Risk factors for overuse injuries in runners’ ankles: a literature review

Julia Maria D’Andréa Greve, Nathalie Ferrari Bechara Andere, Natalia Mariana Silva Luna, Alexandra Carolina Canonica, Ticiane Marcondes F. da Cruz, Mark Peterson, Angelica Castilho Alonso

INTRODUCTION: In spite of the numerous benefits to human health and given the increase of running as an exercise that has become popular worldwide, this type of sport may be the cause of a number of different injuries. The foot, ankle and lower leg comprise almost 40% of the injuries. However, the etiology of these types of injury is still not completely understood.

OBJECTIVE: To investigate the causes of the onset of overuse injury in runners.

METHODS: A systematic search of the electronic database was made: Bireme, Pubmed and PEDro, which were selected that addressed clinical trials, control cases, prospective and cross-sectional studies.

RESULTS: The search through the descriptors yielded 324 references. Using our predefined inclusion criteria (case studies, clinical trials, prospective studies and cross studies that addressed adult runners, amateur or professional) 68 articles remained; 24 citations were excluded after reading the title, and 35 were excluded after reading the abstract and the full text. Therefore nine studies that met the criteria for analysis were included.

CONCLUSION: The etiology of overuse injuries in runners is multifactorial. This review showed that distance, soil type and footwear, as well as a history of previous injuries, biomechanical changes such as increased dorsiflexion and eversion ankle, and greater knee flexion are risk factors that influence the occurrence of these injuries.

KEYWORDS: Ankle; Overuse; Running.

E-mail: angelicacastilho@msn.com
METHODS

This study was developed at the Laboratory of Movement Study, Institute of Orthopedics and Traumatology, Faculty of Medicine, University of São Paulo, Brazil.

Inclusion criteria

The inclusion criteria were case studies, clinical trials, prospective and cross-sectional studies that addressed adult runners (18-44 years old), amateur or professional. The included studies had biomechanical and risk factors evaluation in subjects with a history of overuse injury to the ankle, published over the last 10 years, in English. We excluded studies that addressed disorders that were not overuse injuries in runners. Review articles and case reports were also excluded.

Research strategy

The literature review was carried out in the following electronic databases: Bireme (Regional Medical Library), PubMed (U.S. National Library of Medicine and the National Institutes of Health) and PEDro (Physiotherapy Evidence Database). The search aimed to find articles published on overuse injuries in runners’ ankles, with the following scientific descriptors: overuse injuries, ankle and running.

Review process

Two researchers (NFBA and NMSL) independently conducted the review process. After the pre-selection of articles, titles and abstracts were read to check for compliance to the objectives. The references were selected by reading the titles and abstracts independently, and by creating a single list of all the articles to be included into, or excluded from the study. In case of doubt, the complete text was read. After this stage, the inclusion or not of the articles was decided. The search through the descriptors totaled 324 references. Using the inclusion criteria, 68 studies remained. We excluded 24 citations after reading the title, and 35 after reading the abstract and the full text, leaving therefore nine studies that met the analysis criteria. A third examiner (ACC) inspected the data in quest for any disagreement between the two primary researchers.26

RESULTS

Table 1 presents the results of the primary search. Once the complete articles were acquired and the complete reading of those studies was evaluated, nine studies were eligible for review, as illustrated by the flow chart in Figure 1.

The selected studies were analyzed and data extraction was carried out as the sample characterization, details of the assessment or intervention and conclusion. The year of publication of the articles was from 2004 to 2012 and the sample size ranged 22-1004 subjects. All articles were clinical trials, including a prospective cohort study. Of the nine studies selected, seven included a control group, and six compared subjects with and without injury; in one study all participants had a history of injury and were divided into two groups, one using bracing, one not (group control).

The most recent study investigated overuse injuries in running and associated factors through a questionnaire.27 Two studies assessed the activation of ankle muscles during running using electromyography.28-29 Four studies consisted of kinematic analysis performed by a three-dimensional camera system30-32 whereas a single study included a kinetic analysis performed on a force platform.33 One study used an electronic platform system for assessment of foot type (Novel Electronics Munich, Germany);34 and finally, one study measured the alignment of the lower limbs through measuring devices (tape and goniometer).35

Achilles tendinopathy was the most discussed injury, appearing in four articles29-32, followed by stress fracture (one study).33 However, the other four articles included various overuse injuries in the lower limbs.27,28,34,35

The manner of evaluation during running varied widely. In two studies individuals were evaluated running with standardized neutral shoes,29,33 In the study by Lun et al.36 participants wore their usual running shoes. In the Donoghue et al. study, participants either wore shoes or ran barefoot; in Ryan et al. study,38 all runners ran barefoot. In the other Donoghue et al. study,31 athletes used their own shoes and were evaluated with and without orthosis; in the Baur et al. study,28 the test group used orthosis and the control group did not; in the Nakhaee et al. study34 athletes were evaluated during free gait.
Figure 1 – Flow chart of study selection.
Two studies used only male subjects,\textsuperscript{30,34} whereas Milner et al.\textsuperscript{31} studied females. In six studies, men and women participated.\textsuperscript{27-29,31,32,33} In three trials, subjects were runners with running distances greater than 32 km/week;\textsuperscript{28,29,33} in one study (Ryan et al.\textsuperscript{30}) all volunteers ran at least 30 km per week; in the Lun et al. study\textsuperscript{35} athletes ran at least 20 km/week; the Chung et al. study\textsuperscript{27} included runners who participated in races of 10, 21 and 42 km; Nakhaee et al.\textsuperscript{34} evaluated professional runners training 2 hours 3 times a week; two studies\textsuperscript{31,32} did not mention the type of training, but state that all subjects were involved in racing or in sports where running was the main element, and included control group subjects recruited from running clubs.\textsuperscript{31,32}

Table 2 shows the main features found in nine studies analyzed in this study.

\section*{DISCUSSION}

The evaluation of factors associated with overuse injuries in runners’ ankles had very different objective and methodological approaches in the various studies included in this review; no two articles came up with the same proposal. They diverge mainly in the study population, group choices, evaluation methods, and injury types.

A systematic review study highlighted the differences between athletes with or without calcaneal tendinopathy with respect to the biomechanical profile of their lower limbs during running; the most significant difference was the eversion of the subtalar joint.\textsuperscript{36} This point was corroborated in all the selected studies which did perform a kinematic analysis.\textsuperscript{30,32} Individuals who used shoes showed greater eversion values than those who ran barefoot.\textsuperscript{22} The comparison of individuals running with and without the use of orthoses agreed with previous data on eversion, ankle dorsiflexion and knee flexion in subjects with Achilles tendinopathy: orthoses reduced dorsiflexion, but increased eversion.\textsuperscript{31}

In individuals with no history of lesions, Wiegerink et al.\textsuperscript{37} detected differences with respect to pressure peak, maximal force and contact area when comparing runners wearing two different shoe types; they concluded that these differences may be important when one considers the influence of shoe type upon the occurrence of stress fractures in runners, generally.

Two studies by Baur et al.\textsuperscript{28,29} were eligible for selection. They analyzed the neuromuscular activity by electromyography (EMG), in different situations. One study compared the neuromuscular activity among runners with Achilles tendinopathy vs. healthy subjects;\textsuperscript{29} and the other observed the activation of the peroneus longus muscle before and after eight weeks of use of bracing, in runners with symptoms of overuse injury.\textsuperscript{28}

In the first study, there was less activation of the peroneal muscle during weight bearing in patients with calcaneal tendinopathy when compared to controls. But no differences were found in the pre-activation and push-off, nor in the average of the gastrocnemius amplitude values. Thus, the authors concluded that calcaneal tendinopathy does not seem to change the preprogrammed neural control, but can induce mechanical deficits, loss of strength and ligament looseness in the lower limbs during weight bearing, thus affecting articular stability.

In the second study, in a pre-activation condition, muscle activity was higher in subjects who used the bracing after the intervention. However, the authors conclude that the increased muscular activity of the peroneus longus muscle in pre-activation suggests a pre-programmed activity that can lead to better stability of the ankle, providing a possible mode of action for foot orthoses therapy.\textsuperscript{28}

Other studies show that the use of footwear and orthoses does not reduce lesions in soft tissue after intense running,\textsuperscript{38} nor injuries and stress-related lower limb over use lesions.\textsuperscript{39} This includes a study on the use of bracing in runners with increasing rates of pain in knees and ankles.\textsuperscript{27} However, the evidence base is not strong enough, because the number of trials is small and the bias risk high.\textsuperscript{28}

Stress fractures are common and serious overuse injuries in runners, especially in female runners. The tibia is the most common site with incidence rates of up to 20%.\textsuperscript{33} They may be related to the lower end load characteristics during running.\textsuperscript{40-42} One of the articles included in this study\textsuperscript{35} evaluated runners who suffered tibial stress fracture and noted the significant increase of the vertical force and shock on the tibia, showing the relationship between the history of the injury and the increase in dynamic load variables.

Although some articles enumerate poor alignment as an intrinsic factor related to overuse injuries,\textsuperscript{21,31,33,34} Lun et al.\textsuperscript{27} demonstrated that there is no evidence that the measures of static biomechanical alignment are related to lesions in lower limb runners, except in knee injuries (patellofemoral syndrome), in agreement with other studies investigating precisely this variable.\textsuperscript{45-47}

Little is known about the influence of the height of the longitudinal arch of the foot in overuse injuries in runners. Williams et al.\textsuperscript{48} in a prospective study concluded that the structure of the high or low arch is related to different types of injuries in runners. In opposition, Nakhaee et al.\textsuperscript{34} studied the height of the medial longitudinal arch, peak force, peak pressure and the contact area of the foot in static and dynamic conditions, comparing healthy runners and runners with overuse injuries; they pointed out that the height of the longitudinal arch of the foot not is a risk factor for sport injuries. These reports corroborate other studies suggesting that associated factors such as type of footwear, areas of training, injury history, and distance traveled weekly\textsuperscript{49} can determine the likelihood of injury.\textsuperscript{11,34}
### Table 2 - Studies evaluating the etiology of ankle injuries

<table>
<thead>
<tr>
<th>Study Description</th>
<th>Methodological Details</th>
<th>Findings</th>
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</thead>
<tbody>
<tr>
<td>Risk factors for overuse in runners’ ankles</td>
<td>Questionnaire completed 3 days before the event including: personal characteristics, health status, previous race injury sites, training routine details, shoes and orthoses types used.</td>
<td>Orthosis in knee and ankle was associated with increased pain rate in knee and ankle. Group members who ran the full marathon, who practiced in synthetic track had a higher incidence of pain in the ankle.</td>
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<tr>
<td>Table 2 - Studies evaluating the etiology of ankle injuries</td>
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<tr>
<td>Running injuries and associated factors in participants of ING Taipei Marathon (Chang et al. 2012)</td>
<td>1,004 runners in the ING Taipei International Marathon</td>
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<tr>
<td>Neuromuscular activity of the peroneal muscle after foot orthoses therapy in runners (Baur et al. 2011)</td>
<td>99 runners with symptoms of overuse injury (control x bracing)</td>
<td>The activation of the peroneus longus muscle suggests a preprogrammed altered activity, which may lead to a better stability of the ankle providing a possible mode of action for the foot orthotic therapy.</td>
</tr>
<tr>
<td>Comparison in lower leg neuromuscular activity between runners with unilateral mid-portion Achilles tendinopathy and healthy individuals. (Baur et al. 2011)</td>
<td>60 runners (30 control x 30 with Achilles tendinopathy)</td>
<td>The tendinopathy of the Achilles does not seem to change the preprogrammed neural control, but can induce mechanical deficits of the lower limbs during weight bearing (joint stability).</td>
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<tr>
<td>Kinematic analysis of runners with achilles mid-portion tendinopathy (Ryan et al. 2009)</td>
<td>48 runners men (27 with pain in Achilles tendon and 21 asymptomatic subjects - control)</td>
<td>Increased eversion of the subtalor joint runners with Achilles tendinopathy, which had hyperpronation during the stance phase of running.</td>
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<tr>
<td>Functional data analysis of running kinematics in chronic Achilles tendon injury (Donoghue et al. 2008)</td>
<td>24 runners (12 with Achilles tendinopathy x 12 without lesions in the lower limbs)</td>
<td>Subjects with Achilles tendinopathy showed increased evasion, ankle dorsiflexion and knee flexion. Using bracing was reduced dorsiflexion, but increased evasion. The study showed evidence that the variability is related to the presence of lesions in this clinical population.</td>
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<tr>
<td>Lower limb kinematics of subjects with chronic achilles tendon injury during running (Donoghue et al. 2008)</td>
<td>22 subjects runners (11 controls x 11 with calcaneus tendinopathy history)</td>
<td>The data revealed qualitative differences in the angle-time curves between calcaneus tendinopathy group and control during running with and without shoes. Subjects with tendinopathy showed higher evasion and dorsiflexion of the ankle, and lower leg abduction during the laying, compared to the control.</td>
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<tr>
<td>Biomechanical factors associated with tibial stress fracture in female runners (Milner et al. 2006)</td>
<td>40 long-distance runners (20 with a history of stress fracture of tibia x 20 without lesions in the lower limbs)</td>
<td>The tibial stress fracture history runners is associated with increased variables related to dynamic loads.</td>
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<tr>
<td>The relationship between the height of the medial longitudinal arch (MLA) and the ankle and knee injuries in professional runners (Nakhaee et al. 2008)</td>
<td>47 men professional runners (30 control x 17 with historical damage in ankle/knee)</td>
<td>Have normal longitudinal arch, more or less can not be defined as a risk factor for injuries related to sports.</td>
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<tr>
<td>Relation between running injury and static lower limb alignment in recreational runners (Lun et al. 2004)</td>
<td>87 amateur runners healthy</td>
<td>There is no evidence that the measures of static biomechanical alignment are related to lesions in the lower limbs runners, except patello-femoral syndrome.</td>
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whereas improper changes in duration, frequency or “training errors” are the most common causes of overuse injuries in recreational athletes.\textsuperscript{50}

\section*{CONCLUSION}

The etiology of overuse injuries in runners is multifactorial. This review shows that distance, soil type, footwear and history of previous injuries, apart from biomechanical alterations, such as increased dorsiflexion and inversion ankle, as well as knee alterations (greater flexion) are risk factors that influence the occurrence of these injuries. It must however be stressed that published reports on this problem are few and biased, on account of lack of uniformity, in terms of the evaluation techniques and in terms of targeted populations.

\section*{REFERENCES}


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