendonopathy. Due to the length of time the patient had been experiencing pain (4 months) and mild visual deformity over the right navicular tuberosity he was referred for ultrasound imaging to rule out an avulsion fracture, tendon tear, or accessory navicular ossicle. Diagnostic ultrasound showed thickening of the right posterior tibial tendon and irregularity of the navicular tuberosity bone (indicating an old avulsion fracture or apophyseal injury given the patient's age) (Figure 2).

Treatment

The patient was treated with 4 sessions over 4 weeks. Passive treatment consisted of Active Release Technique® (ART®) therapy to the posterior tibialis tendon insertion

Figure 3 *"Tib post heel-ups" exercise for the posterior tibials muscle, done while squeezing the tennis ball between the medial malleoli.*

and muscle. ART® is used by conservative care practitioners (chiropractors, physiotherapists, and message therapists) with an understanding that anatomical structures throughout the body have traversing tissues located at oblique angles to one another. Areas of tissue overlap are prone to negative changes with trauma producing local swelling, fibrosis and adhesions that can result in pain and tenderness at the location of injury.[12] During ART® therapy the practitioner applies digital tension along the tissue fibers at tender areas of adhesion. The patient is then instructed to actively move the tissue fibers of the injury site from a shortened to a lengthened position.[12,13]

Additionally active care consisted of the patient being prescribed 3 types of rehabilitative exercises. Posterior tibials muscle exercises of "tib post heel-ups" while squeezing a tennis ball between the medial malleoli were given (Figure 3). Lower limb stability exercises consisted of single leg supine bridges on a physioball, single leg squats, and "clock squats" (Figure 4). As well, gluteus medius muscle exercises consisted of hip hikes, side lying abduction, and lateral theraband walking (Figure 5). All exercise programs were done 2 times per day, 6 days per week.

After 4 weeks of treatment the patient was able to finally return to playing soccer relatively pain free (1/10 VAS score with jumping and landing). Functional muscle testing of the posterior tibialis showed decreased weakness and improvement (score of 5/5). This patient was not considered a surgical candidate as his injury was no longer acute at the time of presentation and a trial course of conservative care was successful in allowing him to return to play pain free.

Discussion

Soccer is one of the most popular sports on the planet with hundreds of millions of players throughout the world.[19] In North America its popularity is continuing to rise and soccer is starting to emerge as a major amateur and professional sport.[1] It is a unique sport that involves walking, jogging, running, and sprinting at various times in play. The characteristics of the game along with a high demand for functional activities place significant demands on the athlete's physical and technical skills while playing. Thus many of the injuries and medical problems that arise can be distinct to the sport.[1] Previous studies have demonstrated a high injury rate associated with soccer. In fact more injuries are found in soccer than such contact sports as judo, boxing, and rugby. The most commonly reported injuries among soccer players are the ankle, knee, thigh, groin, and hip.[2] The anatomical dominance of injury to the lower limb region is not surprising when one considers the repetitive forces required from weight-bearing activities such as running, sprinting, jumping, and landing.

The patient in this case report was an adolescent male who sustained a medial foot and ankle injury while attempting to kick the ball, a mechanism of injury all too common to soccer athletes. As previously mentioned the ankle's close approximation to the ball is a possible explanation for the increased incidence of injury in soccer players and the chances of sustaining this type of injury are highest when performing such kicking actions as shooting or dribbling.[2]

The posterior tibialis muscle has proximal attachments on the posterior tibia, interosseous membrane, and proximal third of the fibula. It travels medially around the ankle and inserts distally on the navicular bone in the area

Figure 4 *"Clock squats" exercise for lower limb stability. Flex the knee of the weight bearing leg to 15–20° while reaching the non-weight bearing leg toward each of the four clock positions as shown below. Return to the start position after reaching each clock number.*

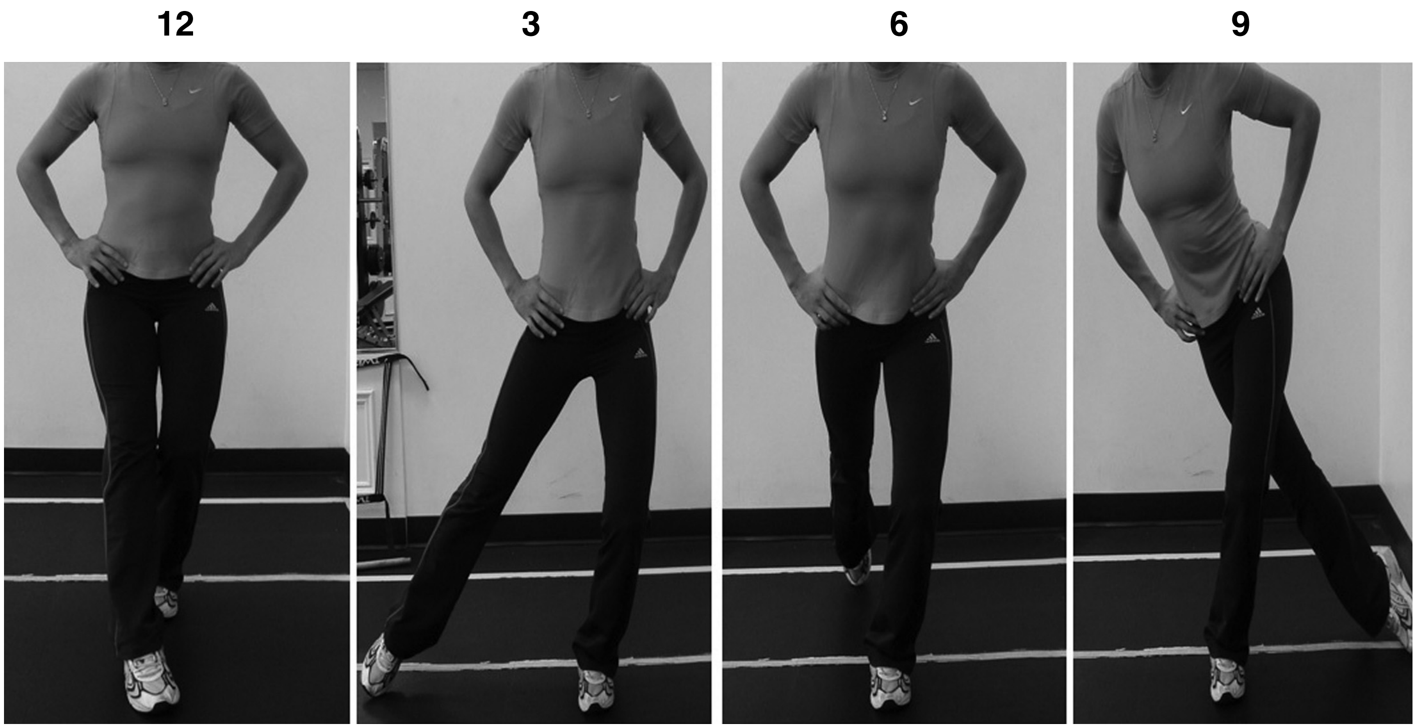

Figure 5 *Lateral theraband walking exercise for gluteus medius muscle rehab. Perform a slow and controlled lateral shuffle to one side (8–10 steps), then repeat to the opposite side.*

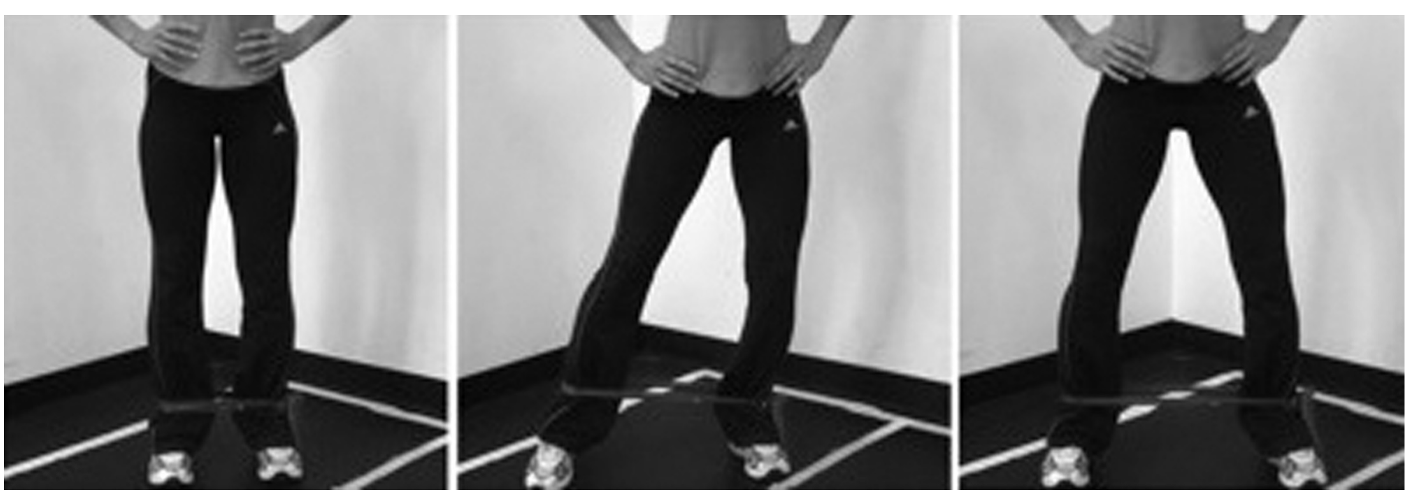

Table 1 *Progressive classification of posterior tibial tendon dysfunction stages.*[13,15,21,22]

Classification Stages	Description
Stage I	The patient has pain and swelling along the tendon, is able to perform single heel raises, flatfoot deformity is minimal, and the subtalar joint is mobile.
Stage II	The patient is unable to perform a single heel raise, flatfoot deformity is pronounced with hindfoot valgus and forefoot abduction, and the subtalar joint remains mobile.
Stage III	The patient cannot single heel raise, flatfoot deformity is more severe, and the subtalar joint becomes ridged.
Stage IV	All of the findings in Stage III as well as valgus tilt of the talus in the ankle mortise joint leading to lateral tibiotalar degeneration

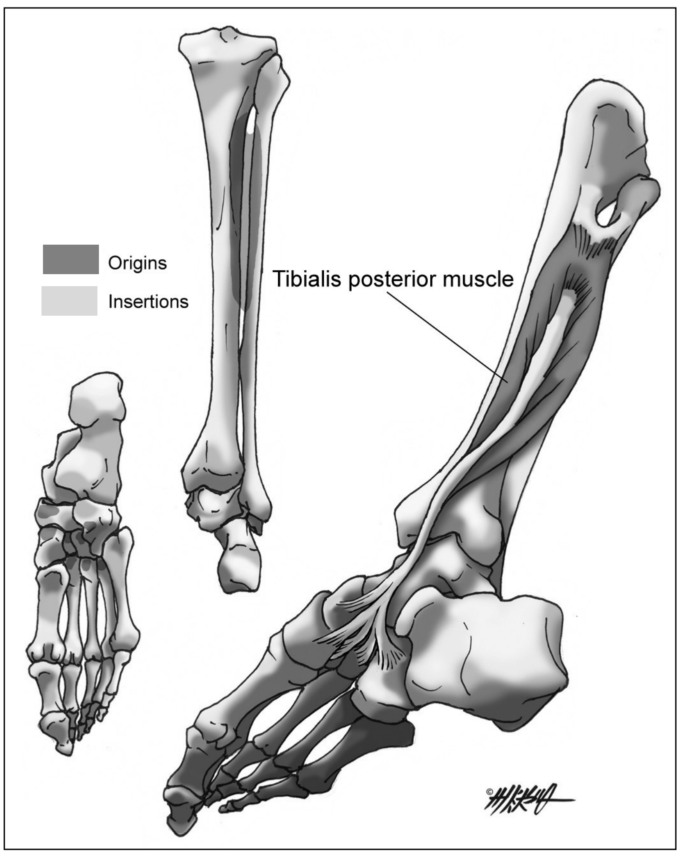

Figure 6 *Anatomical depiction of tibialis posterior muscle and tendon attachments.*

of the midfoot (Figure 6).[13,18] This muscle functions as a plantar flexor and powerful inverter of the foot, it also provides support to the medial longitudinal arch, and stabilizes against hindfoot valgus and forefoot abduction deformities.[16,20] The true etiology of PTT dysfunction still remains unclear. Vascular, metabolic, and mechanical factors have all been suggested to play a part, and conditions such as hypertension, diabetes mellitus, obesity, previous midfoot trauma, seronegative arthropathies, and enthesopathies have been identified as risk factors.[13,16,18] Johnson and Strom originally created a classification system for PTT dysfunction that was later added to by Myerson (Table 1).[21,22]

Navicular avulsions of the PTT in athletes, though rare, have been reported.[8,9] Avulsions of epiphyseal bone can occur after only slight exertion and are thus termed stress avulsions or apophyseal injuries depending on the age of the athlete. Avulsions are far less common after closure of the epiphysis.[8] Several theories have been given to explain the development of apophsyeal injuries in young athletes. The first theory suggests that a major traumatic event, such as a violent contraction, avulses part of the apophysis and inflammation ensues.[5] Theory two proposes repetitive microtrauma to an apophyseal area causes multiple tiny avulsion fractures, followed by an inflammatory cycle developed from repetitive running and jumping (as in sports such as soccer).[5] The third theory is that aphophyseal injury is due to a macrotraumatic event that either preceded or followed multiple episodes of repetitive microtrauma to the area.[5] The purposed mechanism for avulsion injury at the navicular bone involves repetitive cycling of compressive and twisting loads caused by forceful movements of the foot.[8] During maximal effort (occurring during running, jumping, or kicking) the navicular is locked between the proximal and distal tarsal bones, and subjected to bending and compressive forces from muscle and ligament attachments. Pull is suggested to be greatest at the medial aspect of the navicular, where the PTT attaches.[8] It should be noted that cortical avulsion fractures of the navicular occur most often as a result of twisting forces applied to the foot and are seen most frequently in middle aged women wearing high-heel shoes.[9]

The PTT and navicular have been implicated in overuse injuries in athletes, specifically those that have an accessory navicular bone within the tendon or close to the attachment site.[20] The distinction between an accessory navicular bone and a sesamoid bone can be confusing. Clinicians often simplify this and call any bone close the PTT attachment site a "asscessory navicular" and classify it based on size, location, and relationship to the true navicular bone. There are 2 types of accessory navicular, type I bones lie fully within the structure of the tendon proximal to the attachment, while type II bones lie very close to the navicular tuberosity and form a synovial joint with it.[20] While it has long been known that the PTT may have accessory bones within it that can be associated with foot pain, it is now also being associated with PTT tears as well. Chronic irritation of the tendon at its navicular insertion (due to the accessory bone) is the proposed mechanism of injury for the tear. Injury to the synovial joint of a type II accessory navicular combined with tension and shear forces from the tendon prevent healing and predispose the PTT to tearing.[11,18,20] It is important to remember however, that even when degenerative changes are associated with the finding of an accessory navicular bone it does not exclude the possibility of other parts of the PTT, such as behind the medial maleollus, from undergoing injury and thus causing pain.[20]

Stage I and II PTT dysfunction are rarely treated with surgery unless conservative care has failed. There are a variety of isolated soft-tissue procedures designed to compensate for these injuries. A wide variety of operative treatments have been reported for stage III and IV PTT dysfunction, navicular avulsions, and symptomatic accessory navicular bones. Reconstructive surgeries or osteotomies are employed to improve alignment of the hindfoot and forefoot and decrease pain at the site of PTT attachment. However, recovery from reconstructive surgery can be prolonged and an eventual return to pain-free unrestricted activities is variable.[13]

Summary

Foot and ankle injuries in soccer players have been widely reported, however to our knowledge this is the first case where a potential navicular apophsyeal injury has been reported and treated in a young soccer player.[1,2,19] The cause of injury is believed to be multi-factorial and include repetitive microtrauma to the navicular as well as weakness of the PTT due to the forces and mechanics involved with repetitive kicking of the ball in soccer. Conventional treatment aimed at decreasing hypertonicity and improving function of the posterior tibialis muscle and tendon through ART® soft tissue therapy, and rehabilitative exercises focusing on the lower limb stability. In this case, a patient with right chronic medial foot pain due to striking an opponent's leg while attempting to kick a soccer ball appeared to be relieved of his pain after having 4 treatments over 4 weeks.

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