The prevention of shin splints in sports: a systematic review of literature

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ABSTRACT

THACKER, S. B., J. GILCHRIST, D. F. STROUP, and C. D. KIMSEY. The prevention of shin splints in sports: a systematic review of literature. *Med. Sci. Sports Exerc.*, Vol. 34, No. 1, 2002, pp. 32–40. **Purpose:** To review the published and unpublished evidence regarding risk factors associated with shin splints, assess the effectiveness of prevention strategies, and offer evidence-based recommendations to coaches, athletes, and researchers. **Methods:** We searched electronic data bases without language restriction, identified citations from reference sections of research papers retrieved, contacted experts in the field, and searched the Cochrane Collaboration. Of the 199 citations identified, we emphasized results of the four reports that compared methods to prevent shin splints. We assessed the methodologic quality of these reports by using a standardized instrument. **Results:** The use of shock-absorbent insoles, foam heel pads, heel cord stretching, alternative footwear, as well as graduated running programs among military recruits have undergone assessment in controlled trials. There is no strong support for any of these interventions, and each of the four controlled trials is limited methodologically. Median quality scores in these four studies ranged from 29 to 47, and serious flaws in study design, control of bias, and statistical methods were identified. **Conclusion:** Our review yielded little objective evidence to support widespread use of any existing interventions to prevent shin splints. The most encouraging evidence for effective prevention of shin splints involves the use of shock-absorbing insoles. However, serious flaws in study design and implementation constrain the work in this field thus far. A rigorously implemented research program is critically needed to address this common sports medicine problem. **Key Words:** INJURY, LOWER EXTREMITY, ATHLETES

Published studies have shown that shin splints account for 6–16% of injuries among runners (34,47,60,88,94,107,108), and this problem was the third most common injury reported in a 1977 Runners' World survey (82). The most common diagnosis among 495 adult patients reporting leg pain at a Swedish sports medicine clinic was medial tibial syndrome (58%) and, together with stress fractures, accounted for 75% of all shin pain (108). Some researchers consider shin splints to be the most common cause of disabling leg pain in young competitive athletes (1,56). Shin splints accounted for 19.5% of 41 injuries seen in 257 track athletes competing for 17 high school teams during a 77-d season (158). Shin splints were also the most common injury reported in a national survey of ballet companies (157). In military studies, 4–10% of recruits were diagnosed with shin splints in 8- to 12-wk basic training (5,49).

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DEFINITION OF SHIN SPLINTS

Described in 1913 as "spike soreness" in runners (54), the meaning of the term shin splints is controversial. In 1966, the American Medical Association defined shin splint syndrome as "pain and discomfort in the leg from repetitive activity on hard surfaces, or due to forceful, excessive use of foot flexures. The diagnosis should be limited to musculoskeletal inflammations excluding stress fractures or ischemic disorders" (3). The AMA definition, however, has not been accepted universally. Some clinicians argue that the term "shin splints" should be applied to any exertional pain that occurs in the shins (7). Others argue that the term should be used only to describe a few specific clinical entities (95). And still others content that the term "shin splints" should be reserved as a generic term for lower leg pain once stress fractures, specific compartment syndromes, and muscle herniae have been excluded (8,10,45). In our literature search, we used the broadest definition of shin splints, in order to identify all potentially relevant studies. In the intervention studies, we specify the definitions used by the investigators.

Although the pathophysiology of shin splint syndrome remains unclear (83), it is an important performance-constraining injury among athletes that warrants careful study. Clinical and pathological studies have contributed to our understanding of the etiology of shin splints, but these

studies remain incomplete. For example, several studies of medial tibial (or mediotibial) stress syndrome indicate that it is not a compartment syndrome, suggesting to some researchers that periostitis is a likely etiology (97,102). Findings on bone scans, however, do not correlate well with histological observations on specimens obtained during surgery (14). Others believe morphologic bone changes are the basis for shin splints and attribute the pain to stress microfractures (61). In some patients with medial tibial pain, symptoms are relieved by fasciotomy, but surgery is not always successful, and pain is often relieved without surgery (117,153). Some clinical and cadaver studies locate the site of pain at the origin of either the tibialis posterior muscle, the soleus muscle, or the area of the osseous attachment to these muscles (30,99,132), but these findings are not consistent (9). Another hypothesis relates to muscle weakness at the origin of the flexor digitorum longus muscle (43), but this also is speculative.

The purpose of this paper is to review what is known about the pathophysiology of shin splints syndrome, present the evidence regarding associated risk factors, assess the effectiveness of prevention strategies, and offer recommendations for prevention of shin splints. We focus in particular on the assessment of interventions to prevent shin splints.

The cause of shin splints has also been a source of disagreement among clinicians. A variety of conditions, both acute and chronic, have been placed under the rubric of shin splints. Acute conditions include tibial stress reaction or periostitis, enthesis, fibrositis, myositis, traction periostitis, interosseous membrane pain, bone strains, tenosynovitis, and tendonitis of the tibialis anterior, the tibialis posterior, soleus, or the flexor hallucis longus muscles. Chronic conditions include a periosteal reaction that may lead to microfracture, traction periostalgia, chronic tendonitis, fatigue tears of collagen fibers that bridge the connection of muscle fibers to bone, and chronic compartment syndrome (9,32,102,112). Through the years, various theories about the etiology of shin splints have emerged, including stress fractures (33), ischemia of deep compartments (117), or soft tissue injuries (23,136,141).

Despite the AMA statement in 1968, differing opinions about shin splints continue for several reasons (137). First, the definition of "shin" is confusing, varying from "the front part of the leg below the knee," to "the front edge of the tibia," to "the lower part of the leg." Second, specific symptoms may vary by sport activity as different muscles and tendons are stressed. Finally, coaches and trainers usually see the athlete earlier in the clinical course than physicians and, consequently, may be confronted with a different clinical presentation. Understanding this complex problem clearly requires additional clinical and physiological research.

MATERIALS AND METHODS

We identified citations from the reference sections in 20 textbooks of sports medicine, family practice, and other primary care specialties, orthopedics, and general surgery. To identify papers for review, we use OVID version 2 and Internet-based Grateful Med to access several electronic databases: MEDLINE, 1966 to 2000; Current Contents, 1996 to 2000; Biomedical Collection, 1993 to 1999; and Dissertation Abstracts. We searched, without language limitations, for the subject terms "shin splints," "stress fractures," and "sports injury." We further narrowed the search by using the terms "etiology," "epidemiology," and "injury prevention and control." We then identified additional citations from the reference sections of papers retrieved and contacted experts in the field, including the first authors of randomized controlled trials (RCTs) addressing prevention of shin splints. Finally, we contacted the Center for Sports and History in Birmingham, UK, a part of the Cochrane Collaboration (an international network of experts who manually search the literature). We excluded papers that did not provide primary research data, that addressed treatment and rehabilitation rather than prevention, or that provided previously published data (53).

All articles were screened by one author (SBT). Of the 199 citations identified, 154 articles reported the pathophysiology and etiology of shin splints, the risk for shin splints in different sports, the identification of risk factors for shin splints, or methods for preventing shin splints. Of these, four compared methods of preventing shin splints.

We modified a scoring instrument previously used to evaluate the methodologic quality of the cohort studies and RCTs in sports medicine (143). Reviewers were blinded to the primary authors' names and affiliations but not to the study results (which have been shown to have little effect on the validity of quality scores) (13). Each citation was then evaluated independently by three reviewers. After independent evaluation, the reviewers met to reconcile substantive differences in interpretation. There were no differences in rank order of the studies, only in absolute scores.

Two authors independently extracted data from the RCTs to determine when pooling was appropriate. Because of differences in the interventions used, we elected not to pool any of the individual study-effect estimates.

RESULTS

Risk factors. Risk factors that play a part in sports injuries can be categorized as either intrinsic (or personal) risk factors, such as anatomic variations and physical fitness, or extrinsic (or environmental) factors related to the type of sport, such as the status of the athletic field or floor (147,148) (Table 1). Some of these risk factors can be related specifically to the occurrence of shin splints, whereas others are more generically related to overuse injuries. Numerous reviews published about factors associated with lower limb injuries among athletes, particularly runners, generally agree that several intrinsic factors are significantly associated with injuries. These factors include lack of running experience, competitive running, excessive weekly running distances, poor physical condition, and previous injury (4,17,22,38,51,58,62,63,68,71,76,77,89,100, 104,105,106,109,110,116,119,120,122,125,126,142,147,148,

TABLE 1. Intrinsic (personal) and extrinsic (environmental) risk factors that may increase the risk of shin splints.

Intrinsic Factors	Extrinsic Factors
Demographics	Sports-related factors
Age	Type of sport
	Exposure (e.g., running on one side of the road)
Sex	Nature of event (e.g., running on hills)
	Equipment
Physical build	Shoe/surface interface
Height	Venue/supervision
	Playing surface
Weight	Safety measures
Body fat	Weather conditions
	Temperature
Physical defects/anatomic variations	Relative humidity
Femoral neck anteversion	
Genu valgus	
Pes clavus	
Hyperpronation	
Joint laxity	
Previous fitness	
Aerobic endurance/conditioning	
Fatigue	
Strength of and balance between flexors and extensors	
Flexibility of muscles/joints	
Sporting skill/coordination	
Psychological factors	

152,160). Other intrinsic factors that have been proposed but with less consensus among these same experts include the following: older age, female gender, extremes in height and body fat, body build, structural abnormalities such as hyperpronation and femoral neck anteversion, participation in other sports, inadequate warm-up, incomplete stretching, increased running frequency, intensity of performance, lesser skill, instability of running patterns, sudden increase in training mileage, inadequate weight training, lesser strength, poor coordination, lack of flexibility training, imbalance between quadriceps and hamstring muscles, muscle fatigue, psychological factors, and smoking. Proposed extrinsic factors include type of sport, time of day, always running on the same side of the road, hard running surface or uneven terrain, shoes, in-shoe orthoses, climate, and weather conditions.

Epidemiologic studies support the increased risk of overuse injury with younger age (77,93,96), female gender (11,15,67,81,90,91,92,128,134), anatomical variations such as genu valgus and pes clavus (26,27,60,72,128), excess pronation (31,55,98), smoking (2,66), increasing weekly mileage in runners (18,25,52,59,79,93,129,131,155), more hours of aerobic dance (42,123), decreased physical fitness (15,19,20,35,38,42,64,65,66,77,81,96,113,128,130), and previous injury (42,86,91,93,121,128,155). A few contradictory findings suggest that age is not a factor (15,89,154), nor is gender (19,20,28,130,144,154); warming up, cooling down, or stretching (15,114,115,135,148); excess running mileage (98); running on hills (155); running surface (15,93,154); previous athletic activity (101); or joint laxity (57). Psychosocial factors and life stress are not related consistently to injury in the literature (16,29,40,48,73,74,75,87,111,145,146,159,161).

A few studies focus specifically on risk factors for shin splints, rather than on the general area of overuse injuries in lower limbs (31,41,44,84,103,139,151). Several of these studies point to the role of increased pronation of the foot as a risk factor for shin splints (31,44,84,139). In addition, the clinical studies suggest other possible risk factors including an increased varus tendency (139), increased muscular strength of the plantar flexor muscles (44), increased double heel strikes during dance among ballet dancers (41), increased angular displacement during running due to structural or functional differences in the foot and ankle (151), and increased external rotation of the femur with the hip extended (84). Some external risk factors include low calcium intake among female athletes, increased training intensity, hard running surface (123), and use of worn or inadequate shoes (103,140).

Prevention strategies. Textbooks and review articles present many recommendations for the prevention of shin splints. These recommendations, based primarily on expert opinion and clinical experience, include the following: screening for anatomical risks such as hyperpronation with appropriate adaptations for these risks, adequate overall physical conditioning, adequate diet, warm-up exercises, stretching exercises, activities to increase flexibility and strength, good running techniques, training techniques that promote balanced muscle development and do not overstress poorly conditioned athletes, minimization of running on hills and hard surfaces, rehabilitation for those injured previously, generic risk factor prevention activities related to behavioral and psychological stress, appropriate footwear, adaptation to physical factors such as heat and wet surfaces, and, in military settings, the time of day of exercise and the use of boots and running shoes (6,24,25,50,71,118,124,127,148). However, the evidence of effectiveness for any of these interventions is limited.

Methods to prevent shin splints. We found four RCTs (and no cohort studies) that compared methods to prevent shin splints (Table 2 summarizes study results). The first RCT was conducted at the United States Naval Academy in 1972 and 1973 (5). Investigators randomly assigned 2777 first-year midshipmen to one of four intervention groups or to a control group. Midshipmen in the intervention groups used some combination of foam heel pads, heel cord stretching exercises, or a graduated running program. The assignment to each group was done randomly with stratification for previously tested scholastic and athletic aptitude. A series of spot checks of individual platoons and physical education programs were made to ensure compliance. Platoons that were originally allocated to an intervention group but were found not to have carried out the prophylactic regimen were moved to the control group for the purposes of statistical analysis. The authors used the AMA criteria to define shin splints. During the 8-wk summer program, 97 cases of shin splints were recorded (4.1%) with no evidence of a protective effect of any regimen. After injured midshipmen completed an initial treatment regimen and returned to duty, 51 were assigned randomly to use heel pads and 46 were not. Shin splints reoccurred among 11 (22%) of the midshipmen with heel pads and among 5 (11%) of those without, but this difference was not statistically significant.

TABLE 2. Results of randomized controlled trials comparing methods to prevent shin splints.

Author	Year Published	Population	Study Groups	Outcomes	Median Quality Score
Andrish et al. (5)	1974	2777 M navy midshipmen in 8-wk basic training	1) foam heel pad 2) heel stretching 3) heel pad and heel stretching 4) graduated running 5) control	97 with shin splints 1) 15/344 (4.4%) 2) 12/300 (4.0%) 3) 14/463 (3.0%) 4) 13/217 (6.0%) 5) 43/1,453 (3.0%)	29
Bensel and Kish (11)	1983	2074 M, 767 F army trainees in 9-wk basic training	1) hot weather boots 2) standard black leather boots	27 with shin splints or tibial stress reaction 1) M 5/728 (0.69%) F 6/342 (1.75%) 2) M 8/1,346 (0.59%) F 8/425 (1.89%)	46
Bensel and Kaplan (12)	1986	555 F Army trainees in 9-wk basic training	1) urethane foam 2) molded grid 3) standard mesh	37 with shin splints 1) 11/186 (5.9%) 2) 14/198 (7.1%) 3) 12/171 (7.0%)	40
Schwellnus et al. (133)	1990	1388 M military recruits in 9-wk basic training	1) neoprene insoles 2) control	71 with tibial stress syndrome 1) 6/237 (2.8/1000 recruits/wk) 2) 65/1151 (6.8/1000 recruits/wk)	47

Among midshipmen who developed shin splints, 64 (66%) had no physical training immediately before the study compared with 33 (34%) who had prior training ($P < 0.001$).

The second RCT included 2074 men and 767 women in U.S. Army basic training at Fort Jackson, SC, in 1980 (11). Hot weather combat boots consisting of canvas uppers were assigned at random to 728 men and 342 women; the remaining 1346 men and 425 women wore standard black all-leather combat boots. Randomization was compromised by the availability of appropriate-sized hot weather boots and by an unreported number of switches that were made in the boot assignments. This study not only assessed the relative effect of bootwear on injury rates but also compared injury rates between male and female recruits. Shin splints were defined to include pain and discomfort around the anterior portion of the tibia. There were no significant differences in the rates of shin splints or tibial stress reactions (i.e., a suspected stress fracture lacking radiologic confirmation) in either men or women based on the type of boot worn. Women had greater rates of shin splints and virtually all other lower extremity injuries than did men, probably due to lower physical fitness levels on entry compared with men. Men reported more serious consequences of tibial stress reactions than did women (viz., higher rates of restricted duty days, 11% vs 4%).

A third RCT involved 555 women in U.S. Army basic training at Fort Jackson in 1985 (12). The trainees were assigned randomly to use one of three types of boot inserts: urethane foam with fiber backing, a molded network of lever-like projections attached at their base to material in the form of a grid, or the standard multilayered plastic mesh with a top covering of nylon. Injury data were obtained during special examinations in the 3rd, 5th, and final weeks of the 9-wk program as well as from sick-call records. The definition for shin splints is not cited but is likely to have been the same as the 1980 study from the same authors (11). No significant difference was found in the occurrence of shin splints (5.9–7.1%) among any of the study groups. A questionnaire concerning comfort of the inserts was distributed in the 5th week of training. The group wearing urethane foam inserts reported increased comfort compared with trainees wearing other inserts, but the difference was not statistically significant.

The fourth RCT, published in 1990, was conducted among 1511 South African military recruits during a 9-wk training period (133). Neoprene-impregnated flat insoles were provided to 250 randomly selected recruits to wear with their standard footwear. After transfers and exclusions of those with biomechanical problems or previous major injury or illness, 237 remained in the intervention group and were compared with 1151 remaining in the control group. Injuries were defined as an occurrence resulting from physical conditioning during basic training that was severe enough to prevent return to normal activities for at least 1 d after medical consultation. All injuries were monitored and reported to the base hospital where diagnosis was established and treatment instituted by a panel of eight doctors. Uniform diagnostic criteria were established before the intervention period, and all injuries were recorded on an injury report form. A random sample ($N = 260$) of both intervention and control groups completed a questionnaire to document physical activity patterns in the 12 months preceding the study. Injuries were diagnosed among 54 (22.8%) recruits in the experimental group and among 367 (31.9%) in the control group. The rate of injury was increased in the control group (36.3 per thousand per week vs 25.8 per thousand per week) ($P < 0.05$). Tibial stress syndrome (shin splints) was documented in 65 (20.4%) recruits in the control group and 6 (12.8%) recruits in the intervention group. The rates of tibial stress syndrome were 6.8 per thousand per week in the control group compared with 2.8 per thousand per week in the intervention group ($P < 0.05$). The critical finding of the study was that shock-absorbing neoprene insoles can significantly reduce the overall incidence of over-use injury and specifically prevent tibial stress syndrome. The authors noted that the overall incidence of

injuries was considerably less than the 37.9% reported 3 yr earlier in a population undergoing similar training in South Africa (46). The authors hypothesized that the reduction of injuries in the control group was a result of changes made in the physical training program after the previous report and that the use of the insole produced an additional reduction in the overall incidence of injury.

Quality of reported studies. Quality scores for the RCTs ranged from 28 to 53 (of a possible 100) for the individual rater scores; the median scores for the four studies ranged from 29 to 47. None of the RCTs reported adequate methods of randomization, nor did they report whether the assignment of subjects was blinded. Also, interpretation of results was hampered by the lack of attention to possible confounding factors and by both information and selection biases. For example, in the U.S. Naval Academy study (5), if members of an intervention group failed to comply with the study protocol, they were moved to the control group for the analysis, thus compromising the random allocation and introducing the possibility of selection bias. Statistical methods were inadequate in all four studies; indeed, none of the RCTs described basic statistical testing methods. In addition, power calculations were not reported, bias and confounding were addressed inadequately, multivariate analysis was not used even when factors were correlated, and the potential effect of multiple interventions was not assessed.

DISCUSSION

The most important conclusion one draws from this systematic, comprehensive review of the literature is that although many measures are recommended to prevent the occurrence of shin splints in sports, few have been examined rigorously. To date, only shock-absorbent insoles, foam heel pads, heel cord stretching, alternative footwear, and graduated running programs among military troops have undergone assessment in RCTs. Indeed, only four RCTs have been done in this field, and all have serious methodologic flaws. Also, the inclusion of only military populations in these studies limits our ability to extrapolate findings to both younger and older age groups and to civilian populations.

For future studies of this problem, attention to study design, implementation, and reporting is critical (85,116). Subjects in both intervention and control groups should be subject to uniform, consistent, and ongoing monitoring for the occurrence of injuries. Randomization should be blinded and the method of randomization described clearly. Whereas a double-blind study is often not feasible for studies of athletic injuries (for example, users of orthoses know they are wearing them), blinded allocation of subjects is essential to enhance the strength of the evidence. Case definitions must be explicit and easily replicable. In calculating rates of injury, careful consideration must be given to the choice of the denominators. Appropriate statistical methods should be used for data analysis and described clearly in publications. Finally, the reporting of the results should be improved so that the published data clearly support the conclusions.

The following research questions need to be addressed to inform coaches and athletes about injury prevention strategies:

1. Will any of the other interventions often recommended to prevent shin splints—such as specialized training methods, preseason conditioning, new shock-absorbent insoles, or alternative orthoses–prove effective in RCTs?
2. What are the dose response considerations (viz., frequency, duration, intensity of activity) in the prevention of shin splints?
3. Will RCTs conducted outside of the military setting generate different results?
4. What orthoses are most acceptable in terms of cost and comfort?
5. Are the same interventions equally effective for girls and women? (Few studies include women.)
6. Are the same interventions appropriate for all athletes, or do kinesiological and sports-specific considerations require different interventions for different populations?
7. Are the potential interventions as effective for athletes with a history of previous shin splints?
8. What clinical indicators can be used to help coaches and athletes determine when a player can return to competition or training without increased risk of reinjury?
9. What, if any, biologic or anatomic measures can be used as screening measures before a sports season that would warrant specific preventive actions (e.g., sports-specific training or orthoses)?
10. Do inherent behavioral factors associated with sports injuries present particular challenges of access to data and compliance of study subjects (e.g., will coaches or platoon leaders give priority to injury prevention, or what will motivate athletes to use preventive measures such as orthoses)?

On the basis of this review, we make one qualified recommendation to coaches, trainers, and athletes: the use of shock-absorbent orthoses inserts may reduce the occurrence of shin splints in young male athletes, possibly by absorbing shock and/or stabilizing the subtalar joint and by decreasing pronation (36,69,70,160). Effectiveness and acceptability of alternative inserts need to be assessed in different populations (138). On the other hand, interventions often endorsed for prevention of shin splints could well prove to be effective but cannot be supported by this review of available evidence. Some interventions, such as adequate shoes or shock-absorbing inserts, may have benefits beyond the prevention of shin splints, including the prevention of other overuse injuries such as stress fractures (39). Preseason conditioning has been demonstrated to optimize performance and prevent ankle sprains and knee injuries (21,37); evidence suggested in this review indicates that it may also help prevent shin splints. Strength, agility, and flexibility should be emphasized both in preseason training and during the season to optimize performance; they also should be emphasized for injury prevention. Whether general or targeted training will reduce the rate of shin splints awaits further research.

Sports at all levels are popular and health-promoting activities practiced by millions of persons worldwide, but these activities are also an important cause of preventable injury. When coaches and athletes make the effort to prevent athletic injuries, they will seek advice from experts in the field. When weighing this advice, coaches and athletes must be aware of the limits of the data.

After careful scrutiny, what is appealing intuitively can prove unhelpful in practice (150). For example, stretching before running is a standard recommendation; yet, a recently published RCT conducted among more than 1500 Australian military recruits found no decrease in injury risk with stretching (114). In fact, there is evidence that stretching may affect performance adversely (78). Research into the most effective means of preventing injury is crucial, as is effective interpretation of the science and its translation into practice (80,85,149,156). This review of the prevention of shin splints, one of the most common injuries among athletes, suggests that much work still needs to be done in this field.

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