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Contents

JCCA Vol 57 No 4 ISSN 0008-3194 (Print) and ISSN 1715-6181 (Electronic)

Original Articles

Contents

JCCA Vol 57 No 4 ISSN 0008-3194 (Print) and ISSN 1715-6181 (Electronic)

Editorial Board

Cervical artery dissection: a biomechanical perspective

Bruce Symons, DC, MSc*
Walter Herzog, PhD**

Introduction

Although there has been a putative link between cervical spinal manipulative treatment (cSMT) and cervical artery dissection (CAD) ever since Thornton's report in the literature in 1934[1], recent evidence suggests that this is an association rather than a causal relationship. Since 2008, several studies published by Cassidy and co-workers[2-4] have attributed the association between cSMT and CAD to patients seeking chiropractic care for neck pain and headaches during the prodrome of a stroke.

Most reviews in the literature now generally report that there are no convincing data, either to prove or disprove, any causality between cSMT and CAD.[5] However, case reports and case series still accumulate that identify chiropractic as the sole cause of CAD.[6-7] Furthermore, Tuchin[8] recently tested the causality between CAD and SMT using Hill's criteria, and concluded that there is no evidence that SMT is causally related to stroke. Nevertheless, some authors continue to claim that cSMT causes CAD.

Rather than using an epidemiologic approach to assess the risk of whether cSMT can cause CAD, another approach is to investigate the mechanism(s) of how cSMT can cause CAD. Since 2002[9], our laboratory has focused on the latter strategy. Using cadaveric vertebral arteries (VAs) as a model for the *in vivo* neck, we have measured the strains experienced by VAs using ultrasonography to dynamically measure the changes in VA segment lengths during manipulative procedures. The details of the experimental procedures have been described elsewhere.[9-11] We have now replicated these experiments on a total of 16 VAs obtained from 10 cadavers[9-11] in 3 different papers.

Table 1:
Vertebral Artery (VA) and Internal Carotid Artery (ICA) strains obtained during Diversified-style cervical manipulation. For VA, results of the V3 and V1 segments are given. Strains during range of motion (ROM) are also given for reference, as are the strains at which gross mechanical failure was first observed (Fail). ND indicates that no data are available. Note that the strains for the cervical manipulation trials are typically less than 50% of those obtained during normal ROM testing.

	VA V3	VA V1	ICA	ROM	Fail
Symons et al.[9]	5.2%	2.7%	ND	12.5%	62%
Wuest et al.[10]	2.6%	ND	ND	10.8%	ND
Herzog et al.[11]	3.8%	0.9%	ND	12.2%	58%
Herzog et al.[12]	ND	ND	2.0%	7.1%	59%

Please note that we were unable to pool these data due to statistical considerations and advances in the experimental procedure.

More recently, we have extended these experiments to investigate the strains experienced by the internal carotid artery (ICA) during cSMT utilizing essentially the same experimental protocol.[12]

Table 1 shows a summary of the data obtained thus far. The mechanical engineering strains experienced by the V3 segment of the VA, the segment which exits from the C2 transverse foramen and loops around C1 into the foramen magnum, during a Diversified-style cervical manipu-

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lation at C2-C4 vertebral levels ranged from 2.6 to 5.0%. In other words, the V3 segment stretches by roughly 3-5% of its resting length during SMT. In comparison, passive range of motion (ROM) testing exerted a peak 11-13% strain. Typically, contralateral cervical rotation caused the greatest strain values, and hence the ROM testing generally constitutes a test of tolerance to contralateral rotation. The VA underwent gross mechanical failure at 58-62% strain.

When these experiments were replicated on the ICA, similar trends were observed; the ICA underwent 2% strain during cSMT, stretched to 7% strain during contralateral rotation, and failed mechanically at 59% strain.

It is clear from these data that Diversified-style cSMT exerts roughly half or less of the strain that the vessel (VA or ICA) undergoes during ROM movements of the neck, such as shoulder-checking while driving. If the putative mechanism of injury is that forceful SMT causes excessive stretching on the VA or ICA, thus tearing the vessel wall and causing a dissection, then this is highly unlikely to occur in the absence of a pre-existing injury (such as a prodromal dissection) or pre-existing condition (such as collagen disease). If cSMT can indeed precipitate a CAD, then any similar movement of the neck should be a sufficient cause, since the biomechanics of cSMT have now been studied in detail.[13]

Although most of the literature has focused on the VA rather than the ICA for the association between cSMT and stroke, there have been several reports on ICA dissection linked to cSMT.[14,15] However, these reports are rare, and there is no clear association between ICA dissection and cSMT.[16]

Armed with the epidemiologic studies from Cassidy and co-workers plus the biomechanical evidence described above, it is reasonable that most clinicians tend to discount any association between CAD and cSMT. Furthermore, Murphy[17] suggested that with the recent evidence pointing towards a temporal association rather than a causal association, chiropractors should shift their focus from managing CAD as a complication of SMT to recognizing patients who are in the prodromal phases of CAD. However, case reports on chiropractors causing CAD still continue to accumulate despite the growing body of basic research and epidemiology to the contrary. Researchers in this area need to continue their investigations into the association between CAD and cSMT.

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The Clinical Practice Guideline Initiative: A joint collaboration designed to improve the quality of care delivered by doctors of chiropractic.

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Background

One important reason patients consult primary care professionals, including general practitioners and chiropractors, is for musculoskeletal (MSK) conditions.[1] Musculoskeletal conditions (spinal pain, consequences of injuries, osteoporosis, and arthritis) result in an enormous social, psychological, and economic burden to society[1-8], and are the leading cause of physical disability.[9] Chiropractic is a regulated health profession (serving approximately 10% of the population)[10] that has contributed to the health and well-being of North Americans for over a century.

Despite available evidence for optimal management of back and neck pain[11-13], poor adherence to clinical practice guidelines and wide variations in services have been noted.[12,14,15] Utilization of clinical practice guidelines (CPGs) is an important way to help implement research findings into clinical practice. Guidelines aim to describe appropriate care based on the best available scientific evidence and broad consensus while promoting efficient use of resources.[16,17] These tools have the potential to improve the quality and safety of healthcare.[18,19]

Over a decade ago, the Canadian Chiropractic Association (CCA) and the Canadian Federation of Chiropractic Regulatory and Education Accrediting Boards (CFCREAB or Federation) launched the CPG project to develop clinical practice guidelines in order to improve chiropractic care delivery in Canada. Guidelines developed by the CPG project include the management of neck pain due to whiplash injuries[20], headaches[21], and neck pain not due to whiplash[22,23] (an update of which is expected by the end of 2013).

Recent advances in methods to conduct knowledge synthesis[24], derive evidence-based recommendations[25], adapt high quality guidelines[26], and increase the uptake of Clinical Practice Guidelines[27,28] have prompted an update of the DIER (development, dissemination, implementation, evaluation, and revision) Plan published in the JCCA (Journal of the Canadian Chiropractic Association) in 2004.[29] The 140 page report was submitted to the stakeholders of the Guideline Initiative for consideration. The report updates the structure, methods and procedures for the development, dissemination and implementation of clinical practice guidelines in chiropractic. It is anticipated that new updates will be necessary as the art and science of guideline development, dissemination and implementation continue to evolve and new standards are established. The Full Report will be available on the new Guideline Initiative website, expected to be up and running in the first quarter of 2014.

This is the first paper of a two part presentation of the Guideline Initiative and its expected deliverables. The second paper will present the guideline development, dissemination, and implementation framework which will be the foundation of the Initiative. We intend to engage clin-

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icians, leaders and decision makers in the profession right from the beginning as integral participants of the overall strategy to enhance patient care.

Overall purpose of the Guideline Initiative:

The overall purpose is to develop evidence-based Clinical Practice Guidelines and to facilitate the utilization of these and existing guidelines among chiropractors. Further, it aims to enhance academic, clinical and research partnerships to help close the gap between research knowledge and its implementation in clinical practice in order to improve health outcomes.

Scope:

The scope of the Guideline Initiative is limited to non-specific MSK conditions commonly seen by chiropractors including adult spinal and extremity disorders, headaches, pediatric conditions (scoliosis), and pre-specified objectives (e.g., assessment and/or treatment of low back pain). Studies on musculoskeletal disorders resulting from destructive and progressive pathologies affecting the spine will be excluded. However, diagnostic and assessment studies related to ruling out fractures, dislocations and other pathologies will be included in the scope of the Guideline Initiative.

Fundamental principles and values:

Principles and values behind the process are as follows:

Guidelines produced by the Guideline Initiative will be developed using the best available evidence and involving stakeholders in a transparent and collaborative manner. Stakeholders include professional organizations, health care professionals, consumers, and organizations that fund or carry out research. CPGs should address multiple dimensions of decision making. Providing open access to products developed by the Guideline Initiative (e.g., technical reports, guidelines, practitioner guides, and tools to facilitate dissemination and implementation) is one of the primary principles.

Despite significant challenges related to the management of chronic MSK conditions and associated comorbidities, a large proportion of chiropractors are solo practitioners. Management of these complex conditions requires inter-professional collaborations to improve the probability of favorable patient outcomes. Work undertaken by the Initiative will reflect the fact that an increasing number of chiropractors practice in multidisciplinary environments in the private sector, and more recently in the public setting as well.

The Institute of Medicine (2011) recently revised the definition of Clinical practice guidelines as: *'Statements that include recommendations intended to optimize patient care that are informed by a systematic review of evidence and an assessment of the benefits and harm of alternative care options'*.[30]

Primary objectives of the Guideline Initiative:

1. To identify existing best practices for the management of patients with MSK conditions in the area of primary care AND to identify clinical areas where there is a need to develop best practice guidelines.

Sub-objectives

- To complete systematic searches and critical reviews of the scientific literature on MSK conditions, including the epidemiology, assessment/diagnosis, prognosis, economic costs when possible, and treatment of MSK disorders;
- To identify and compare the relative risks of treatments (harm) of MSK conditions;
- To develop guideline recommendations using a process that is scientifically sound and takes into account the views of end users (clinicians and patients), leaders/decision makers, and third party payers.
- To integrate the evidence on harm/benefit trade-off with patient preferences.

2. To promote the use of best available evidence and expert consensus to inform clinical decision making in order to improve the quality of care of patients with MSK conditions.

Sub-objectives

- To develop knowledge translation strategies and to help disseminate and implement these to increase guideline utilization, thus improving patient care and health.

3. To complete original Knowledge Translation (KT) research to assess the level of uptake of CPG recommendations.

Target audience:

The primary audience for the use of the guidelines are chiropractors (and their patients). The Guideline Initiative acknowledges that a secondary audience may take considerable interest in the recommendations, including other health disciplines, third party payers, attorneys and expert witnesses.

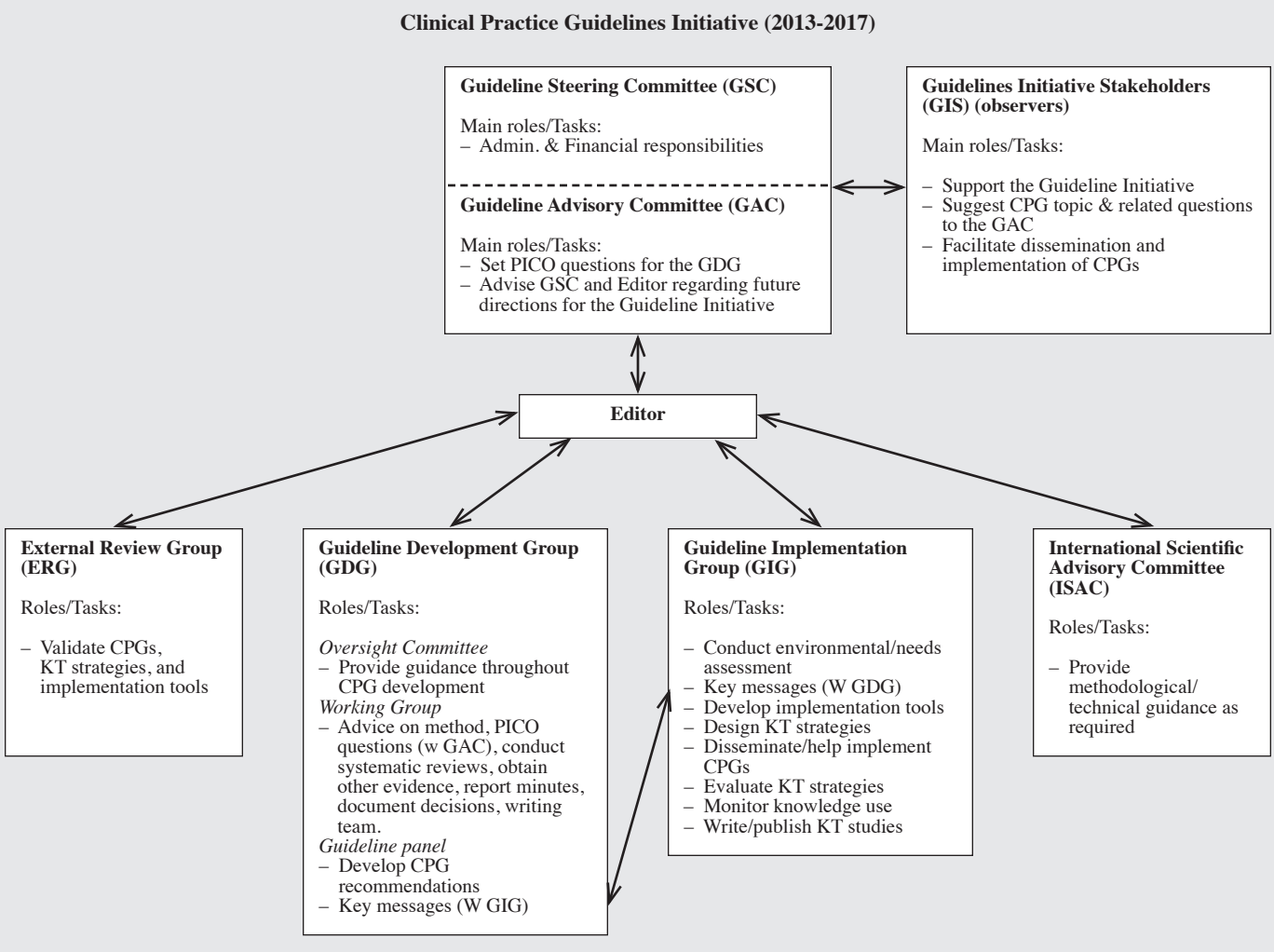
Structure of the Guideline Initiative:

Diagram 1 illustrates the structure of the Initiative.

Composition of the Guideline Initiative working groups:

There is consistent empirical evidence that the composition of guideline development groups influence the resulting recommendations. Further, the Institute of Medicine recommends developing patient-centered guidelines using multidisciplinary and international collaborations (IOM, 2011). The Guideline Initiative includes individuals from all relevant professional groups, and has established a partnership, the North-Atlantic Research Consortium (NARC), uniting researchers from four other

Diagram 1. Structure of the Guideline Initiative



countries (Denmark, Norway, Switzerland, UK) to help develop, disseminate and implement CPGs among chiropractors.

Clinical Practice Guidelines (CPGs):

Since the first LBP guideline was released in 1987 by the Quebec Task Force, there has been a steady worldwide interest, resulting in the publication of numerous CPGs in several countries over the past decades. More recent published CPGs are of better quality, although there remain areas of discrepancy between available guidelines that need to be resolved. Few guidelines created for chiropractors currently exist, and some of these are now outdated. Topics covered include: Neck pain with and without whiplash, Headaches, Diagnostic imaging, and Low back pain. CPGs should address multiple dimensions of decision making, including: effectiveness; harm; quality of life; health-service delivery issues (i.e., dissemination and implementation), provider and patient compliance, and resources, use and cost. Guidelines produced by the Guideline Development Group (GDG) will be developed using the best available evidence and involving stakeholders and health disciplines in a transparent and collaborative manner. Stakeholders include professional organizations, clinicians, consumers, and organizations that fund or carry out research.

Knowledge Translation: Despite available evidence for optimal management of MSK conditions, poor adherence to guidelines and wide variations in services have been noted across spine care providers.[31, 32] Similar gaps (between what works and what is done in daily practice) have been observed for other conditions across the health care system in industrialized countries.[33-35] Closing the research-practice gap involves modifying clinical practice, a complex and challenging endeavour of Knowledge Translation (KT). Putting knowledge into practice is a dynamic, iterative, and complex process. Success requires an integrated approach where all involved parties work together to select, tailor, and implement KT procedures.

Knowledge Translation Research:

KT research is the scientific study of the determinants, processes and outcomes of dissemination and implementation.[36] The Guideline Dissemination/Implementation Group (GIG) will aim to regularly publish its work in peer reviewed journals.

Deliverables of the Guideline Initiative:

Deliverables of the Guideline Initiative during the next 4 years will include:

1) the dissemination and assisting with the implementation of the new Neck Pain Guideline,
2) the development of a clinical practice guideline on treatment-based classification systems for low back pain, and
3) updating an existing CCA-Federation CPG.

It is important to acknowledge that completion of projects undertaken by the Guideline Initiative is to a large extent contingent on both the work produced by a number of collaborators of the Guideline Initiative and ongoing funding from stakeholders.

Already, work is underway to ensure that these objectives are met. Progress made on projects undertaken by the Initiative will be regularly monitored. The Strategic work plan will be formally reviewed at the end of 2013 to identify areas of risk and modify the plan accordingly. The Strategic work plan will be assed annually thereafter.

It should be noted that both the Strategic Work Plan and the Full Report of the Guideline Initiative are living documents and continue to be updated regularly. A Gantt Project Management model will be used to help manage the various projects of the Initiative.

Questions regarding the Guideline Initiative, supporting documents and projects may be directed to Dr. André Bussières DC, PhD, FCCS(C), Editor-In–Chief of the Guideline Initiative at: andre.bussieres@mcgill.ca.

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Chiropractors as Primary Spine Care Providers: precedents and essential measures

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Chiropractors have the potential to address a substantial portion of spinal disorders; however the utilization rate of chiropractic services has remained low and largely unchanged for decades. Other health care professions such as podiatry/chiropody, physiotherapy and naturopathy have successfully gained public and professional trust, increases in scope of practice and distinct niche positions within mainstream health care. Due to the overwhelming burden of spine care upon the health care system, the establishment of a 'primary spine care provider' may be a worthwhile niche position to create for society's needs. Chiropractors could fulfill this role, but not without first reviewing and improving its approach to the management of spinal disorders. Such changes have already been achieved by the chiropractic profession in Switzerland, Denmark, and New Mexico,

Les chiropraticiens ont la possibilité de traiter une partie importante des affections vertébrales, mais le taux d'utilisation des services de chiropratique est resté faible et largement inchangé depuis des décennies. D'autres professions de la santé telles que la podologie, la physiothérapie et la naturopathie ont réussi à gagner la confiance du public et des professionnels, améliorer leur champ de pratique et développer des créneaux distincts au sein des systèmes de soins de santé dominants. En raison de la lourde charge que placent les soins de la colonne vertébrale sur le système de soins de santé, la création d'un « prestataire de soins primaires de la colonne vertébrale » pourrait combler un créneau utile pour satisfaire les besoins de la société. Les chiropraticiens pourraient assumer ce rôle, mais non sans avoir d'abord examiné et amélioré leur approche de la gestion des affections vertébrales. Ces transformations ont déjà été réalisées par la profession chiropratique en Suisse, au Danemark et au Nouveau-

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whose examples may serve as important templates for renewal here in Canada.

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KEY WORDS: primary care, spine, chiropractor

Mexique. Leurs exemples peuvent servir de modèles importants pour la réforme au Canada.

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MOTS CLÉS : soins primaires, colonne vertébrale, chiropraticien

Introduction:

Between 1999 and 2008 the mean inflationary adjusted costs for ambulatory neck and/or back pain in the United States increased by a factor of 95%.[1] According to the study by Davis et al the largest proportion of increased costs are associated with specialty visits rather than primary consultations, clearly indicating that spine care places a tremendous burden upon the health care system.[1] Davis et al make recommendations with respect to cost containment for spine-related disorders which are similar to those put forth by Maniadakis and Gray ten years ago; and many of these revolve around reducing the reliance on specialty management.[2] A number of professionals with diverse backgrounds (chiropractors, massage therapists, physical therapists, osteopaths, and physicians) care for spinal pain patients. However unlike some other health care professions that have focused upon the management of condition-specific maladies, no one group has chosen to do so for certain aspects of the spine patient. Perhaps lessons learned from other condition-specific professions such as optometry and podiatry could provide important guidance in this regard.

Precedents for Professional Growth and Development:

Optometry:

For many years prior to the 1970s, the optometry profession struggled with its identity and status in the health care field. Other health care professions regarded optometrists as glorified technicians providing vision assessments and eyeglasses for the general public.[3] However, subsequent to a pivotal meeting in 1968 (where the optometry leadership came to terms with the profession's shortcomings and subsequently enacted crucial steps necessary to rectify these problems), fundamental changes were made with respect to the utilization of pharmaceuticals and optometric education. Thereafter revised state laws including enhanced legislation came into effect.[3]

Podiatry and Chiropody:

Podiatry was first licensed in 1895[4], and many years later in 1978 admission pre-requisites and educational curricula changed to better parallel that of mainstream medicine. The chiropody profession illustrates a pattern of professional progress similar to podiatry. Chiropody education spans three years, and the Chiropody Act of 1991 outlines minor surgery (and, more recently, limited prescription rights) within chiropody's regular scope of practice.[5] Today both podiatry and chiropody are quite well integrated into the contemporary health care system.[4,6]

What optometry and podiatry have in common is that a necessary combination of political will and respect for scientific research 'from within' led to successful integration and the establishment of a niche position within the broader health care system for their respective condition-specific professions.

Naturopathy:

Naturopaths in Ontario and British Columbia have recently gained the legislative right to the prescription of certain drugs.[7] In some areas, naturopathic doctors can also perform minor surgery.[8] Naturopathy encourages disease prevention and responsibility to one's own health[8] but despite precedence for natural treatment, the profession realizes the need for an expansion in its scope of practice and greater collaboration with other health care providers.

Chiropractic:

Chiropractors study for a minimum of four years (normally following at least a baccalaureate degree) with a curriculum that has a significant emphasis on the diagno-

sis and management of spine-related disorders. Currently, the World Federation of Chiropractic (WFC) website lists 41 chiropractic schools globally, most of which reside in the United States.

The chiropractic profession like other health care delivery professions has developed evidence-based clinical practice guidelines for the management of various conditions including but not limited to neck pain[9] and headaches[10]. However despite the development of these guidelines there remains much heterogeneity in the provision and style of chiropractic services. A recent Internet-based search of Google and YouTube yielded 22,500 hits using 'chiropractic treatment' as a search term. The first page of the Google search listed such items as 'chiropractic care may not be as safe as reported', 'animal chiropractic', and 'dangers of chiropractic under-reported'. The 'dangers of chiropractic under-reported' quote was taken from a systematic review published in the New Zealand Medical Journal.[11] Clearly an unscientific Google search using such an arbitrary term as 'chiropractic treatment' does not define a profession. However analogous searches in the context of other health care professions do not yield similar controversial results.

Utilization, Challenges and Milestones:

Appropriate treatments offered by chiropractors can provide benefit to patients yet the percentage of back pain patients that consult chiropractors has remained stable at relatively low utilization rates.[1,12]

Despite progressive educational and legislative changes, beginning in 1963 chiropractic endured a prolonged and tenacious attempt by the American Medical Association to eradicate the profession[13]. The AMA was investigated for violating federal antitrust laws and finally the conspiracy was brought to an end in 1980.[13] Is it possible that at least some of the motivation behind the efforts to eradicate chiropractic included unscientific/unjustifiable claims and practices made by chiropractors?

In 1975 the National Institute of Neurologic and Communicative Diseases and Stroke arranged a conference on spinal manipulative therapy and as a result of this conference chiropractic ignited its involvement in scientific research.[13] The Journal of Manipulative and Physiological Therapeutics emerged in 1978 as a direct result of this need to integrate scientific research in chiropractic clinical practice.[13]

Primary Spine Care Provider (PSCP):

Low back pain is associated with a lifetime prevalence of up to 80%.[14] It is a major source of spinal disability and is ranked amongst the top five health care complaints with approximately 27 million patient visits per year in the USA.[15] Despite the obvious burden of back pain on the health care system, according to the 1996-97 Ontario Health Survey only 9.9% of the population seeks chiropractic care.[16]

In order to improve spinal pain assessment and treatment, the PSCP should have specialized training in matters related to the spine, maintain an evidence-based practice and a clear understanding of when and to whom to refer appropriate patients. The PSCP should also be intimately aware of the capabilities of other spine care providers who can provide necessary complementary interventions (both surgical and non-surgical). Akin to optometrists for eye conditions, the PSCP would not assume the role of a primary care physician, but instead serve as the expert in a subset of spinal disorders. In this regard, why would the PSCP not be a chiropractor?

The World Federation of Chiropractic (WFC) defines chiropractors as "spinal health care experts in the health care system"[17] suggesting that the WFC sees the chiropractor as the PSCP. Although chiropractic expresses particular focus on the spine, it must be recognized that interest and attention alone do not translate into expertise. Expertise requires extensive knowledge, training and skill in the relevant field and a clear understanding of when to refer a patient to other experts.[18] In Canada, chiropractors have access to limited diagnostic imaging, and unlike chiropody and naturopathy they do not have prescription rights.[19] Regrettably, the public does not uniformly regard chiropractors as spinal health care experts, presumably because chiropractors have not yet—at least in the eyes of the public—earned such a distinction. The 2009 national survey conducted by the Canadian Chiropractic Association revealed that 60% of Canadians recognize that chiropractors treat back pain, and just over 40% regard chiropractors as experts in back pain.[20]

Despite the challenges faced by the spinal pain patient and the host of providers involved, no profession has meaningfully embraced the role of the PSCP. Meanwhile, evidence supports the efficacy of chiropractic treatment for back pain, neck pain, and headaches[4] that is at least as good as any other available therapy and in some cases

superior.[21] Furthermore there is evidence that properly accessed and provided chiropractic treatment has the potential to reduce health care costs by hundreds of millions each year.[22,23,24,25] In light of the preceding there seems to be an obvious disconnect between what chiropractic as a profession would like to represent and the reality of public perception. Refining the profession's expertise by demonstrating excellence with respect to the management of spinal disorders would provide the chiropractic profession with much needed recognition, cultural authority and a well-deserved niche role for managing patients with spinal pain and dysfunction.[18]

Among health care providers in general, chiropractors have been ranked lowest with respect to honesty and ethics.[4] Although chiropractic has made improvements in this area, it lacks a reasonable level of public and interprofessional trust and confidence.[4,19]

Standardization in Clinical Practice:

It could be argued that chiropractic suffers from too much tolerance of clinical practices that do not meet evidence-based standards. At the very least, chiropractic should realize that ongoing references to confusing terminology such as 'subluxation' without clarifying what this term is meant to convey is a stumbling block to the advancement of the profession.[26] Also surprisingly there are numerous associations/groups within chiropractic that suggest that diagnosis is unnecessary and that chiropractic need only detect and remove the 'subluxation'.[19,27] We do not dispute the existence of mechanical spinal pain that is amenable to spinal manipulative therapy; in fact there is good evidence to this effect. However the mechanical lesion that is the subject of spinal manipulation is yet to be scientifically defined and characterized. As health care providers, should chiropractors not also follow best practices and standardization of approaches to diagnosis and treatment? An example of how standardization of approaches to treatment can be helpful is embodied within The Standardized Spine Care Pathway that has demonstrated cost-effectiveness and patient satisfaction in spinal assessment and treatment at a health care facility in Plymouth, Massacheusetts.[14] This model involves the triage and appropriate categorization of patients for treatment by chiropractors in a hospital-based setting.[14] Overall, 95% of patients in this study deemed the care they received to be of excellent quality and studies concerning this approach led to average pain ratings dropping from 6.2 to 1.9 on a scale of 1-10.[14] Perhaps this approach to the diagnosis and treatment of spine conditions by chiropractors in other jurisdictions would produce similar benefits.

Research and Academic Affiliation:

If chiropractic has the desire to assume a leadership position in spine health, it should also take a lead in spine research. The profession is making headway on several levels in this regard, especially in Canada through the initiatives of the Canadian Chiropractic Research Foundation (CCRF). The CCRF, acting in concert with the CCA and various provincial bodies, has created chiropractic research chairs within a number of universities throughout Canada, thereby creating a footprint for the profession within institutes of higher learning and in specialty research areas. The Canadian Memorial Chiropractic College (CMCC) has also demonstrated professional leadership by establishing preliminarily situated, yet still integrated, chiropractic clinics within unique hospital-based settings at St. Michael's Hospital and at St. John's Rehabilitation Hospital, both of which are located in Toronto.

Recently, CMCC and the University of Ontario Institute of Technology have begun efforts to collaborate on an academic level. Affiliations with academic institutions that offer professional health care programmes could provide springboards to improved communication and superior education[28], ultimately elevating the profile of the chiropractic profession beyond these collaborative initiatives. In the meantime, so long as current public impressions continue to negatively affect the utilization of chiropractic[28], in Canada at least, university affiliation may be a necessary step towards convincing the public of the high quality of our chiropractic education.[28]

Models of Spine Care Internationally:

The state of chiropractic differs from country to country and region to region. In Switzerland, legalization of the chiropractic profession occurred in 1939.[29] Chiropractic students there must pass the medical entrance examination and fulfill all basic medical courses.[30] Inter-professional referrals to chiropractors occur frequently with many patients receiving treatment in the early phases of spinal disorders.[30] Since 1995, chiropractors in Switzer-

land have also had limited prescription rights[31], which is regarded as a valuable option by Swiss practitioners[32], and which has paved the way for full integration of chiropractic in Swiss health care.[30]

In Denmark, a chiropractor obtains a license to practice following a five-year Master's Degree and one-year internship programme, during which clinical training is conducted in both hospital settings and private clinics.[33]

Similar to Switzerland and Denmark, in the United States there are some areas where chiropractors have obtained significant increases in their legislative acts. For example, chiropractors in New Mexico have recently obtained limited prescription rights and have had access to sophisticated imaging such as computed tomography (CT) scanning and magnetic resonance imaging (MRI) for some time now. According to the President of New Mexico Chiropractic Association, all chiropractors in that jurisdiction enjoy a diverse scope of practice. Some chiropractors have limited prescription rights and all chiropractors have access to advanced investigations including any imaging or laboratory study they deem necessary for the diagnosis and treatment of their patients (Robert Jones, DC, APC, President of New Mexico Chiropractic Association, personal communication, July 21, 2013).[34] The scope of practice in New Mexico includes manipulative therapy (for all skeletal articulations), physical therapy modalities, soft tissue manipulation, treatment by light (cold lasers), diet and exercise counseling, prescription of nutriceuticals, and prescription of over-the-counter medications.[35] Furthermore, with advanced training and certification, chiropractors in New Mexico can perform injectable procedures and prescribe from a limited pharmaceutical formulary.[36]

The bid to obtain limited prescription rights in New Mexico met with tremendous opposition from some elements within our own profession. In fact, the International Chiropractic Association (ICA) and traditional colleges such as Life University and Life Chiropractic College West have protested against the inclusion of these procedures within the profession (Robert Jones, DC, APC, President of New Mexico Chiropractic Association, personal communication, July 21, 2013). These protests have resulted in the ICA joining a legal challenge initiated by the New Mexico medical board and New Mexico pharmacy board with respect to the intent and interpretation of advanced chiropractic practice procedure law in New Mexico.[37,38,39,40]

Could the Chiropractor Serve as the PSCP?

Essentially, the profession holds the keys to its own future. Increased collaboration, an emphasis on evidence-based treatment and continued efforts to broadly expand the research base will resolve many lingering obstacles. Since the role of the PSCP has not yet been claimed by any one provider group, there could be other professions interested in performing such a role. The function of the PSCP could easily be assumed by chiropractic, but this window of opportunity may be limited. If chiropractic does not seek to evolve, what role does chiropractic have left to perform? Lessons learned from international experiences in Switzerland, Denmark, and New Mexico could be applied to the provision of chiropractic practice worldwide, and that would have to adhere to the following success-related criteria: (1) be evidence-based, (2) be scientifically defensible, (3) be clinically-relevant and (4) embrace collaborative and integrated health care. Movement towards such an integrated model is already being undertaken by the physiotherapy profession. For example, advanced practice physical therapists have the legislative ability to prescribe analgesics and anti-inflammatory medications in the United Kingdom (effective April 2013) and similar changes in legislation are underway in Australia.[41] Such changes in legislation reflect excellence in education and training, and confidence on the part of governmental regulatory colleges that such changes will be clinically effective, and cost-effective.

If the chiropractic profession wishes to assume the role of the primary spine care clinician it will be necessary to relegate the profession's traditional role as provider of the 'adjustment' (only) to the past.[15] This PSCP role will require a number of changes, some perhaps easier to make than others. For example, qualities that the primary spine care provider ought to embody are:

a) An in-depth knowledge of non-operative alternatives (including, pharmaceutical therapies, percutaneous invasive therapies and other treatments);
b) Familiarity with surgical interventions and their evidence-based indications;
c) The ability to both screen for psychosocial morbidity that may contribute significantly to the develop-

ment of spinal pain syndromes, and then professionally communicate with appropriate providers of care for these conditions and other aspects of biopsychosocial rehabilitation. This particular criterion represents a bold cultural shift intra-professionally, but will also set chiropractic apart from other candidate professions in this area.

d) An understanding of the biological reality that the source of many spinal pain disorders is difficult, if not impossible, to identify;
e) Acceptance of the notion that chronic spinal pain is often incurable;
f) An ability to establish reasonable patient (and doctor) expectations at the outset of the patient-doctor relationship, and a commitment to addressing modifiable risk factors, activities and other behaviours during daily life, work and recreation.

With respect to clinical practice the PSCP will need:

a) To understand the indications, risks and benefits of spine surgery and make recommendations appropriately following best evidence practices;
b) To understand the differences between systemic/inflammatory disease and degenerative spine conditions; and
c) To have a working dialogue with other spinal pain care providers such as family physicians, spinal surgeons, rheumatologists and internists in order to appropriately cross-refer.[15]

It has been stated that the chiropractic status quo threatens the future of the profession.[19] What happens if chiropractic fails to reform? As other health care professions adapt according to evolving evidence to best meet societal needs, is it possible that chiropractic could lose its relevance? Podiatry, optometry, chiropody and naturopathy have made significant efforts in professional reform and modernization and as a consequence have made significant gains in their respective scopes of practice and legislation. If chiropractic aspires to become the PSCP of the present and future, it need not reinvent the wheel; it needs only to look as far as its own front door.

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JCCA Sports Chiropractic 5th Issue

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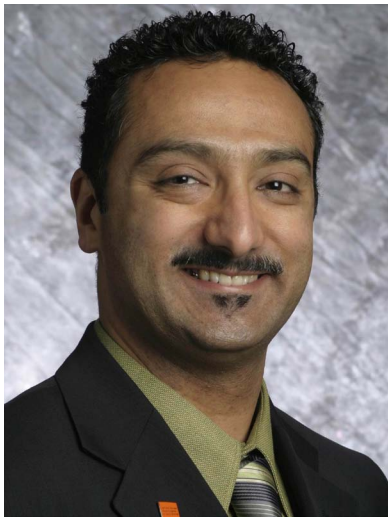

Dr. Mohsen Kazemi, RN, DC, MSc, FRCCSS(C), FCCPOR(C)

I am honored to report to you that the last four Sports Issues of JCCA were a great success and most popular. We were able to attain our goal to provide a venue to showcase our Chiropractic Sports research in various streams. The current 5th Sports Issue includes Sports research papers which are broad in nature and have crossed barriers such as, "A profile of the Youth Taekwondo Athlete", and "Addressing the risk factors and prevention of Sudden Cardiac Death in young athletes: a case report" to showcase the wide diversity of research done by chiropractors and for those involved with various sports to consider risk and understand the nature of their sports. This issue also includes specific hot topic such as, "A multidisciplinary approach including the use of platelet-rich plasma to treat an elite athlete with patellar tendinopathy – a case report", "The female athlete triad: a case series and narrative overview" and "The effects of kinesiotape on athletic-based performance outcomes in healthy, active individuals: a literature synthesis". Furthermore there are specific case reports with clinical application on gastrocnemius tear, osteomyelitis, and saphenous nerve entrapment.

As I mentioned in the past, one of the most important factors in facilitating the inclusion of the Sports Chiropractor in multidisciplinary health teams for major and minor Games is scientific evidence. As you can see we have been successful to encourage our young and veteran researchers not only to focus on Sports Chiropractic research but also to publish their research.

I hope this issue inspires you to get involved in Sports Chiropractic research. May this issue be encouraging, thought provoking and clinically applicable to your day-to-day practice.

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A profile of the Youth Olympic Taekwondo Athlete

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Our study aims to identify trends in anthropomorphic attributes and competitive strategies of successful (medalists) versus non medalist young Olympic Taekwondo competitors by gender in terms of body mass, body-mass index (BMI) and fighting technique at the Youth Olympic Games 2010. Results were then compared to adult Taekwondo Olympic athletes in 2000, 2004 and 2008. Data on 96 Taekwondo athletes were obtained from the official Youth Olympic website. A LOGIT analysis was performed on the following six independent variables: height, body mass, body mass index, gender, techniques used to score, and warnings obtained during a match. The study did find some differences between winners and non-winners for males and female, although none of the differences were statistically significant. Consequently, training personnel may enhance winning potential of Taekwondo competitors by focusing on offensive versus defensive techniques and improving the quality of punching.

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KEY WORDS: profile, Olympic, Youth, Taekwondo, Martial arts, success, athlete

Notre étude visait à identifier les tendances, aux Jeux Olympiques de la Jeunesse de 2010, dans les attributs anthropomorphiques et les stratégies compétitives des jeunes athlètes olympiques champions (médaillés) de taekwondo par rapport à ceux des non-médaillés, par sexe, du point de vue de la masse corporelle, de l'indice de masse corporelle (IMC) et de la technique de combat. Les résultats ont été ensuite comparés aux athlètes olympiques adultes de Taekwondo de 2000, 2004 et 2008. Les données sur les 96 athlètes de taekwondo ont été obtenues du site Web officiel des Jeux Olympiques de la Jeunesse. Une analyse LOGIT a été réalisée sur les six variables indépendantes suivantes : hauteur, masse corporelle, indice de masse corporelle, sexe, techniques utilisées pour marquer, et avertissements obtenus lors d'un match. L'étude a établi quelques différences entre les gagnants et les non-gagnants, pour les hommes comme pour les femmes, mais aucune des différences n'était statistiquement significative.
Par conséquent, les entraîneurs peuvent améliorer la chance de gagner des athlètes de Taekwondo en mettant l'accent sur les techniques offensives au lieu de défensives, et en améliorant la qualité des coups.

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MOTS CLÉS : profil, olympique, jeunesse, taekwondo, arts martiaux, réussite, athlète

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Introduction

Taekwondo, a Korean martial art form was traditionally used for self-defence during warfare and has been developed for over 20 centuries in Korea.[1] The term 'Taekwondo' literally translates as "*tae-*" to hit using the foot, *"-kwon-*" to hit using the fist, and *"-do*" referring to the art[2] thus directly translating 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. It is a popular organized activity (particularly in Korea), and recent studies have shown that related training activities such as sparring and kicking drills along with repetition can improve cardiovascular function, anaerobic power and leg strength. It increases lean body mass in adult male and female participants, thus Taekwondo training may be a useful organized activity for improving essential elements of overall physical fitness.[3]

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 excess mass is in the form of adipose tissue which is less metabolically active than muscle. Therefore these parameters are important factors for Taekwondo competitors to consider when training. Variables such as height, body mass, body-mass index (BMI), and VO2 max have been investigated in various body mass-classed sports such as freestyle wrestling[4], and karate[5].

Previous studies have indicated that elite Olympic Taekwondo athletes used kicks to score points 98-100% of the time.[6,7,8] A large emphasis is placed on lower limb power in the sport of Taekwondo due to the large amount of explosive leg power needed for kicking[9], though punching is a trained aspect of the sport used in combat.

Determining the ideal body composition for any sport can be challenging. Studies have been conducted in an attempt to identify predictors of the ideal competitor. The first Youth Olympic Games took place in Singapore in August 2010, whereby athletes were younger than 17 years of age (athletes were restricted to those born in 1993 and 1994). The profile of adult Taekwondo Olympic athletes has been investigated in the past[6,7,8], however, the profile of young Olympic Taekwondo athletes has not. As such our study aims to identify trends in anthropomorphic attributes and competitive strategy of young Olympic Taekwondo competitors winners (medallists) versus non-winners by gender in terms of body mass, BMI and fighting technique, and compare them to those of Adult Olympic Taekwondo athletes. Results of this study will allow Taekwondo coaches and competitors to practice evidence-based success in sport.

Methods

Participants

The data on 96 male and female Taekwondo athletes participating in the 2010 Youth Olympic Games for this study was obtained from the official 2010 Youth Olympic website, http://www.singapore2010.sg/ a public domain website. The average age of the 96 competitors, males and females are 16.17, 16.38 and 15.97, respectively. The information obtained from this website included the following: participants in each category, participants body mass, height, date of birth, country, each round fought report, points obtained, warnings, deduction points, defensive kicks, offensive kicks, offensive and defensive punches, list of referee and judges with country of origin.

Data Procurement

The data set used in this study was procured from a public domain website. As such there was no need to obtain consent and all names of participants were kept confidential. The work reported has been approved by the ethics committee and review board of Canadian Memorial Chiropractic College.

Statistical Analysis

The independent variables (height, body mass, body mass index, gender, technique used to score, and warnings obtained during a match) described in the data set have been analyzed to determine the outcome measures of winners (medallists, either gold, bronze, or silver) versus non-winners. The data was entered into an Excel spreadsheet and transferred to a STATA file. Variables were coded and labelled. To minimize bias in the data entry both secondary investigators independently input data into a sheet and the two sets of data were compared for differences. A LOGIT analysis was performed using the following six independent variables: height, body mass, body mass index, gender, techniques used to score, and warnings

Table 1:
Demographic Profiles of Athletes in 2000, 2004, 2008 & 2010 Olympic Games. Data are Means (±SD). P-value for winners 0.13 and non-winners 0.44

			Characteristics		
			HEIGHT (m)	**BODY mass (kg)**	**BODY mass index**
2010	**Female**	Winners (N=20)	1.68 (0.08)	54.28 (8.23)	19.11 (1.87)
		Non-winners (N=29)	1.64 (0.09)	53.90 (8.93)	20.04 (4.65)
	Male	Winners (N=20)	1.77 (0.09)	63.14 (13.32)	19.95 (3.07)
		Non-winners (N=27)	1.73 (0.08)	61.35 (10.42)	20.50 (2.59)
2008	**Female**	Winners (N=16)	1.68 (0.08)	59.85 (9.44)	21.0 (2.36)
		Non-winners (N=48)	1.70 (0.06)	60.73 (8.65)	20.69 (1.92)
	Male	Winners (N=16)	1.83 (0.09)	74.92 (14.65)	22.01 (2.64)
		Non-winners (N=48)	1.79 (0.08)	73.13 (12.41)	22.46 (2.35)
2004	**Female**	Winners (N=12)	1.73 (0.06)	61.3 (10.50)	20.4 (2.50)
		Non-winners (N=48)	1.63 (0.07)	60.9 (9.40)	21.1 (2.20)
	Male	Winners (N=12)	1.83 (0.11)	75.8 (16.10)	22.4 (2.30)
		Non-winners (N=52)	1.81 (0.08)	74.1 (13.00)	22.5 (2.50)
2000	**Female**	Winners (N=16)	1.70 (0.07)	60.3 (9.10)	20.8 (2.30)
		Non-winners (N=32)	1.69 (0.08)	61.3 (10.90)	21.3 (2.70)
	Male	Winners (N=16)	1.83 (0.08)	73.4 (12.10)	21.9 (2.40)
		Non-winners (N=38)	1.79 (0.08)	73.7 (14.30)	22.8 (3.30)

obtained during a match. The sample size has been determined based on the number of independent variables to ensure reliability of the regression model. We needed a minimum of 60 subjects based on ten subjects for each independent variable. Hence the sample of 96 was sufficient . A secondary evaluation was performed by comparing the results of this study to similar previous studies by the contact investigator. The sample size is limited to the number of participants who competed.

Results

Descriptive statistics for the 2010, 2008, 2004 and 2000 samples according to height, body mass and BMI can be found in Table 1. There were no statistically significant differences found between winners and non-winners with respect to height, body mass, or BMI stratified by gender. However, both male and female winners were slightly taller, heavier, with marginally lower BMIs when compared to non-winners.

Analysis of mean total points per match, mean offensive points and mean defensive points were conducted, and indicated that winners evidently incurred more points in all 3 categories (mean points winners: offensive = 2.61, defensive = 2.33, total points per match= 4.94; mean points non-winners: offensive = 0.85, defensive = 1.27, total points per match=2.12) (See Table 2). Furthermore,

Table 2:
Offensive, Defensive, and Total Points Per Match: Winners vs. Non-winners, p-value 0.04

		Variables		
		OFFENSIVE points	**DEFENSIVE points**	**TOTAL points per match**
NON-WINNERS	Mean (N=56)	0.85 (1.48)	1.27 (1.75)	2.12 (2.52)
	Proportion of Points (%)	40	60	—
WINNERS	Mean (N=40)	2.61 (1.38)	2.33 (1.84)	4.94 (2.39)
	Proportion of Point (%)	52	47	—

Table 3:
Gender Techniques Among Winners:
Males Versus Females in Relation to Offensive, Defensive and Total Points; p-value 0.11

	OFFENSIVE techniques (%)	**DEFENSIVE techniques (%)**	**TOTAL points**
FEMALE	176 (56%)	137 (44%)	313 (53.9%)
MALE	133 (49.6%)	135 (50.4%)	268 (46.1%)
TOTAL	309 (53.1%)	272 (46.8%)	581 (100%)

Table 4:
Punch Utilization in Tournament: Winners Versus Non-Winners.

	OFFENSIVE punch mean points (SD)	**DEFENSIVE punch mean points (SD)**
NON-WINNERS (N=56)	0 (0)	0 (0)
WINNERS (N=40)	0.075 (0.35)	0.125 (0.52)

Table 5:
Offensive & Defensive Kick Utilization in Tournament by Type:
Winners Versus Non-Winners in Percentage.

	TYPE 1	**TYPE 2**	**TYPE 3**
NON-WINNERS	64.5	2.15	33.3
WINNERS	65.0	4.58	29.8

Table 6:
Averages of Warnings Through Competition, by Gender and Outcome (Winning Verse Non-Winning).

		BODY mass category	Kyong-go (KG)		Gam-jeom (GJ)	
			# Of events	AVERAGE KG/match	# Of events	AVERAGE GJ/match
WINNERS	Male	<48kg	10	1.0	2	0.2
		<55kg	23	2.09	9	0.81
		<63kg	28	2.33	11	0.92
		<73kg	21	2.1	8	0.80
		>73kg	17	1.7	8	0.80
		TOTAL	**99**	**9.22**	**38**	**3.53**
	Female	<44kg	15	1.25	5	0.42
		<49kg	19	1.36	5	0.36
		<55kg	14	1.17	4	0.33
		<63kg	17	1.7	8	0.80
		>63kg	17	1.7	6	0.60
		TOTAL	**82**	**7.18**	**28**	**2.51**
NON-WINNERS	Male	<48kg	6	1.2	2	0.4
		<55kg	20	2.0	9	0.9
		<63kg	5	0.83	1	0.17
		<73kg	14	1.75	6	0.75
		>73kg	7	1.75	3	0.75
		TOTAL	**52**	**7.53**	**21**	**2.97**
	Female	<44kg	4	0.8	2	0.4
		<49kg	12	1.5	5	0.625
		<55kg	6	0.86	1	0.14
		<63kg	4	0.67	1	0.17
		>63kg	3	0.5	0	0
		TOTAL	**29**	**4.33**	**9**	**1.33**

the proportion of points, categorized by offensive points and defensive points highlighted a statistically significant difference whereby non-winners gained less points offensively (40% offensive points, 60% defensive points). Winners, however, gained more points offensively and less points defensively (52% of points offensively and 47% defensively).

No statistically significant relationship was elicited after conducting logistical regression for offensive and defensive points stratified by gender. Table 3 indicates that females used offensive techniques to accumulate 56% of points, while men used this strategy to obtain 49.6% of points in this sample. Alternatively, females used defensive techniques to gain 44% of their points, while males used defensive techniques to gain 50.4% of their points in this sample. While not statistically significant, overall, offensive strategies were used slightly more commonly than defensive techniques (53.1% offensive vs. 46.8% defensive) and females gained slightly more overall points than males.

Logistical regression analysis revealed that non-winners did not score any offensive nor defensive punches during combat. Winners used defensive punches to score more often (mean points=0.125) compared to offensive punches (mean points=0.075) (See Table 4).

Table 5 indicates the chi-square analysis results for 3 different types of kicks used to score, compared between non-winners and winners. Two types of kicks were used,

offensive and defensive. The different types of kicks indicate how many points a successful landing of that kick is worth. According to the World Taekwondo Federation (WTF), one point is awarded for a valid attack on the trunk protector, two points for a valid turning kick (180° rotation) to the trunk protector and three points for a valid kick to the head (http://www.wtf.org/wtf_eng/site/rules/competition.html). The common technique used by winners was a trunk kick followed by a head and then body shot that involved rotation, types 1, 3 and 2 respectively. Although statistically insignificant (p-value=0.501) Table 5 indicates that a type 1 kick was used more commonly (64.5% non-winners, 65% winners), followed by type three kick (33.3% non-winners, 29.8% winners), and lastly type 2 kick (2.15% non-winners, 4.58% winners). Each type of kick was used in similar proportions between winners and non-winners.

According to the World Taekwondo Federation[2] penalties are considered prohibited acts with two types of penalties existing: *Kyong-go* and *Gam-jeom*. A kyong-go is a warning penalty with two kyong-gos being 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. Winning males on average tabulated more penalties, kyong-gos (9.22) and gam-jeom (7.53), when compared to non-winners (7.53 kyong-go; 2.97 gam-jeom). This pattern also occurred in winning females with 7.18 kyong-go and 2.51 gam-jeom, respectively.

Discussion

Three previous studies investigated the anthropomorphic profile of adult Olympic Taekwondo athletes that participated in the 2000, 2004 and 2008 Olympic games[6,7,8] with the average age of competitors ranging from 22-25. This study, as the previous, did not find any statistically significant differences between winners and non-winners with regards to body mass, height and BMI. There are, however, certain tendencies that were observed. This study is the first of its kind to review anthropomorphic data collected in young Olympic Taekwondo athletes, as well as the first to compare results of the Youth Olympic Taekwondo athletes to their adult counterparts. The specific profile qualities reviewed in the young athletes may not be as fully developed as they are compared to adults.

As with the 2008 Olympic Taekwondo competitors, the average height of male winners was slightly more than non-winners, which corresponds well with previous studies conducted on the 2000 and 2004 Olympic games.[6,7,8] The average height of the female winners was also slightly higher than that of non-winners, which is in sync to the female Taekwondo athletes in the 2000 and 2004 Olympic games but contrary to the females in the 2008. A trend exists between youth and adult males, where taller athletes may have a 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.

In the 2000 Olympic games male and female Taekwondo winners were lighter than the non-winners. In 2008, the male winners were slightly heavier than the male non-winners whereas the female winners were slightly lighter than their counterparts. In comparison to the 2004 Olympic Taekwondo athletes, both male and female winners were slightly heavier than the non-winners. This was maintained in the 2010 youth athletes, where both male and female winners were heavier than non-winners. As such, no distinct trend exists between body mass and outcome.

The 2000 games revealed winners having slightly lower BMI than their body mass category average.[6] This tendency continued in the 2004 and 2010 games for both sexes and only males in 2008.[6,7] Contrary to the female winners in previous studies, the female 2008 Olympic Taekwondo winners had higher BMI than their non-winner counterparts.[7] Another study[10] determined that the physiological profile of male and female Taekwondo black belts consisted of very low body fat percentages and a high lean body mass. Such results mirror those of the current study, as well as previous studies[6,7,8] whereby athletes with lower BMI were linked to winning through above average results for muscle strength, flexibility, anaerobic and aerobic capacities compared to their higher BMI counterparts[10]. Moreover, studies evaluating BMI in relation to speed, speed-endurance and flexibility show that successful Taekwondo competitors are leaner, which has a positive effect on performance which can lead to medallist status.[11] Elite female Taekwondo athletes were found to be more mesomorphic with less fat than collegiate female Taekwondo athletes.[12]

The 2000 games also revealed that both male and fe-

male winners received more warnings per match than non-winners[6], which is consistent with the 2010 games. In 2004 males had on average 3.7 kyong-go and 1.41 gam-jeom deductions per match versus females who had on average 2.32 kyong-go and 0.75 gam-jeom deductions per match.[7] The 2008 games showed males had a 5.08 kyong-go and 2.38 gam-jeom on average, while females had 7.44 and 1.9 on average, respectively. Between 2004 and 2008 there was no significant variation in the ratio of penalties to warnings although the frequency of warnings did decrease by approximately 65.7%.[8] Considering winners and non-winners in 2010, males on average suffered 8.37 kyong-go and 3.25 gam-jeom with females incurring 5.76 and 1.92 on average. This may indicate that the winners were more aggressive in their game plan.

In 2004, males and females both used offensive and defensive one-point kicks more often then the two-point versions.[7] This continued in 2008 where 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.[8] During the 2000 Olympic games, there was no extra point awarded for different types of kicks (to the body or head, rotational and non rotational) used to score and all were awarded only one point.[6] Nonetheless, it is known that offensive techniques were used slightly more than defensive.[6] In 2000 games, 52% of the techniques used to score points were offensive kicks, rather than defensive ones.[6] Ninety-eight percent of all techniques used to score were kicks. For the 2010 games, Type 1 offensive and defensive kicks were also two-thirds of the time to score points. This was followed by three-point then two-point kicks. It is rationalized that the lower limb has the greatest length and power potential. 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 in Taekwondo athletes.[13-17] No tendency can be solidified between all years due to various changes in methods and points for scoring techniques and lack of data recorded and reported in the 2000 games.

The lack of statistical significance might be as a result of small sample size per Olympic Game. Limitations of this study include a) lack of a priori sample size, and b) possible lack of power to detect significance between group difference due to the small sample size. Further research may consider investigating Taekwondo athletes sampled from several Olympic games rather than one at a time.

Conclusion

This is the first study to look at the profile of First Youth Olympic Games Taekwondo athlete winners versus non-winners. Certain tendencies became apparent which divide winners from non-winners and genders. Female winners used more offensive versus defensive kicks to score, and almost all punches used to score were from winners (both male and female). Though further research with larger sample size is required, Taekwondo training personnel may enhance the winning potential of their athletes by focusing on offensive verse defensive techniques and improving the quality of punching technique.

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A multidisciplinary approach including the use of platelet-rich plasma to treat an elite athlete with patellar tendinopathy – a case report

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Objective: *Patellar tendinopathy affects a substantial proportion of athletes involved in jumping or kicking activities. Platelet rich plasma (PRP) injections may be a promising treatment used in conjunction with common traditional therapies.*

Clinical Features: *Patellar tendinopathy is often the result of repetitive or excessive overload on the patellar tendon. Activity modification, cryotherapy, eccentric exercises, shockwave therapy, and PRP have been indicated as treatment options during various stages of this condition.*

Intervention and Outcome: *A 23 year old female, elite track and field athlete was managed for patellar tendinopathy with a combination of traditional therapeutic interventions as well as a PRP injection. This athlete returned to pre-injury level of competition six months post-injection.*

Conclusion: *Emerging literature on PRP appears to be promising for patellar tendinopathy, however, it remains unclear which patients may benefit most and*

Objectif : *la tendinopathie rotulienne affecte une proportion considérable des athlètes dont les activités consistent à sauter ou à donner des coups de pied. Les injections de plasma riche en plaquettes (PRP) peuvent être un traitement prometteur lorsqu'utilisées avec les traitements traditionnels courants.*

Caractéristiques cliniques : *la tendinopathie rotulienne résulte souvent d'une surcharge répétitive ou excessive sur le tendon rotulien. La modification des activités, la cryothérapie, les exercices excentriques, la thérapie par ondes de choc et le PRP ont été indiqués comme des options de traitement au cours des différentes étapes de cette affection.*

Intervention et résultat : *une femme âgée de 23 ans, une athlète d'élite en athlétisme, a été traitée pour une tendinopathie rotulienne au moyen d'une combinaison d'interventions thérapeutiques traditionnelles ainsi qu'une injection de PRP. Cette athlète a regagné son niveau de compétitivité d'avant blessure six mois après l'injection.*

Conclusion : *les documents scientifiques récents sur le PRP semblent être prometteurs pour la tendinopathie rotulienne, mais il est difficile de savoir quels patients*

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whether the stage of the disorder has an impact on the clinical outcome.

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KEY WORDS: platelet-rich plasma, platelet-rich fibrin, autologous blood, patellar tendinopathy, patellar tendinosis, patellar tendinitis

pourraient en bénéficier le plus, et si le stade de l'affection a un impact sur le résultat clinique.

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MOTS CLÉS : plasma riche en plaquettes, fibrine riche en plaquettes, sang autologue, tendinopathie rotulienne, tendinose rotulienne, tendinite rotulienne

Introduction

Patellar tendinopathy is a sudden or repetitive injury resulting in pain and loss of tensile strength of the patellar tendon. It is common among athletes involved in jumping or kicking activities, such as basketball, soccer, jumping events, and volleyball.[1] The pain is localized to the inferior pole of the patella and initially presents as post-exertional knee pain and stiffness while stairs, running, squatting, and kneeling often aggravate the knee pain. Patellar tendinopathy is a result of excessive or repetitive overloading of the patellar tendon that exceeds the reparative capacity of the tendon and has a characteristic increase in signal intensity on magnetic resonance imaging (MRI).[2] Rees et al. recommend the use of the term tendinopathy as a generic descriptor of this condition and reserve the use of the terms "tendinosis" and "tendinitis" only after histopathologic evaluation of inflammation.[3] Evidence from animal models of induced tendinopathy reveal that inflammation is only a component of the most acute tendon-loading protocols and commonly has no role in the progression or propagation of the disease process.[3] Furthermore, histopathological studies of surgical specimens in patients diagnosed with tendinopathy demonstrate collagen disorganization, hypercellularity, fibrosis, nerve and vessel ingrowth and consistently exhibit absent or minimal inflammation.[4,5] However, inflammation often plays an important role during the early reactive phase of the condition.[6] Repetitive strain on the tendon can result in the production of inflammatory molecules by the tenocytes as well as microruptures of collagen fibrils.[5] Distinguishing between the acute inflammatory phase of the condition versus chronic degenerative tendon changes is crucial for proper management. A variety of treatment options are used for the treatment of patellar tendinopathy, however, there is currently no optimal management strategy that has emerged from the literature and treatment selection often depends on the phase of the condition. Common treatment modalities include rest, ice, manual therapy, non-steroidal anti-inflammatory drugs (NSAIDs), instrument-assisted soft-tissue mobilization, eccentric exercise, shockwave therapy as well as a newer treatment option, platelet-rich plasma (PRP) injections.

PRP has gained popularity over the past few decades for the treatment of various common musculoskeletal complaints. Numerous elite athletes have elected PRP treatments with the hopes of accelerating the rate of healing and a faster return to sport. PRP was first employed in 1987 during open-heart surgery to avoid excessive transfusion of homologous blood products and over the past 10 years it has become widespread throughout various medical fields including; dentistry, maxillofacial surgery, neurosurgery, and orthopedics.[7–10] Preparation of PRP involves centrifugation of autologous blood and extraction of the plasma portion once minimum concentration of 1,000,000 platelets per microliter in 5 milliliters of plasma is achieved.[11] This equates to a three to five fold increase in platelet concentration compared to whole blood.[11] The PRP is then injected into the affected area with the goal of enhancing the body's natural healing abilities. Platelets are typically involved during the early inflammatory phase of healing and contain numerous proteins, cytokines, growth factors (GFs), and other bioactive substances.[11,12] Growth factors and chemokines have been shown to promote angiogenesis, cell migration, proliferation and differentiation as well as protein deposition which all have a role in restoring normal tissue structure and function.[7] The high concentration of platelet-derived GFs delivered to the site of tissue injury is believed to be

Figure 1
Magnetic resonance imaging (T2 weighted) revealed high signal intensity and a 5mm transverse defect in the left lateral tendon at the base of the patella

the primary contributor to the therapeutic effects of PRP. As with any form of injection, adverse events from PRP may include infection, scar tissue formation, calcification at the injection site and neurovascular injury.[13,14] Although no long term clinical studies exist for the use of PRP for musculoskeletal conditions, a significant number of patients have been treated worldwide and Wang-Saegusa et al. reported that no adverse effects were observed when PRP was utilized in more than 800 patients.[15] Despite the widespread use of PRP, there are few controlled, clinical trials that have been published to date on its effectiveness.

Case Presentation

The patient was a 23 year old Canadian National track and field team athlete with a 6 year history of chronic undiagnosed bilateral knee pain who injured her left knee while performing one-step high jump take-off drills over four successive 33 inch hurdles. On beginning her third set, she felt a sudden sharp pain in the anterior knee on take-off and was unable to continue with training. On presentation to a sport-specialist physician the following day, she described a dull pain in the anterior knee with walking which was rated as 7 out of 10 on a visual analogue scale (VAS). The patient had severe pain with palpation of the patellar tendon, moderate pain at the inferior patellar pole with resisted knee extension and pain at 30 degrees of knee flexion with a double leg squat. A magnetic resonance image (MRI) was ordered and originally read by the sport-specialist physician as patellar tendinosis. The patient began treatment with low-level laser therapy (12 J, pre-set muscle/joint category) and eccentric decline-board squats (2x10 daily) with a chiropractor on advice from the sport-specialist physician. Two weeks later, a second opinion of the MRI from a DACBR (Diplomate, American Chiropractic Board of Radiology) chiropractor revealed patellar tendinitis with a 5mm transverse defect in the left lateral tendon at the base of the patella (Figure 1) which was agreed upon by the sport-specialist physician to be the more accurate diagnosis. At this point, the chiropractic plan of management was altered to address the more accurate diagnosis by eliminating the eccentric squats and increasing modalities to decrease the inflammation. The chiropractor also re-assessed the patient for biomechanical causes of the tendinopathy and found hypomobility

Figure 2
A second MRI (T2 weighted) that revealed an increase in size of the patellar tendon defect to 8mm

of the right sacroiliac (SI) joint, extremely limited dorsiflexion at the left ankle mortise joint and hypomobilty of the left subtalar joint, along with hypertonic bilateral iliopsoas, left hamstring, gastrocnemius and soleus muscles. The patient was co-treated by the chiropractor and a registered massage therapist with low-level laser therapy, soft tissue therapy consisting of muscle release therapy and trigger point therapy to the musculature of the hip, thigh and lower leg, spinal manipulative therapy to the right SI joint, extremity manipulative therapy to the left ankle mortise and subtalar joint, and active daily quadriceps stretching for four weeks. She was also instructed to lessen the degree of impact and volume of her training in preparation for a major international event taking place in four weeks. Following the competition and after one month of complete rest, the patient had no pain on walking and only minimal pain on palpation of the patellar tendon. She returned to training with aqua jogging and rehabilitation with eccentric squats for four weeks. The patient gradually returned to the track by initiating jogging, sprinting, and then jumping over a two month period. During this time the patient was symptom-free.

After two months of pain-free jumping in training sessions, the patient entered a minor competition and felt a sharp pain in her left anterior knee during warm-up for the high jump. A second MRI was ordered by the sport-specialist physician and revealed an increase in size of the patellar tendon defect to 8mm (Figure 2). The patient began extracorporeal shockwave therapy (2000 hits, 2.2 bars, 10Hz) to the left patellar tendon in addition to the previously mentioned plan of management with the chiropractor which was also advised by the sport-specialized physician. After 1 session per week for 4 weeks, the patient continued to train and her knee pain was self-managed during competitions by using non-steroidal anti-inflammatory drugs (NSAIDs), topical analgesics, kinesiotape (Y band around patella), and using cryotherapy and topical anti-inflammatories post-competition on the advice of the sport-specialized physician. When the pain persisted one month following the shockwave therapy, the patient was prescribed topical nitrogen patches to apply directly to the injury site, followed by oral COX-2 inhibitors and topical diclofenac sodium solution by the sport-specialist physician to be used in conjunction with

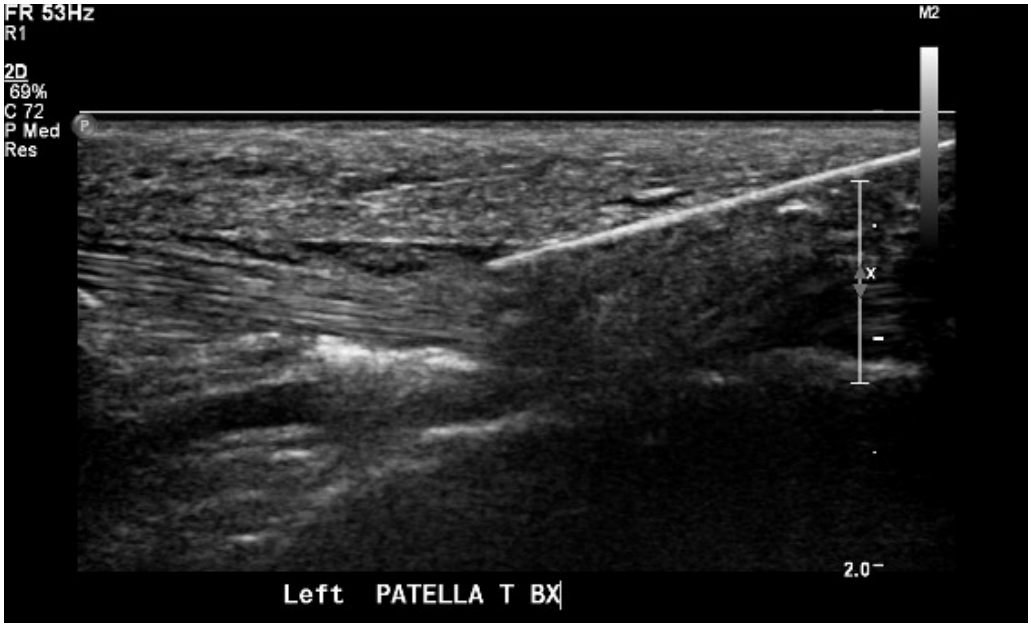

Figure 3
Platelet rich plasma injection with a fat graft into the patellar tendon guided by diagnostic ultrasound

the previously described chiropractic plan of management.

After five months (of which the final two consisted of complete rest and discontinuation of all anti-inflammatories) there was no evidence on diagnostic ultrasound of healing at the location of defect in the tendon and no improvement of the patient's symptoms. At this point, the patient underwent a single injection of PRP with a fat graft (injection of 3 cc of adipose followed by 2 cc of PRP with buffy coat) guided by ultrasound (Figure 3). The injection was completed by a second sport-specialist physician with extensive experience in the procedure. Following the injection, the patient was non-weight bearing for two weeks and 50% weight-bearing for an additional week. She was also instructed to refrain from taking or using any anti-inflammatory medication or topical for at least one week. This was followed by four weeks of rehabilitation exercises (eccentric decline-board squats, 3x10 daily) and no other activity, followed by three weeks of rehabilitation and aqua jogging. Two months post-injection, a diagnostic ultrasound confirmed complete resolution of the defect and the patient was symptom-free. She performed a gradual return to training over the following two months and returned to full competition level six months post-injection.

Discussion

The addition of PRP to the management of this case of patellar tendinopathy highlights the potential for PRP to be used as an adjunctive therapy aimed toward accelerating the rate of healing and return to sport. Activity modification to reduce the overload on the patellar tendon is often the first step when treating an individual with patellar tendinopathy. Cryotherapy is also commonly used to reduce the inflammation during the acute phase of the condition and may help to reduce pain during the later phases of healing. Instrument-assisted soft-tissue mobilization (IASTM) has also been discussed as a beneficial treatment for chronic tendinopathy with proposed benefits of creating controlled microtrauma with capillary hemorrhage inducing a localized inflammatory reaction to stimulate the body's natural healing cascade and reparative system.[16] Graston technique, a form of IASTM, was designed to "detect and release scar tissue, adhesions

and fascial restrictions".[17] Currently there is a paucity of literature, limited to case reports/series, evaluating the effects of IASTM on pain or function for patellar or other tendon pathologies and therefore was not included in the treatment plan for this case. However, it is important to note that a lack of evidence does not imply the treatment is ineffective, it only indicates that more research is needed for this form of therapy. The use of NSAIDs for chronic tendinopathies has been a topic of debate considering that recent discoveries have shown that inflammation is often not part of the pathology of the chronic form of this condition.[18] A 2002 study found that anti-inflammatories did not provide long-term benefit when used for chronic tendinopathies.[19] Furthermore, no strong evidence supports the use of injection of anesthetic or corticosteroids into or around the patellar tendon during rehabilitation.[14,20] A systematic review by van Ark et al. in 2011 found that steroid treatment is only effective in the short term and that any observed effects deteriorated in the long term.[14] Furthermore, it has been shown that steroid injection in tendons leads to impaired synthesis of collagen and increased risk of tendon atrophy.[13,21]

Eccentric exercise (EE) training has become increasingly popular as a treatment for tendinopathy since it was first presented in 1984 by Curwin and Stanish and it is now one of the most well studied interventions for this condition.[22] Despite this, there is still a paucity of evidence supporting the effectiveness of EE training in the treatment of tendinopathy and controversy over the appropriate protocol as well as when this form of therapy should be introduced. A review by Woodley et al. determined that due to a dearth of high-quality studies demonstrating clinically significant results, solid conclusions on the effectiveness of EE training could not be drawn.[23] This review noted that there were limited levels of evidence to propose that EE training demonstrated a positive effect on pain, function, and patient satisfaction compared to various other treatment interventions.[23] In contrast, a study comparing the effects of corticosteroid injection, eccentric decline squat training, and heavy slow resistance training found that subjects with chronic tendinopathy who performed long-term (6 month follow-up) eccentric and heavy resistance training maintained clinical improvements and patient satisfaction while these parameters declined with corticosteroid injections.[21] In 2007, Visnes and Bahr found that while most studies suggest EE training may have a positive effect, the ability to propose a specific protocol in the treatment of chronic patellar tendinopathy is limited.[24] However, based on the few studies reviewed, Visnes and Bahr made the recommendations that EE training should be performed with some level of discomfort, on a decline board, and during a period of athlete withdrawal from sport.[24] More recently, Saithna et al. critiqued the conclusion that athletes should be removed from their sport during EE training, demonstrating the lack of high-quality evidence to support this action and citing the negative psychological and physiological effects this could have on an athlete, such as low self-esteem and depression.[22]

Extracorporeal shockwave therapy (ESWT) has been shown to be a safe and favorable treatment for chronic patellar tendinopathy that elicits a positive effect on pain and function.[25] Numerous studies have described promising results of ESWT with success rates ranging from 73.5% to 87.5% in athletes with patellar tendinopathy.[26] A recent randomized clinical trial (RCT) assessed the effects of ESWT for symptomatic chronic patellar tendinopathy in jumping athletes who continued to participate in their respective sport throughout treatment.[25] Using the Victorian Institute of Sport Assessment Patellar Tendinopathy Questionnaire (VISA-P) at 1, 12, and 22 weeks following the final treatment, the authors concluded that there was no improvement in the course of the condition when athletes continued to train and compete during ESWT treatment.[27] Peers et al. studied patients with chronic patellar tendinopathy resistant to conservative treatment and compared the outcome of 13 knees treated surgically and 15 knees treated with ESWT.[28] They observed that ESWT had equivocal functional outcomes to surgery in this cross-sectional analysis.[28] In patients with patellar tendinopathy secondary to patellar tendon harvesting for ACL reconstruction, Wang et al. compared 30 knees treated with ESWT and 24 knees treated conservatively over a 2 to 3 year follow-up period.[26] The ESWT group showed significantly greater patient satisfaction, increases in the patellar tendon vascularity, and a trend towards reduction in tendon thickness on ultrasound compared to the conservative treatment group.[26] Although ESWT appears to be beneficial for chronic cases of patellar tendinopathy, there is limited evidence to recommend a specific treatment protocol and whether the athlete can continue participating in their sporting event. Furthermore, there is

currently a paucity of evidence to recommend the use of ESWT during the acute phase of tendinopathy.[25]

A systematic review in 2011 by van Ark et al. highlighted three studies that investigated the effects of PRP injections for the treatment of patellar tendinopathy.[14] Although all of these studies concluded that PRP injection appears to be a promising treatment option, the quality of the studies were low and all had numerous, significant limitations. The first study looking at PRP for chronic patellar tendinopathy was by Volpi et al. in 2007.[29] This was a prospective cohort study of eight subjects receiving a single injection of PRP coupled with individualized rehabilitation protocols. After 120 days post-injection, seven of the eight subjects had significant improvements in their pain scores and MRI images demonstrated a noticeable reduction in the irregularity of the patellar tendon compared to pre-injection images for 80% of the subjects.[29] Kon et al. (2009) conducted a prospective study of 20 subjects with chronic patellar tendinopathy treated with PRP and followed for a minimum of six months.[30] Approximately 6.8 million platelets were injected into the tendon every 15 days for a total of three injections. Non-steroidal medications were allowed and stretching exercises and mild activities were only allowed after the second injection. The results showed statistically significant improvements in all pain and function outcome measures however there was no control group to compare the results and the sample size was small.[30] Finally, Filardo et al. (2009) performed a similar study with 31 subjects who received three injections of PRP spaced 15 days apart.[31] This study did have a control group that only received physical therapy and the results of this study found no statistical differences in terms of pain, time-to-recovery or patient satisfaction but did find statistically significant greater improvements in sport activity level in the PRP group.[31] A fourth study, published after the systematic review, was a prospective cohort study with 36 subjects receiving a single injection of PRP.[32] The study found statistically and clinically meaningful improvements in pain and function compared to pre-injection status and also noted that subjects who had not previously been treated with ethoxysclerol, corticosteroid, and/or surgical treatment had the largest improvements and therefore largest healing potential.[32] The strongest quality study to date on PRP for patellar tendinopathy was done recently by Vetrano et al. (2013).[33] This was a randomized controlled trial with 46 consecutive athletes with jumper's knee treated with either two autologous ultrasound-guided PRP injections over two weeks or three sessions of focused extracorporeal shock wave therapy at 48 to 72 hour intervals.[33] Each athlete was also given a standardized stretching and strengthening protocol one week after the final treatment to be conducted for two weeks followed by water activities if there was only mild pain. This study reported clinically and statistically significant improvement of symptoms in both groups at 2, 6 and 12 month follow-up and no difference between groups in the VISA-P, VAS and modified Blazina scale scores at 2 month follow-up. However, the PRP group showed statistically significant improvement over the ESWT group in VISA-P and VAS scores at 6 and 12 month follow-up and in the modified Blazina scale at 12 month follow-up.[33] Finally, and of particular interest to sports therapists, a case series by van Ark et al. (2013) outlined an exercise-based physical therapy program for patients treated with PRP injection.[34] The study is an excellent initial resource for practicing clinicians and further controlled trials would be beneficial to compare this program to other commonly utilized protocols. Although the results of these studies appear promising, the lack of high-quality randomized controlled trials, poor standardization, and differing protocols of PRP preparation and administration make it difficult to determine whether its utility in athletes for acute or chronic injuries is beneficial.

Despite the specific treatments utilized, the prognosis for patellar tendinopathy is good with the majority of individuals improving via activity modification and conservative care. However, it also has the potential to be a debilitating condition that may significantly affect an individual's quality of life and sports performance. In a cross sectional study of 100 athletes with patellar tendinopathy, 33% were unable to return to sport for more than six months and 18% were unable to participate in their sport for greater than 12 months.[18,35]

Conclusions

Patellar tendinopathy is a condition that affects a large portion of the athletic population and can have a substantial impact on an athlete's performance and quality of life. Currently, there is no ideal treatment plan for this condition and there is a paucity of high quality literature providing justification for commonly utilized ther-

apies and at what stage of the injury that these therapies should be implemented. This case study highlights the importance of recognizing the pathological stage of patellar tendinopathy and applying sound knowledge of the histological components involved to determine which intervention may be most beneficial. Furthermore, it emphasizes the possible benefits of adding PRP injections as a complimentary therapy along with manual therapy, pain-relieving modalities, shockwave therapy, and eccentric exercises. This case report was of a high level athlete treated more aggressively to allow for earlier return to competition and may not be the ideal course of treatment for the general population. Considering the limited value of a single case report with the absence of a control group, further research is warranted to more conclusively determine the best course of therapy for patellar tendinopathy.

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Ganglion cyst of the foot treated with electroacupuncture: A case report

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Objective: *To present the clinical management of a ganglion cyst presenting on the dorsolateral aspect of the foot.*

Clinical Features: *A 45-year-old female cyclist complaining of ganglion cyst following training period.*

Intervention and Outcome: *Patient was treated with high-frequency electroacupuncture in four consecutive sessions over four weeks, and reported resolution of the cyst following therapeutic intervention.*

Conclusions: *Ganglion cysts of the foot are relatively rare connective tissue tumours with variable treatment approaches. Electroacupuncture may be a novel and non-invasive conservative approach for the treatment of ganglion cysts. Further evaluation of the efficacy of such treatment is warranted.*

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KEY WORDS: ganglion, acupuncture, foot, cyclist

Objectif : *présenter la gestion clinique d'un kyste ganglionnaire se manifestant sur l'aspect dorsolatéral du pied.*

Caractéristiques cliniques : *une cycliste de 45 ans se plaint de kystes après l'entraînement.*

Intervention et résultat : *la patiente a été traitée par électropuncture à haute fréquence en quatre séances consécutives sur quatre semaines. Le kyste a disparu après l'intervention thérapeutique.*

Conclusions : *les kystes ganglionnaires au pied sont des tumeurs des tissus conjonctifs relativement rares nécessitant des approches de traitement diverses. L'électropuncture peut être une nouvelle approche conservatrice non invasive pour le traitement des kystes ganglionnaires. Une évaluation plus poussée de l'efficacité d'un tel traitement s'avère nécessaire.*

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MOTS CLÉS : ganglion, acupuncture, pied, cycliste

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Introduction

Ganglion cysts are rather common benign cystic tumours which originate from connective tissue such as joint capsules and tendon sheaths, and less commonly within bone. Electron microscopy demonstrates randomly oriented, multi-directional sheets of loose collagen layers composing the wall of the ganglion, which contain focal areas of mucinous degeneration.[1] Ganglion cysts contain high-viscosity fluid comprised mainly of hyaluronic acid; with glucosamine, globulins and albumin also present.[1,2,3] The origin of the ganglion are highly theorized. Pre-existing intra-articular joint pathology, joint stress leading to mucioid degeneration of adjacent extra-articular connective tissue, and joint stress stimulating mesenchymal cells to secrete mucin are most commonly warranted within the literature.[1]

Early literature suggests that 7-11% of ganglia within the body are located in the foot and ankle area, to which they are the most common soft tissue tumours in this region.[2,4] To date, there are no reports of foot or ankle ganglion cysts within the chiropractic literature. Anatomically, the majority of ganglion cysts within this region are located on the dorsum of the foot (48-66%), with a greater preponderance in females.[2,5,6,7] Patients seeking care for these cysts generally complain of local pain and tenderness, and less often parasthesia when compressing a local nerve. Footwear often exacerbates cyst compression and symptoms. When pain is present, patients will often consider it to be an annoyance and of low intensity, rather than debilitating in nature.[8]

The natural history of ganglions is unknown, and few well conducted studies have evaluated the resolution of untreated ganglions. Studies have reported 8-50% spontaneously resolve in adults over approximately 2 years.[1,2,8,9] The treatment methods for ganglion cysts have proved inconsistent and variable. It is predicted that aspiration therapy has a success rate of only 30-50%, with greater chance of reoccurrence than surgical excision.[2,10] Sclerosing treatments have also been used for the treatment of ganglia in the foot. However, joint damage risk via sheath connections amongst the ganglia and tendon or joint capsules has led most authors to not recommend such injections.[9] Surgical excision remains the gold standard for the treatment of ganglion cysts, and appears to have significantly lower reoccurrence rates as compared to conservative therapy, cited as 11% to 63% respectively in a comparative study of 63 ganglions.[2] However, reoccurrence rate ranging from 7-43%[2,10,11] are cited in the literature, and is likely attributed to imperfect excision and surgeon experience[2,10,11].

This case report illustrates the conservative management of a ganglion cyst of the dorsolateral aspect of the

Figure 1 and 2

Images depict the ganglion cyst located on the dorsolateral aspect of the foot, located distal and medial to the base of the 5th metatarsal. The cyst was measured at 1.5 by 1.5cm when the patient initially visited the sports chiropractic clinic. The arrows represent the superior, inferior, medial and lateral borders of the cyst. Two needles were inserted into the cyst during treatment, from the medial and lateral direction (as indicated by the arrows).

Figure 3
Following 4 treatments with the sports chiropractor, the ganglion cyst located on the dorsolateral aspect of the right foot had resolved. The outline represents where the ganglion cyst had originally presented.

Figure 4
This image shows a comparative view of the dorsolateral left foot in the patient.

foot using electroacupuncture. The report also outlines epidemiology and pathophysiology of ganglion cysts and management procedures, as well as the theoretical bases and literature application of electroacupuncture.

Case

A 45-year-old female patient presented to a sports chiropractic clinic with the complaint of a ganglion cyst on the dorsal aspect of the right foot, located distal and medial to the base of the fifth metatarsal. She had been training for a charity cycling ride that entailed riding 200km over two days. She reported that this was her first time training as a cyclist and the first time she road "clipped into the pedals". To unclip from her bike she used the right leg to initiate the mechanism, which entailed internal rotation of the ankle. The patient also stated that she sustained a minor fall on her bike, but did not recall any pain in her foot. The patient noticed the cyst during the last weeks of training and stated that the cycling shoes may irritate the cyst but otherwise did not notice it.

Upon physical examination, a hard soft tissue nodule was noted on the dorsum of the foot. It measured 1.5cm by 1.5cm in diameter (see Figure 1 & 2). It was not painful with palpation and the patient had no limitations in ankle range of motion. Lower limb neurological examination was normal, and no parasthesia was present over the dorsum of the foot.

The patient was treated with four sessions over four weeks consisting of high frequency electroacupuncture, commencing ten days following the 200km bike ride. She ceased to ride for the duration of the treatment and thereafter. During the treatment, 4 needles were used (40mm length, 0.3mm diameter). A single needle was inserted into Stomach-36 (ST-36), which is located on the anterior aspect of the lower leg, distal to the anterior crest of the tibia within the tibialis anterior musculature. Another needle was inserted into Liver-3 (LR-3), which is located on the dorsum of the foot, between the first and second metatarsals. Two needles were then inserted into the cyst on opposite sides and stimulated for 15 minutes at 5Hz.

At 11 days following the final electroacupuncture treatment, the patient reported that the ganglion cyst was no longer present (see Figure 3).

Discussion

The vast majority of ganglion cysts are located on the dorsum of the wrist, but also occur within the palm of the hand, and the dorsum of the foot.[5,12] Early literature suggests that 7-11% of ganglia within the body are located in the foot and ankle region. Ganglion cysts have been identified as the most common soft tissue tumours

in this region, accounting for 30-40% of total lesions.[2,4,5,6] The majority of ganglion cysts within this region are located on the dorsum of the foot (48-66%), with a greater preponderance in females.[2,5,6,7] There are conflicting opinions within the literature regarding age of onset, but appear to occur most commonly between the third and sixth decades.[6,13] The pathogenesis of ganglion cysts is largely unknown. Hoeftman in 1876 first proposed ganglia arose due to metaplasia of cells within or surrounding ligaments, joint capsules, and tendon sheaths with mucin production.[14] Most authors suggest that they are the result of myxoid degeneration of connective tissue at sites of capsular stress.[7,13] Pontious retrospectively analyzed 63 cases of ganglia at the foot and ankle, in which 33% of patients indicated a history of trauma to the area. In the case presented, constant friction within the cycling cleats and repeated trauma when initiating the unclipping mechanism may have resulted in capsular stress on the dorsolateral aspect of the foot, and is a suspected mechanism for the ganglion cyst formation.

Ganglion cysts often communicate with surrounding tissue. Rozburch and colleagues first described a lower extremity ganglion tissue classification, and identified 42% within the tendons, 36% within the joints, and 19% not traceable to a specific structure. Particularly within the tendons, the fibularis tertius and fibularis brevis are the most prevalent, with cases also noted at tibialis anterior, flexor digitorum longus, extensor digitorum longus, and tibialis posterior.[7,13] When arising from within the joints, the tarsometatarsal, metatarsophalangeal and calcaneocuboid are common origin points.[7,13] It is suggested that these areas are most subject to continuous physical stress preceding myxoid degeneration.

Few well conducted studies have evaluated the resolution of untreated ganglions. Studies which have reported 8-50% spontaneous resolution in adults are limited by study follow-up duration, loss of patient to follow-up, and poor study design.[1,2,8,9] Dias and colleagues conducted a long term follow-up of 236 patients comparing surgical excision, aspiration with or without steroid injection, and no intervention. Within the no intervention group, 42% demonstrated spontaneous disappearance within the 6 year follow-up. The average timeline for resolution was not provided. Interestingly, patients who did not receive treatment were significantly less satisfied with care although no significant differences in pain, stiffness, or weakness were noted between the groups.[14] The data on spontaneous resolution of dorsal foot ganglia is guarded, as literature stems primarily from cases of ganglia on the dorsal wrist. Therefore, the natural history and spontaneous resolution rates of ganglion cysts within the dorsal foot require further investigation.

The treatment of a ganglion cyst is initially conservative. Recommendations for padding and change in footwear are often recommended.[7] Non-surgical treatments include aspiration, steroid injection, or a combination of aspiration with steroid injection. The most popular conservative form of treatment is aspiration followed by various amounts and types of steroid injection.[11] This intervention is theorized to remove fluid from the cyst and promote scar formation to limit future communication with the degenerative joint capsules or tendons. A retrospective analysis of 40 patients undergoing conservative injections compared steroid, aspiration, and aspiration with steroid intervention. Pontious revealed 62.5% of patients to have reoccurrence of ganglion, with no significant difference between injections received. Aspiration in combination with steroid injection has not provided any greater effectiveness, which may be expected as there is no evidence to support the presence of inflammatory mediators within the acellular cyst.[1] Although reoccurrence rates are generally high, the risk during aspiration intervention remains low, including low risk of local skin infection and increased pain.[14] Techniques designed to increased inflammation to enhance scarring and closing of the potential space were postulated early in the literature, such as sclerosing therapy.[9] Currently, this intervention is not recommended due to potential damage within the communicating joints and tendons.

Following failed conservative treatment, surgical excision is often recommended for the painful cyst.[7] Surgical excision of foot ganglion does appear to have significantly lower reoccurrence rates as compared to non-surgical interventions, cited as 11% and 63% respectively in a comparative study of 63 ganglions.[2] A retrospective analysis of surgical excision specifically targeted 54 ganglion cysts of the lower extremity. Satisfaction amongst patients receiving primary excision was high (83%), and a 10% recurrence rate was determined.[13] The average time to reoccurrence was 1 year. This investigation did not compare surgical and non-surgical interventions. Following surgical excision, reoccurrence rates ranging

from 7-43% are cited in the literature, likely attributed to imperfect excision.[2,10,11] Removal of the degenerative capsular or tendon tissue as well as the cyst requires thorough excision procedures. Surgeon experience also appears to impact the recurrence rates.[14] Due to a tendency for short follow-up evaluation, the reoccurrence rate may indeed be higher than currently depicted in the literature. A randomized prospective trial is required to accurately compare the reoccurrence rates amongst non-surgical and surgical intervention.

Surgical excision remains the gold standard for the treatment of ganglion cysts. However, excision protocols come with greater risk (than aspiration therapy) such as increased pain and stiffness, infection, scarring, and permanent or temporary neurological damage. However, patients perception of cosmetic or malignancy concerns may explain increased satisfaction following surgical excision regardless of rate of pain resolution.[1,8] At this time, treatment approaches for ganglion cysts of the foot provide variable and inconsistent results.

Acupuncture is defined by the World Health Organization (WHO) as "to puncture by needle", however many application techniques exist, including that of electric or electroacupuncture. Generally speaking, acupuncture performed by a well-trained professional is safe and adverse reactions are minimal. The availability and practicality of acupuncture are also important factors, in which it is considered a simple and convenient intervention. The WHO also states that acupuncture could "serve as a valuable alternative treatment for many conditions in which modern conventional treatments are unsuccessful". Within the WHO acupuncture review of controlled clinical trials; analgesia, protection against infection, and regulation of various physiological functions are considered therapeutic mechanisms.

The effectiveness of acupuncture analgesia is well established within controlled clinical trials. Electroacupuncture literature supports the analgesic effects and short-term decreases in pain threshold mediated via humoral factors.[15,16] These analgesic effects appear to be greater than those following manual acupuncture.[17] Following the continued demonstration of effectiveness, a standardized protocol including site, frequency, intensity, duration, and stimulation intervals can be recommended for the treatment of different disorders.

The treatment of ganglion cysts with electroacupuncture is an innovative approach. To the knowledge of the authors, only a single case report investigating the utilization of electroacupuncture for the treatment of a ganglion cyst located on the dorsal wrist is available in the literature.[18] In this report, a two-needle (50mm length, 0.3mm diameter) acupuncture technique was utilized. The first needle was inserted through the ganglion towards the wrist joint, and the second needle was inserted at Large Intestine-11 (LI-11), which is located over the lateral epicondyle of the elbow. Electrostimulation at a high frequency of 5Hz was then applied to the needles and intensity increased to maximum patient tolerance. The technique was repeated over four treatments in two weeks, and significantly reduced the size of the cyst. Patient follow-up at one year confirmed no reoccurrences or complaints, and complete resolution of the ganglion cyst. The authors credited the improvement to either "natural resolution, fluid leakage, or specific local effects of electroacupuncture".[18] The authors included potential explanations for the theoretical basis of acupuncture effectiveness to be attributed to acute local vasoconstriction and vasodilation from mediator release of bradykinin, acetocholine and leukotrienes, or endorphin and corticosteroid release. In the case presented, it cannot be definitively concluded that ganglion cyst resolution was attributed to the acupuncture intervention or spontaneous resolution over time. However, the electroacupuncture intervention may have induced fluid leakage and corticosteroid release as cited in the previous case report.

Conclusions

Ganglions are the most common soft-tissue tumours found within the ankle and foot.[6] The origin of ganglion cysts are highly theorized, and include pre-existing intra-articular joint pathology, joint stress leading to mucoid degeneration, and joint stress stimulating mucin secretion.[1]

A wide variety of treatment options for ganglion cysts likely result from frequent presentation to medical practitioners and lack of fully satisfactory mode of treatment.[1] The ideal intervention strategy must be targeted to minimize symptoms and reoccurrence, while limiting associated risks. Following subsequent research, electroacupuncture may serve as a valuable and safe alternative treatment for ganglion cysts, a condition which demonstrates variable effectiveness of conventional treatment methods.

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The female athlete triad: a case series and narrative overview

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Objective: *To illustrate the varying presentations of the female athlete triad and to inform the practitioner of the potential sequelae of this common condition.*

Clinical Features: *Four patients presented with a variety of signs and symptoms of the female athlete triad including low caloric intake, osteoporosis, amenorrhea and/or endothelial dysfunction.*

Intervention and Outcome: *A conservative treatment approach was utilized in each case including education on the female athlete triad, education on increased caloric intake and a referral to the family physician.*

Conclusion: *Health care practitioners should be aware of the different clinical presentations of the female athlete triad. A narrative review of the literature is provided to educate practitioners on the components of the female athlete triad, proper diagnosis and appropriate management.*

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KEY WORDS: triad, athlete, female, osteoporosis, amenorrhea, endothelial

Objectif : *illustrer les différentes manifestations de la triade de l'athlète féminine et d'informer le praticien des séquelles potentielles de cette affection courante.*

Caractéristiques cliniques : *quatre patients ont manifesté une variété de signes et de symptômes de la triade de l'athlète féminine, y compris un faible apport calorique, l'ostéoporose, l'aménorrhée ou une dysfonction endothéliale.*

Intervention et résultat : *une approche de traitement conservateur a été utilisée dans chaque cas, y compris une formation sur la triade de l'athlète féminine, une formation sur l'augmentation de l'apport calorique et un renvoi au médecin de famille.*

Conclusion : *les professionnels de la santé devraient connaître les différentes manifestations cliniques de la triade de l'athlète féminine. Un examen narratif de la documentation est offert pour renseigner les praticiens sur les composantes de la triade de l'athlète féminine, le bon diagnostic et la prise en charge appropriée.*

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MOTS CLÉS : triade, athlète, femme, ostéoporose, aménorrhée, endothéliale

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Introduction

In the early 1900s females were excluded from sport, specifically the Olympic games, because it was thought that sport might be too stressful for the female body, particularly the reproductive organs. Fortunately, the landscape of female athletics has changed dramatically in the past three decades. The change in female athletics is largely due to the induction of Title IX in the United States of America in 1972.[1,2,3] Since the passage of Title IX female athletic participation has drastically increased worldwide. The passage of Title IX mandated equal access for sport participation in schools for males and females alike.[1,2,3] Since the induction of Title IX in 1972 there has been a one thousand percent increase in the number of female athletes participating in sport. Female athletics have shown to increase self-esteem and self-confidence and reduce risky behaviours such as drug abuse and teen pregnancy in females. However, females face a unique set of psychological pressures in sport. Western society has placed a strong emphasis on ultra-thinness as the ideal body shape and size for females. This cultural ideal places females at an increased risk of developing disordered eating patterns in an effort to conform to the ultra-thin ideal of Western society.[1] The female athlete is not immune to societal pressures of ultra-thinness. A desire to improve performance, a win at all cost mentality, combined with an overly controlling parent or coach, may increase the athlete's risk for developing disordered eating patterns, ultimately leading to the female athlete triad.

In 1992, the American College of Sports Medicine (ACSM) task force on women's issues provided the first definition of the female athlete triad.[4,5] Initially, the female athlete triad was recognized as three separate but interrelated entities; eating/low energy availability, menstrual disturbance/amenorrhea, and bone loss/osteoporosis.[4,5,6] The ACSM position stand states that females that are at risk for developing the female athlete triad are those that are required to have frequent weigh-ins, consequences for weight gain in sport, pressure to win at all costs, and societal pressures to look a particular way. The female athlete triad most commonly presents in sports that have subjective scoring of the female's performance, endurance sports, sports that emphasize low body weight, sports that have multiple weight categories and prepubertal athletic participation, and finally, sports that require the athlete to wear revealing or tight clothing.[4]

The updated 2007 ACSM position stand now recognizes that the female athlete triad is a spectrum of symptoms and conditions ranging between health and disease.[4] The three spectrums include energy availability, menstrual function, and bone mineral density.[4,7,8] The position stand states that the three spectrums occur on a sliding scale ranging from optimal energy availability, eumenorrhea, and optimal bone mineral density to low energy availability with or without an eating disorder, functional hypothalamic amenorrhea, and osteoporosis respectively.[4] Low energy availability may occur unintentionally in female athletes with or without an eating disorder.[7] The three distinct clinical entities may occur alone or in combination with the other disorders. All three clinical entities may also occur at a subclinical level. The athletes' condition may move along each spectrum at a different rate, in one direction or the other, according to her diet and exercise habits.[4,7,8]

This case series presents various scenarios of the female athlete triad syndrome presenting with musculoskeletal pain to chiropractors. To our knowledge this is the first case series and narrative overview on the female athlete triad in the chiropractic literature. This is important due to the large number of female athletes that present to chiropractors and because of the increased female participation in recent years (added with the competition and societal pressures previously mentioned), chiropractors are likely to see these patients more commonly in practice. Therefore, the purpose of this paper is to present the variety of presentations of the female athlete triad syndrome in young premenopausal athletes and provide practitioners with a narrative overview.

Case One

A 27 year-old female runner presented to a chiropractor with right-sided lateral ankle pain of two weeks duration. No specific mechanism of injury was reported. The pain was localized to the lateral aspect of the right ankle, 3.5cm proximal to the inferior pole of the lateral malleolus. The pain was described as a "sharp" sensation directly over the lateral malleolus. The pain had progressively increased one week prior to presentation to the chiropractor. Relieving factors included rest, cessation of running, ice and nonsteriodal anti-inflammatory drugs (NSAIDS). The pain was aggravated with full weight bearing in walking and running, as well as during the toe-off phase of ambu-

Image 1
Ankle radiograph – AP
Arrow shows sclerotic line through the distal fibula

Image 2
Ankle radiograph – Medial oblique
Arrow shows sclerotic line through the distal fibula

Image 3
Ankle radiograph – AP bright light
Arrow shows sclerotic fracture line. Arrowhead shows periosteal reaction

lation. Systems review was unremarkable. No constitutional signs or symptoms were noted.

The patient reported introducing running back into her routine after a three-month absence. At initial examination she was recreationally running five kilometers, three times per week. Four years prior to examination the patient was diagnosed with secondary amenorrhea from her medical physician. She was not being treated for amenorrhea. However, she was advised by her medical physician to start a regime of calcium and vitamin D supplementation.

On physical examination, observation revealed mild edema 3.5cm proximal to the distal aspect of the lateral malleolus. There was no ecchymosis, deformity, or scarring at the level of reported pain. Gait was unremarkable for pain or discomfort in the lateral ankle. Active and passive range of motion of the right ankle revealed limitation in dorsiflexion and inversion by 25% due to pain. All other active and passive ranges of motion were full and pain free. Orthopedic examination of the right ankle revealed pain on the proximal aspect of the distal fibula with the anterior drawer test (test for the cruciate ligaments) with no associated laxity. No other ankle orthopedic tests were provocative for pain. Bony tenderness was elicited 3.5cm proximal to the distal aspect of the fibula. Malleolar squeeze elicited pain on the lateral aspect of the ankle. The tuning fork test (256Hz) was positive 3.5cm proximal to the distal aspect of the lateral malleolus. A neurological examination of the lower extremity was unremarkable including sensation, manual muscle testing, and deep tendon reflexes.

Right ankle radiographs were performed by the chiropractor and revealed a faint linear sclerotic line traversing the distal fibular metaphysis, 3.5cm proximal to the tip of the lateral malleolus, associated with a focal cortical distortion. Joint effusion was noted in the talotibial joint with anterior displacement of teardrop fat pad anterior to the talotibial joint. Soft tissue swelling was also noted lateral to the lateral malleolus on the radiograph. This patient was diagnosed with a recent stress fracture of the right distal fibular metaphysis (please refer to images 1, 2, and 3).

This patient was subsequently diagnosed with the female athlete triad due to her recent stress fracture and her

hypothalamic amenorrhea. She was managed by her chiropractor with education on the female athlete triad and advice to seek nutritional counseling to increase her caloric intake. This patient's stress fracture was managed conservatively with rest, ice, rehabilitation, manual therapy, and cessation of running for three weeks. At three weeks post-injury, follow-up radiographs of the right ankle were performed. The radiographs showed a dense sclerotic line traversing the metaphysis of the fibula 3.5cm proximal to the distal aspect of the lateral malleolus with associated callus formation.

Case Two

A 27 year-old recreational level athlete (and chiropractor) presented to a chiropractic clinic with a history of 10 previous fractures. All fractures occurred during athletic pursuits. Her first fracture was a broken clavicle at age four. Another fracture was at the age of nine where she had pins and plates surgically placed into her tibia after a comminuted distal tibial fracture. She then fractured the base of the first metacarpal on the left at age 11. At age 13 she fractured the shaft of her first metacarpal on the left and the fourth distal phalange on the left foot. At age 14 she fractured her other clavicle, age 15 she fractured the shaft of her fifth metacarpal on the left hand. She fractured her nose twice, once at age 16 and once at age 18. Finally, at age 25 she fractured her fifth distal phalange on the left. All fractures were identified on routine radiographs. Due to the large number of fractures the patient does not remember how all fractures occurred but does report that they were all sustained during athletic pursuits.

At the age of 13 this patient was referred by her general practitioner for a DEXA scan to rule out osteopenia. The DEXA scan was read as unremarkable. However, her z-score was –2.2. There was no family history of osteopenia or osteoporosis. This patient was asked during her initial evaluation a series of questions in regard to the female athlete triad. She reported never being diagnosed with an eating disorder or disordered eating habits in the past. She did not report to ever keeping a food diary. She reached menarche at the age of 13 and has had 12 cycles per year since the onset of menarche. She also reports to have never been diagnosed with oligomenorrhea or amenorrhea. There is no history of menstrual dysfunction. She reports to have never been concerned with the female athlete triad and that no medical professional has previously asked her questions in regard to the triad.

Due to significant fracture history, this patient was diagnosed with the female athlete triad due to a z score of –2.2. Education was provided to the patient in regards to increasing caloric intake. This patient may have been inadvertently not ingesting enough calories for her level of activity. She was referred to an osteoporosis specialist for further investigation of her low bone mineral density and a significant fracture history from her family physician.

Case Three

A 23-year old female professional contemporary dancer presented to a chiropractor with left foot pain localized to the first, fourth and fifth metatarsal heads. The pain was aggravated with weight-bearing, walking, running, and dancing. At times, it would reach an intensity of 8 on a 10-point scale, particularly during the 'demi-point' (i.e. tip-toe) dance position. The pain in the foot was relieved with rest and taking time away from dance. No constitutional signs or symptoms were reported. Systems review was unremarkable.

Upon physical examination, no swelling was noted with observation of the left foot. Active and passive range of motion of the left ankle and metatarsal joints were full and pain free. Joint palpation of the first, fourth, and fifth metatarsal heads reproduced the chief complaint. There was no pain on palpation of the surrounding foot musculature. Tuning fork test of the metatarsal heads was unremarkable. The patient was subsequently diagnosed with metatarsalgia due to over training of the left first, fourth, and fifth metatarsals.

The patient reported to the chiropractor that she sustained previous stress fractures in her proximal tibia bilaterally one year earlier and a fractured base of her fifth metatarsal due to excessive dancing. During treatment for the metatarsalgia, the patient reported performing a plank (core stability exercise) and feeling immediate discomfort on the angle of the eighth rib on the right. She immediately had pain on palpation of the eighth rib, pain with inhalation and exhalation. The patient reported to the emergency room due to the extreme pain. Radiographs and an ultrasound examination of her ribs confirmed a fracture of the anterolateral aspect of the eighth rib on the right. The medical physician referred her for a DXA scan of the entire body that was read as unremarkable by the radiolo-

gist (no osteopenia or osteoporosis). The patient was then prescribed a course of oral contraceptive medication from her family physician.

Suspecting the female athlete triad, the chiropractor proceeded with a more thorough medical history. The dancer reported no previous history of amenorrhea or oligomenorrhea. She reported a normal menstrual cycle since the age of 12. The patient reported eating two meals a day and dancing six and a half hours per day five days per week. The chiropractor asked the patient to perform a seven-day diet diary to assess for disordered eating habits. The patient denied any previous clinical eating disorders, but reported that her family physician had diagnosed her with 'non-cognitive disordered eating' (i.e. inadvertent low caloric intake) in the past. This dancer was diagnosed with the female athlete triad by the chiropractor. The case was managed with education on the female athlete triad, communication with the patient's family physician on the suspicion of the triad, and dietary counseling to increase caloric intake.

Case Four

A 16-year old National level ice dancer presented to the chiropractor with pain in the left ankle. The pain was constant in nature and was localized to the medial malleolus. She previously presented to a sports physician and was diagnosed with medial malleolar bursitis. The bursitis was previously managed with aspiration of the bursa and a corticosteroid injection, this procedure was performed twice with no relief of signs or symptoms. There was no referred pain or numbness and tingling surrounding the left medial malleolus. Further history revealed that she has not menstruated and had no secondary sex characteristics at the age of 16. Questions surrounding her diet and exercise habits revealed that she trains approximately five hours per day, seven days per week, and consumes limited calories. A diet analysis was then performed, revealing a significant caloric deficiency. At 16 years of age she has not reached menarche and has not shown any secondary sex characteristics. The chiropractor immediately referred her to the medical physician for a physical examination due to the suspicion of the female athlete triad. The examination revealed that she was 78lbs and five feet in height. Primary amenorrhea was diagnosed and subsequently the female athlete triad. The patient's medial malleolar bursitis was managed conservatively by the chiropractor, and the medical physician recommended increased caloric intake to manage the triad. Approximately one year later the patient is yet to increase her caloric intake and subsequently has not advanced to menarche.

Discussion

The components of the female athlete triad are the following:

1. Energy Availability

Maintaining a low body weight for the sake of performance and aesthetic purposes is a common feature among young female athletes. Energy availability refers to the amount of energy that remains in the body to be used for training and sport performance. Female athletes experience energy deficient states with high-energy expenditure due to training without adequate compensation in energy intake. Energy availability occurs along a spectrum ranging from optimal energy to low energy with or without an eating disorder or disordered eating.[9] The prevalence of inadvertent low energy is unknown. However, the prevalence of disordered eating among athletes is 28-62%.[9] Clinical eating disorders are also common in female athletes including anorexia nervosa, bulimia nervosa, and eating disorders not otherwise specified according to the DSM IV. The prevalence of eating disorders according the to the DSM IV in female athletes is 25-31%. Some female athletes may have no energy available for training and sport participation because they intentionally restrict daily caloric intake while others may fall into a negative energy balance because they are unaware of the calories needed for their specific sport.[4,8-12]

All cases presented in this case series were managed with increasing caloric intake due to disordered eating patterns potentially caused by a negative energy balance from excessive training schedules. None of the athletes presented were diagnosed with a clinical eating disorder from the DSM IV.

2. Menstrual Function

Menstrual function ranges from eumenorrhea (normal menstruation) to amenorrhea (no menstruation > 3 months). In adolescent female athletes under the age of eighteen the prevalence of menstrual dysfunction is 45-50%.[9] The prevalence of menstrual dysfunction in adult female athletes over the age of eighteen is estimated to

be 12-79%.[9] Comparatively, the prevalence of menstrual dysfunction in adult non-athletes is approximately two to five percent.[9] The prevalence of oligomenorrhea is extremely difficult to determine in adolescent females since menstrual cycle intervals of >35 days are encountered in approximately 65% of females during their first 12 months following menarche.[9,13] Ovulatory status and menstrual cycle lengths are highly variable for the first five years post-menarche in females.[9,13]

Eumenorrhea is described as menstrual cycles lasting 28+7 days in duration.[5,14] To maintain eumenorrhea females need to consume approximately 45kcal/kg free fat mass (FFM) per day.[5,14] FFM is described as the weight of the athlete minus the weight of their fat and water mass. Oligomenorrhea is defined as menstrual cycles lasting >35 days in duration and can occur in females consuming <30kcal/kg FFM per day. Lastly, the most severe form of menstrual dysfunction is amenorrhea which is described as menstrual cycles lasting >90 days in duration.[4,5,9,14] There are two specific types of amenorrhea, primary and secondary. Firstly, primary amenorrhea occurs in females that are 15 years of age or older with the absence of menstruation with the presence of other secondary sex characteristics. Furthermore, primary amenorrhea can also be described as females that are 14 years of age with no secondary sex characteristics present. Case four represents a case of primary amenorrhea. This female figure skater was 16 years of age with no secondary sex characteristics and had not reached menarche. Secondly, secondary amenorrhea occurs in females with a cessation of menstruation for >90 days that once menstruated.[4,5,9,14] The latter is common in female athletes and can be termed functional hypothalamic amenorrhea (FHA). Case one represents a case of secondary amenorrhea. This female runner had menstruated previously; her cycles had stopped for a duration of 4 years. This patient was diagnosed with functional hypothalamic amenorrhea.

FHA occurs in female athletes due to low energy availability due to intentional or unintentional caloric restriction.[13,15] FHA is associated with increased exercise and weight loss resulting in hypoestrogenism, ultimately resulting in a failure to obtain peak bone mass.[13] Low energy availability in the female athlete results in changes in physiological and neuroendocrine response including a decrease in leptin, T3, insulin, IGF-!, and plasma glucose, and a resultant increase in grelin, cortisol, and growth

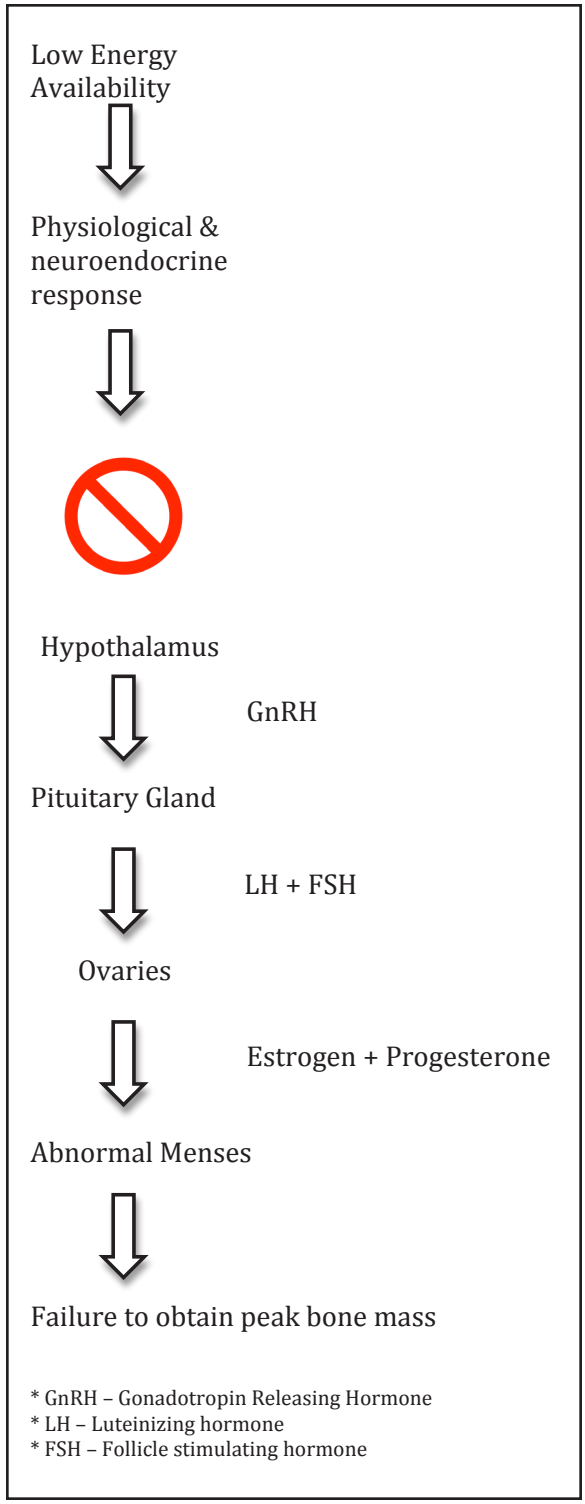

Image 4
Functional Hypothalmic Amenorrhea[13-18]

hormone. Physiological and neuroendocrine changes within the body will signal to the hypothalamus to stop producing gonado-tropin-releasing hormone (GnRH). A decrease in GnRH halts the releases of Luteinizing hormone (LH) and follicle stimulating hormone (FSH) from the pituitary gland. Further, an overall decrease in LH and FSH suppresses the ovaries from producing estrogen and progesterone leading to abnormal menses in the female athlete.[13,15,16,17,18,19,20] (See Image 4).

3. Bone Mineral Density

Osteoporosis is defined as a skeletal disorder characterized by compromised bone strength predisposing a person to an increased risk of fracture. Osteoporosis develops not only through the loss of bone mineral density during adulthood but it can also develop through the failure to accumulate sufficient bone mass during adolescent years.[5,13,21,22] In postmenopausal women osteopenia is defined as a T-score between –1 and –2.5 and osteoporosis is < –2.5. However, the terms osteopenia and osteoporosis in premenopausal females are not used in the same manner.[13] Z-scores are defined as the number of standard deviations above or below the mean for the patient's age, sex and ethnicity on a bone mineral density scan (DXA). T-scores are defined as the number of standard deviations above or below the mean for a healthy 30-year-old adult of the same sex and ethnicity as the patient.[22]

According to the International Society for Clinical Densitometry (ISCD) t-score on DXA scans are not to be used in the adolescent premenopausal population instead z-scores are to be used for comparison.[23] Low bone mass is defined as bone mineral density lower than expected for age-matched norms. Osteoporosis in young females should only be made with a z-score below –2 together with the presence of a stress fracture, a clinically significant fracture history, disordered eating patterns, or hypogonadism.[5,9,13,24] Currently the epidemiological data relating to bone mineral density and fractures in premenopausal females is lacking and there is no agreement on standards for adjusting bone mineral density for bone size, pubertal stage, skeletal maturity, or body composition. Thus, fracture risk for premenopausal females cannot be predicted in the same manner as postmenopausal females.[9,13]

The ACSM recommends that DXA scans for premenopausal females suspected to have the female athlete triad in the following situations; oligomenorrhea/amenorrhea > six months in duration, disordered eating/eating disorders for equal to or more than six months in duration, and the presence of a stress fracture or a fracture from minimal trauma.[4] Thus, the diagnosis of osteoporosis in young females is not made on densitometric criteria alone.[9] Clinically significant fracture history is defined as a long bone fracture of the lower extremity, a compression fracture of the spine, or two or more long bone fractures of the upper extremities. DXA scans are recommended for the lumbar spine and forearm in female athletes due to the weight bearing nature of sport. Female athletes will have an increase in bone mineral density in hips and ultimately of full body. The lumbar spine and the forearm should be carefully monitored in young female athletes because of the presence of rich trabecular bone and are submitted to little or no weight bearing during sport.[4,9,25-28]

Case two represents a case of a female athlete with a clinically significant fracture history. According to the ISCD it was clinically relevant to order a DXA scan for this athlete due to her clinically significant fracture history and fractures from minimal trauma. This athlete's DXA results showed a z-score of –2.2 and a diagnosis of premature osteoporosis was made.

Emerging research states that the female athlete triad is no longer a triad but it is now a tetrad of interconnected conditions.[29,30,31] The new emerging component is endothelial dysfunction leading to an increased risk of heart disease. It has been proposed that endothelial dysfunction is caused by a decrease in estrogen ultimately from low energy availability.[1,29,30,31] Endothelial dysfunction is concerning because the sentinel event in cardiovascular disease pathogenesis is impaired endothelial function. Vessels contain estrogen receptors allowing for estrogen to play a regulatory role in vascular function. Estrogen stimulates the production of endothelial nitric oxide synthase, leading to increased production of endothelial-derived nitric oxide ultimately leading to vasodilation.[1,29] Amenorrhea is similar to menopause because low estrogen levels, whether in a pre or post-menopause, will theoretically cause impaired endothelial cell function and resultant impaired arterial dilation leading to cardiovascular disease.[1,29,30,31]

There are many clinical implications to reduced flow mediated dilation within vessels in athletes. Firstly, a loss of flow mediated dilation in conduit arteries may lead to a restriction in exercise-induced dilation of the ves-

sels and limit maximum blood profusion to the tissues being supplied.[1,31] This process may lead to a reduction in exercise capacity and performance by restricting the amount of blood flow to critical muscles involved in exercise. Further, chronic endothelial dysfunction can lead to premature vascular changes by leading to accelerated development of atherosclerosis further leading to an increased risk of cardiovascular events.[1,31]

The triad may increase the risk of cardiovascular disease.[1,31,32] However, the strongest evidence in regard to health consequences of the female athlete triad is related to stress fractures.[13] The most common site for stress fractures in females is the tibia, accounting for 25-63% of all stress fractures. When a female athlete has menstrual irregularities it may increase the risk of stress fractures. However, it does seem to be controversial of whether age of menarche and oral contraceptive use play a role in stress fracture risk.[13,33]

Pre-participation Screening

Identification of the triad takes thorough screening of all female athletes. Pre-participation screening for the triad should be performed prior to participating in any level of sport. The screening should include questions on menstrual history, exercise level, and diet history and past injuries including energy expenditure.[34] Important questions to ask all females prior to sport participation is age of menarche and number of menstrual periods in the past 12 months to determine if the athlete eumenorrheic, oligomenorrheic, or amenorrheic. Secondly, pre-participation screening questions must include inquiries in regard to exercise patterns, training intensity and frequency for the sport, past repetitive injuries, including history of fractures, and DXA scan scores if available.[34]

Management

The management of the female athlete triad is controversial in the current body of literature.[13] The primary health care provider needs to be astute and willing to work collaboratively with a multidisciplinary team including sports psychologists, sports dieticians, coaches, therapists, physicians, and parents. Sports dieticians facilitate the design of healthy nutritional choices and maintaining an ideal body weight. Primary care providers can educate females in regard to preventing caloric deficit and maintaining a positive energy balance. Sports psychologists manage the eating disorders and the effects on the psyche including self-esteem and self-confidence. Coaches can modify the athletes exercise intensity if needed. Parents can monitor progress, assess for compliance, and provide support and encouragement. Therapists including physiotherapists, chiropractors, and athletic therapists can assist with pain control, education on the condition and nutritional counseling. Finally physician's can be used for advanced imaging techniques and approach referrals.

Currently there is little knowledge about the clinical management of the female athlete triad, specifically, how to manage low bone mineral density and fracture risks in young females.[9] Haberland et al was the first group to conduct a survey on the clinical management of athletic amenorrhea in female athletes.[35] The results of the survey suggested that 92% of physician's surveyed used oral contraceptives and other hormonal therapeutic regimens to treat athletic amenorrhea despite the paucity of data demonstrating their efficacy in preserving bone mass.[9,35,36,37] One of the most recent surveys revealed that 80% of clinicians believe there are insufficient guidelines for the management of the female athlete triad, specifically for the evaluation of menstrual dysfunction, the use of bone density scans for diagnosing osteopenia in pre menopausal females and treatment modalities.[4]

The efficacy of estrogen therapy in the form of oral contraceptives for improving bone health in premenopausal female athletes is extremely controversial in the current body of literature.[9] Some authors reported no change in bone mineral density after several months of oral contraceptive usage.[26,36,37] However, there are some studies reporting an increase in bone mineral density in the lumbar spine, hips, radius, and whole body with oral contraceptive use compared to healthy controls.[38-42] Studies need to control for weight gain during oral contraceptive usage due to the ultimate goal of managing the triad is to return of regular menses through proper nutrition and maintaining a reasonable body weight. Gibson at al. performed a pilot study and determined that to have an effect of 80% studies need 1180 subjects to participate, many studies are under-powered.[37] Further studies are required to determine if oral contraceptives can be used to replace bone loss once it has already occurred. There is consensus that oral contraceptives can be used to prevent further bone loss in female athletes. However, bone loss may be irreversible in premenopausal females.

Another pharmacological intervention for athletes suffering from the female athlete triad syndrome and functional hypothalamic amenorrhea (FHA) causing low bone mineral density is the use of bisphosphonates.[9,43,44,45] Bisphosphonates have been proposed to prevent further bone loss from occurring in young females athletes with FHA.[43,44,45] Bisphosphonates have not been shown to be superior in preventing bone loss when compared to vitamin D and calcium supplementation.[43,45] More research is needed to determine bisphosphonates full effects on bone mineral density in premenopausal females. Further, bisphosphonates are currently not approved by the Food and Drug Administration (FDA) for the use by premenopausal females.[9]

FHA impairs the attainment of peak bone mass in young premenopausal females.[15] It has been hypothesized that FHA may lead to an increased risk of fractures later in life due to a failure to reach peak bone mineral density in peak years.[15] There are several studies that have looked at the effects of increasing caloric intake and increasing weight gain for increasing bone mineral density in females with FHA.[46-51] The results of the aforementioned studies show promising results for increasing caloric intake as a successful and essential strategy for improving bone mineral density in premenopausal females with FHA with a resumption of regular menstruation with weight gain.[15,46-51] There is a need for further long-term studies to determine the effects of caloric intake and future fracture risks.[15]

Folic acid has been studied recently as a treatment for decreased flow mediated dilation in female athletes with FHA.[52-54] Folates have been hypothesized to participate in the endogenous regeneration of tetrahydrobiopterin, an essential cofactor in the production of endothelial nitric oxide synthase (eNOS). A decrease in eNOS will lead to significant decreases in nitric oxide (NO), an essential cofactor for maintaining healthy cardiovascular function.[52-54] Further, folic acid has a known homocysteine-lowering effect that may contribute to improvements in endothelial function and overall cardiovascular health.[52-54] Folic acid may also have a direct antioxidant effect in the conduit vasculature of the heart, increasing NO bioavailability, which may increase cardiovascular FMD.[52-54] Folic acid in 10mg dosage has been shown to improve endothelial function in various disease states but before amenorrheic female athletes can be added to this group, a large cohort study followed for several years needs to be performed.[52-54]

Summary

In summary, the female triad may actually be a tetrad of coexisting conditions including disordered eating, menstrual dysfunction, low bone mineral density, and endothelial dysfunction. A female athlete presenting with one component of the triad/tetrad should be assessed for other components by a health care practitioner to ensure proper management of the condition. It is important to note that the tetrad is not an inevitable consequence of training or of being an athlete. Rather, it mandates a call to educate young female athletes and those involved in their training of the consequence of the tetrad. It is important to educate athletes, parents, and coaches about the requirement for optimal energy intake, energy balance, and fuel intake. Oral contraceptive medication may be considered to prevent further loss of bone mineral density in athletes with FHA over the age of 16 and only if bone mineral density is decreasing despite nutrition. Bisphosphonates are approved for postmenopausal females but should not be used in young females with FHA because it is not FDA approved for use. Prevention, recognition, and treatment of the tetrad must be a priority to ensure that female athletes maximize the benefits of regular exercise and achieve optimal health as well as optimal performance.

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Diagnosis and rehabilitation of gastrocnemius muscle tear: a case report

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Objective: *This case study presents the epidemiology, etiology, diagnostic criteria, and therapeutic interventions for a common clinical condition – gastrocnemius injury.*

Clinical Features: *A 44-year old male presented with acute calf pain with a palpable defect, loss of range of motion, and loss of strength after sustaining a soft tissue injury to the lower leg. The differential diagnosis of tear of the medial head of the gastrocnemius was confirmed by physical examination and diagnostic ultrasound imaging.*

Intervention and Outcome: *The patient was treated over a 6 week period. Initially, rehabilitation was approached using the PRICE principles for symptomatic relief, followed by stretching, strengthening, proprioception, and conditioning exercises. At 9-month follow-up post injury, there was no residual impairment in the gastrocnemius muscle function.*

Summary: *This case demonstrates the importance of epidemiology, clinical assessment, and the use of diagnostic ultrasound and MRI imaging in the diagnosis of a tear of the medial head of the gastrocnemius muscle. With an accurate diagnosis and comprehension*

Objectif : *cette étude de cas présente l'épidémiologie, l'étiologie, les critères diagnostiques et les interventions thérapeutiques pour une affection clinique courante – la blessure du muscle gastrocnémien (muscles jumeaux).*

Caractéristiques cliniques : *un patient de 44 ans a présenté des douleurs aiguës au mollet avec une anomalie palpable, une perte d'amplitude de mouvement et une perte de tonus après avoir subi une blessure aux tissus mous de la jambe inférieure. Le diagnostic différentiel de la déchirure du chef médial des muscles jumeaux a été confirmé par un examen physique et une échographie diagnostique.*

Intervention et résultat : *le patient a été traité pendant une période de 6 semaines. Au début, la réadaptation a été abordée selon les principes PRICE du soulagement symptomatique, suivi par de l'étirement, d'exercices de musculation, de la kinesthésie et d'exercices de mise en forme. Au suivi, neuf mois après la blessure, on n'a révélé aucune détérioration résiduelle dans la fonction des muscles jumeaux.*

Résumé : *ce cas démontre l'importance de l'épidémiologie, de l'évaluation clinique et de l'utilisation de l'échographie diagnostique et de l'imagerie IRM dans le diagnostic d'une déchirure du chef médial des muscles jumeaux. Grâce à un diagnostic précis et la compréhension de la classification des*

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of classification of muscle injuries, management of gastrocnemius tears is straightforward.

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KEY WORDS: injury, muscle, gastrocnemius, diagnosis

lésions musculaires, la gestion des déchirures des muscles jumeaux est simplifiée.

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MOTS CLÉS : blessure, muscle, muscles jumeaux, gastrocnémien, diagnostic

Introduction

Muscle injuries in the calf are a relatively common clinical condition[1-6], and are also termed "tennis leg" in general because of the prevalence in that sport[3,7]. However, middle-aged or older patients, usually over the age of 40, often present with lower leg muscle injuries following strenuous exercise or sometimes innocuous activity.[5]

There is a consensus to classify myotendinous strains as first degree (stretch injury), second degree (partial tear), and third degree (complete rupture).[5,8] This type of classification takes into consideration the physical findings and pathological correlation as described above, and the disabilities that is, absent, mild, or complete loss of muscle function.[6,7] The term strain does not accurately reflect the structural characteristics of injuries of muscles; rather it is more of a biomechanical description of the mechanism of injury[9], and as such, the term tear should be used as it more accurately describes the structural injuries of muscle fibres[8]. Mueller-Wohlfahrt et al.[8] discusses the use of a classification system that describes four types of indirect (acute) muscle injuries, and recommends the use of the term tear to describe the injuries of muscle fibres and bundles (Table 1).

A tear to the gastrocnemius muscle is, more often than not, implicated in lower leg trauma and is considered at high risk of injury because of its position spanning across two joints: the knee and ankle, and because of the high density of type-two fast twitch muscle fibres.[2,3,6] The gastrocnemius muscle functions to plantar flex the foot at the ankle joint and flex the leg at the knee joint in the non-weight-bearing state.[7] Although studies documenting the injury rates of calf muscle tears are limited[7], a 5-year study of European soccer players revealed that 12% of the muscle injuries sustained were injuries to the gastrocnemius muscle, and the gastrocnemius was categorized as one of the top five muscles injured[5].

The diagnosis of the gastrocnemius tear is often clinical. Sudden onset of pain, tenderness localized to the musculotendinous junction of the medial head of the gastrocnemius, and a palpable defect in the medial belly of the gastrocnemius just above the musculotendinous junction are pathognomonic for a gastrocnemius tear.[4,10]

Muscle tears located in the calf region are often associated with other pathologies such as thrombophlebitis, soleus tear, Achilles tendon rupture, and posterior compartment syndrome, making it more difficult for the practitioner to formulate a correct diagnosis, despite performing an accurate clinical examination.[1] Researchers concur that conservative management is effective in the treatment of gastrocnemius tears.[1,4,5,7,10]

This paper will draw attention to the diagnostic and therapeutic procedures associated with gastrocnemius tears. A case will be presented which emphasizes the use of advanced imaging to reach an accurate diagnosis which aides in the process of developing an appropriate course of treatment.

Case

A 44-year old male presented with a chief complaint of right posterior calf pain, and provided consent to the use of specifics related to his clinical information. He reported the onset of symptoms a few days prior during a dancing session. He stated that he experienced a sudden and sharp sensation at the back of his calf as he extended the leg backwards while planting the heel on the ground. He stated "I thought someone kicked the back of my leg…but when I turned around, there was no one there". The pain was located along the medial aspect of

Table 1:
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Comprehensive muscle injury classification: type-specific definitions and clinical presentations						
Type	**Classification**	**Definition**	**Symptoms**	**Clinical signs**	**Location**	**Ultrasound/MRI**
1A	Fatigue-induced muscle disorder	Circumscribed longitudinal increase of muscle tone (muscle firmness) due to overexertion, change of playing surface or change in training patterns	Aching muscle firmness. Increasing with continued activity. Can provoke pain at rest. During or after activity	Dull, diffuse, tolerable pain in involved muscles, circumscribed increase of tone. Athlete reports of 'muscle tightness'	Focal involvement up to entire length of muscle	Negative
1B	Delayed-onset muscle soreness (DOMS)	More generalised muscle pain following unaccustomed, eccentric deceleration movements.	Acute inflammative pain. Pain at rest. Hours after activity	Oedematous swelling, stiff muscles. Limited range of motion of adjacent joints. Pain on isometric contraction. Therapeutic stretching leads to relief	Mostly entire muscle or muscle group	Negative or oedema only
2A	Spine-related neuromuscular muscle disorder	Circumscribed longitudinal increase of muscle tone (muscle firmness) due to functional or structural spinal lumbopelvical disorder.	Aching muscle firmness. Increasing with continued activity. No pain at rest	Circumscribed longitudinal increase of muscle tone. Discrete oedema between muscle and fascia. Occasional skin sensitivity, defensive reaction on muscle stretching. Pressure pain	Muscle bundle or larger muscle group along entire length of muscle	Negative or oedema only
2B	Muscle-related neuromuscular muscle disorder	Circumscribed (spindle-shaped) area of increased muscle tone (muscle firmness). May result from dysfunctional neuromuscular control such as reciprocal inhibition	Aching, gradually increasing muscle firmness and tension. Cramp-like pain	Circumscribed (spindle-shaped) area of increased muscle tone, oedematous swelling. Therapeutic stretching leads to relief. Pressure pain	Mostly along the entire length of the muscle belly	Negative or oedema only
3A	Minor partial muscle tear	Tear with a maximum diameter of less than muscle fascicle/bundle.	Sharp, needle-like or stabbing pain at time of injury. Athlete often experiences a 'snap' followed by a sudden onset of localised pain	Well-defined localised pain. Probably palpable defect in fibre structure within a firm muscle band. Stretch-induced pain aggravation	Primarily muscle-tendon junction	Positive for fibre disruption on high resolution MRI*. Intramuscular haematoma
3B	Moderate partial muscle tear	Tear with a diameter of greater than a fascicle/ bundle	Stabbing, sharp pain, often noticeable tearing at time of injury. Athlete often experiences a 'snap' followed by a sudden onset of localised pain. Possible fall of athlete	Well-defined localised pain. Palpable defect in muscle structure, often haematoma, fascial injury Stretch-induced pain aggravation	Primarily muscle-tendon junction	Positive for significant fibre disruption, probably including some retraction. With fascial injury and intermuscular haematoma
4	(Sub)total muscle tear/ tendinous avulsion	Tear involving the subtotal/ complete muscle diameter/ tendinous injury involving the bone-tendon junction	Dull pain at time of injury. Noticeable tearing. Athlete experiences a 'snap' followed by a sudden onset of localised pain. Often fall	Large defect in muscle, haematoma, palpable gap, haematoma, muscle retraction, pain with movement, loss of function, haematoma	Primarily muscle-tendon junction or Bone-tendon junction	Subtotal/complete discontinuity of muscle/ tendon. Possible wavy tendon morphology and retraction. With fascial injury and intermuscular haematoma
Contusion	Direct injury	Direct muscle trauma, caused by blunt external force. Leading to diffuse or circumscribed haematoma within the muscle causing pain and loss of motion	Dull pain at time of injury, possibly increasing due to increasing haematoma. Athlete often reports definite external mechanism	Dull, diffuse pain, haematoma, pain on movement, swelling, decreased range of motion, tenderness to palpation depending on the severity of impact. Athlete may be able to continue sport activity rather than in indirect structural injury	Any muscle, mostly vastus intermedius and rectus femoris	Diffuse or circumscribed haematoma in varying dimensions

**Recommendations for (high-resolution) MRI*: high field strength (minimum 1.5 or 3 T), high spatial resolution (use of surface coils), limited field of view (according to clinical examination/ultrasound), use of skin marker at centre of injury location and multiplanar slice orientation.

the posterior calf and extended upwards toward the knee and distally towards the ankle. He described the pain as tight and throbbing. The pain was aggravated with general ankle movements.

Examination revealed an antalgic gait, favouring the right leg. He was unable to balance on the right leg unassisted. Inspection revealed moderate soft tissue swelling of the right calf with discoloration and bruising extending to the posterior aspect of the foot. Measurement of the calf was 41 cm on the right and 38.5 cm on the left, measured 10 cm below the patella. A visible defect of the medial gastrocnemius muscle was evident and was palpable at this juncture. In addition, a mass was palpated at the posterior calf, likely the rupture of the gastrocnemius muscle. Palpation revealed tenderness along the entire medial gastrocnemius muscle, particularly at the musculotendinous junction.

The Thompson Squeeze Test was negative for an Achilles tendon rupture, as it was painful but produced plantar flexion. Active and passive ankle dorsiflexion produced moderate pain. Resisted plantar flexion of the ankle also reproduced the symptoms. There was mild pain with active knee flexion. There was difficulty performing a single leg calf raise with the affected leg.

The patient was referred for a venous doppler of the right lower leg that normal compressibility, phasic flow and augmentation in the deep veins of the lower extremity from the common femoral vein to the popliteal confluence below the knee. A diagnostic ultrasound study of the right calf revealed an abnormality at the medial aspect of the gastrocnemius muscle, described as "a complex cystic structure at the medial aspect of the gastrocnemius muscle…adjacent to the plantaris tendon/muscle". There was concern of a soft tissue hematoma with a partial thickness tear of either the medial gastrocnemius muscle or the plantaris tendon/muscle. Based on the epidemiology, mechanism of injury, clinical findings, and diagnostic ultrasound findings, the patient was diagnosed with a type 3 tear of the medial gastrocnemius muscle.

Bleakley[11] elaborates on the widely accepted approach in the treatment of soft tissue injuries as protection, rest, ice, compression, and elevation, commonly shortened by the acronym 'PRICE'. Campbell[4] suggests that rest, ice, compression, and elevation, along with the use of protection may be required for symptomatic relief of gastrocnemius tears. The components of the PRICE principle were applied during the first phase of therapy (week 1-2) to minimize pain and discomfort.

At the onset of treatment, the patient was advised to limit activities. The use of a compression sleeve for the calf was recommended to decrease the hemorrhaging. He was directed to apply ice to the area with 10 minutes on, 10 minutes off and then repeat for symptomatic relief. He was educated on the proper technique of elevating the limb slightly above the level of the heart to reduce the swelling. The patient was comfortable with weight-bearing and declined the use of crutches and/or walking boot to assist his mobility.

In phase 1 of rehabilitation (week 1-2), the patient commenced active range of motion exercises for the knee and ankle in the pain-free range. Chiropractic treatments included gentle mobilization of the knee and ankle joints. In addition, associated lumbo-pelvic dysfunction and pain, likely due to altered gait mechanics, were addressed.

The second phase of therapy (week 3-4) consisted of progression from active range of motion exercises to isometric exercises and exercises against resistance. There was a specific focus on plantar flexor strengthening exercises, in conjunction with general strengthening exercises of the quadriceps, hamstrings, and lateral and anterior compartment muscles. In addition, the patient was encouraged to begin stationary biking to improve aerobic fitness. Furthermore, he commenced various poprioception exercises such as balancing with one leg on the floor, and progressing to balancing with both legs on a wobble board. Chiropractic treatments included mobilization of the knee and ankle joints, soft tissue therapy of the calf musculature, and treatment to the lumbo-pelvic region. The treatment modality of choice for this particular patient was Low Level Laser Therapy (LLLT), with parameters set for anti-inflammatory and biostimulatory effects.

During the third phase of therapy (week 5-6), return to pre-injury sport activities was initiated. The patient continued range of motion and strengthening exercises, and added calf raises and leg presses to his program. The proprioception exercises progressed to rocking the board and performing one-leg balance exercises. Chiropractic treatment of joint mobilization, soft tissue techniques, lumbopelvic treatments, and the use of LLLT was continued. He was gradually introduced to sport-specific movements, specifically eccentric movements of the calf, quick pivots, jumping, and squatting. He achieved pain-free full

range of motion in the affected leg. Manual muscle testing showed MRC grade five strength in all major muscle groups of lower limbs, including hip, knee, and foot muscles. There were no signs of giveaway weakness from pain inhibition noted in the muscle testing of the affected limb.

At 9-month follow-up post injury, there was no residual impairment in the gastrocnemius muscle function, however, palpation and inspection revealed a slight defect of the medial wall of the gastrocnemius tendon. The strengthening and stretching exercise routine was continued to reduce the risk of re-injury.

Discussion

The tear of the gastrocnemius muscle is sometimes termed "tennis leg", due to its frequent occurrence in younger athletes involved in the sport.[1,2] This injury, however, is not limited to the athlete, and is commonly seen in middle-aged or older patients, usually over the age of 40[1,2,4] participating in physically demanding activities despite suboptimal physical presentation[10]. In this category, the muscle may become predisposed to injury as a result of certain factors such as physiologic changes associated with muscle aging and a general loss of flexibility.[4] The mature athlete may experience gastrocnemius muscle tears while performing maneuvers that require sudden and swift changes in direction leading to overstretching of the muscle.[2]

The mechanism of a gastrocnemius tear is related to the extension of the knee with simultaneous forced dorsiflexion of the ankle.[2] In an effort to contract, the forces of the eccentric movement on the already lengthened gastrocnemius muscle lead to injury at the myotendinous junction.[12]

In the pathogenesis of this injury, studies have associated the tearing of the medial head of the gastrocnemius muscle at the musculotendinous junction.[1] Several factors have been documented to contribute to the susceptibility of a muscle to tear including the composition of type II fibres (fast contracting), extension across two joints, eccentric action, and fusiform stretch.[4,5,6,9] The gastrocnemius muscle injury is caused by the combination of its "biarthrodial architecture" and "rapid forceful contraction of type two muscle fibers".[7]

In an effort to identify the nature of the injury, a thorough interview may reveal that the patient is able to clearly recall the single major traumatic event at the source of the pain.[6] In addition, there is a significant decrease in the level of function of the patient immediately following the specific moment of injury. With a muscle tear or rupture, the patient is likely to have difficulty continuing with the sport or action.[13] The patient may make it know that there was sudden calf pain with a concomitant audible "pop".[4] The patient may also report the feeling of being physically struck in the lower calf.[4]

Observation of the patient typically shows an antalgic gait, bruising in the calf area, visible ecchymosis and significant swelling.[4,10] The physical examination aids in clinical diagnosis and may reveal a palpable defect in the medial belly of the gastrocnemius just above the musculotendinous junction.[2] There is usually muscle weakness with plantar flexion in the affected leg.[12]

Research has established that it is more common to find the involvement of the medial head of the gastrocnemius muscle in calf muscle tear injuries.[1,2,5,10] However, injuries to other soft tissue elements of the lower leg can lead to a differential diagnosis of tear to the plantaris tendon, soleus tendon, or peroneus longus.[2,4,12,13] The lateral head of the gastrocnemius has also been found to be involved in calf muscle tear injuries, although, rarely.[4] Clinical presentation may also suggest Achilles tendon strain or deep vein thrombosis or thrombophlebitis.[4,9,10,14] Likewise, the findings can often implicate a ruptured Baker's cyst as the source of the pain.[1]

The differential diagnoses can present a challenging obstacle for the practitioner and further imaging is often required.[15] Radiological examinations can prove invaluable in order to confirm the diagnosis and prepare an appropriate course of therapy.[10] The practitioner will find plain x-rays of no benefit as muscle tears in the calf do not affect the bones.[4,13]

Diagnostic ultrasound imaging can be considered the modality of choice to confirm or exclude grastrocnemius tear, to determine the extent of soft tissue injury, and to evaluate possible hematomas.[1] Diagnostic ultrasound technique can differentiate partial tears from complete tears of the muscle rupture, and detect the size of the defect.[4] When there is a question of possible deep vein thrombosis, Doppler ultrasound investigation is very useful for diagnostic clarification.[4] Diagnostic ultrasound imaging may reveal discontinuity of muscle fibres associated with extensive edema and hematoma and hypoechogen-

icity indicative of intramuscular fluid collection.[9] Some studies have concluded that the presence of a hematoma at the musculotendinous junction suggests that the tear is located at the medial head of the gastrocnemius muscle as opposed to the plantaris tendon which is an avascular structure.[5]

Magnetic resonance imaging (MRI) is most often used to delineate muscle injuries and allows differentiation between gastrocnemius and other soft tissue injuries, improving treatment management.[4] MRI imaging often reveals intramuscular or musculotendinous junction hyperintensity, indicative of edema and hemorrhage and hematoma at the musculotendinous junction is pathognomic.[9]

When considering the use of imaging, cost and availability are limiting factors that may determine the selection of certain diagnostic imaging modalities. There are advantages and disadvantages of diagnostic ultrasound and MRI investigations[12], but both can be used to confirm the tear, localize the injured muscle and determine extent of injury[7]. However, affordability and accessibility make diagnostic ultrasound the modality of choice.[5,16]

The literature supports the conservative treatment of gastrocnemius tears[1,4,5,7,10,13,17] with healing occurring anywhere from 3-6 weeks[2] with comprehensive rehabilitation. Factors such as non-compliance to treatment and the presence of widespread bruising for days preceding treatment have been demonstrated to delay recovery.[13] Henning et al.[18] emphasized that with respect to the natural history of the gastrocnemius tear, there are no clear patterns. While research has demonstrated that rehabilitation can facilitate return to function, the threat of re-injury remains. In addition, the patient may experience long term symptoms of pain and limited function based on the severity of the injury and success of therapy.[7]

Initial intervention includes limitation of activities and the use of crutches or a cane to assist with mobility, and this can be useful for the first 1-2 weeks. This can help control hemorrhaging and pain.[7] In addition to protection of the lower leg, researchers recommend rest, ice, compression, and elevation.[4,5,7,10,13] Neoprene sleeves are useful for early compressive treatment to decrease in the amount of hemorrhage following the injury amount and facilitate early ambulation.[10,19] However, studies have shown that the application of heat and soft tissue techniques such as massage are contraindicated in the initial phase of therapy as these therapeutic interventions may increase the risk of hemorrhage.[7]

In the sub-acute phase, rehabilitation should consist of passive and active stretching program, soft tissue techniques, and proprioception training.[7] The use of modalities such as low level laser therapy, therapeutic ultrasound, and electrical stimulation are appropriate as part of the treatment plan.[7] In addition, friction massage may help decrease the formation of adhesions.[7] As range of motion improves, the patient may progress from isometric and isotonic exercises, to dynamic training exercises.[7] The general conditioning exercises, closed-chain exercises, and sport-specific exercises helped the patient gain strength and agility.[7]

Orchard et al.[20] concluded that there is a lack of agreement in the current research regarding guidelines for return-to-sport following muscle tears. An appropriate benchmark for return to pre-traumatic activity level is the ability to ambulate without pain.[10]

Medical management is required if a large hematoma is present and requires drainage or there is the development of myositis ossificans that complicates the clinical presentation.[7,13] Surgical intervention, such as a fasciotomy, is considered when there is an associated acute compartment syndrome.[8,13,21] In fact, some studies have shown the inability to perform a single heel rise is an indicator for surgical intervention.[13]

Conclusion

Calf muscle tear injury, also termed "tennis leg", is a relatively common clinical condition involving damage to the medial head of the gastrocnemius muscle. Understanding the epidemiology and obtaining a comprehensive clinical history can aid in the diagnosis. The physical exam, including observation, palpation, orthopedic testing, and gait analysis, allows the practitioner to localize the area of injury and asses the severity of soft tissue damage. Both diagnostic ultrasound and MRI imaging allow the practitioner to rule out other pathologies and provide useful information to direct therapeutic management. MRI imaging is considered the gold standard in suspected gastrocnemius tears due to the better-quality soft tissue contrast and spatial resolution, in addition to greater reproducibility.[5] The diagnostic ultrasound, however, is more accessible and cost effective, perhaps making it the preferred modality for evaluating injuries to soft tissue structures.[5]

With an accurate diagnosis and comprehension of classification of muscle tear injuries, management of gastrocnemius tears is straightforward. Applying the principles of protection, rest, ice, compression, and elevation at the onset of injury is critical. Rehabilitation in the subacute phase facilitates the healing process and timely return to pre-accident activities.

The possibility of an isolated tear of the medial gastrocnemius tendon should be considered in a patient presenting with posterior lower leg pain and a palpable defect in the posterior aspect of the calf.

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Chronic recurrent multifocal osteomyelitis in a 13 year old female athlete: a case report

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Chronic recurrent mutlifocal osteomyelitis (CRMO) is an extremely rare skeletal disorder in the younger population. It presents with multifocal bony lesions that often mimic more sinister diagnoses such as infection or neoplasm. The cause of this condition remains unknown and there is limited evidence on effective treatments. In this case, a 13-year-old female athlete presented to a sports chiropractic clinic with non-traumatic onset of right ankle pain. After failed conservative management, radiographs and MRI were obtained exhibiting a bony lesion of the distal tibia resembling osteomyelitis. The patient was non-responsive to antibiotics, which lead to the diagnosis of CRMO. CRMO should be considered as a differential diagnosis for chronic bone pain with affinity for the long bones of the lower extremity in children and adolescents. The role of the primary clinician in cases of CRMO is primarily that of recognition and referral for further diagnostic investigations.

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KEY WORDS: osteomyelitis, bone lesion, athlete, leg pain, adolescent

L'ostéomyélite multifocale chronique récurrente (OMCR) est une maladie du squelette extrêmement rare qui touche les jeunes. Elle présente des lésions osseuses multifocales qui imitent souvent des diagnostics plus sinistres tels qu'une infection ou une tumeur. La cause de cette maladie reste inconnue et il y a peu de preuves sur les traitements efficaces. Dans ce cas, une athlète de 13 ans s'est présentée à une clinique chiropratique sportive avec l'apparition non traumatique de douleurs à la cheville droite. Après l'échec des traitements conservateurs, les radiographies et l'IRM ont montré une lésion osseuse du tibia distal ressemblant à une ostéomyélite. Comme les antibiotiques n'agissaient pas sur la patiente, on en conclut qu'elle souffrait d'une OMCR. L'OMCR doit être considérée comme un diagnostic différentiel des douleurs osseuses chroniques, surtout des os longs des membres inférieurs chez les enfants et les adolescents. Le rôle du médecin traitant en cas d'OMCR est de la reconnaître surtout et de renvoyer le patient pour des tests diagnostics avancés.

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MOTS CLÉS : ostéomyélite, lésion osseuse, athlète, douleur à la jambe, adolescent

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Introduction

Chronic Recurrent Multifocal Osteomyelitis (CRMO) is an extremely rare skeletal disorder most commonly found in the long bones of children and adolescents. CRMO was first described in the literature in 1972 by Giedon et al.[1] who described the lesion as "an unusual form of multifocal bone lesions with subacute and chronic symmetrical osteomyelitis". Since 1972 approximately 200-300 cases have been reported in literature[2], and none in the chiropractic literature. Its estimated prevalence is 1-2 per 1 million people and accounts for only 2-5% of osteomyelitis diagnoses.[3] But this statistic may be misrepresentative of the true prevalence, as this condition is thought to be under reported or misdiagnosed. As more research becomes available and awareness for CRMO increases, the reported number of cases may increase accordingly.

The name CRMO was derived from its radiographic appearance which is similar to osteomyelitis. It generally presents as lytic destruction with sclerotic borders within the metaphysis, mimicking an infectious or neoplastic process. Despite the radiographic similarities, CRMO is a misnomer. The condition although chronic and recurrent, is not an infectious process. Hence, CRMO is commonly used interchangeably with Chronic Non-Bacterial Osteomyelitis (CNO). Also, it need not be multi-focal as cases have shown uni-focal presentations as well. CRMO is widely believed to be a pediatric equivalent of SAPHO syndrome.[4] SAPHO syndrome (synovitis, acne, pustulosis, hyperostosis and osteitis) is an inflammatory bone disorder that commonly presents with skin manifestations.

This case report focuses on CRMO of the distal tibia and highlights the importance of considering this diagnosis for chronic recurrent, lower extremity bone pain in adolescents. This case report outlines the pertinent aspects of epidemiology, clinical presentation, diagnosis and management of this condition.

Case

A 13 year old female patient presented to a sports chiropractic clinic with right ankle pain of 2 weeks duration. She did not recall a precipitating event and related the pain to her active lifestyle. She localized the pain to the anterior region of the right medial malleolus and described the pain as sharp and painful to touch. The ankle pain was aggravated during her dance and volleyball practices when she was jumping, lunging or running. Although rest improved her symptoms, the pain remained constant and rated between a 6-8/10 in intensity.

She had no history of lower extremity injuries but reported a history of bilateral Achilles tightness, sore feet and right ankle stiffness attributed to her training. She reported a history of chronic musculoskeletal complaints including bilateral knee pain, back pain, shoulder pain and headaches. She additionally noted that she suffered from dry, sensitive eczematous skin. She reported no symptoms of fever, lethargy or weakness.

Her family history revealed that her father suffers from chronic spinal pain particularly in the thoracic region with notable hyperkyphosis of the thoracic spine, bilateral wrist pain with weakness and aquagenic pruritis.

On examination the patient presented with no noticeable swelling, bruising or deformity of the right ankle. On standing observation there was moderate pes planus bilaterally, but otherwise foot and ankle alignment was unremarkable. The patient reported mild pain with walking and displayed a mild ($<10^0$) out-toeing on the right. On palpation the patient reported tenderness over the right medial malleolus and distal tibia, and muscular tenderness along extensor hallicus longus, tibialis anterior and tibilias posterior on the right. Active range of motion revealed a 25% decrease in dorsiflexion of the right ankle in comparison to the left. Resisted testing of anterior, lateral and posterior compartments of the lower leg revealed full strength. Anterior drawer test, Kleiger's test and Syndesmotic testing was negative. Reflexes, sensory and motor testing of L4-S1 was within normal limits bilaterally.

The clinical impression was chronic repetitive strain of the anterior and deep posterior compartments. The patient was educated on the possibility of a stress fracture and was advised to visit her family physician regarding an x-ray.

The patient underwent a course of treatment including myofascial release of lower leg muscles, mobilization/manipulation of the ankle mortise joint and Tanda laser therapy (3-660 nm red SLDs; 33-870nm infrared SLDs; delivering 5 Joules/cm^2 over 3 minutes). The patient was seen weekly for 4 weeks. The patient was also recommended to take a two week rest period from active participation in dance and volleyball.

Subsequent to 4 weeks of treatment the patient had re-

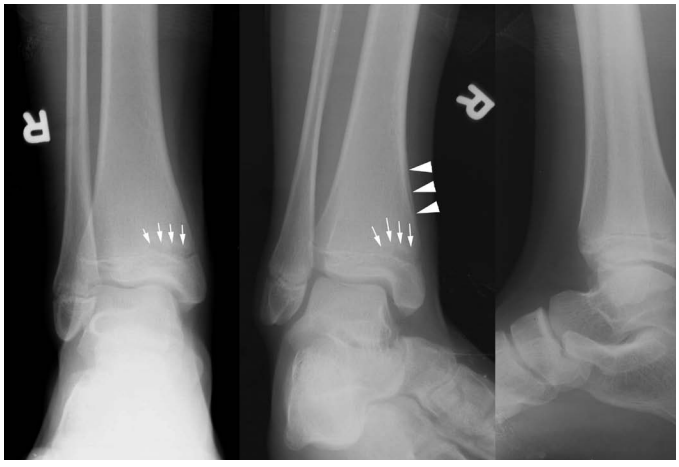

Figure 1
Plain films of AP, medial oblique and lateral views of right ankle. Radiographic images of the right ankle show a geographic lucent lesion with a hazy band of sclerosis at the medial aspect of the distal tibial metaphysis abutting the growth plate spanning 1/3 of the tibial girth (white arrows).

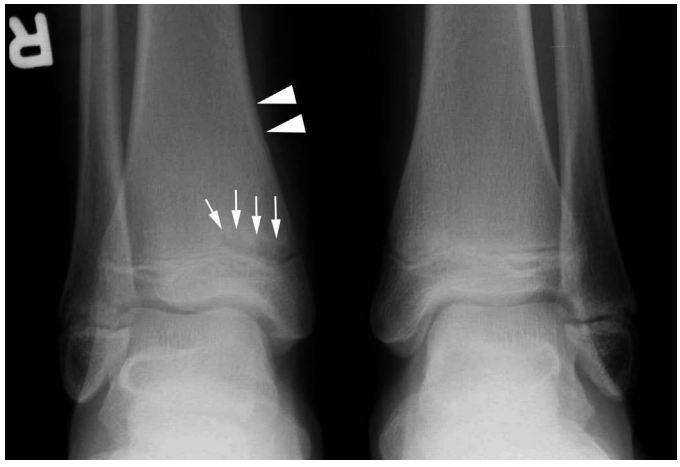

Figure 2
AP comparison view of both ankles. A comparison view the ankles allows for better appreciation of the lucent metaphyseal lesion. A subtle thin layer of periosteal reaction (arrow heads) is observed at the medial metadiaphysis of the distal tibia on the anteroposterior view and better appreciated on the medial oblique view in Figure 1.

sumed her normal activities and had considerable relief of symptoms. She was recommended to continue with her normal activities and follow up in two weeks.

Two weeks later, the pain began to intensify again and plain film radiographs were ordered. (Figures 1 and 2). A diagnosis of osteomyelitis was rendered and the patient was started on a course of oral antibiotics for 4 weeks.

During the course of antibiotic treatment, the patient reported a worsening of symptoms. She was subsequently recommended for an MRI to assist in ruling out any other causes of her symptoms. MRI of both ankles was obtained with gadolinium contrast injection (Figures 3-4). The patient was referred to a rheumatologist and was prescribed a course of celebrex and symptomatic relief was achieved. Based off the MRI findings, clinical presentation, ineffective response to antibiotic treatment and effective NSAID treatment the diagnosis of Chronic Recurrent Multifocal Osteomyelitis was made.

Once symptomatic relief was achieved the patient was removed from the course of celebrex and has since been symptom free. The patient currently takes Aleve on an as needed basis. The patient has returned to full activities of daily living and sport with no recurrence of symptoms to date.

Epidemiology

CRMO is a rare pediatric bone disorder that has unknown etiology. Although exact cause of CRMO is unknown, theories include inflammatory disorder, genetic disorder, autoimmune disorder, juvenile seronegative spondyloarthropathy (SNSA) or a low virulence infectious organism.[5]

CRMO is most commonly found in the metaphysis of long bones of the lower extremity in children and adolescents. Common locations for CRMO include the tibia, pelvis and femur, but some cases have been shown in the calcaneus, spine, clavicle, mandible, sternum among other locations.[6] The mean age of onset is 10 years of age (range 4-17) and CRMO appears more commonly (up to 67-85%) in females.[7]

The clinical course of CRMO is prolonged, recurrent and self-limiting. Prognosis of CRMO is unpredictable in nature and can last for upwards of 25+ years and is thought to resolve spontaneously, regardless of inter-

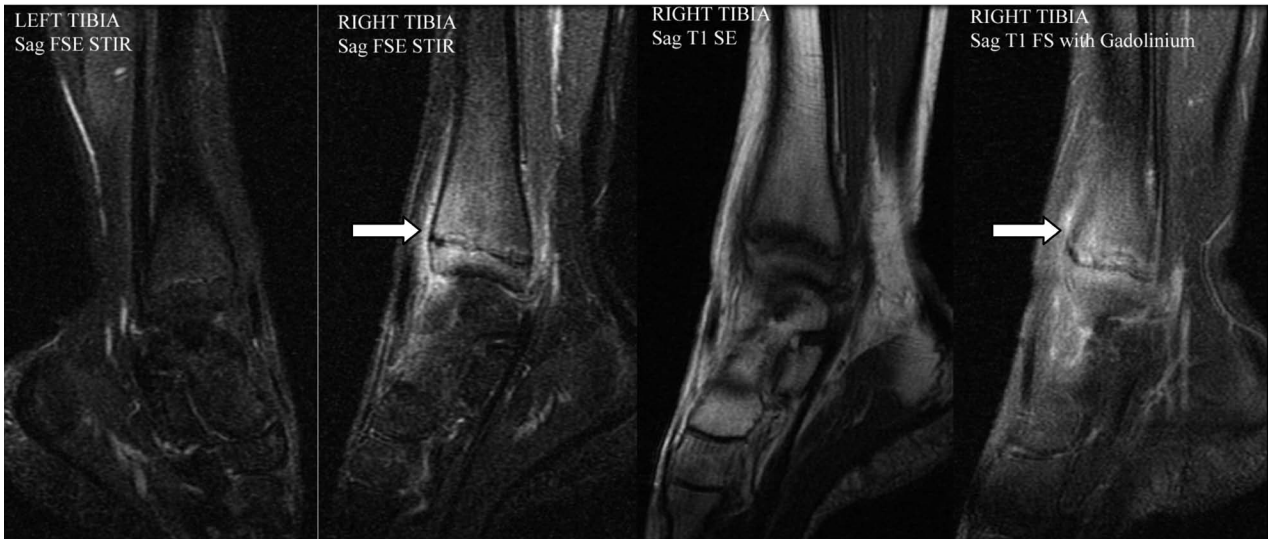

Figure 3
Medial parasagittal images of the right ankle in STIR, T1 and T1 with gadolinium contrast sequences with comparison left parasagittal STIR image in the same plane show marrow edema in the distal tibial metaphysis and epiphysis and surrounding soft tissue edema in the right distal tibia.

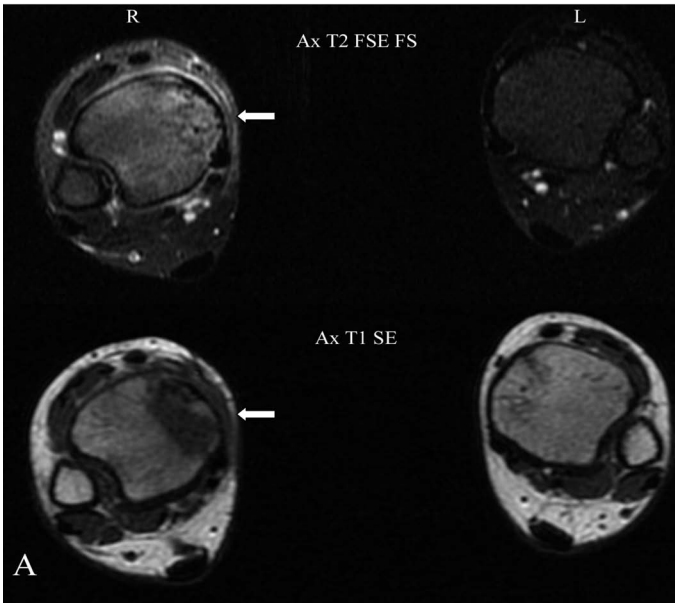

Figure 4A
Axial T2 FSE FS and T1 SE images at the level of distal tibial metaphysis above the physis show marrow edema (hyperintense T2 and hypointense T1) at the medial third of the tibial metaphysis when compared to the normal left distal tibia.

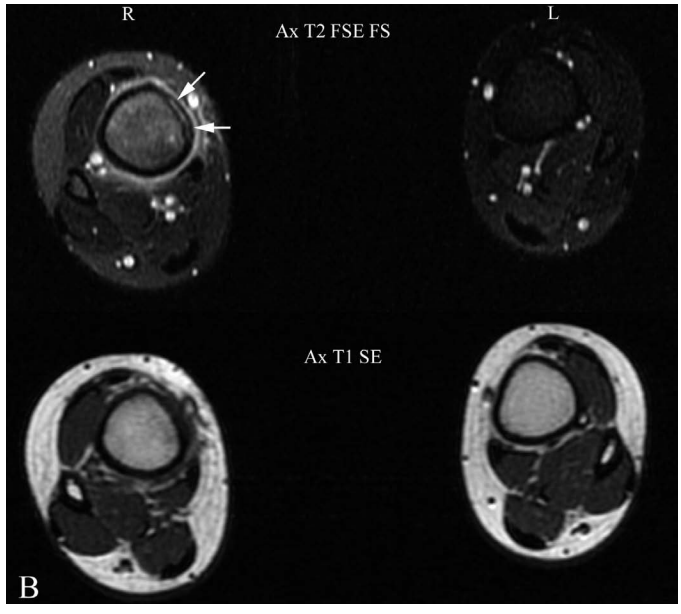

Figure 4B
Axial T2 FSE FS and T1 SE images at the level of distal tibial metadiaphysis show marrow edema, surrounding soft tissue edema as well as a layer of periosteal reaction (white arrows) at the medial aspect of the tibia observed on the axial T2 FSE fat saturation sequence.

vention. Retrospective studies looking at the course of CRMO have documented a prevalence of 25-59% after a median of 10 years follow up.[7]

Clinical Presentation

The clinical presentation of CRMO is variable, dependent upon the location of the lesion and stage of the disorder. CRMO is a chronic disorder that can cycle in and out of painful bouts of localized bony pain and tenderness for months to years. Many cases may have been mistaken as growing pain and thus delay the correct diagnosis. The pain is insidious in onset and can present with associated swelling. The lesions are commonly multi-focal and symmetrical.[8] The average number of lesions is 3-4, but has ranged from 1-13. Symptoms can recur repeatedly at the same location, or new areas can be affected with subsequent flare ups. The flare ups occur insidiously and pain is often worse at night. Patients may experience low grade fever or general malaise associated with flare ups.[9] This has led to the incorrect diagnosis of osteomyelitis in many cases of CRMO. CRMO does not respond to antibiotic therapy as shown in this case. Similar to SAPHO, patients with CRMO may also present with an accompanied skin disorder such as pustulosis palmoplantaris or acne. In fact, current estimates suggest that up to 25% of CRMO patients have some sort of accompanying inflammatory disorder.[10] Also, it is estimated that nearly 50% of first degree and second degree relatives have an inflammatory disorder, suggesting a significant genetic component.

Diagnosis

An adolescent presenting with bony pain of the lower extremity generates a large list of differentials. CRMO should be included as one of these differential diagnoses. However, CRMO is a diagnosis of exclusion relying upon combination of clinical findings, diagnostic imaging and negative histological and microbiological examinations. Since there is no gold standard test to diagnose this condition, the path to diagnosis relies upon ruling out all other possibilities.[11] Due to the complex presentation, there is a large and variable list of differential diagnoses to consider (Figure 5). The mean time from symptom onset to diagnosis is estimated at 18 months (ranging from few weeks to several years), highlighting the difficulty of arriving at this diagnosis.[7]

Iyer et al.[12], have formulated systematic approach to assist in making the diagnosis of CRMO by exclusion using the following criteria:

DIFFERENTIAL DIAGNOSES FOR CRMO

- Bacterial Osteomyelitis
- Bone Bruise
- Fracture
- Osteonecrosis
- Juvenile Idiopathic Arthritis
- Osteosarcoma
- Ewing's Sarcoma
- Osteoblastoma
- Osteoid Osteoma
- Leukemia
- Lymphoma
- Neuroblastoma

Figure 5.
Differential diagnoses for chronic recurrent multi-focal osteomyelitis

1. Lack of causative organism
2. No abscess, fistula or sequestra formation
3. Radiographic appearance of sub-acute or chronic osteomyelitis
4. Atypical location compared to infectious osteomyelitis
5. Non-specific histopathologic and laboratory findings compatible with sub-acute or chronic osteomyelitis or other known disease process
6. Prolonged (> 6 months) and recurrent painful symptoms
7. Accompanying pustulosis palmoplantaris or acne

The laboratory findings suggest an inflammatory process with evidence of elevated ESR, C-reactive protein and alkaline phosphatase in approximately two-thirds of cases.[3] A tissue biopsy is commonly required in order to rule out more sinister diagnoses such as tumour or infec-

tion.[13] Cultures of blood and bone, along with microbial laboratory assays are negative for infectious processes.[10]

Imaging

Plain film imaging should be the initial assessment for children and adolescents with musculoskeletal symptoms that do not resolve within the natural history of soft tissue injury. Due to the variability of growth centres and subtleness of CRMO in the initial development, a comparison view of the contralateral side is crucial for proper imaging assessment of CRMO.

Diagnosing CRMO is challenging as it may manifest radiographically as normal, lytic lesion, sclerotic lesion or mixed lesion.[15] The varying manifestations are in part related to the age of the lesion and severity of the disease. Initially, CRMO manifests as a juxta-physeal lucent lesion in the metaphysis of long bones. Other sites include medial clavicle, vertebral bodies, mandible, pelvis and ribs. Due to its inflammatory nature, reactive bone formation surrounding the lucent lesion as well as periosteal reaction eventually develop. Radiographically, this state of CRMO can be confused with chronic physeal injuries in adolescent athletes.[16] With some CRMO cases where the course of the disease is recurrent and progressive, hyperostosis, medullary sclerosis and rare bony deformity may develop. In majority of CRMO cases, the disease is mild and the affected bones eventually remodel and normalize prior to skeletal maturity.

Use of bone scan, particularly the whole-body bone scan, is supported by many authors for the detection of multiple lesions, some of which may be asymptomatic at presentation. Increased uptake at the metaphysis of long bone in soft-tissue and delayed whole-body scintigraphy confirms abnormal bony activity at the metaphysis. Bilateral and multifocal presentation lends support to the diagnosis of CRMO which should be correlated and confirmed with plain film study. If plain film study is noncontributory, advanced imaging such as magnetic resonance imaging (MRI) is the imaging modality of choice.

Clinicians should choose MRI over CT scan in the imaging of young patients suspected of CRMO, particularly as it has no radiation hazard and it is very sensitive in detecting early subclinical lesions. Inflammatory process of CRMO manifests as marrow edema which shows up as hypointense on T1 and hyperintense T2 signals in the affected metaphysis, the adjacent epiphysis as well as the surrounding soft tissue.[17] As the disease progresses, hypointense T1 and T2 signal in the medullary space and cortex represents medullary sclerosis and cortical thickening observed on plain films as well as CT scan. Gadolinium contrast will enhance the bony lesion of CRMO and show up as hyperintense area.

Management

Due to the rarity of CRMO, there has been no randomized control trials regarding treatment of this condition and treatment has yet to be standardized. Treatment recommendations rely on expert opinion, and relatively small retrospective or prospective case series. No treatment to date has shown any promise for treating the disease itself. However, the most commonly used and accepted first line therapy is NSAIDs.[14] NSAIDs anecdotally have been shown to decrease symptoms in upwards of 80% of the population. NSAIDs can be used during painful attacks or can be used as maintenance therapy to prevent attacks. The goal of the treatment is to eliminate symptoms and minimize bone destruction until the disease resolves on its own. If NSAIDs do not provide pain relief then TNF-alpha antagonists, glucocorticoids, sulfasalazine, colchicine and bisphosphonates are considered for more severe cases. Although originally thought to be an infectious process because of its radiographic presentation and symptomatology, anti-microbial therapies have no effect on disease symptoms or progression and should therefore not be administered for CRMO.[5]

CRMO was first thought to lead to no long lasting deformity or disability in the majority of cases.[11] However, recent data suggests that residual physical impairments may persist in up to 50% of patients with CRMO.[2] These physical impairments include chronic pain, bone deformities, leg length inequalities and early growth plate closures. Due to nature of the pathological process in combination with some of the medications prescribed for CRMO, the integrity of the bone may be compromised. Patients should be advised of this, as pathological fractures have occurred in this condition.[10] The patient should be placed on modified activities until the integrity of the bones is more thoroughly assessed with imaging.

Discussion

Overall, CRMO is an extremely rare condition that can mimic much more sinister diagnoses such as malignancy or

infection. This case demonstrates a typical case of CRMO in an adolescent female. CRMO should be considered as a differential diagnosis for chronic, bone pain with affinity for the long bones of the lower extremity in children and adolescents. The key to diagnosing CRMO relies on ruling out a long list of potential alternative causes. The role of the primary clinician in cases of CRMO is primarily that of recognition. The first step of investigations for CRMO is radiographs. Due to the subtle radiographic findings of CRMO in early state of the disease and variability of adolescent bones, a radiograph of the unaffected side should be included as comparison. As articulated in this case, CRMO can resemble bacterial osteomyelitis which results in treatment with anti-microbial therapy. When a patient with suspected osteomyelitis does not respond to anti-microbial therapy then CRMO should rise higher on your list of differential diagnoses. Other factors that should raise your clinical suspicion for CRMO would be a personal or family history of autoimmune or inflammatory conditions, multiple lesions and prolonged, fluctuating nature of symptoms. It often takes months to years to arrive at diagnosis of CRMO.

This case illustrates a relatively quick arrival at diagnosis as the health care providers ordered radiographs and subsequent MRI when the patient was not responding to care. When diagnosed with CRMO, NSAIDs appear to be the first line of therapy and a trial should be administered. Clinicians should inform patients on the self-limiting, recurrent and prolonged nature of CRMO. They should also be aware that the nature of this condition, along with some of the medications for it can lead to decreased integrity of the bone. There have been reported pathological fractures with CRMO and this rare, but severe consequence should be articulated. Although CRMO is an extremely rare condition, the symptoms it manifests can lead to a patient seeking chiropractic care. A child or adolescent with insidious, recurrent bony pain will put any clinician on high alert. As a primary care clinician it is important to keep the diagnosis of CRMO in your mind under the circumstances stated in this case report, as this condition can commonly go undetected, misdiagnosed or mistreated.

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Entrapment of the saphenous nerve at the adductor canal affecting the infrapatellar branch – a report on two cases

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Objective: *To present 2 cases of entrapment of the saphenous nerve at the adductor canal affecting the infrapatellar branch, and to provide insight into the utilization of nerve tension testing for the diagnosis of nerve entrapments in a clinical setting.*

Rationale: *Saphenous nerve entrapments are a very rare condition within today's body of literature, and the diagnosis remains controversial.*

Clinical Features: *Two cases of chronic knee pain that were unresponsive to previous treatment. The patients were diagnosed with an entrapment of the saphenous nerve at the adductor canal affecting the infrapatellar branch using nerve tension techniques along with a full clinical examination.*

Intervention and Outcome: *Manual therapy and rehabilitation programs were initiated including soft tissue therapy, nerve gliding techniques and gait retraining which resulted in 90% improvement in one case and complete resolution of symptoms in the second.*

Conclusion: *Nerve tension testing may prove to be*

Objectif : *présenter 2 cas de compression du nerf saphène interne au niveau du canal adducteur affectant la branche sous-rotulienne, et donner un aperçu de l'utilisation des tests de tension nerveuse pour le diagnostic des compressions nerveuses dans un cadre clinique.*

Justification : *les compressions du nerf saphène interne sont une affection très rare dans les documents scientifiques actuels, et le diagnostic reste controversé.*

Caractéristiques cliniques : *deux cas de douleur chronique au genou qui ne répondaient pas au traitement précédent. Le diagnostic des patients souffrant d'une compression du nerf saphène interne au niveau du canal adducteur affectant la branche sous-rotulienne a été réalisé grâce à des techniques de tension nerveuse et un examen clinique complet.*

Intervention et résultat : *des programmes de thérapie manuelle et de réadaptation ont été lancés, y compris le traitement des tissus mous, les techniques de glissement nerveux et la rééducation de la démarche, qui se sont traduits par une amélioration de 90 % dans un cas et la disparition complète des symptômes dans le second.*

Conclusion : *les tests de tension nerveuse peuvent*

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an aid in the diagnosis of saphenous nerve entrapments within a clinical setting in order to decrease time to diagnosis and proper treatment.

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KEY WORDS: nerve, saphenous, entrapment, adductor canal

s'avérer être une aide au diagnostic des compressions du nerf saphène dans un milieu clinique permettant de réduire le temps de diagnostic et de traitement.

(JCCA 2013; 57(4):341-349)

MOTS CLÉS : nerf, saphène, compression, canal adducteur

Introduction

Saphenous nerve entrapment affecting the infrapatellar branch can be a difficult diagnosis to make due to the intimate relationship of the nerve to many other pain generating structures in the knee. Saphenous nerve entrapment has been reported within the literature to be associated with or mimic a number of conditions including lumbar radiculopathy,[1,2] patellofemoral disorders,[2] suprapatellar plica,[2] tear of medial meniscus,[3] tibial stress fracture,[4] pes anserine tendonopathy or bursitis,[1,4] osteochondritis dissecans,[2] nonspecific synovitis[2] and reflex sympathetic dystrophy.[1,5-8]

It has been reported that less than 1% of adults presenting with lower extremity pain suffer from saphenous neuropathy,[9,10] however injury to the saphenous nerve is associated with a number of surgical interventions commonly utilized in today's medical community. Depending on the technique utilized, the incidence of sensory disturbances in patients who undergo arthroscopic surgery has been reported as 0.06% – 77%.[11-16] With regards to meniscal repairs specifically it has been reported that saphenous nerve injury occurs in 1-20% of patients.[3,17] Those undergoing ACL repairs are at risk of damage to the saphenous nerve at a rate of 30% – 59% depending on the technique utilized.[16,18-24] In patients undergoing treatment for varicose veins, it has been reported that damage to the saphenous nerve occurs in 0.5-5% of those undergoing endovenous laser ablation[25] and in up to 58% of those undergoing stripping of the great saphenous vein.[26] While cases of saphenous neuropathy following trauma do exist in the literature they are extremely rare despite the nerve's superficial location in the body and vulnerability during sport.[10,27] A potential reason for this may lie in the diagnosis of this condition.

The diagnosis of saphenous nerve entrapment is a difficult one to make and is met with controversy within the literature. Nerve conduction studies as well as diagnostic corticosteroid or anesthetic injections have been discussed in the literature as means to diagnose this pathology, however authors argue on the merits of either intervention for the diagnosis.[28-32] Furthermore, there is currently no literature available on the reliability or accuracy of these tests in the case of a saphenous nerve entrapment. The use of MRI and diagnostic ultrasound have also been discussed in the literature.[10] All of these diagnostic tests pose financial and time limitations in the clinical setting, particularly for the manual practitioner. The purpose of the current paper is to present 2 cases of saphenous nerve entrapment at the adductor canal and to highlight a nerve tension technique to aid in the clinical diagnosis of this condition.

Case 1 Presentation

A 29 year old recreational female baseball player and runner presented with right sided knee pain that had been increasing for 1 year in duration. The pain initially presented 15 years prior following a direct blow to the anteromedial patella from a line drive in a game of baseball. Radiographs were taken at this time and no fracture was reported. The initial pain from the trauma subsided, however a constant throbbing sensation was felt throughout the right leg. Physical therapy was performed over a 4 year period including ultrasound, interferential current, taping techniques and rehabilitative exercises which had no effect on the pain.

The pain was described as fullness in the knee with associated dull aching throughout the right leg and occasional stabbing sensations felt at the inferomedial aspect

of the right knee. Aggravating factors included prolonged standing, running, climbing or descending stairs. Pain during running would increase at the 4 minute mark and last for 24 hours. The pain was relieved by ice applied over the painful areas. The patient was a recreational runner, averaging between 10-15 kilometers per week, as well as participating in weight lifting and yoga. Within the past year a diagnosis of fat pad irritation of the right knee had been made and there was treatment for 7 months using Graston and muscle release techniques to the retinaculum of the knee, and affected soft tissue structures surrounding the joint. This had no effect on the patient's symptoms.

On June 21st, 2011 the patient's numerical pain rating scale was 10/10 immediately at the onset of running and her Lower Extremity Functional Scale (LEFS) was 71/80.[33]

Physical examination revealed full and pain free range of motion in the right knee, hip and ankle. Palpation revealed pain and tenderness along the inferior pole of the patella, superomedial retinaculum of the patella, vastus medialis, adductor canal, sartorius and psoas muscles on the right. Ligament and meniscal testing of the knee was negative. The chief complaint was recreated when palpation of the medial thigh at the adductor canal was performed. The saphenous nerve was tensioned by placing the leg in hip extension and abduction with full knee flexion (Figure 1). In this position, palpation of the adductor canal as well as the femoral triangle was increasingly painful and recreated the patient's chief complaint. During running gait analysis it was noted that the patient crossed midline resulting in an 'egg beater' gait pattern. The patient was diagnosed with saphenous nerve entrapment at the adductor canal affecting the infrapatellar branch.

The patient was treated 2 times per week for 8 weeks using vibration therapy for the saphenous nerve, muscle release therapy to hypertonic musculature surrounding the saphenous nerve and nerve flossing (Figure 2 A&B). The patient was also advised to run on a marked track to help avoid crossing midline during running, as well as to avoid aggravating positions and activities.

At the end of the treatment plan the patient subjectively reported a 90% recovery to date and was able to run 50 minutes without pain and experienced no pain after running. On September 13th, 2011 numerical pain rating scale

Figure 1
Position of neural tension for the saphenous nerve. Patient is placed in a side lying position with the hip extended and abducted and the knee flexed. In the present image the adductor canal is being palpated simultaneously in an attempt to recreat the patients chief complaint.

Figure 2 A & B
Starting and finishing position for saphenous nerve gliding technique. Patient begins the motion in relative hip extension, abduction and slight knee flexion and progresses to increasing amounts of knee flexion while decreasing the amount of relative hip extension in an effort to maintain a constant amount of neural tension while gliding the nerve along its anatomical path.

was 5/10 at 30 minutes of running and on December 10th, 2011 her score was 5/10 when running past 50 minutes duration. LEFS scores were 70/80 on September 13th, and 69/80 on December 10th.

Case 2 Presentation

A 55 year old recreational runner and triathlete presented with a complaint of chronic right medial knee pain. The pain began after the patient was climbing down from a shelf at work and felt a pull in the knee as she put her foot down onto the ground. She did not report any pops or snaps, swelling or any radiation or paresthesia into the leg, foot, hip or low back. The pain had quickly subsided however she went for a jog shortly after the initial pain for a distance of 4.5 km and felt pain return. The pain in the knee went away following the run. The patient had a previous history of similar knee pain due to her training regimen that included running, biking and swimming. She had previously been diagnosed with pes anserine bursitis secondary to lower kinetic chain dysfunction and had responded well to treatment including extremity manipulation, soft tissue therapy of the lower limb bilaterally and rehabilitation including stretches to the affected tissues.

Physical examination revealed point tenderness at the pes anserine insertion, tenderness of the muscle bellies and tendons of the gracilis, sartorius, and semitendinosus. A further assessment of her kinetic chain showed muscle tenderness in the psoas, gluteus medius and minimus, and at the border of her hamstring and adductor musculature. Joint restriction of her right ankle mortise and subtalar joints was also noticed. These findings were all consistent with her previous presentations and she was subsequently diagnosed with right pes anserine bursitis secondary to lower kinetic chain dysfunction.

The patient was treated 4 times over the course of 5 months and would report improvement following therapy but the pain would resume fairly soon after (sometimes within 2 hours of treatment). Her lack of progress was felt to be due to her continued training and her lack of consistent treatment. After 5 months of similar pain, the patient was increasingly frustrated with the lack of results and her inability to train at her expected level. A re-evaluation of her condition included a check of her femoral and saphenous nerves which were painful on palpation along their path including the medial border of the tibia, pes anserine insertion, the medial joint line at the sartorius and gracilis (just adjacent to the adductor hiatus), the adductor canal, femoral triangle and lateral border of psoas. The saphenous nerve was then placed in a position of tension (Figure 1) and palpation of the previously tender spots was increasingly painful. While in the position of tension, palpation of the adductor canal and medial joint line recreated the pain of chief complaint at the pes anserine insertion. The patient's diagnosis was revised to peripheral entrapment of the saphenous nerve at the adductor canal.

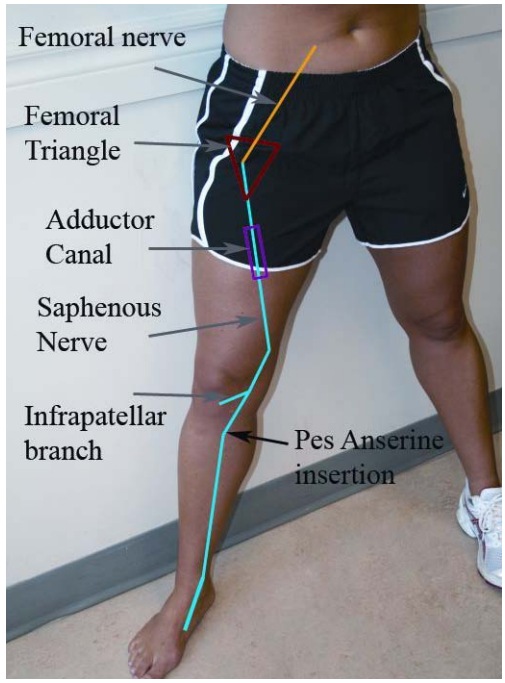

Figure 3
Anatomical course of the saphenous nerve

The patient's treatment plan was revised to include acupuncture of the right leg, myofascial release of the saphenous and femoral nerves, vibration therapy as needed and nerve flossing of the femoral and saphenous nerves (Figure 2 A&B). She felt a major improvement after the first visit and was treated twice more over a 2 week period. A follow up two months after the third visit revealed a complete resolution of the knee pain after the last visit. She reported being pain free for the two months even with training that included running, biking and swimming.

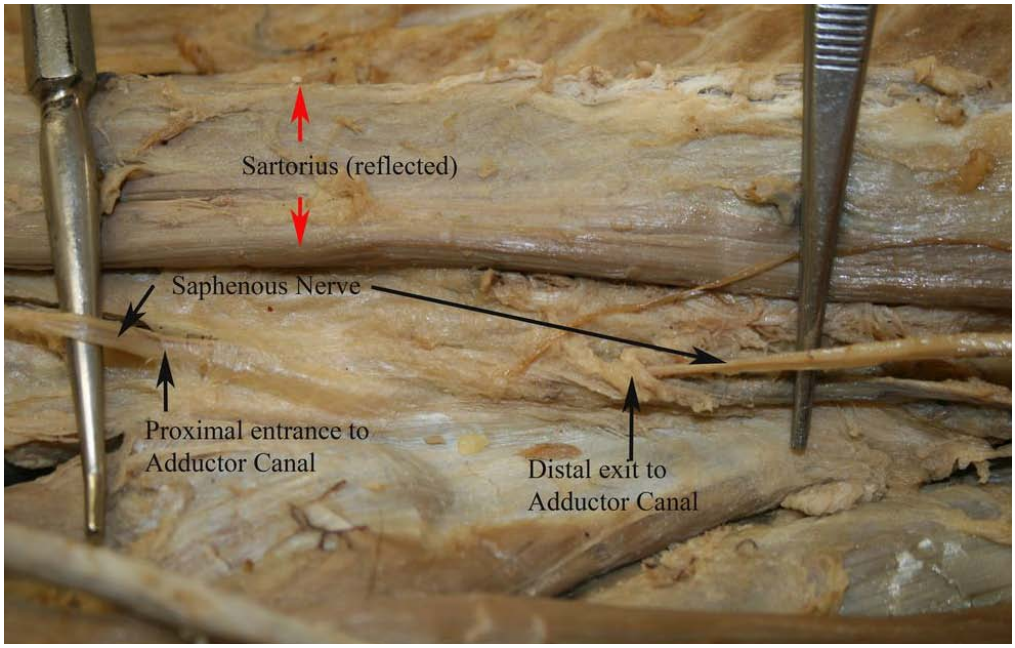

Figure 4
Saphenous nerve entering and exiting the adductor canal deep to the reflected sartorius muscle.

Discussion

The saphenous nerve is a purely sensory nerve, and is the longest terminal branch of the posterior division of the femoral nerve, arising from the L3 and L4 nerve roots.[10,34] From its origin below the level of the inguinal ligament, it travels within the thigh anteriorly with the femoral artery, until it becomes more superficial where it runs with the saphenous vein (Figure 3).[34,35] During its entire course in the thigh, the saphenous nerve runs deep to the sartorious muscle.[34-36] Within the proximal third of the thigh, the nerve enters the subsartorial, adductor or Hunter's canal, which is formed by a fibrous band spanning between the vastus medialis and the adductor magnus and adductor hiatus (Figure 4).[10,34,37] Here the saphenous nerve joins with the saphenous branch of the descending genicular artery and both structures pierce the roof of the subsartorial canal just proximal to the adductor hiatus.[10,34,35,37] It is at this point as well as within the adductor canal where the saphenous nerve is most susceptible to entrapment.

In addition to the saphenous nerve, contents of the subsartorial canal include the femoral vessels, the nerve to the vastus medialis, and other motor branches.[37] After exiting the subsartorial canal, the saphenous nerve branches into its two terminal branches, the infrapatellar branch, which innervates the infrapatellar fat pad as well as the rest of the anteromedial knee, and the descending branch which provides the distal sensory innervation to the skin and fascia on the anteromedial aspect of the leg and foot to the first metatarsal (Figure 5), as well as articular branches to the knee and ankle.[10,34-36]

The descending branch pierces the sartorius muscle or the superficial fascia between the gracilis and sartorious muscles to enter the subcutaneous tissue and travel distally in the leg.[10] The infrapatellar branch has also been described as piercing through the sartorious muscle to reach the subcutaneous layer.[38] At the level of the knee, the infrapatellar branch is susceptible to entrapment between the prominent edge of the medial femoral condyle and the tendon of the sartorious muscle (Figure 6).[10,39] The infrapatellar branch commonly presents with two terminal branches, superior and inferior, which have been identified as having two possibly variations in their orientation about the knee.[10,12,28,39] In the first variation the infrapatellar branch traverses across the proximal tibia medial

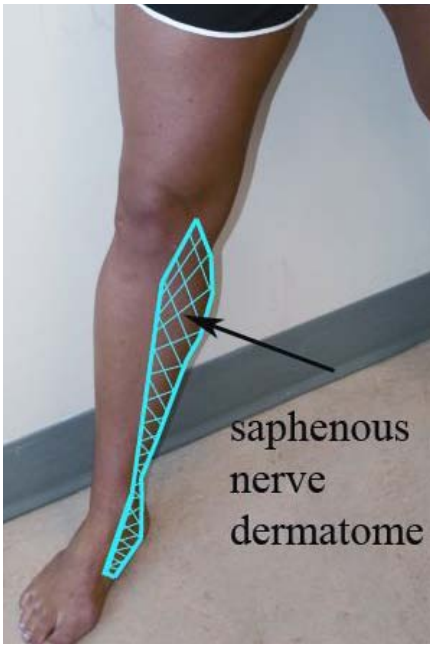

Figure 5
Sensory distribution of the saphenous nerve

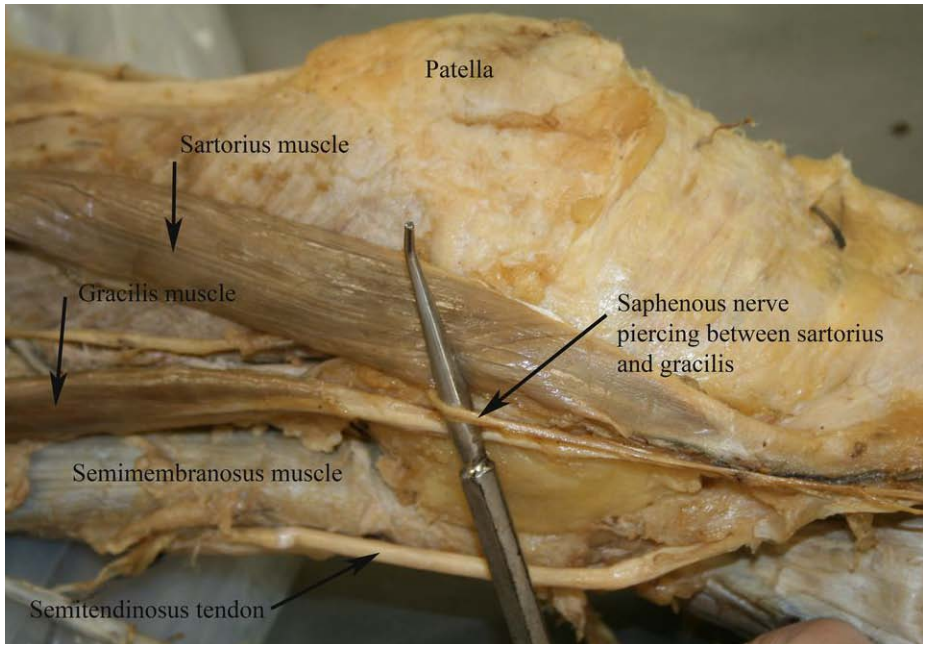

Figure 6
Saphenous nerve after it has exited the adductor canal passing between the sartorius and gracilis muscles at the level of the knee

to the patellar tendon, while in the second variation, the nerve passes laterally across the joint line and does not pass over the proximal tibia (Figure 7).[12]

A clinical examination of a patient with suspected saphenous nerve entrapment should include thorough history and physical examinations. On historical examination patients will typically present with complaint of medial knee and or leg pain,[9,29-32,40] pain with kneeling,[11,41] and there may be an associated trauma to the saphenous nerve via blunt trauma or previous surgical procedures.[10,32,41] The distribution of pain in saphenous nerve entrapment patients has been reported as at the knee (90%), thigh (7%) and calf (3%),[35] and it may also be present at night.[32] Physical examination may elicit hypoesthesia or dysesthesia in the absence of any motor weakness and a positive Tinel's test at the site of injury.[10] Patients may also present with pain on gait[30,32,40,41] and resisted adduction or flexion at the hip,[10,32,40] as well as pain on palpation at the adductor canal or the medial femoral condyle where the saphenous nerve pierces or wraps around the sartorius muscle.[35] Pain may also be elicited with prone hip extension (reversed Lasegue's sign) due to an increase in neural tension along the saphenous nerve.[10] Nerve tension testing is a technique utilized in aiding a number of diagnoses including cervical and lumbar radiculopathy, thoracic outlet syndrome and a number of peripheral nerve entrapments. By placing a patient with suspected saphenous nerve entrapment into a position of hip extension and abduction with full knee flexion (Figure 3), the clinician may be able to create further tension along the nerve in an attempt to recreate symptoms and assist clinicians with making a difficult clinical diagnosis. Our patients presented with knee pain which was reproduced in a position of neural tension for the saphenous nerve and increased in intensity upon palpation at the adductor canal and femoral triangle.

Once a clinical diagnosis of saphenous nerve entrapment has been made, further diagnostic testing such as nerve conduction studies, diagnostic injections or advanced imaging may be warranted. In the presented cases, this diagnosis was not confirmed using nerve conduction testing, diagnostic injections or imaging. In a paper by Pendergrass et al., they report that despite having nerve conduction studies, MRI and ultrasound imaging in a case involving trauma to the adductor canal, the diagnosis of

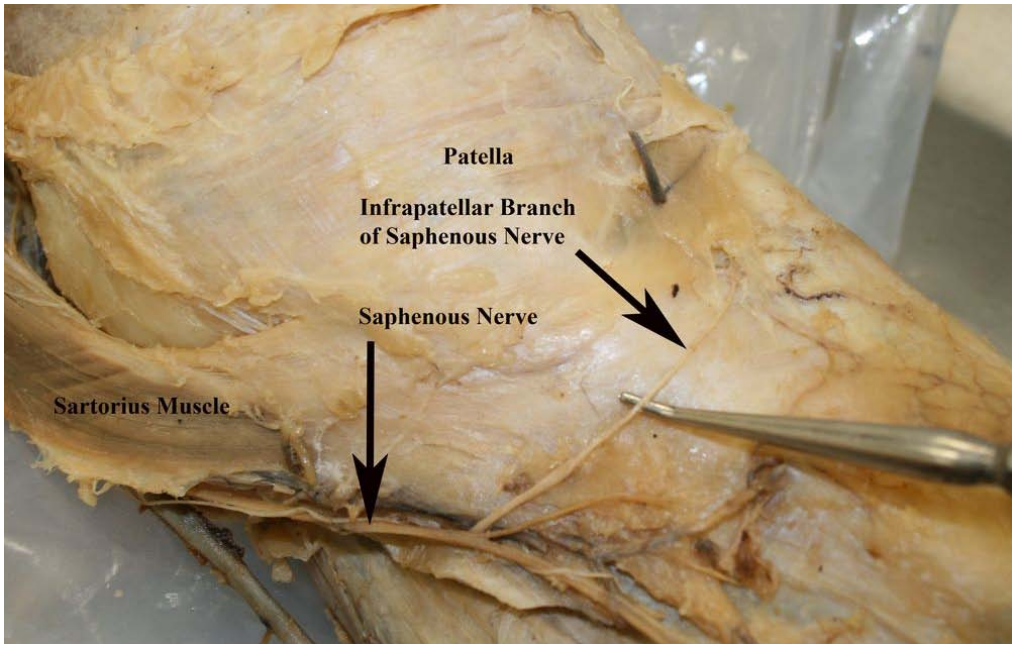

Figure 7
Saphenous nerve distal to the level of the knee giving rise to the infrapatellar branch and continuing into the distal leg

saphenous nerve entrapment was only considered after a thorough follow up clinical examination.[10] While nerve blocks are being performed as part of the diagnostic criterion for a number of case series in the literature,[1,29,30,35] this may not always be practical in a clinical setting, particularly when a trial of conservative treatment is going to be employed.

Treatments cited within the literature for saphenous nerve entrapments typically include corticosteroid injection and surgical debridement of any fibrous tissue surrounding the nerve.[9,10] To date there are no cases reported in the literature on manual therapy for the treatment of this condition. There is however a body of literature reporting on manual therapy for the treatment of a number of peripheral nerve entrapments including cubital tunnel syndrome, carpal tunnel syndrome, thoracic outlet syndrome, superficial fibular nerve entrapment and femoral nerve entrapment.[42-48] Within this literature, techniques utilized to treat the entrapment include nerve gliding, joint manipulation, soft tissue techniques, taping techniques and rehabilitative exercises to address joint dyskinesis.[42-46,48-50] In 2008, Coppieters et al. showed that an increase in nerve excursion of up to 30% can be seen in nerve gliding techniques versus nerve tensioning techniques, and showed up to 12.6mm of excursion of the median nerve using gliding techniques.[50] This data provides insight into the utilization of nerve gliding, vibration and manual therapy techniques for saphenous nerve entrapments. Caution should be utilized what selecting conservative treatment techniques for nerve entrapments as the literature available on these techniques is largely comprised of case reports and clinical commentary which limit our understanding of the impact a given treatment may truly have and what role natural history plays in a patient's recovery.

Due to the rarity of saphenous nerve entrapments, little is known on the prognosis or natural history for these patients. Difficulty in diagnosing this pathology warrants further research into its diagnosis, natural history and prognosis in a primary care setting. Diagnostic difficulties may be lessened through the systematic usage of nerve course palpation, nerve tensioning and palpation during neural tensioning, with the intent to recreate the patients chief complaint. The utilization of these techniques may

provide a key clinical tool for clinicians to utilize in the early detection and treatment of saphenous nerve entrapments and should be explored in future research.

Conclusions

Saphenous nerve entrapments are a very rare condition within today's body of literature. Difficulty in diagnosing this pathology may provide insight as to why there is such a limited body of evidence. Currently the main treatment options include surgical debridement and corticosteroid injections, however there is a body of evidence supporting the use of many manual therapy techniques for the treatment of various nerve entrapments throughout the body. Further insight into the utilization of palpation and nerve tension testing for the diagnosis of saphenous nerve entrapment in a clinical setting may pave the road for further insight into this rarely reported condition.

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Addressing the risk factors and prevention of Sudden Cardiac Death in young athletes: a case report

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Background: *Mandatory prescreening for the identification of risk factors and prevention of sudden cardiac death (SCD) is a widely debated topic within academic literature. In addition, the effective emergency management of sudden cardiac arrest (SCA) has reported lower survival outcomes (9% with bystander CPR, 24% with AED application) although improvements, such as strategic placements of AED units and Hands-Only (compression only) CPR, are being made.*

Purpose: *This case will outline the importance of establishing a true SCD incidence rate and the increased need for trained personal with proper equipment available to deliver immediate emergency cardiac management.*

Conclusion: *Given the lack of overall expert consensus and the low survival outcomes associated with SCD, a true incidence rate will need to be determined prior to developing a widely accepted policy. Since pre-screening all young athletes does not*

Contexte : *le dépistage obligatoire pour l'identification des facteurs de risque et la prévention de la mort subite par arrêt cardiaque est un sujet largement débattu dans la documentation spécialisée. En outre, la gestion efficace des urgences d'un arrêt cardiaque soudain s'est traduite par des taux de survie plus faibles (9 % avec les RCP de spectateurs, 24 % à l'aide de DEA) bien que des améliorations, comme les placements stratégiques des unités DEA et des RCP manuelles (pression uniquement), soient effectuées.*

Objectif : *ce cas va souligner l'importance d'établir un taux d'incidence réel des morts subites par arrêt cardiaque et le besoin accru de personnel qualifié doté d'équipement adéquat accessible pour assurer une gestion d'urgence immédiate des arrêts cardiaques.*

Conclusion : *compte tenu de l'absence de consensus global d'experts et les faibles taux de survie associés aux morts subites par arrêt cardiaque, il faut définir un taux d'incidence réel avant d'élaborer une politique largement acceptée. Étant donné que le dépistage*

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appear to prevent all SCD's, having properly trained personnel and easily accessible equipment at sporting venues, especially in remote locations, appears to be key.

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KEY WORDS: Sudden cardiac death, prevention, athletes

préliminaire de tous les jeunes athlètes ne semble pas empêcher toutes les morts subites par arrêt cardiaque, il semble qu'avoir un personnel bien formé et du matériel facilement accessible sur les sites sportifs, en particulier dans les régions éloignées, est essentiel.

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MOTS CLÉS : mort subite par arrêt cardiaque, prévention, athlètes

Introduction

Sudden cardiac death (SCD), a manifestation of electrical instability resulting in ventricular fibrillation or tachycardia, is defined as death occurring within 1 hour of symptoms.[1] Prescreening, a form of primary prevention of SCD, has been highly debated. In addition, secondary management through the use of cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) to improve survival outcomes reports low success rates.[2] Regardless of whether any and/or all athletes receive prescreening for cardiovascular risk factors, the necessary emergency training and equipment will need to be provided immediately if a life is to be saved.

Case Report

A 23-year-old professional hockey player collapsed during a recreational hockey game. There were no previous symptoms, contact or trauma reported with the collapse. Two other players began first aid. Due to the absence of pulses, they immediately began CPR, instructed bystanders to contact emergency medical services (EMS) while another player brought an AED to the scene. The AED was applied and discharged three times. The paramedics arrived 12 minutes after the onset of CPR and immediately transferred the patient to the local hospital. Following assessment, he was air transported to a major cardiac centre.

Upon admission to the intensive care unit (ICU), he was intubated and underwent hypothermic protocol. He had excellent recovery in the ICU and was subsequently transferred to the critical care unit for further monitoring. He underwent two echocardiograms; the first was performed almost immediately post-arrest and demonstrated decreased left ventricular function. The second however, demonstrated a normal left ventricular ejection fraction with moderate dilation of the right ventricle. Magnetic resonance imaging revealed some dilation of both ventricles, however, this may be secondary to his career as a professional athlete. According to the 2010 Revised International Task Force Criteria,[3] there was no evidence of arrhythmogenic right ventricular dysplasia/cardiomyopathy (ARVD/C). Additionally, there was no evidence of myocardial infarction, fibrosis, or scarring. Finally, angiography revealed normal coronary arteries.

The patient was diagnosed with sudden cardiac arrest (SCA) of idiopathic origin, and was recommended genetic testing follow up regarding the potential for non-structural channelopathies. Family history reveals the patient's father had successful triple bypass surgery otherwise previous history for heart conditions was unremarkable. The patient received an implantable cardioverter-defibrillator; correct QRS pattern was verified on electrocardiography and proper connection was confirmed. He was discharged with no medication and advised to follow up with the arrhythmia clinic and his family doctor. Since discharge, all testing has been unremarkable and he has not experienced recurrences of accelerated rhythms. It is important to note that due to the patient being a professional level athlete, he reports being pre-screened including a heart rate, blood pressure and electrocardiograph testing at the beginning of every season without any abnormalities observed.

At the current time, the patient has not been cleared to return to professional hockey. He was allowed to participate in physical activity although intense, vigorous

activity was to be avoided. It is not known to the authors whether this hockey player will ever return to the competitive level.

Discussion

The incidence rates of SCD in athletes from the ages 12-30 years old vary in the literature with a range of 1-3.6 per 100,000 athletes per year.[1,4] In a major prospective study conducted in the Veneto region of Italy, the incidence rate of SCD in athletes was 1.9:100,000.[4] The Corrado et al. study was significant as it was the first to observe a nation wide, mandatory reporting of sudden death. The study confirmed the cases of SCD using autopsy, considered the gold standard of SCD diagnosis.[4] North American sporting bodies have yet to implement a mandatory reporting database although the National Collegiate Athletic Association (NCAA) does collect information as part of health and safety reports.[6] Although SCD appears rare, the true incidence rates of SCD in athletes will remain elusive so long as sporting bodies do not have a national database to report confirmed cases of SCD. The current case presents the difficulties in reporting for sport governing bodies. The incident did not occur during an official team practice or game; therefore recording the incident in an official sport registry would prove difficult.

Given the reported rarity of the event and the public attention received from high profile cases, improved reporting will be necessary before any conclusions on the risk of SCD in young athletes can be made. In addition, since a true measure of risk has yet to be ascertained and the events often appear spontaneous, the focus on secondary prevention through emergency management is paramount.

The survival rates of children and young adults under the age of 35 years old experiencing sudden cardiac arrest (SCA), considered to be cardiac arrest without progressing to sudden death, are reportedly low.[5] In a long term retrospective study, the overall survival rates of SCA in the general population under the age of 35 was 40.2%.[2] The main factors associated with improved survival rates were: witnessed arrest, initial rhythm of ventricular fibrillation or tachycardia, bystander CPR, and a public location of the event.[2] When an AED is used conjunction with CPR the survival rates improve significantly. In a large heterogenous population based study, the survival rates improved from 9% with just CPR alone to 38% with the use of an AED.[2] It should be noted that the study involved the entire population and one could speculate that the survival rates would be significantly higher at a sporting event where a trained individual with access to an AED unit is on site for the sole purpose of providing emergency management. Secondary prevention or emergency management within the sporting environment and academic literature has received much less attention than the role of primary prevention or prescreening. The importance of beginning secondary management immediately is reflected in the recent changes to CPR protocols. The American Heart Association (AHA) guideline on CPR and emergency cardiovascular care now recommends chest compressions to begin immediately.[6] Instead of proceeding with ABC's (Airway, Breathing, Chest compressions) assessment the new guidelines suggest C-A-B (Chest compressions, Airway, Breathing).[6]

The current case is an example of how effective properly trained individuals providing immediate emergency management can help save lives regardless of whether the athlete has been prescreened several times. It is also an indication of how remote environments such as recreational ice hockey games can increase the risk of SCD if a trained provider and AED is not available.

Prescreening is considered a primary prevention tool for preventing SCD in young athletes; however the protocols are debated in the literature. Some experts suggest a mandatory history and physical while others suggest a mandatory ECG in addition to a history and physical.[7] In 2005, the European Society of Cardiologists (ESC) published a consensus statement on mandatory prescreening in young athletes.[7](Table 1) Based on expert opinion, the consensus statement recommends all young competitive athletes be screened for cardiac abnormalities with a 12-lead ECG in addition to a history and physical.[7] In 2007, the AHA also published a consensus statement based on expert opinion.[8] The statement also recommends a targeted history and physical evaluation involving 12-key elements to be completed by a qualified examiner.[8] (Table 1) Although the two consensus statements differ in screening process (Figure 1), they agree a nation-wide screening protocol is necessary. The two statements also recommend a 2-year follow up after the initial screen. The statements do not however discuss the outcomes of false negatives and false positives. Given that athletes have albeit low risks for SCA and/or SCD, position statements

Table 1:
Detailed pre-participation cardiovascular screening protocols in athletes, of the European Society of Cardiology (2005) and the American Heart Association (2007). A positive finding in any of the screening criteria, as judged at the discretion of the examiner, clinically warrants further evaluation. Differences are denoted in bold font.

Preliminary Examinations		
	European Society of Cardiology	***American Heart Association***
Family History	– Premature cardiac death of any close family member **(<50 for males, <65 for females)**	– Premature cardiac death of any close family member **<50 years**
	– Heart disease disability of any close family member **(<50 for males, <65 for females)**	– Heart disease disability of any close family member **<50 years**
	– Knowledge of cardiac conditions of family members: cardiomyopathy, Marfan syndrome, arrhythmia, long QT syndrome, **Brugada syndrome**	– Knowledge of cardiac conditions of family members: cardiomyopathy, Marfan syndrome, arrhythmia, long QT syndrome
Personal History	– Chest Pain – Unexplained syncope or near-syncope – Unexplained dyspnea/fatigue out of proportion with exertion – **Palpitations or irregular heart beat**	– Chest Pain – Unexplained syncope or near-syncope – Unexplained dyspnea/fatigue out of proportion with exertion – **Prior recognition of murmur** – **History of elevated systemic blood pressure**
Physical Exam	– Physical findings suggestive of Marfans – Diminished femoral pulses – Presence of heart murmurs – Elevated brachial blood pressure – **Abnormal cardiac rate and/or rhythm** – **Abnormalities in ECG**	– Physical findings suggestive of Marfans – Diminished femoral pulses – Presence of heart murmurs – Elevated brachial blood pressure

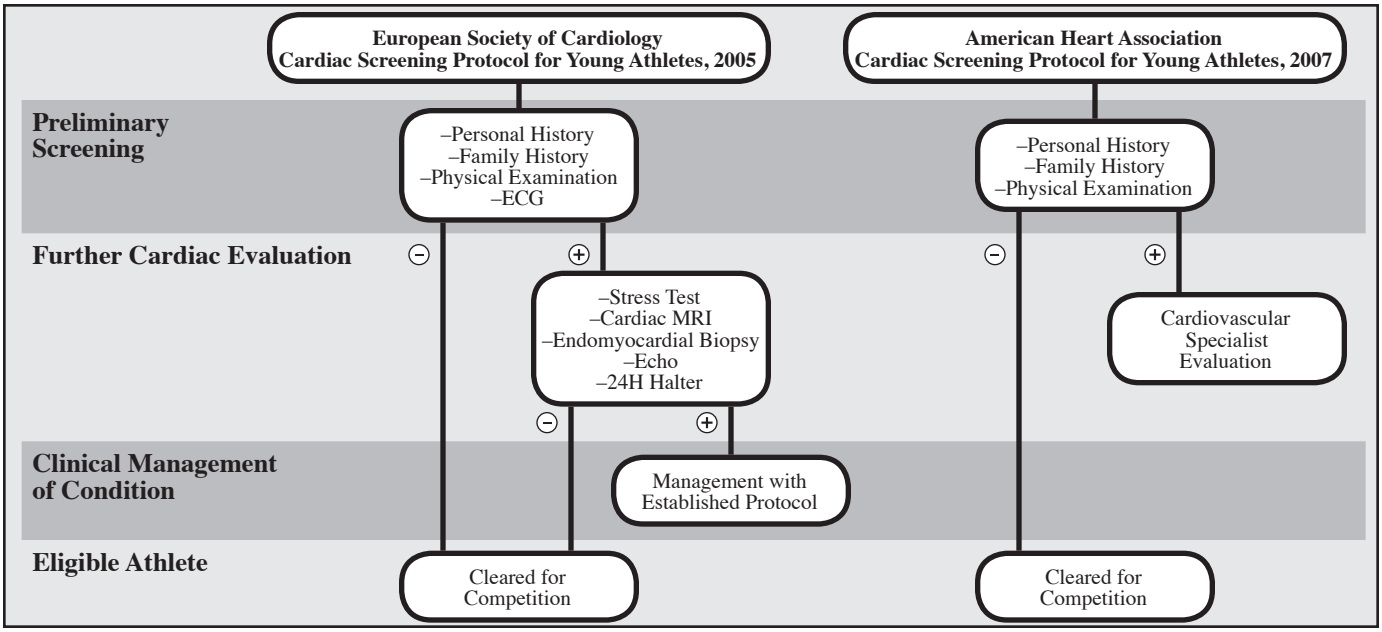

Figure 1
Flow chart comparison between 2005 consensus statements published by the European Society of Cardiology and the 2007 American Heart Association.

offered by governing bodies in sport indicates the importance of the issue. The American College of Sports Medicine (ACSM) currently recommends following the pre-participation screening supported by the AHA, although the ACSM also acknowledges that rigorous testing on pre-screening has yet to be completed.[9] The Canadian Academy of Sports Medicine (CASM) does not currently offer a position statement with respect to pre-participation cardiovascular prescreening. In the current case report it is possible that the athlete may not have been identified as 'at risk' for a cardiac abnormality using the above consensus statements. Prior to the cardiac emergency, the athlete participated in mandatory pre-screening each year provided by the league that included a cardiac pre-screen. He reported the pre-season screening involved a 12-lead ECG, history and physical for which he passed. Furthermore, after the incident occurred, the athlete's diagnosis was officially SCA of idiopathic origin.

Currently, the academic debate on mandatory pre-screening continues while the focus on secondary care survival outcomes involving CPR and AED within literature involving cardiovascular emergencies in young athletes at sporting events appears to be limited. As health-care providers begin to participate more and more in on-field care and acute emergency management, they will need to be prepared for SCA with possible progression to SCD. Advanced training in emergency first responder and the purchase of an AED unit is highly recommended and often a mandatory requirement of sport specialty fellowships.

Future studies need to identify the true incidence of SCD in athletes. A mandatory national-based reporting system that does not use media reports and are confirmed by autopsy needs to be established. Long-term athlete follow up is also necessary. Future studies will also need to address varying degrees of risk factors involved in SCD. For example, a case-control study may wish to examine the level of vigorous physical activity in individual sport. The amount of physical exertion required to participate may identify higher risk groups, however an absolute risk will be more difficult to elucidate.

Conclusion

In conclusion, SCD is a rare, however tragic, event that affects young, otherwise healthy, athletes. Given the low incidence rates of SCD in North America and the lack of clear supportive evidence in the role of primary prevention of SCD, secondary management with CPR and AED appears critical.[1] As observed in the current case, cardiac pre-screening did not prevent the cardiac emergency from occurring however the emergency on-site management may have effectively saved the athlete's life.

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The effects of kinesiotape on athletic-based performance outcomes in healthy, active individuals: a literature synthesis

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Context: *The effect of the application of kinesiotape to skin overlying musculature on measurable athletic-based performance outcomes in healthy individuals has not been well established.*

Objective: *To systematically search and assess the quality of the literature on the effect of kinesiotape on athletic-based performance outcomes in healthy, active individuals.*

Methods: *An electronic search strategy was conducted in MANTIS, Cochrane Library and EBSCO databases. Retrieved articles that met the eligibility criteria were rated for methodological quality by using an adaption of the critical appraisal criteria in Clinical Epidemiology by Sackett et al.*

Results: *Ten articles met the inclusion criteria. Seven articles had positive results in at least one athletic-based performance measure compared to controls.*

Conclusion: *Evidence is lacking to support the use of kinesiotape as a successful measure for improving athletic-based performance outcomes in healthy*

Contexte : *l'effet de l'application du Kinesiotape à la peau recouvrant la musculature sur les résultats des performances athlétiques mesurables chez les personnes saines n'a pas été bien établi.*

Objectif : *rechercher et évaluer systématiquement la qualité de la documentation sur l'effet du Kinesiotape sur les résultats des performances athlétiques chez des personnes saines et actives.*

Méthodologie : *une stratégie de recherche électronique a été mise au point pour les bases de données de MANTIS, Cochrane Library et EBSCO. Les documents extraits qui répondaient aux critères d'admissibilité ont été évalués pour leur qualité méthodologique à l'aide d'une adaptation des critères d'évaluation critique dans l'ouvrage Clinical Epidemiology par Sackett et autres.*

Résultats : *dix articles ont satisfait aux critères d'inclusion. Sept articles ont donné des résultats positifs dans au moins une mesure de performance athlétique par rapport aux groupes de contrôle.*

Conclusion : *on manque de données pour appuyer l'utilisation du Kinesiotape comme une mesure efficace pour améliorer les résultats de la performance athlétique*

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individuals. However, there is no evidence to show that kinesiotape has a negative effect on any of the performace measures.

(JCCA 2013; 57(4):356-365)

KEY WORDS: kinesiotape, performance, athlete

chez les personnes saines. Néanmoins, il n'existe aucune preuve pour montrer que le Kinesiotape a un effet négatif sur l'une des mesures de performance.

(JCCA 2013; 57(4):356-365)

MOTS CLÉS : Kinesiotape, performance, athlète

Introduction

Therapeutic taping protocols have demonstrated a well-established presence in the sporting world for years. The three main taping techniques accepted in North America are athletic taping, McConnell taping technique, and Kinesio Taping® technique.[1] It has been theorized that taping may prevent acute injury acquisition by enhancing proprioception via cutaneous afferent stimulation of the skin.[2] Kinesio Taping® technique, employing the newest form of elastic tape developed in the 1970s by Dr. Kenzo Kase, is customarily used for the treatment of sports injuries primarily by orthopedists, chiropractors, acupuncturists, and other medical practitioners.[3,4]

Today, Kase's product is marketed by various companies under brand names such as Spider Tech™, Kinesio® Tape, Kinesio® Tex Tape, Gold Tech™, KT Tape®, PerformTex™ and RockTape®, commonly known as kinesiotape (KT). After garnering international television exposure at the 2008 Beijing Olympic Games, KT has recently gained mainstream recognition for use on a number of conditions by therapists and patients of all backgrounds.[3] Over 150 thousand medical practitioners worldwide utilize KT in their practice.[5]

Kase describes KT as differing from traditional white athletic tape through its wave-like grain, elastic adhesive material, ability to stretch to 20-40% of its original length, and mimicking the thickness of human skin. When applied to the skin, KT is said to lift the fascia and soft tissue to produce additional space below the area of application.[6] Using the methods outlined by Kase et al.[6], the following advantageous effects are proposed to occur: (i) increasing proprioception by providing constant cutaneous afferent stimulation through the skin, (ii) realigning fascial tissue function by normalizing muscle tension, (iii) creating more space for improving circulation of blood and lymph flow by eliminating extra fluid, edema, or bleeding beneath the skin, (iv) correcting muscle function by strengthening muscle weakness, and (v) decreasing pain through neurological suppression. It has also been stated that KT can be used in the treatment and rehabilitation of injuries or as a preventative measure; it is designed to assist the body's natural healing process, provide support and stability to muscles and joints without limiting range of motion, and to extend the benefits of manual therapy by providing extended soft tissue manipulation.[7]

Despite its recent gain in popularity and the proposed theories of effectiveness, there remains a lack of sufficient evidence supporting these claims and current literature is limited in its ability to draw discernible conclusions. At this time, there is no known systematic literature review commenting on the effects of KT on athletic performance outcomes in healthy individuals. KT has the potential to be a valuable clinical intervention due to the fact that it is highly accessible, simple to apply, and not very restrictive. Therefore, it is important to evaluate the proposed theories to determine their efficacy. The aim of this literature synthesis is to assess the effects of KT on athletic-based performance outcomes in healthy, active individuals.

Methods

Search Strategy

A literature search was conducted using MANTIS, Cochrane Library and the following data bases, through EBSCO publishing: MEDLINE, CINAHL, SportDISCUS, Index to Chiropractic Literature, Alt Health Watch, AMED, Nursing and Allied Health Collection, Psychology and Behavioural Sciences Collection, Rehabilitation & Sports Medicine Source. Only peer reviewed English language articles from January 2000 through to October

2011, purporting to contain information on the subject of the effects of kinesiotape on measurable athletic performance outcomes were selected for review. The selection criteria for incorporated articles consisted of literature reviews, randomized controlled studies, cohort studies and cross-sectional studies to ensure all relevant information was obtained. A series of searches were performed using the following MeSH terms: kinesiotape, kinesiotaping, kinesio tape and kinesio taping and similar terms in CINAHL and SportDISCUS. These terms were combined with text words to capture, for completion: athletic tape, endurance, strength and performance, which were not MeSH terms. Using the AND Boolean operator, a combination of MeSH terms with text words was conducted. Reference list examination was conducted to further identify potential relevant articles that may not have been included in the initial electronic search.

Table 1:
Review of Eligibility Criteria

Inclusion Criteria	Exclusion Criteria
Literature reviews, randomized controlled trials, cohort studies and cross-sectional studies	Case-control studies, case studies, and personal narratives
Published in peer-reviewed journal	Published in a non-peer reviewed journal
Published in the English language	Not published in the English language
Human subjects	Animal subjects
Published between January 2000 and October 2011	Published before January 2000
Intervention group provided with Kinesiotape	Intervention group did not use Kinesiotape
Control group that did not use Kinesiotape	No control group
Healthy subjects	Unhealthy subjects
Performance-based outcomes	Non athletic-based outcomes

Screening of Citations

The three authors independently evaluated the results from the electronic search. The titles and abstracts found in the electronic search were examined to determine which articles met the basic criteria to be included in the review. All of the obtained full text manuscripts were evaluated using the inclusion criteria indicated in Table 1. Interventions included the use of KT compared to a control group without KT. Studies must have contained information on the subject of the effects of KT on measurable athletic performance in healthy individuals only. These criteria were applied to all of the obtained manuscripts. Upon completion of the independent reviews, the authors compared their results and if disagreement between reviewers was identified, it was resolved by consensus.

Data Collection Process

The researchers collectively chose a total of 10 articles that met the inclusion criteria which were further evaluated based on the presence of 10 specific criteria. The criteria utilized to appraise each article were chosen collectively as a group among the researchers. However, to ensure that the appraisal scores were highly accurate depictions of each article's study design and protocol, each researcher independently evaluated the articles without collaboration. The 10 criteria chosen in order to critically appraise each article reflected the study's protocols and methods by evaluating specific details of the study's use of randomization and blinding procedures, interventions, sources of error and specific outcomes.

Firstly, details of the population used in the study were evaluated, including the procedures used in the assignment of subjects, the baseline characteristics of the subjects used in the study and the utilization of prognostic stratification, which reflected the study's ability to limit bias through the use of randomization. Secondly, the study method protocol was critically examined including the use of blinding procedures, the compliance to study methods, the costs and resources required for the study, the explanation of follow up procedures used in the study and the identification of sources of error, contamination or co-intervention in the study. Lastly, the outcomes of the research study were evaluated including the ability of the author to document the statistical and clinical significance of the outcomes derived from the study, as well as their relevance. Pooling of statistics was not completed for the included studies. The critical appraisal scores that were derived for each article were therefore based on the presence of 10 appraisal criteria, are highly accurate depictions of each article's design and protocol, and complete the data collection process utilized in the literature synthesis.

Table 2:
Critical Appraisal Criteria

1.	Was the assignment of subjects randomized?
2.	Were baseline characteristics of subjects similar between groups to limit bias?
3.	Was prognostic stratification used?
4.	Was an appropriate blinding protocol followed?
5.	Is the study method protocol realistically feasible?
6.	Was compliance to study methods at least 80% or otherwise adequately explained?
7.	Were follow-up procedures adequately explained?
8.	Were sources of error, contamination or co-intervention identified?
9.	Was statistical significance given for all outcomes?
10.	Was relevance of clinical outcomes and their clinical significance given?

Quality of the Studies

Using an adaption of the critical appraisal criteria in Clinical Epidemiology by Sackett et al.[8] found in Table 2, the authors independently evaluated the methodological quality of the 10 studies that met the eligibility conditions. The appraisal criteria used for this review consisted of 10 questions scoring either 2 for acceptable or 1 for lacking, which resulted in a total out of 20. A score of 10-12 was considered of poor methodological quality; 13-15 of moderate quality; 16-18 of high quality; and 19-20 was considered to be of superior methodological quality. Scores from the methodological appraisal can be found in Table 4.

Results

A total of 10 articles were found and included in this literature synthesis.[9-18] The search of EBSCO databases in MEDLINE, CINAHL, SportDISCUS, Index to Chiropractic Literature, Alt Health Watch, AMED, Nursing and Allied Health Collection, Psychology and Behavioural Sciences Collection and Rehabilitation & Sports Medicine Source, using all MeSH terms with limiters resulted in 140 articles in total. Adding all the MeSH terms and search terms combined with limiters produced 22 articles. Upon reviewing the titles and abstracts of these articles, 12 were discarded because they did not meet the inclusion criteria for this review. The principle reason for discarding these articles was due to the inclusion of non-healthy subjects. No additional studies were identified after conducting a reference check of the included articles. The 10 selected articles were then read in full. [9-18] All were found to meet the inclusion criteria and were included in this review. No unpublished preliminary studies were included. For a summary of the results for each of the 10 articles see Table 3.

Methodological Quality

The quality score assigned to each of the 10 studies included in this review is provided in Table 4. In order to systematically evaluate the methodological quality of each study and to aid in developing an objective measurement of the results of the appraisal, an adaptation of the critical appraisal criteria in Clinical Epidemiology by Sackett et al.[8] was applied. The majority of studies (n= 8) included in this review were of high methodological quality.[9,11-13,15-18] None of the studies were considered to be of poor or superior methodological quality. Two studies, namely the study completed by Stupik et al.[14] and Soylu et al.[10], were

of moderate methodological quality and were graded the lowest score consistently among the reviewers. Each study utilized in this review was lacking at least three of the critical appraisal criteria outlined in Table 2. Therefore, the highest score awarded was 17/20, which was achieved by Fu et al.[11], Chang et al.[12] and Yoshida et al.[16]

Three of the 10 appraisal criteria, specifically method protocol, compliance and clinical significance, were utilized in all 10 studies. Firstly, every study demonstrated a study method protocol that was considered to be realistically feasible. The requirements necessary to complete the study procedure were clearly outlined in each paper. Additionally, the data collection methods, which were implemented by the researchers, were outlined sufficiently so that the study could be repeated similarly. Secondly, all of the studies had at least 80% compliance or adequately

Table 3:
Results Summary Table

Author(s)	Population	Subjects and Intervention	Outcome Measures	Results
Lee et al., 2011 16/20	Healthy employees of Jinju Seran Hospital free of neurological problems	17 subjects (9 males, 8 females); single group	Measured Orthodromic conduction (bipolar percutaneous stimulator, EP/EMS system; 1ms pulse duration; 20mA to ulnar and median nerves, 30mA to radial nerve) KT applied to volar side of dominant forearm	No statistically significant difference in nerve conduction velocity, latency and amplitude of median, ulnar or radial nerves before and after KT application
Soylu et al., 2011 15/20	Healthy right hand-dominant adults free of masseter, chewing and dental problems	11 subjects (7 males, 4 females); single group	Measured MVCs of sEMG; Ag/AgCl electrodes placed along right and left masseter muscles with 2mm gap (10-500Hz, 5000Hz, 5KΩ, 120 dB) KT applied posterior to TMJ with no tension to mouth and along jaw line to TMJ with 0-15% tension	No statistically significant differences in any measured parameters before and after KT applications
Fu et al., 2008 17/20	Healthy kickboxing athletes from National College of Physical Education and Sports free of active knee pain, lower limb trauma in prior 3 months or history of lower limb surgery	14 subjects (7 males, 7 females); single group, three conditions, order randomly assigned: 1. Without tape 2. immediately after tape application 3. 12h after taping with tape still in situ	Measured MVC concentric and eccentric of quadriceps and hamstring at 60°/s and 180°/s (Cybex NORM isokinetic dynamometer) Y-shaped KT applied to dominant quadriceps with circle around patella	Lowest peak torque in concentric contraction of quadriceps at 180°/s without tape; No significant differences among subjects in other assessments; No significant interaction effect between conditions and assessments
Chang et al., 2010 17/20	Healthy male collegiate athletes from Chung Shan Medical University and National Chang hua University of Education free of elbow, wrist or forearm problems	21 subjects, single group, three conditions, order randomly assigned: 1. Without tape 2. Placebo tape 3. Kinesiotape	Measured MVC of grip (JAMAR Hydraulic Hand Dynamometer) KT Y-strip applied along common wrist flexors with 15-20% tension Placebo tape applied across belly of common wrist flexors 5cm inferior to medial epicondyle with 15-20% tension	No statistically significant differences in grip strength; Statistically significant differences found in absolute and related force sense errors with KT having the smallest errors and absolute force sense errors measurement
Vithoulka et al., 2010 16/20	Healthy, inactive female adults free of knee pain or other musculo-skeletal discomfort	20 subjects, single group, three conditions, order randomly assigned: 1. No taping 2. Placebo tape 3. Kinesiotape	Measured peak muscle torque of dominant knee extensors (Con-Trex MJ Zurich isokinetic dynamometer) at 60 and 240°/s concentric and 60°/s eccentric KT applied to rectus femoris, vastus medialis and vastus lateralis in direction of muscle bellies Placebo tape applied in two strips transverse to quadriceps muscle group at 5cm proximal and distal to middle of femur	Statistically significant increases found with KT application compared to other two taping modes in peak eccentric torque at 60°/s and during both concentric and eccentric mode of quadriceps; No statistically significant differences in peak concentric torque between taping conditions at 60 and 240°/s
Slupik et al., 2007 14/20	Healthy adults free of present or prior knee problems	36 subjects with kinesiotape applied to medial head of dominant quadriceps; 27 (12 females, 15 males) randomly assigned to protocol 1, 9 (5 females, 4 males) randomly assigned to protocol 2	Measured peak torque (Neuro Trac® Simplex transdermal EMG) with active electrodes applied according to SENIAM standards; protocol 1 measured before tape placement, after 10 minutes, 24, 72 and 96 hours; protocol 2 measured before KT placement and after 24 hours, then again 48 hours after removal of tape	Protocol 1 demonstrated statistically significant increases in bio-electric activity and motor unit recruitment after 24 and 72 hours only; Protocol 2 revealed statistically significant increases in peak torque both after 24 hours of KT and after another 48 hours following KT removal; No statistically significant differences at other time intervals

Table 3 continues on next page

explained and provided valid reasoning as to why full compliance was not achieved. Monitoring protocol compliance is essential in order to establish the validity of the study. Lastly, the relevance of clinical outcomes and their clinical significance was provided by all 10 studies. This is necessary in order to continuously improve care in a clinical setting, as well as to guide further research related to the results of the particular study.

Conversely, one of the 10 appraisal criteria was not incorporated into any of the studies. Follow-up procedures were either not adequately explained or not utilized entirely in all 10 studies. Half of the studies (n=5) did not use adequate randomization protocols[9,10,14,15,17] and therefore, the study results did not adequately represent the entire population and ultimately could not be applied to the general population. Randomization procedures are neces-

Table 3:
Results Summary Table (continued)

Author(s)	Population	Subjects and Intervention	Outcome Measures	Results
Aktas et al., 2011 16/20	Healthy, active university students free of lower limb pathology in past 12 months and no history of ankle sprain	20 subjects (11 females, 9 males), single group, four conditions, order randomly assigned: 1. control 2. bracing 3. Kinesiotape 4. KT plus brace	Measured peak torque/weight, angular velocity (Isomed 2000 isokinetic dynamometer) at 60 and 180°/s, vertical jump and one leg hop distance KT applied using quadriceps muscle and patellar mechanical correction techniques Brace used was DonJoy tru pull advance system, worn unilaterally in testing	Statistically significant increases found in one leg hop test: between control and KT in dominant leg for males and non-dominant for females; between males and females for KT and KT plus brace; Statistically significant increases found in normalized peak torque: between control and KT, and brace and KT in males and females at 180°/s; between males and females in control and KT results at 180°/s; KT more effective than brace and KT plus brace; No statistically significant differences in vertical jump or peak torque at 60°/s
Yoshida et al., 2007 17/20	Healthy adults free of lower trunk injury or pain in 6 months prior	30 subjects (15 females, 15 males), single group, two conditions conducted in sequence: 1. No tape 2. Kinesiotape	Measured trunk ranges of motion (flexion, extension and lateral flexion) with tape measure KT Y-strip applied along lower trunk from center of sacrum without stretching to mid thoracic spine	Statistically significant increase found in trunk flexion between control and KT application; No statistically significant differences in trunk extension or lateral flexion
Huang et al., 2011 16/20	Healthy, inactive adults free of history of spinal or lower limb pathology, fracture and impairment	31 subjects (19 males, 12 females), single group, three conditions, second two conducted randomly after baseline: 1. No tape 2. Kinesiotape 3. Micropore non-elastic tape	Measured jump height (Motion Analysis Corp. video-based motion analysis system), vertical ground reaction force (Kistler force platform) and EMG activity of medial gastrocnemius, tibialis anterior and soleus muscles (Motion Control MA-300 EMG system with Ag-AgCl electrodes) KT Y-strip applied to calf muscles using KT protocol Micropore tape applied to mimic KT	Statistically significant increases found in VGRF and EMG activity of medial gastrocnemius with KT applied; Statistically significant decrease in jump height with Micropore tape applied; No statistically significant differences in other protocols
Lee et al., 2010 16/20	Healthy adults free of upper limb range of motion limitations or orthopedic problems	40 subjects (20 males, 20 females), single group, three conditions, order randomly assigned: 1. No tape, head-neck neutral 2. No tape with head-neck rotation toward non-dominant hand 3. Kinesiotape, head-neck neutral	Measured dominant hand grip strength (Jamer Hydraulic Hand Dynamometer) with forearm in supination KT applied along full length of forearm flexor group with 15-25% stretch	Statistically significant increases found in grip strength for males and females with KT over no tape and head-neck rotation position; No statistically significant difference between no tape and head-neck rotation position

Table 4:
Methodological Quality Appraisal Results

No.	Item Description	Lee et al.[9]	Soylu et al.[10]	Fu et al.[11]	Chang et al.[12]	Vithoulka et al.[13]	Slupik et al.[14]	Aktas et al.[15]	Yoshida et al.[16]	Huang et al.[17]	Lee et al.[18]
1	Randomized	1	1	2	2	2	1	1	2	1	2
2	Baseline Characteristics	2	2	2	2	2	1	2	2	2	2
3	Prognostic Stratification	1	1	1	1	1	1	1	1	1	2
4	Blinding	1	1	1	1	1	1	1	1	2	1
5	Method Protocol	2	2	2	2	2	2	2	2	2	2
6	Compliance	2	2	2	2	2	2	2	2	2	2
7	Follow-up	1	1	1	1	1	1	1	1	1	1
8	Sources of Error	2	2	2	2	1	1	2	2	1	1
9	Statistical Significance	2	1	2	2	2	2	2	2	2	1
10	Clinical Significance	2	2	2	2	2	2	2	2	2	2
	Total Score	16/20	15/20	17/20	17/20	16/20	14/20	16/20	17/20	16/20	16/20

sary in order to eliminate a selection bias. Each study ensured that baseline characteristics of subjects were similar between groups to limit bias, except for the research completed by Stupik et al.[14] The two groups used in this study differed in the average age of group members, the total number of group members and the percentage of females versus males within each group. The majority of studies (n=9) failed to adequately report or incorporate blinding procedures into their study protocol,[9-16,18] except for the research completed by Huang, et al.[17] In this study, the test sequence was randomly processed for each subject in order to avoid potential bias. The majority of studies (n=6) successfully identified the potential sources of error in the discussion portion of their paper.[9-12,15,16] Lastly, most of the studies (n=8) reviewed provided statistical significance for all outcomes.[9,11-17] Only two studies, namely those completely by Soylu et al.[10] and Lee et al.[18], failed to accurately reveal this appraisal criteria.

Participants

The sample sizes in the 10 studies ranged from 11 to 40. All of the studies had an average age range of 20.86 to 34.35 years old.[9-18] Eight of the studies mentioned average height and weight with respective ranges of 167.06 to 181.24 cm and 56.94 to 72.86 kg.[9-13,15,17,18] One study measured BMI in subjects and excluded individuals with BMI > 25 from participation.[15] Two studies utilized subjects of only one sex.[12,13] Two of the studies used collegiate athletes[11,12] and two other studies specified that subjects were previously inactive[13,17]. All of the studies used healthy volunteers with no current pain or injury.[9-18]

Primary Outcome

In all the articles examined, the primary health outcome measured was always athletic based performance. In many of the experimental studies, the primary aim of the study was to improve maximum voluntary contraction.[10-12] All 10 of the studies looked at different methods of measuring athletic based performance including MVC[10-12], grip strength[18], peak muscle torque[13-15], muscle bioelectrical activity[14], range of motion[15], vertical ground reaction force[17], and Orthodromic conduction[9]. This lack of homogeneity amongst outcome measures in the studies prevented the ability to pool statistical data. The most common control intervention used within the studies was repeated measures within a single group, with and without KT (n=3).[9,10,16] Three studies involved a single group with three conditions, order randomly assigned.[11-13] One study had a single group with four conditions, order randomly assigned.[14] One study was a single group with three conditions, the second two conducted randomly after the controlled baseline.[17] Another study divided participants

into two protocol groups, both tested without KT initially. The first group was then tested at 10 minutes, 24 hours, 72 hours, and 96 hours after KT application. The second group was tested at 24 hours after KT application and 48 hours after removal of tape.[14] The final study was a single group with three conditions randomly assigned, two being without tape and one with KT.[18]

The timing of the testing varied between all 10 studies in this review. The timing of testing ranged from immediately after the application of KT to 96 hours after the application. The results show that KT has beneficial effects on athletic performance up to 72 hours after application.[14] The number of variables tested in each individual ranged from one to four different conditions. The location of KT application varied between studies and included the forearm muscles[9,12,18], masseter muscles[10], quadriceps and hamstring muscles[11-15], lumbar erector muscles[16], and gastrocnemius, soleus, and tibialis anterior muscles[17]. Four of the intervention studies showed no statistically significant differences in any measured parameters before and after KT applications.[9-12] Five studies found immediate statistically significant increases in grip strength, vertical ground reaction force, EMG activity, range of motion, and peak torque with KT over no tape when measurements were taken between 0 and 45 minutes following tape application.[13,15-18] Lee et al.[18] showed an increase in dominant hand grip strength for males and females with KT applied to the flexor muscles over no tape. Huang et al.[17] showed increases found in vertical ground reaction force and EMG activity of medial gastrocnemius with KT applied and a statistically significant decrease in jump height with the non-elastic tape applied, after 30 minutes of tape application. Yoshida et al.[16] found an increase in trunk flexion between control and KT application, when measured immediately following tape application. Aktas et al.[15] found increases in the single-leg hop test and in normalized peak torque between control and KT, with KT being more effective than the brace and KT plus brace groups, when testing was completed 45 minutes after tape application. Vithoulka et al.[13] showed increases with KT application to the rectus femoris, vastus lateralis and vastus medialis over placebo and no tape methods in peak eccentric torque at 60°/s and during both the concentric and eccentric mode of quadriceps contraction. None of the previous studies included follow up to assess the sustained effects of KT application. One study, by Slupik et al.[14] evaluated the longer term results of KT application and found increases in bio-electric activity and motor unit recruitment of the vastuss medialis after 24 and 72 hours of KT application, and at 48 hours following KT removal, with no improvement found 96 hours after removal.

Discussion

The evidence is not adequately strong to determine the effectiveness of KT on improving athletic-based performance outcome measures in healthy individuals. Merely six studies showed positive results of KT as an effective method for improving some measures of athletic-based performance.[13-18] This review demonstrates that there is scant evidence that KT application immediately improves grip strength, vertical ground reaction force, gastrocnemius EMG activity, trunk flexion, single-leg hop test and peak torque within 0 to 45 minutes of application.[13,15-18] As well, it was shown that bio-electric activity and motor unit recruitment in the vastus medialis was increased after 24 and 72 hours of KT application and after 48 hours following removal of the KT only.[14] There are numerous studies assessing the effectiveness of using KT as a treatment for a variety of injuries and disorders; however, only 10 studies[9-18] evaluating its effect on performance in healthy individuals were identified. Evidence to suggest that KT should be used as a method for improving athletic-based performance is lacking. Consequently, chiropractors and other healthcare practitioners should proceed with caution when considering the use of KT as a method for improving athletic-based performance measures.

Limited conclusions can be made on recommendations for appropriate instructions, location and duration of KT application due to variation in age, sex, tape application protocols and duration of application of tape. In addition, the wide variety of athletic-based performance measures assessed in each study and the dearth of sufficient intervention sizes makes it difficult to draw definite conclusions as to whether or not KT affects athletic-based performance measures in healthy persons.

This review has potential limitations including the limitations of the original literature, such as the inherent bias that may have been present in these studies. The language bias in this review is another possible limitation as we included articles published in the English language alone. It may stand to reason an additional flaw of this review was the inclusion criteria. The search timeline expanded

back only as far as the year 2000, which could have excluded studies that may have had an impact on the results of this review. The inclusion of cohort and cross-sectional studies and not limiting the studies to RCTs could have limited the quality of the results found in this review. However, a thorough search strategy was conducted using multiple electronic databases with hand reference searching of the obtained articles, thus actions were taken to assess the current state of the literature. The lack of pooled statistics may have also limited the quality and strength of our results. Furthermore, this review focused entirely on athletic-based performance outcomes, limiting the clinical application of these results to the general population.

The principle limitation amid the included studies was the lack of homogeneity of the methodological designs and outcome measures resulting in inconclusive findings regarding appropriate instructions, location and duration of KT application to affect athletic performance. Additional limitations present in the articles of this review include small study sizes, inadequately described follow-up procedures, lack of blinding protocols, failure to describe the experience level of those applying the KT, failure to address the possible placebo effect of KT and lack of control groups. There were only ten studies identified in total which involved entirely healthy subjects, which also limited the conclusiveness of results found in this review.

There are currently no literature reviews assessing the effects of KT on athletic-based performance measures in healthy individuals. Future research in this area should focus on higher quality RCTs involving larger study sizes, appropriate blinding procedures and extended follow-up protocol. More consistent use of outcome measures should also be included in future research to enable comparison and pooling of data. Additionally, research focused on confirming the mechanism of the function of KT, assessing the potential placebo effect of KT, assessing the importance of application experience on various outcome measures, determining the rates at which chiropractors apply or recommend kinesiotaping techniques as a means of improving athletic performance and the effects produced with KT use in combination with other treatment protocols should be conducted.

Conventionally, KT has been used in the treatment of athletic injury or to limit pain in athletes and is used as a substitute for the traditional white athletic tape. The evidence is lacking to support the use of KT in improving athletic-based performance outcomes in healthy subjects; however, there was no evidence KT had a negative effect on the measured outcomes. A more extensive review of the effect of KT on various athletic injuries would be beneficial, as its ease of use, its relatively low risk of minimal side effects and the non-detrimental impact it appears to have on athletic performance give KT the potential to be a viable treatment option. Chiropractors and other healthcare providers need to educate themselves, coaches and athletes on the possible benefits KT can have on athletic performance with caution since more research is required to establish concrete outcomes.

Conclusions

KT has quickly garnered popularity in the athletic population as it has gained more mainstream use since the 2008 Beijing Olympic Games. It has been suggested by its creator, Dr. Kenzo Kase, that KT has the following effects: (i) increasing proprioception by providing constant cutaneous afferent stimulation through the skin, (ii) realigning fascial tissue function by normalizing muscle tension, (iii) creating more space for improving circulation of blood and lymph flow by eliminating extra fluid, edema, or bleeding beneath the skin, (iv) correcting muscle function by strengthening muscle weakness, (v) decreasing pain through neurological suppression.

There is scant evidence to support kinesiotaping techniques as a successful means of affecting athletic-based performance outcomes such as improved strength, proprioception and range of motion, in healthy persons. Regardless of the heterogeneity of the study methods there is some evidence showing KT can improve certain athletic-based performance outcomes. Results from this literature review give pause to chiropractors and other healthcare practitioners looking to justify using KT for improving athletic performance in healthy athletes. Although it does not seem to further hinder athletic performance, additional research is needed before any conclusive statements can be made with regard to the recommended use of KT and its effects on athletic-based performance outcomes.

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Book Reviews

Human Locomotion: The Conservative Management of Gait-Related Disorders
Thomas C. Michaud
Newton Biomechanics, Newton, Massachusetts, U.S.A.
2011
Hardcover, 412pp, Regular Price $100.00
ISBN: 978-0-615-51645-5

Human Locomotion provides an in-depth, referenced analysis of human gait as related to its evolution, function and conservative management. Michaud begins by detailing the evolution of bipedality starting with the earliest ancestors of mankind, and explores theories proposing why humans transitioned from quadrupeds to upright walkers. Structural and functional anatomy of the lower kinetic chain is examined and seamlessly integrated into the evolution of man. Within this context, it allows the reader to appreciate the intricate design of the human body and how evolution has specifically allowed humans to adapt to environmental demands. The next two chapters carefully scrutinize normal and abnormal motions of the gait cycle. The author reviews in detail the various biomechanical events that occur during the different phases of gait and finishes with a thought provoking discussion on the characteristics differentiating sprinters and endurance runners. The section on abnormal motion during the gait cycle is extremely detailed and depicts deviations in the bones and joints of the lower extremity that can perpetuate injury. Biomechanical examination of the lower body is discussed with validity and reliability for many of the tests included. Foot orthotics and the shoe-gear is reviewed before the final chapter delves into an evidence-based approach to treating gait-related conditions. Overall, *Human Locomotion* is an excellent educational journey through human gait from evolution to management. The text is wonderfully detailed, referenced and illustrated and should be high on the list of any clinician, regardless of discipline, interested in furthering their knowledge on the subject.

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Corrective Exercise Solutions to Common Shoulder and Hip Dysfunction
Evan Osar
On Target Publications, Aptos, California, U.S.A.
2012
Paperback, 336 pp, Regular Price $66.97
ISBN: 978-1905367269

Corrective Exercise Solutions to Common Shoulder and Hip Dysfunction is a well-received resource for health care practitioners. Upon completion the reader can draw from its principles and methods, easily implementing them into daily practice. Author Evan Osar begins by outlining many of the flaws in current rehabilitation and training programs and discusses more suitable paradigms. The anatomy of the shoulder and hip complexes are reviewed, but it is a cursory overview with many details omitted. The assessment section reviews common movement dysfunctions and their evaluation, but is not intended as a 'cookbook' for the reader, rather as a guide to complement individual practices. Osar then describes the proper development of corrective exercise programs, depicting principles rather than specific methods. In doing so, he provides the reader with underlying concepts that serve as the foundation for all rehabilitation programs, empowering the reader to think independently and apply these concepts in daily practice. Osar then describes specific rehabilitative exercises that can be used to address the most commonly observed movement dysfunctions. The text is well illustrated and accompanied by supplemental online videos. Unfortunately it is poorly bound and there are many formatting and grammatical errors littered throughout. This is a minor complaint however, as Osar's text is a fantastic resource for the rehabilitation professional. Unifying the theories, concepts and practices of many renowned therapists including the likes of Vladamir Janda, Pavel Kolar, Gray Cook, and Shirley Sahrmann, it is a resource that readers will continuously use as a reference for many years.

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Essentials of Neuroanatomy for Rehabilitation
Leah Dvorak, Paul Jackson Mansfield
Pearson Education, Inc, Upper Saddle River, NJ
320 pp; $73.50 CAN
ISBN-10:0135023882, ISBN-13: 9780135023884

A comprehensive understanding of neuroanatomy and rehabilitation is fundamental in the field of chiropractic medicine. *Essentials of Neuroanatomy for Rehabilitation* aims to present essential neuroanatomy information in a simple and concise manner and to provide clinical relevance to aid in clinical application.

The text consists of sixteen well-organized chapters and is centralized on the theme of simplicity and clinical application. The main strength of this text is that it is written in an extremely clear, simple and effective writing style which is appropriate for chiropractors and students of all levels. The text provides relevant information related to neuroanatomy and does not overburden the reader with excessive details. This can also serve as a limitation for those looking for more in-depth details or treatment recommendations.

I recommend *Essentials of Neuroanatomy for Rehabilitation* to students who are looking to gain a better understanding of neuroanatomy and its application for clinical practice. This book is also recommended for health care professionals who are looking to refresh their knowledge of neuroanatomy on an ongoing basis.

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