Return to Running After a Tibial Stress Fracture: A Suggested Protocol

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ABSTRACT

Background and Purpose: Typical treatment of tibial stress fractures requires cessation of weight bearing activity followed by a gradual return to running. The purpose of this review was to examine the evidence behind increasing running mileage by 10% per week and develop an evidence-based return to running program. **Methods:** A literature search was conducted using search terms related to running, stress fractures, and bone healing. Relevant articles were identified through a 3-stage study selection process. **Findings:** The search produced 15 articles. One article contained a randomized controlled trial examining a graded training program. Eight articles contained return to running protocols. **Clinical Relevance:** This article provides an evidence-based protocol encompassing the most important aspects of stress fracture management. **Conclusion:** An original source or evidence for use of the 10% guideline was not found. Several articles suggested protocols or evidence for certain aspects of treatment, but none provided a complete evidence-based guideline or treatment plan.

Key Words: bone, injury, rehabilitation, sport

INTRODUCTION AND BACKGROUND

Long distance running is a commonly practiced means of engaging in exercise, physical activity, and leisure among the general population. Easy accessibility and a growing interest in disease prevention contribute to its increasing popularity.[1] Although distance running provides many positive health effects, injuries can and do result from this training mode. Overuse injuries frequently occur in the lower extremities due to repetitive tissue stress.[1] Edwards et al[2] estimate that 26% of recreational and 65% of competitive runners will sustain some form of overuse injury in any given year. Further, a higher incidence of injury has been appreciated in runners with previous lower extremity pathology.[1]

One overuse running injury that commonly plagues both elite and recreational athletes is a stress fracture. Stress fractures account for 15% to 20% of overuse injuries in runners.[2] A stress fracture is a mechanical failure of the bone in which activity of the osteoblasts cannot keep pace with activity of the osteoclasts. A repetitive, cyclical loading of the bone with inadequate recovery transpires and the bone is unable to repair itself between exercise sessions.[3] Unfortunately, the repetitive and high loading nature of running creates an ideal environment for stress fracture development. Other factors such as an increase in training intensity, running on hard surfaces, inappropriate footwear, and poor biomechanics may contribute as well.[4] The tibia is reported to be the most common site of stress fracture occurrence, accounting for 35% to 56% of all stress fracture injuries.[5] Tibial stress fractures in runners are most commonly located at the junction of the middle and distal thirds of the tibia along the tibial shaft.[6]

Etiology of Injury and Risk Factors

A number of extrinsic and intrinsic elements are considered risk factors for tibial stress fractures. An extrinsic element is an external factor that can impose additional stresses on the bone while running. Examples include training regimens, footwear, and running surfaces. An intrinsic element is an internal factor that can impose additional stresses to the bone. Examples of intrinsic elements include running mechanics, anatomical variations, and individual health factors including poor bone health (osteoporosis and low bone density).

Evidence suggests that improper training regimens are a key extrinsic factor in the occurrence of stress fractures. According to Reeder et al,[3] it is important to focus on the runner's training regimen and history in order to identify potential injury-causing factors. A sudden increase in the intensity and duration of training puts the runner at risk for developing a stress fracture.[7] A study by Matheson et al[8] states approximately 30% of athletes who had stress fractures incurred the injury within 12 weeks of a change in training regimen. The mileage run per week can also be a factor in the occurrence of stress injuries. Higher mileage per week is associated with increased risk of overuse injuries.[7] Studies show that running more than 64 km/week (approximately 40 miles/week) is a significant risk factor for lower extremity injuries.[9] Likewise, limited evidence suggests running year round without a break from training is a significant risk factor for lower extremity injuries.[1]

Other changes in training regimen such as changes in running surfaces or footwear are associated with injury as well.[3] Both Ballas et al[7] and Taube et al[10] suggest running on hard surfaces consistently (such as concrete) may increase the risk of stress fractures. Conversely, van Gent and colleagues[1] suggest the evidence behind this association is limited. Although some studies show footwear can play a preventative role in stress injuries overall, it may not play a significant role in the reduction of tibial stress fractures specifically.[11] Some evidence suggests that proper footwear may be a protective factor for female runners only.[1]

Inappropriate running mechanics are common intrinsic factors associated with stress factors. Specifically detrimental are running mechanics such as deviations in hip and ankle motions that increase tensile forces on the tibia.[5] Abnormal kinematics during running can also contribute to altered loading patterns on the tibia.[5] Pohl et al[5] identified increased peak hip adduction, peak rearfoot eversion, and peak absolute free moment as significant predictors of tibial stress fractures. Hindfoot and forefoot varus and compensatory hyperpronation were also linked to tibial stress injuries.[12]

Bennell et al[13] describe reduced muscle size and strength, particularly in the calf muscles, as another predisposing factor to stress fractures. Additionally, the interplay between running mechanics and factors related to bone healing suggest that changes in stride length and running speed may also be important to consider as an athlete returns to running.

Anatomical factors play a role in predisposition to stress fractures. Clinically relevant leg length discrepancy is found to increase the likelihood of stress fractures in an athletic population.[13] A pes cavus foot is linked to stress fracture incidence; because this foot type is more rigid, it does not absorb shock and passes impact forces to the tibia therefore increasing risk for a tibial stress injury.[13] Abnormal lower extremity range of motion such as increased hip external rotation and decreased ankle dorsiflexion are also associated with stress fractures.[13]

There are also physiological factors that affect injury risk. A history of injuries is a significant health factor associated with lower extremity injury, as is poor physical fitness before beginning a training regimen.[1,14] Additionally, females are more likely to develop stress fractures.[1] This may be due to lower bone density as compared to males.[5] Females may also suffer from amenorrhea due to high training levels, abnormal eating patterns, and decreased body weight (commonly known together as the female athlete triad). Amenorrhea is linked to low bone mineral density and susceptibility to stress fractures.[3]

Intervention

Typical intervention for a tibial stress fracture requires full cessation of weight bearing activity followed by a gradual return to painfree activities.[15] Raasch et al[11] reported that runners are often noncompliant with the recommended full cessation of running, as they commonly exhibit a "need to run attitude." The high motivation of this population to return to sport quickly calls for the careful compilation of an appropriate and gradual return-to-running protocol that takes into account the many factors involved with successful healing of a tibial stress fracture. Unfortunately, there are few concrete guidelines established to assist runners during the "return to running" process. One such guideline that is commonly referenced in this regard is the "10% rule."[7]

The 10% rule suggests that runners increase their mileage by no more than 10% per week. Incrementally increasing running volume is a factor in preventing an overuse or reinjury as it allows the body to gradually adjust to external impact forces.[16] The 10% rule alone however does not adequately address the variance among runners, or the numerous factors that can contribute to a stress fracture. In fact, Bennell et al[13] reported there are no published studies comparing different return to running programs that include evidence for progressive increases in loading. Despite the lack of evidence, the 10% rule has become a well-known standard rehabilitation protocol for returning runners to their prior level of training. Therefore, the purpose of this review was to examine the evidence behind the 10% rule for return to running following a tibial stress fracture, and to develop an evidence-based and safe return to running program post tibial stress fracture.

METHODS

Search Strategy

The databases of Medline, SportDiscus, EMBASE, PEDRO, CINAHL, the Cochrane Library, and the National Guideline Clearinghouse were searched for relevant literature. The following search terms were used: stress fractures, running/injuries, running/education, athletic injuries, lower extremity injuries, fracture/bone healing, physical education training/rehabilitation, cumulative trauma disorders, and exercise therapy/therapy. The search was limited to English-language articles published within the last 20 years. Initially, all papers associated with lower extremity athletic related injuries were included. Articles were excluded if subjects in the study were either less than 18 or greater than 65 years of age.

Study Selection

The study selection was a 3-stage process. The first stage evaluated relevance to this topic by reviewing the article titles. The article was included if the title met at least one of the following criteria: related to a fracture of the lower extremity, referenced a running protocol, or discussed the rehabilitation process for return to running. A total of 4 reviewers participated in this stage. The articles generated by the initial search were divided in half. Two reviewers were assigned to each half. Each reviewer individually identified articles that met the selection criteria. All articles identified as meeting the search criteria were included in the next stage of review, even if only one of the two reviewers identified it as relevant.

The second stage in the study selection process consisted of one reviewer further assessing the title and qualitatively reviewing the abstract of each paper. For a paper to be retained for further scrutiny, the title or the abstract had to be associated with tibial fractures, use humans as subjects, or allude to running related protocols. Exclusion criteria for this stage of the selection included femur, fibula, tarsal and foot bone fractures, muscular related running injuries, and lower extremity injuries related to athletic activities other than running.

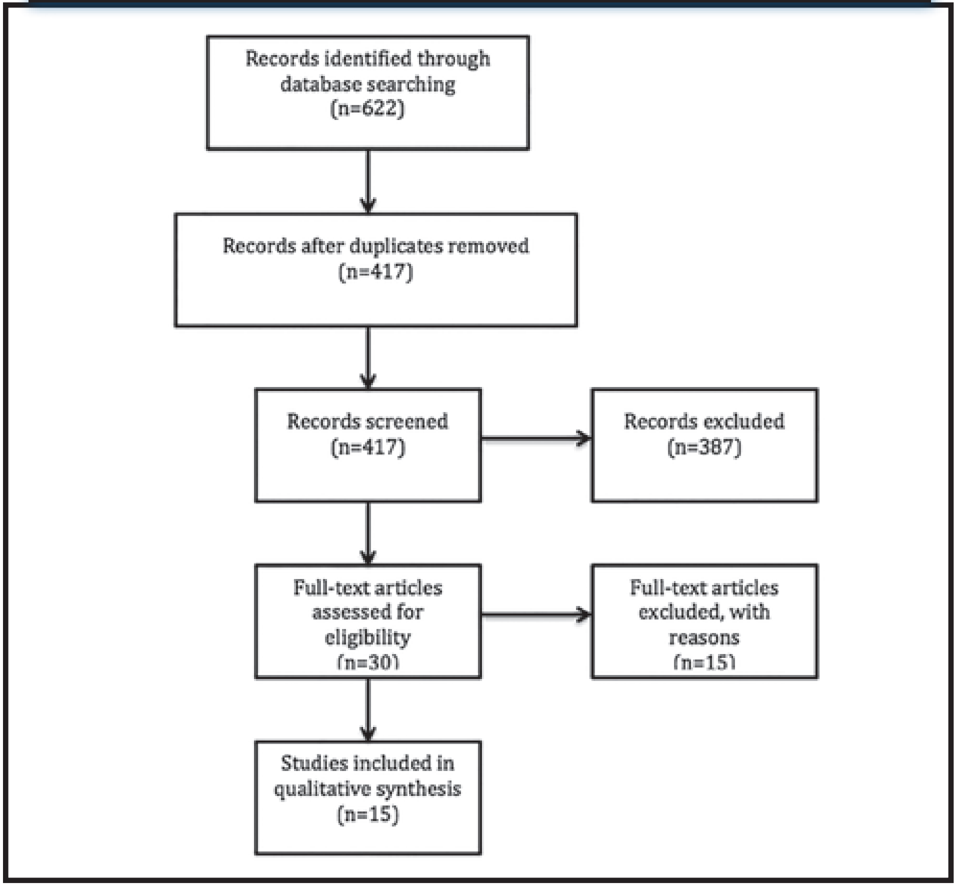
The third and final stage of the study selection involved two reviewers reading the title, abstract, and full text of each article, again searching for relevance to our review's purpose. Papers included during this final stage were confirmed via reading of the full text to include clear references to risk factors associated with stress fracture in addition to return to running protocols, or currently accepted treatment of tibial stress fractures. Papers were excluded if they were opinion pieces/case studies, included only a limited population (females only, military only, professional athletes only), or were determined to be unrelated to our purpose (psychological readiness for return to sport). Each reviewer assessed the articles independently. In the event of a disagreement between the two reviewers, a single third reviewer was asked to read the article and make an inclusion decision. The types of studies that were reviewed for inclusion were randomized controlled trials, case studies, and systematic reviews.

After these 3 stages of the initial study selection, we performed a final search to identify any additional relevant articles that could contain helpful information related to our purpose and may have previously been missed. To do this, the references of all articles that remained were compiled into a master list. Duplicates and all articles previously screened out during the selection process were removed from this list. From those articles that remained, we hand searched to identify articles with information relevant to our review and scrutinized each using the same 3-stage process (Table 1) previously described.

Protocol Creation

In order to create our own protocol, we gathered the components of each existing protocol from the articles we accepted for use in our study into one large document, separately listing each component. Components varied widely amongst the protocols and included elements such as a non-weight

Table 1. PRISMA 2009 Flow Diagram



bearing (NWB) phase, cryotherapy, hamstring stretching, strengthening, and return to activity. Using the literature we identified through our original search, as well as separate searches if necessary, we cited the existence and level of evidence behind each component separately (Table 2). If there was no evidence available for any listed component, it was excluded from the final protocol. Once all the evidence was graded, we organized it in such a way that the order and progression was logical. We used the Agency for Healthcare Research and Quality criteria to grade the evidence (Table 3).[22]

RESULTS

Search Results

Through database searching, 623 records were identified. After duplicates were removed, 417 publications met the inclusion and exclusion criteria for the title. Of these 417 publications, 387 were excluded based on the title and abstract. This left 30 full-text articles to be assessed for eligibility for inclusion. Fifteen of those articles were excluded due to inappropriate sample population and lack of protocol relevance, leaving 15 articles for inclusion in this study. The final hand search did not generate any additional articles used in this review (Table 1).

Validity of 10% Rule

Of the 15 articles produced by this search, none specifically examined and demonstrated the validity of the 10% rule for increasing mileage in running. Arendt et al[17] examined the occurrence rate of stress fractures in Division I athletes (in all sports including track and cross country but excluding football) at the University of Minnesota over a 10-year period. Although, this study was able to show that 48% of the stress injuries to bone could be correlated to a change in training regimen.[17] This study however did not specifically examine a 10% increase in mileage per week in the running athletes. The study also indicated higher grade stress injuries required a significantly longer time to return to full activity than lower grade stress injuries.[17]

Existing Protocol Review

Eight of the articles located through our search included protocols for return to running after stress fracture. We extracted categories of information from each article including the initial weight bearing status of the patient, recommendations for cross-training, and intervention based on specific identified intrinsic and extrinsic risk factors. There were several discrepancies and differences between these protocols regarding each of these categories. For example, recommendations related to weight bearing ranged from NWB to weight bearing as tolerated (WBAT) by the patient. Similarly, intervention recommendations ranged from modalities such as ice, transcutaneous electrical nerve stimulation (TENS), and ultrasound to changes in training surfaces. The lack of standardization regarding stress fracture management and return to running postinjury indicates validity of our purpose, the necessity of careful examination of existing evidence. Additionally, it indicates the usefulness of compilation of the best-supported portions of each protocol into a new and comprehensive return to running program. It should be noted that we do not support a "one size fits all" approach to treatment of any dysfunction. We do however, support the creation of a general protocol that includes specifically graded evidence for each intervention and allows clinicians to make educated decisions as they adapt it to each individual patient. In recognition of this, although several protocols were identified, we noted that none offered evidence that the interventions included had been tested in a systematic scientific fashion, nor did any of the identified protocols specifically grade their evidence.

DISCUSSION

While compiling the current evidence regarding return to running after a tibial stress fracture, multiple protocols were found. Although many of these protocols call upon the existing evidence regarding factors such as running mechanics and bone healing, none of the protocols grade the evidence behind their protocol development and activity recommendations. Since these protocols do not contain graded evidence for their interventions, we identified a need for an updated evidence-based return to running protocol for athletes with tibial stress injuries. This new protocol (Appendix) compiles the evidence behind the causes and the modifiable risk factors of tibial stress injuries and the existing return to running protocols. Again, the graded evidence behind each component of the new protocol is presented in Table 2.

Table 2. Graded Evidence

Phase I: Rest

PHASE I: 3-10 days	**Initial Exercises**		
Goal	Minimize pain, inflammation, and edema Promote proper tissue healing Strengthen proximal musculature Stretch tight musculature		
WB	Nonweight bearing until walking pain-free		
Precautions	Do not force weigh bearing status, progress as pain allows		
Progression Criteria	Painfree during all exercises May progress to Phase II exercises when walking is pain-free for half mile		
Treatment Suggestions/Precautions	Education: etiology, footwear, training factors, nutrition, risk factors, biomechanics, the recovery process Pain management: rest, cryotherapy Exercises:		
	Name	**Level of Evidence**	**Description**
	Cryotherapy (Hubbard and Denegar, 2004)	Moderate	Use until swelling subsides
	Sidelying hip abd/ER (Reiman et al, 2012)	Moderate	Sidelying with hip flexion, raise flexed lower extremity
	Bird-dog quadruped (Reiman et al, 2012)	Moderate	Kneel on all 4 extremities, with contralateral arm/leg lift
	Gastrocnemius and soleus stretch (Fredericson M, 1996)	Moderate	Long-sitting, use foot strap for gastrocnemius. Seated, knees flexed with foot strap for soleus
	Hamstring stretch (Fredericson M, 1996)	Moderate	Long sitting, reach for toes
	Nonweight bearing until painfree (Arendt et al, 2003)	Strong	Do not load the lower extremity until pain is 0/10

Phase II: Cross Training

PHASE II: 4-7 weeks	**Transition Exercises**
Goals	Gradually increase muscle strengthening activities into weight bearing activities Incorporate cardiovascular conditioning via low-impact cross-training Reintroduce multi-planar movement Continue to stretch tight musculature Begin core strengthening Reintroduce jogging

WB	No limitations in weight bearing for daily activity
Precautions	Do not overstress during strengthening activities Proper education and supervision are required for elliptical use No more than 30 minutes daily for lower extremity conditioning, but no limitations for upper extremity conditioning Alternate strength and cardiovascular training by every other day For any pain, regress exercise protocol by one week Do not start jogging before week 3
Progression Criteria	Painfree during all exercises May progress to Phase III exercises when patient can jog 10 minutes painfree
Treatment Suggestions/Precautions	Exercises:

Name	Level of Evidence	Description
Low impact cardiovascular training (Arendt E et al, 2003)	Strong	Walking, deep water pool running, aqua walking/jogging, stationary bike, elliptical training
Non-competitive freestyle swimming	Moderate	Freestyle swimming using upper and lower extremities to propel the body forward
Upper extremity ergometry (Taube RR & Wadsworth, LT 1993)	Moderate	Adjust arm resistance as tolerated
Gastrocnemius, soleus and hamstring stretch (Fredericson M, 1996, Taube RR & Wadsworth LT, 1993)	Moderate	Stand on slant board with LE extended or flexed for gastrocnemius and soleus, respectively. Long sitting with foot strap for hamstrings
Heel raises (Taube RR & Wadsworth LT, 1993)	Moderate	Standing and lifting heels off of the ground
Bridge/plank and side bridge (Reiman et al, 2012)	Moderate	Prone or sidelying, raise trunk while WB through forearms and knees/toes
Side stepping with abductor band (Reiman et al, 2012)	Moderate	Initially, side step without a band; Place band proximal to ankle and step laterally
Two leg bridging (Reiman et al, 2012)	Moderate	Supine, knees flexed and feet flat on the table. Raise pelvis off the table. Maintain neutral spine and pelvic alignment
Lunge (Reiman et al, 2012)	Moderate	Standing, flex single hip and knee forward into lunge position. Make sure knee does not pass toes and hip, knee, and 3rd toe are in proper alignment

(Continued on page 42)

Table 2. Graded Evidence *(Continued from page 41)*

Phase III: Running			
PHASE III: 4 weeks	**Running Exercise**		
Goals	Restore muscular strength Restore cardiovascular endurance Incorporate sport-specific plyometrics Educate proper running form, biomechanics, and training Maintain strength training and flexibility from Phase II exercises Progress to pain-free running at moderate intensity		
Precautions	Two week progression and one week regression If any pain, regress exercise protocol by one week		
Progression Criteria	Make appropriate adjustments to running stride (cadence, stride length, speed) Gradually increase mileage and intensity		
Treatment Suggestions/Precautions	Exercises:		
	Name	**Level of Evidence**	**Description**
	Elliptical training (Raasch WG & Hergan DJ, 2005)	Moderate	Lower extremity and upper extremity cyclic movement on cross trainer
	Sport-specific drills (Podlog et al, 2010)	Moderate	Progress forward hops, bounding, step hops, high knees, etc.
	10% stride length reduction (Edwards B et al, 2009)	Moderate	Smaller steps while running
	Decrease running speed by 1 m/s (Edwards B et al, 2010)	Moderate	Reduce running pace
	Running progression (Liem BC, Truswell HJ & Harrast MA, 2013)	Low	Progress conservatively; watch for compensations in gait

Suggested Protocol

Our return to running protocol comprises 3 phases. The first phase (Phase I) is a resting phase. This phase begins as soon as a tibial stress injury is identified. Once diagnosed, the runner is then classified into one of two groups. Group I contains runners that are at a high level of fitness (clinician estimated $VO_2max \geq 45$ ml/kg/min), are of younger age (≤ 35 years of age), have good bone health, do not have a history of previous stress injury, have minimal pain at rest (≤ 3/10 as measured by a numeric pain rating scale) and early detection of their stress fracture (within one month of pain onset). Group II contains runners who have a high pain level at rest (> 3/10), history of previous lower extremity running related injury, low to mid-level fitness levels, later identification of injury after initial pain onset, poor bone health (evidence of osteopenia, osteoporosis, or other factors such as the female athlete triad), or for any other reason are not appropriate for Group I. During this phase, runners in both groups are recommended to be NWB until the athlete is painfree at rest and cleared to weight bear by their physician. The focus of intervention will be on educating the athlete, pain management, assessing muscular imbalances, strengthening and stretching. After the runner is painfree at rest, they can begin walking/weight bearing as part of their normal activities of daily living (ADLs).[10] Once the member of group one can complete their ADLs for 3 to 5 days painfree, they move on to the next phase (Phase II).[17] Members of Group II must be painfree with ADLs for 7 to 10 days before moving to the next phase.[7] If at any time the runner starts to experience pain again, they must return to Day 0 of their painfree rest day count and progress through the phase as before.

Phase II of the protocol is the transition and cross-training phase. The focus of this phase is to progress strengthening exercises and introduce cross-training as tolerated. This phase also begins to introduce high impact activity in a cyclical nature in order to allow for proper bone healing. Our research suggests that one full cycle of bone healing will take 16 to 24 days (about 3 weeks), and that extra care should be taken during the last 6 to 10 days of this cycle to avoid overstressing the new deposition.[4] Submaximal loading is important during the first two weeks as this stress stimulates the activity

Table 3. Agency for Healthcare Research and Quality (AHQR) - Strength of Evidence	
Strong	**High confidence that the evidence reflects the true effect.** Further research is very unlikely to change our confidence in the estimate of effect.
Moderate	**Moderate confidence that the evidence reflects the true effect.** Further research may change our confidence in the estimate of effect and may change the estimate.
Low	**Low confidence that the evidence reflects the true effect.** Further research is likely to change the confidence in the estimate of effect and is likely to change the estimate.
Insufficient	Evidence is either unavailable or does not permit a conclusion.

of osteoblasts. Given this, our cycles are 3 weeks in length with the third week reserved for reduced loading. During this phase, the runner must remain painfree in order to allow continuation through the protocol. If the runner experiences pain, they return to the previous week's activity level. By the end of this phase, runners of both groups will complete 10 minutes of painfree light jogging before moving onto the final phase of the protocol.

Phase III of the protocol is the return to running phase. This phase focuses on continued education of the runner as well as making minor adjustments to running speed and stride length to reduce the risk of reinjury. Edwards et al[14] suggest that reducing running speed is an effective kinematic adjustment that can be implemented during the regimen's initial stages to reduce the probability for tibial stress fracture. Additionally, as return to running progresses, it must be considered that changes in stride length are naturally occurring in conjunction with changes in running speed.[2] The reduction in external ground reaction forces appears to be more related to decreased stride length rather than changes in speed.[2] Therefore, the athlete further into recovery can benefit from attention to cadence as an increase in cadence allows a reduction in stride length without sacrificing running speed.

The early portion of this phase is structured as the runner increases the amount of high impact activity and introduces different running surfaces. Group I will complete a minimum of one structured training cycle and then be given recommendations on how to progress to their previous activity level if they remain painfree. Members of Group II will remain on the structured program for 4 cycles before beginning their independent progression to their previous activity level. Four cycles allows adequate time for complete maturation of the new bone in this more high risk group.[4]

Many factors were considered in the development of this protocol. Athlete education is introduced early in the protocol to keep the runner from making training choices in the future that may lead to reinjury. Strengthening and stretching are also introduced early on to address some of the biomechanical factors that predispose a runner to injury. A cyclic approach to training that incorporates a rest phase reduces the risk of reinjury during the weaker phases of bone remodeling. Forms of low impact exercise are used during the cross-training phase to help maintain the athlete's fitness level without over-stressing the bone. It should be noted as well that along with the suggested protocol presented here, clinicians should always tailor interventions to the unique risk factors and specific needs of each patient based upon subjective history reports as well as physical examination findings.

CONCLUSION

The purpose of this review was to examine the evidence behind increasing running mileage no more than 10% per week, and to compile existing evidence regarding tibial stress fracture rehabilitation and return to running protocols. The majority of the articles produced by our search referenced gradual training progression and many of them specifically mentioned a 10% per week increase in mileage per week, but none of the articles cited a specific source or origin of the 10% guideline. Furthermore, none of the articles have tested or provided evidence for use of the 10% guideline. With regard to our protocol creation, it should be noted that although we are confident in the content and evidence behind our suggested protocol, we recognize that its validity is also limited until it too has been tested in a formal, randomized trial.

CLINICAL APPLICATIONS

Tibial stress fractures are a common injury plaguing runners across the ability spectrum, and can be difficult to treat. Runners are often instructed to "rest and return gradually," but this treatment suggestion is ambiguous and may be misinterpreted. It also does not take into account each athlete's unique characteristics such as previous bone health, age, running biomechanics, and training status, all of which are important factors in rehabilitation. The clinical application of the literature review culminates in our creation of a return to running protocol.

Given the complexity of the rehabilitation from stress fracture to a return to running, we identified a need for an evidence-based set of guidelines considering the most important aspects of stress fracture management: bone healing time and phases, pain as an indicator of healing, and a multimodal approach to the return to activity and running.[17] We researched and considered carefully the effects each of these have on a safe progression. Although we acknowledge that it has not been tested formally, we believe that the evidence and research behind each component make it a useful resource for physical therapists treating this injury.

Overall, this protocol is easily adapted for use with a wide range of athletes. It uses pain (a very individual experience) as an indicator for progression through the phases, so that each athlete is considered uniquely and appropriately for his or her personal response to the rehabilitation. This, along with suggestions for interventions along the recovery continuum, and explicit evidence grading for each, make these guidelines useful widely in the clinic.

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Appendix. Return to Running Protocol

Phase I: Rest (Duration: 3-10 days)

Initially, subjects are classified into either Group 1 or Group 2.

Criteria for Group 1:
- Stress fracture diagnosed within one month of onset;
- Higher estimated fitness level (VO2 max>45ml/kg/min);
- Age ≤35 years;
- Good bone health;
- Hormonally 'normal';
- Resting pain level at onset ≤3/10.

Criteria for Group 2:
- Stress fracture diagnosed after one month of onset;
- Lower estimated fitness level (V02 max<45ml/kg/min);
- Age ≥35 years old;
- Poor bone health (e.g. osteopenia/osteoporosis);
- Previous running related injury;
- Resting pain level at onset ≥3/10.

Baseline: Nonweight bearing until painfree at rest and released to weight bearing by physician

Suggested interventions include:
- Education: recovery protocol, etiology, footwear, training (surfaces, intensity, progression), nutrition, risk factors, biomechanics
- Assess muscular imbalances, biomechanical errors (distal and proximal)
- Hip strengthening: open chain exercises (e.g. sideling hip abduction, bird-dog)
- Pain management: cryotherapy
- Stretching (eg, gastrocnemius, soleus, hamstrings)

"Painfree Transition"
Patients in Group 1 must be painfree with walking for 3 to 5 days before transitioning to Phase II while patients in Group 2 must be painfree with walking for 7 to 10 days before transitioning to Phase II.

Phase II: Transition/Cross-training (Duration: 4-7 weeks)

Baseline: Patient is painfree in normal weight bearing activities and can complete activities for daily living for 3 to 5 days painfree.

Suggested interventions include:
- Progress core/hip strengthening into weight bearing multi-planar activities
- Monitor impact with running
- Low impact cross-training (cycling, pool running, swimming, upper extremity ergometry)

- Phase II guidelines:
  - Cardiovascular training (cross-training or jogging) every other day with strength exercises (sidelying hip abductors, etc.) on off days.
  - A cycle consists of a two week progression (increasing jog time) and one week regression (decreasing jog time).
  - Unlimited UE activity is allowed for cardiovascular health.
  - Total daily cardiovascular training time (cross training time + jogging time) will be 30 minutes each day.
  - Jogging time is recommended approximately halfway into the cardiovascular training time.
  - If any pain is present, regress protocol by one week.

Group 1 (one cycle)			Group 2 (two cycles)		
	Cross-train time (mins)	Jogging time (mins)		Cross-train time (mins)	Jogging time (mins)
Week 1	20, 25, 30	0, 0, 0	Week 1	20, 20, 25	0, 0 ,0
Week 2	29, 27, 25	1, 3, 5	Week 2	25, 30, 29	0, 0, 1
Week 3 (rest)	30, 30, 28	0, 0, 2	Week 3 (rest)	30, 30, 30	0, 0, 0
Week 4	25, 23, 20	5, 7, 10	Week 4	29, 27, 25	1, 3, 5
↓			Week 5	25, 23, 21	5, 7, 9
			Week 6 (rest)	30, 28, 26	0, 2, 4
			Week 7	22, 21, 20	8, 9, 10

If 10 minutes of jogging is painfree, progress to Phase III

(Continued on page 45)

Appendix. Return to Running Protocol *(Continued from page 44)*

Phase III: Return to Running (Duration: 4+ weeks)

Baseline: Patient must be painfree with activities of daily living for 7 to 10 days and can jog painfree for 10 minutes.

Suggested interventions include:

- Education: shock attenuation activities, biomechanics, training surfaces, gradual mileage increase.
- Biomechanics adjustments: decrease running speed by 1m/s and reduce stride length by 10%.
- Maintain strength training and flexibility from previous phases.
- Progress to painfree running.
- Continue training cycle of 2 week progression and 1 week regression.
- Workout days may progress from 3 to 4 days/week.
- Surface changes are introduced in week 4 if painfree.
- If any pain is present, regress protocol by one week.
- Group 1 and Group 2 begin Phase III with the same treatment protocol and progression shown below.

Phase III Sample Protocol

	Cross-train time (mins)	Jogging time (mins)
Week 1	15, 10, 5	15, 20, 25
Week 2		25, 30, 35
Week 3 (rest)		35, 30, 30
Week 4		35, 35, 40
Week 5	If patient is painfree and is educated on gradual mileage progression, patient may progress individually from this point forward.	

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