LITERATURE REVIEW

EXERCISE RELATED LEG PAIN (ERLP): A REVIEW OF THE LITERATURE

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ABSTRACT

Exercise related leg pain (ERLP) is a regional pain syndrome described as pain between the knee and ankle which occurs with exercise. Indiscriminant use of terminology such as "shin splints" has resulted in ongoing confusion regarding the pathoanatomic entities associated with this pain syndrome. Each of the pathoanatomic entities – medial tibial stress syndrome, chronic exertional compartment syndrome, tibial and fibular stress fractures, tendinopathy, nerve entrapment, and vascular pathology – which manifest as ERLP are each described in terms of relevant anatomy, epidemiology, clinical presentation, associated pathomechanics, and intervention strategies. Evidence regarding risk factors for ERLP general and specific pathoanatomic entities are presented in the context of models of sports injury prevention.

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INTRODUCTION

Leg pain associated with exercise is a common experience among athletes. One of the earliest published descriptions of leg pain was by Hutchins in 1913.[1] He described "spike soreness" as soreness in the medial leg in runners. He stated, "Specifically, the area begins four and a quarter inches above the internal malleolus and extends about an inch along the tibial border."[1] Over time, the term "shin splints" came to be associated with leg pain. Some used the term with regard to medial leg pain,[2-4] while others have used the term more generically. Slocum[5] reported that shin splints "designates a symptom complex characterized by pain and discomfort in the lower part of the leg after repetitive overuse in walking and running."

In 1966, the American Medical Association (AMA) Committee of the Medical Aspect of Sports, Subcommittee on Classification of Sports Injuries published the Standard Nomenclature of Athletic Injuries. This book defined shin splints as "pain and discomfort in the leg from repetitive running on hard surface or forcible excessive use of the foot flexors; diagnosis should be limited to musculotendinous inflammations, excluding fatigue fracture or ischemic disorder."[6] Detmer[7] opined that the AMA definition of shin splints was too restrictive, and suggested that the term include "injuries which are not obvious muscle strains, tendinitis, stress fracture, or compartment problems." Recognizing the confusion in terminology regarding "shin splints," Batt[8] wrote a review of terminology associated with leg pain. He concluded that the term "shin splints" is a generic term which does not refer to any specific pathology, but rather, to the location of pain.

Other generic descriptions of pain syndromes exist based on the location of pain, including anterior knee pain, metatarsalgia, and low back pain. As the term "shin splints" is accompanied by a great deal of confusion as to the type and location of pain, it is reasonable to use a term that more accurately describes the location and association of the pain. Brukner[9] recommended avoiding use of the term "shin splints" and proposed the term "exercise related lower leg pain" to describe shin, calf, ankle, or foot pain associated with or aggravated by exercise. Reinking and Hayes[10] suggested the use of the term "exercise related leg pain" (ERLP) to describe pain between the knee and ankle which is associated with exercise. These authors recommended elimination of foot pain from this syndrome as the foot is anatomically distinct from the leg, and also suggested elimination of the term "lower" from the syndrome name as ERLP can and does occur along the length of the leg. This nomenclature confusion has delayed development of a good understanding of leg pain. The objective of this paper is to provide a literature review of ERLP including epidemiology, pathoanatomic entities, risk factors, and preventative strategies.

METHOD OF REVIEW

Searches of two electronic databases were conducted: the National Library of Medicine (MedLine) and the Cumulative Index for Nursing and Allied Health Literature (CINAHL) over the past 10 years during this ongoing research on exercise related leg pain. Searches have included terms such as shin splints, exercise related lower leg pain, exercise related leg pain, leg pain, lower leg pain, chronic leg pain, medial tibial stress syndrome, stress fracture, tibial stress fracture, fibular stress fracture, chronic exertional compartment syndrome, exertional compartment syndrome, exertional leg pain, tendinopathy, tendinitis, tendinosis, nerve entrapment, arterial occlusive disease, popliteal artery, tibial artery, injury prevention, and sports injury prevention. Searches have been limited to articles written in English using human subjects. Over 350 articles appeared relevant based on titles or abstracts and were screened for inclusion in this review. A total of 111 articles were selected for use in this paper including epidemiological studies, observational studies, randomized controlled trials, literature reviews, systematic reviews, meta-analyses, and case reports. As this is not a systematic review, the intent was not to critically evaluate the evidence but rather to provide a summary of the literature on ERLP to assist the sports physical therapists in better understanding the conditions that present as ERLP.

EPIDEMIOLOGY OF ERLP

While only a few studies have investigated ERLP epidemiology in athletes, the data consistently show it to be a commonly experienced pain syndrome. Running (cross-country and distance track events) has the most common occurrence of ERLP; other sports with reported occurrence of ERLP include soccer, volleyball, field hockey, basketball, gymnastics, and dance.[11] Orava and Puranen[12] reported an 18% incidence of ERLP over a five year period in a group of 2750 athletes presenting to a

Finnish sports clinic with overuse injuries. Researchers at a sports medicine clinic in British Columbia have published three epidemiological reports of overuse running injuries from 1981 to 2002. In those studies, the percentage of total running injuries attributed to ERLP were 13.2% of 1819 injuries,[13] 20.4% of 4173 injuries,[14] and, most recently, 12.8% of 2002 injuries.[15] In a study of 63 collegiate cross-country athletes, 52% reported a history of ERLP which interfered with running.[16] Sallis et al[17] reported the most common site of injury in collegiate cross-country runners was the leg. In 2005, the National Collegiate Athletic Association (NCAA) began to collect overuse injury data for men's and women's cross-country as a part of the NCAA Injury Surveillance System. The data indicated that in men's cross country, ankle sprains and ERLP were the most common practice and race injuries that kept participants out seven days or more. Exercise related leg pain was also one of the most common injuries for women's cross country that kept participants out seven days or more.[18] In a 15-year longitudinal study of high school cross country running injuries, Rauh et al[19] reported that the leg was the most common site of injury and re-injury.

PATHOANATOMIC ENTITIES

Exercise related leg pain includes the pathoanatomic entities of medial tibial stress syndrome (MTSS), chronic exertional compartment syndrome (CECS), tibial or fibular stress fractures, tendinopathies (posterior tibialis, anterior tibialis, peroneals, and Achilles), nerve entrapment syndromes, and vascular syndromes. Of these conditions, MTSS, stress fractures, CECS, and tendinopathies are the most common causes of ERLP.[11] Nerve entrapments and vascular syndromes are very rare entities in athletes.[20-22] A review of the pathoanatomy, clinical signs and symptoms and, as available, specific epidemiological data for six pathoanatomic entities follows.

Medial Tibial Stress Syndrome

Medial tibial stress syndrome presents as pain along the posteromedial border of the distal two-thirds of the tibia, usually most localized at the intersection of the distal and middle thirds.[23] The pain typically intensifies at the initiation of the exercise session, may subside during exercise, and resolves with rest. No neurological symptoms are associated with MTSS.[24] Mubarak et al[3] published the first descriptive paper on MTSS in 1982. These authors reported that Dr. Drez was the individual who coined the term "medial tibial stress syndrome" based on his clinical experience with the presentation of the condition. The investigators studied a group of 12 patients with posterior-medial leg pain and using compartmental pressure studies, ruled out chronic compartment syndrome. They identified the condition as most likely a periostitis along the posterior medial border of the tibia.

Traditionally, the tibialis posterior muscle was considered the anatomic source of medial leg pain associated with MTSS.[25] However, anatomic studies have challenged this hypothesis as the tibialis posterior tibial origin is lateral to the area of symptom identification.[4,26] These studies suggested the soleus muscle and its investing fascia, along with the flexor digitorum longus and the deep crural fascia, are responsible for traction-induced posterior-medial periosteal pain. Bouche and Johnson[27] used fresh frozen cadaver limbs to examine the pathomechanics of MTSS. They concluded that distal tibia fascial traction is generated by contraction of the superficial and deep posterior compartment muscles and this tension contributes to the development of MTSS.

Detmer[28] developed a classification system for MTSS with three types of lesions. Type I involves tibial stress fractures or stress reactions, Type II involves the fascial attachment of soleus to the tibia, and Type III is a chronic deep posterior compartment syndrome. However, this classification system is not recommended[24] as the system combines multiple diagnostic entities, perpetuating confusion regarding the tissue origin of the athlete's pain. In this paper, MTSS will be used to describe pain along the fascial insertion of the soleus muscle on the tibia.

Regarding the epidemiology of MTSS, the terminology confusion in the literature confounds precise identification of the incidence of this condition. An early study of MTSS in runners showed 239 runners of a group of 1650 (14.5%) developed medial tibial pain, but this work was done before clarity existed in the diagnostic parameters of MTSS.[13] James et al[25] reported 13% of 232 injuries to runners was "posterior tibial syndrome," a condition described similar to MTSS. Two studies of high school cross-country runners have shown an overall MTSS incidence of 12%[29] and 15%,[30] with higher incidence in females than males.

Although MTSS is a condition involving the interface of soft tissue and bone, evidence exists that MTSS is associated with decreased tibial bone density. In a study of leg pain in male soccer players, tibial bone density in the MTSS group was 15% lower than a group of non-athletic control subjects, and 23% lower than a group of athletic control subjects.[31] These data should not be misinterpreted that the decreased bone density caused MTSS; in fact, lower bone density may have been a result of chronic MTSS. However, this research is the first to raise the question of the relationship between bone health and MTSS. In a follow-up study, Magnusson et al[32] found that the low regional density of the distal tibial returned to normal following recovery from pain symptoms. The authors concluded that the decreased bone density develops in conjunction with MTSS, but whether a causal relationship exists is unknown.

Treatment for MTSS is largely based on anecdotal reports rather than evidence-based practice. Early management of MTSS pain often includes relative rest from the offending activity, cross-training, and the use of modalities such as icing and ultrasound. Other recommendations include ankle muscle strengthening, stretching, and a progressive return to running. Little, if any, evidence exists to support such recommendations.[23,24] A survey study of the effect of custom foot orthotics on MTSS suggested that most athletes who were prescribed foot orthotics reported that the orthotics helped their condition.[33] In recalcitrant cases, fasciotomy of the superficial and deep fascia of the posteromedial leg may be recommended, but the outcome of this surgery is not always successful in returning the athlete to sport.[34]

Chronic Exertional Compartment Syndrome

The second condition in the ERLP complex is CECS. This conditions was first described 1956 by Mavor[35] in a professional soccer player. The leg has five osseofascial compartments, each bounded by an inelastic layer of fascia.[36] These compartments – anterior, lateral, superficial posterior, deep posterior, and posterior tibialis – enclose the ankle and foot musculature. When the volume of these compartments increases, the compartmental pressure increases, potentially affecting the movement of blood, lymph, and nerve impulses through the compartment and inducing tissue ischemia. This increase in compartmental pressure is referred to as compartment syndrome, and can be caused by either macrotraumatic or microtraumatic events. In the case of a macrotraumatic injury to a limb, acute compartment syndrome may occur as bleeding into the compartment increases the compartmental volume and pressure. This condition is a medical emergency and must be dealt with promptly. Chronic exertional compartment syndrome, on the other hand, is a microtraumatic condition associated with overuse and results from increased muscle volume within a compartment during exercise.

The onset of CECS is usually distinct from MTSS as the athlete describes pain that does not begin at the initiation of exercise but rather begins at a predictable point after exercise initiation. The pain is characterized as “cramping” or “burning” and may or may not subside immediately after exercise. In addition, complaints of numbness and weakness in the lower leg and foot are frequent.[36] The classic diagnostic sign of CECS is elevated intra-compartmental pressure with exercise. The anterior compartment is the most common site of symptoms.[36,37]

The epidemiology of CECS is uncertain as much inconsistency exists in the populations studied with regard to age, sport, and sex. Some authors report CECS is most common among distance runners.[38,39] In their retrospective review of 2002 running injuries, Taunton et al[15] reported 28 cases (1.4%) of anterior compartment syndrome. The anterior compartment is described as the most commonly affected, followed by the lateral compartment.[36,39,40] In a review article, Blackman[36] reported that the preponderance of the literature indicates CECS commonly presents bilaterally with no difference in incidence of CECS between males and females. Styf[38] investigated the cause of ERLP in 98 athletes with purported CECS. He found that 27% of the patients had elevated compartmental pressures with exercise; the other patients had diagnoses including MTSS and peroneal nerve compression.

Little evidence exists to support conservative treatment for CECS. Blackman et al[41] reported that in a pilot study, a combination of massage and stretching intervention increased the amount of work performed prior to onset of symptoms, but no change in the intra-compartmental pressures occurred. Recalcitrant cases may require compartmental fasciotomy for symptom reduction.[36,42]

Stress Fracture

Bony overuse injury is a third category of ERLP. Bone is a dynamic tissue with a mineral component that is constantly being remodeled based on the imposed stresses. In normal bone, a balance exists between mineral deposition and mineral resorption and no net loss of bone mineral content. However, with excessive repetitive stress over time, bone mineral resorption can exceed deposition. This condition causes a net loss of bone mineral content resulting in a fatigue fracture.[43] Unlike the macrotraumatic acute bone fracture injury caused by a large imposed force in a short period of time, the fatigue fracture is a microtraumatic injury representing a maladaptation to smaller repetitive forces. This condition was first described as leg or foot pain in soldiers after marching, and hence, was initially named "march fractures."[44]

The onset of pain is usually gradual, and pain decreases with rest in early stages. As the stress fracture develops, the pain may persist after exercise and occur during daily activities.[45] Tibial stress fractures are more common than fibular, consistent with the fact that the tibia bears greater load in ambulation.[46] As the tibia is the more medial bone of the leg, the symptoms of stress fracture may present indistinguishable from MTSS; the athlete will typically complain of pain along medial leg. In order to make a definitive diagnosis, the gold standard imaging technique is the triple-phase bone scan.[45] On a bone scan, a stress fracture will present as intense uptake in one focal site of the bone, whereas MTSS presents as diffuse uptake along the medial tibial border.

Few studies have been done examining the incidence rates of stress fractures in athletes. Bennell and Brukner[47] stated, "Incidence rates, expressed in terms of exposure, have rarely been reported for stress fractures in athletes. Nevertheless, available data suggest that runners and ballet dancers are at relatively high risk for stress fractures." Johnson et al[48] tracked injuries for all athletes at a Division II institution over a two-year period. During this time, 34 stress fractures in 24 athletes were diagnosed in the 914 athletes. Of the 34 stress fractures, 13 were tibial, more than any other anatomic site. Of those 13 fractures, nine occurred in females and four in males. Goldberg and Pecora[49] studied three years of data on stress fracture occurrence in collegiate athletes at a large private university. They found an annual incidence of 1.9%, but 67% of the injuries were in freshmen. The authors suggested the injuries were a result of the significant increase in training volume between high school and college. The tibia was the second most common region of stress fracture in the study, following the metatarsals of the foot.

Female athletes are at greater risk for stress fractures than male athletes.[43,46,47,50-52] Several hypotheses have been forwarded to explain this increased risk. In a review article, Bennell et al[53] stated, "menstrual disturbances, caloric restriction, lower bone density, muscle weakness, and leg length differences are risk factors for stress fracture." However, these authors note that no evidence exists to support lower extremity alignment issues such as pelvic width and knee valgus as risk factors for stress fracture.

Shaffer and Uhl[54] recently completed a systematic review of the prevention and treatment of stress fractures in athletes. They reported that while no high level evidence supports any prevention strategies, limited evidence exists to support the use of shock absorbing insoles for stress fracture prevention. Likewise, another systematic review of the interventions for prevention and treatment of stress fractures found evidence that the use of shock absorbing inserts in footwear reduced the incidence of stress fractures in military personnel.[55] These authors also found limited evidence to support the use of a pneumatic brace during the rehabilitation period after a stress fracture.

Tendinopathy

The fourth diagnostic entity within ERLP is tendinopathies, or pathologic conditions affecting tendon tissue. Tendons are collagenaceous structures which link muscle to bone. In a normal tendon, the collagen fibrils are arranged in a parallel fashion. In a pathologic tendon, the collagen alignment is disorganized with abnormal intratendinous material. Khan et al[56] described the two primary tendinopathies as tendinitis and tendinosis. These authors used histologic evidence to support their contention that tendinitis is a rare condition and tendinosis is the more common tendon pathology. A key finding in much of the research on tendon pathology is the conspicuous absence of inflammatory cells in involved tendon tissue. In an essay on the use of language in medicine, Bernstein[57] pointed out that the words we use influence how we think. The pervasive and indiscriminant use of the term "tendinitis" to describe any tendon pathology causes health care practitioners and patients to continue to view tendon pathology as inflammatory, which is, in fact, rarely the case.

The pain pattern of an athlete with tendon pain depends on the chronicity of the condition. In an early stage, the athlete may have tendon pain only after exercise. As the condition progresses, the pain may become constant with all daily activities.[58] The pain is typically located along the course of the tendon, in some cases at the enthesis site and in other cases as the tendon passes around a bony prominence. Tendon pain is typically intensified with resisted testing of the involved muscle group.

As with the other ERLP conditions, little accurate epidemiological information is available regarding the tendon conditions. Several authors report tendon pathology is a "common" overuse injury,[59-63] but give no specific incidence of injury. In their study of injuries in runners, James et al[25] reported Achilles tendinitis was the third most common problem behind knee pain and posterior tibial pain, with 11% of the running injuries in this category. Using a population of 2002 injured runners, Taunton et al[15] identified Achilles tendinitis in 96 runners (4.8%), peroneal tendinitis in 13 runners (0.65%), and posterior tibialis tendinitis in 11 runners (0.55%). All tendon pathologies in this study were referred to as "tendinitis."

Interventions for tendon pain also are largely based on anecdotal reports and clinical lore. Such interventions include relative rest, cross-training, stretching, strengthening, ultrasound, iontophoresis, cryotherapy, counterforce bracing, foot orthotics, non steroidal anti-inflammatory medications, extracorporeal shock wave therapy, and surgery. At present, the only conservative intervention that is supported by evidence is the use of eccentric training.[64-70]

Nerve Entrapment

Nerve entrapment is a rare clinical condition in athletes, but one that the clinician must recognize from a thorough examination. The peripheral nerves involved in entrapment syndromes of the leg include the saphenous, common peroneal, superficial or deep peroneal, sural, and tibial nerves. The symptoms of these syndromes may include pain, paresthesia, motor weakness, and decreased coordination, depending on the specific nerve. For example, the saphenous nerve is a sensory nerve only, and entrapment may result in sensory loss or medial leg pain that may mimic vascular claudication type pain. Hirose and McGarvey[71] describe three stages of nerve entrapment: Stage 1 in which patients feel pain and occasional paresthesia, especially at night; Stage 2 in which the paresthesia is more constant throughout the day and muscle weakness may develop; and Stage 3 in which patients experience constant pain, and sensory and motor loss.

Nerve symptoms may occur secondary to CECS and compartmental pressure assessments are necessary to distinguish CECS from nerve entrapment. The etiology of nerve entrapment is not well understood, but is hypothesized to be a result of either blunt trauma or repetitive motion leading to scarring of the nerve sheath.[21] No epidemiological data pertaining to nerve entrapment in the leg were found in the literature. Detail regarding specific nerve entrapments is outside the scope of this paper; the reader is referred to excellent review papers on this topic for more information.[21,22,71]

Treatment of nerve entrapment includes such conservative measures as nerve flossing, padding, orthotic prescription, and corticosteroid injections. Recalcitrant cases may require a surgical decompression of the nerve entrapment.

Vascular Pathology

The last of the clinical entities within the umbrella of ERLP is vascular pathology. Entrapments of the popliteal artery or the anterior tibial artery have been reported in the literature but are extremely rare.[20,72] This condition presents with symptoms very similar to CECS, and diagnostic differentiation requires compartmental pressure testing. Distal pulses are diminished in this condition, and the athlete will describe a deep ache or "cramping" sensation.[20] If identified, this condition requires surgical intervention.

EXERCISE RELATED LEG PAIN RISK FACTORS

Van Mechelen et al[73] proposed a "sequence of prevention" model for sport injury which involved four steps: (a) identifying the extent of the injury problem, (b) understanding the etiology and mechanism of injury, (c) introducing appropriate preventative measures, and (d) assessing the effectiveness of those measures. In a systematic review on the prevention of exercise-related leg pain (ERLP) in athletes,[74] the authors concluded there is "little objective evidence to support the widespread use of any existing interventions to prevent shin splints." A primary reason for this paucity of evidence regarding interventions is that the risk factors for ERLP are not well understood. Multiple factors are hypothesized to contribute to the development of ERLP including intrinsic and extrinsic factors. Intrinsic factors are those contained within a person, including sex, race, bone structure, bone density, muscle length, muscle strength, joint range of motion, diet, and body composition. Extrinsic factors are those outside of a person, including training volume (frequency, duration, and intensity), types of conditioning activities, specific sport activities, training surface, shoes, and environmental conditions.

Extrinsic Risk Factors

Extrinsic factors, including training volume, training surfaces, shoes, and sport activities, are often cited as causes of lower extremity overuse injury. However, consensus evidence is generally lacking to support most of these factors. A preponderance of evidence suggests that excessive training mileage in runners is a risk factor for lower extremity overuse injury.[13,25,75-77] Macera et al[76] reported that the most important predictor of lower extremity overuse injury was running 40 or more miles per week. A study of overuse injuries in 1300 United States Marine Corps recruits indicated that a higher weekly training volume was associated with an increase in lower extremity overuse injuries.[78] However, although excessive training is commonly mentioned as a risk factor for ERLP, no supporting evidence exists specific to ERLP.

Sport type is another purported risk factor for ERLP. Ugalde and Batt[11] stated, "A high incidence of shin pain is associated with running and jumping sports," but offered no specific epidemiological information. In their prospective study of athletes with acute shin splints, Batt et al[79] found that most of the athletes (83%) were cross-country runners or track athletes. In a study of ERLP in collegiate female athletes, Reinking[80] found the highest incidence in cross-country and field hockey athletes.

Intrinsic Risk Factors

More research has focused on intrinsic risk factors associated with lower extremity overuse injuries. Several studies have reported a greater risk of lower extremity overuse injury in athletes with a pronatory foot type.[25,59,81-84] However, conflicting data exist suggesting excessive foot pronation is not an intrinsic risk factor for lower extremity overuse injury.[85-88] Three recent studies have not supported this relationship.[10,30,95] Potential confounding issues in the conflicting results regarding foot pronation and ERLP include the variation in the static and dynamic foot pronation measures, sample populations, and pathoanatomic entity included in the study.

Poor musculotendinous flexibility is another commonly cited intrinsic factor for generic lower extremity overuse injury.[61,96-98] Kaufman et al[59] reported that tight posterior calf muscles as measured by limited ankle dorsiflexion with the knee extended was a risk factor for lower extremity overuse injury, but close examination of his data show that this was only true for the development of Achilles tendon pain. In a review of the relationship between flexibility and sport injury, Gleim and McHugh[99] concluded "There is no scientifically based prescription for flexibility training and no conclusive statements can be made about the relationship of flexibility to athletic injury." This conclusion was supported by a second systematic review on the effect of stretching on sport injury.[100]

Neely[101] conducted a comprehensive review of the literature on intrinsic risk factors for ERLP using studies of both military and civilian populations. The review focused on intrinsic factors including age, somatotype, sex, past history of injury, and physical fitness. From the review, the author concluded that "overwhelming evidence" supports several intrinsic factors as increasing the risk of ERLP. Those factors are female sex, including age > 24 years, a high body mass index (BMI), low BMI in females, poor physical fitness as measured by a 1- or 2-mile timed run, and past history of injury. The BMI data indicated that for both men and women, a higher percentage of body fat resulted in a greater risk of injury. The authors suggested that higher body fat may be a consequence of excessive forces placed on tissues because of additional weight. However, women showed a bimodal relationship between BMI and injury; not only was more body fat a risk for injury but also less body fat than normal.

Intrinsic factors associated with bone-related ERLP (stress fractures) include sex, menstrual function, bone density, and foot type. It is well documented that stress fractures are more common in females than in males.[43,46,49-52,102,103] Barrow and Saha[104] found stress fractures to be more common in collegiate female runners with menstrual irregularity. These authors also found a much higher incidence of disordered eating in the women with menstrual abnormalities. These results were corroborated in a study of 113 track and field athletes, where the authors found not only menstrual dysfunction to be a risk factor for stress fractures in female athletes but also low bone density.[105] Based on anecdotal evidence, foot pronation is considered a risk factor for tibial stress fractures, while others have reported that excessive supination is a causal factor.[106,107] In a literature review on risk factors for stress fractures, Bennell et al[53] stated, "time-honoured risk factors such as lower extremity alignment have not been shown to be causative even though anecdotal evidence indicates they are likely to play an important role in stress fracture pathogenesis."

PREVENTION OF ERLP

As described earlier in this paper, van Mechelen[73] proposed a sport injury prevention model involving four steps: (1) identifying the extent of the injury problem, (2) understanding the etiology and mechanism of injury, (3) introducing appropriate preventative measures, and (4) assessing the effectiveness of those measures. The second step of his model, injury etiology and mechanism, was further developed by Meeuwisse[108] in which he described a multifactorial causation model involving intrinsic and extrinsic factors. In this model, intrinsic factors predisposed an athlete to injury, and subsequent exposure to extrinsic factors resulted in injury to susceptible athletes. Bahr and Krosshaug[109] focused on the complex interaction of intrinsic and extrinsic factors as an inciting event in sports injury etiology. Based on these previous models,[73,108,109] Meeuwisse et al[110] has proposed a new expanded model of sport injury etiology which takes "the cyclic nature of changing risk factors into account to create a dynamic, recursive picture of etiology." This model attempts to take into account both intrinsic and extrinsic risk factors as well as repeated exposures and changing circumstances that combine to cause injury. The current problem with ERLP is that very little is understood about the specific intrinsic and extrinsic factors which may predispose an athlete to injury with repeated exposures.

In a recent systematic review on the prevention of ERLP in athletes, Thacker et al[74] concluded there is "little objective evidence to support the widespread use of any existing interventions to prevent shin splints." In another systematic review focused on the prevention of stress fractures in athletes and soldiers, the authors reported that their comprehensive review of the literature "highlights how little we know about what works to prevent one of the most common and potentially serious sports- and exercise-related overuse injuries."[111] These two systematic reviews on the status of ERLP prevention strategies exemplify the lack of understanding of the etiology of ERLP and highlights the need for future research in this area.

CONCLUSION

In summary, it is evident from this review that in spite of the common occurrence of ERLP in athletes, the lack of success in the prevention and treatment of ERLP is a reflection of the limited understanding of the risk factors which lead to the development of ERLP. In Van Mechelen's sequence of prevention model,[73] development of successful prevention strategies requires development of knowledge of the mechanisms and factors associated with the development of the condition. In addition to a lack of consensus knowledge, another barrier to the development of successful approaches to address this problem is the indiscriminate use of terms such as "shin splints," which can unintentionally lead one to not consider the complexity of the different pathoanatomic entities that manifest as ERLP. Careful and thorough examination identifying the location, nature, and chronology of symptoms as well as static and dynamic neuromusculoskeletal impairments is essential in the development of an appropriate intervention plan. A great need exists for ongoing high quality research both in the identification of extrinsic and intrinsic risk factors and the development of successful intervention programs.

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