Interventions for preventing lower limb soft-tissue injuries in runners (Review)

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ABSTRACT

Background
Overuse musculoskeletal injuries occur frequently in runners. Suggestions for prevention have focused on stretching exercises, modifying training schedules and the use of protective devices such as braces and insoles. To date, no systematic analysis of the literature on the effectiveness of these strategies in the prevention of overuse injuries has been published.

Objectives
The objective of the review was to evaluate the evidence from randomised controlled trials on the prevention of lower limb soft-tissue running injuries.

Search strategy

Selection criteria
Any randomised or quasi-randomised trials evaluating interventions to prevent lower limb soft-tissue running injuries.

Data collection and analysis
All trials fulfilling the selection criteria were assessed by two reviewers independently. Data were also extracted independently by the two reviewers using a pre-derived data extraction form. Exploratory analyses, including pooling of results from groups of trials of similar designs were undertaken, using a fixed effects model. Results were reported as relative risks (RR) with 95 per cent confidence intervals (95% CI).

Main results
Twelve trials with 8,806 participants were included. In one trial, a single control group was matched to three different included intervention groups. The effectiveness of stretching exercises (5 trials, 1944 participants in the intervention groups, 3159 controls), and of insoles and footwear modification (5 trials, 903 participants in the intervention groups, 3006 controls) in the prevention of lower extremity soft tissue injuries associated with running is unknown. Reducing the distance, frequency and duration of running may be effective in the prevention of lower extremity soft tissue injuries associated with running (3 trials, 514 participants in intervention groups, 1663 controls). Wearing a knee brace with a patellar support ring may be effective in the prevention of running-associated anterior knee pain (1 trial, 27 participants in the intervention group, 33 controls).

Authors’ conclusions
This review provides some evidence for the effectiveness of the modification of training schedules, but there is insufficient evidence to determine the effectiveness of stretching exercises for major lower limb muscle groups in reducing lower limb soft-tissue running injuries. More studies are required to confirm that knee braces may prevent knee pain, to clarify the role of stretching, and to quantify...
optimal training loads. Generalisability of the results may be limited by the intensive nature of military training (the context for most of the studies) and the inclusion of only small numbers of women.

SYNOPSIS

Modification of training schedules can have some impact on lower limb soft-tissue running injuries

Lower leg soft-tissue injuries are common in runners. Suggestions for prevention have included stretching exercises, modifying training schedules and wearing protective insoles in footwear. This review of trials found that injuries from running are reduced by modifying training schedules by duration, frequency or running distance. However, no guidelines were available from trials about the best training schedule to adopt to avoid injury. There was insufficient evidence to suggest if stretching exercises and the use of shock absorbing insoles are effective in the prevention of injuries.

BACKGROUND

Running injuries, primarily of the lower limb, are commonly treated sports-related injuries. For instance, in a study of sports injuries seen at an Australian sports clinic during a 12 month period, people with distance running injuries were the second highest presenters among participants in the most common sports played (Baquie 1997). Several risk factors appear to be associated with these injuries such as weekly mileage, history of previous running injuries, number of years in running, training characteristics (speed, frequency, surface, timing), training surface and footwear (Marti 1988; Macera 1992).

It has been noted that the definition of running injury often differs between studies which makes comparison difficult (Hoeberigs 1992). They are, however, generally lower-limb overuse injuries, most commonly stress fractures and soft-tissue injuries. Of the latter, iliotibial band syndrome, tibial stress syndrome (often referred to as ‘shin splints’), patellofemoral pain syndrome, Achilles tendinitis, posterior tibial tendonitis and plantar fasciitis constitute some of the commonly diagnosed injuries (Heir 1996; Vleck 1998). These injuries present in a spectrum of severity ranging from inflammation to structural degeneration.

Preventive strategies are often dependent on modifying the training schedule, the use of stretching or warm-up/cool down exercises and modifying footwear. This review aims to identify randomised and quasi-randomised trials which test interventions for the prevention of lower limb soft-tissue running injuries resulting from distance running, and to evaluate those trials aimed at reducing the incidence and severity of soft-tissue running injuries.

OBJECTIVES

The objective of this review is to evaluate the evidence for efficacy of interventions (particularly those relating to modification of training schedule, stretching exercises and footwear) for the prevention of lower limb soft-tissue running injuries in individuals from adolescence to middle age.

The specific null hypothesis tested is:

There are no differences in outcome between any intervention and no intervention aimed at preventing lower limb soft-tissue running injuries.

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

Types of studies

All randomised and quasi-randomised (for example, allocation by dates of birth or alternation) controlled trials which compared interventions for the prevention of soft-tissue injuries of the lower limb in running were included.

Types of participants

Trials involving individuals of either gender from adolescence to middle age were included. Where possible, the results were stratified by age (into groups up to 30 years and over 30 years), gender, occupation (recreational or professional athletes) and previous history of lower limb injury.

Types of intervention

Trials investigating any intervention which has been used to prevent lower limb soft-tissue running injuries were included. Excluded were trials which investigated laboratory based measures which had no proven relationship to clinical outcomes. Also excluded were trials that involved surgical intervention, trials which targeted the prevention of stress fractures alone, and those which investigated the prevention of joint injury in contact sports.

Types of outcome measures

Data for the following were sought:

1. Incidence (overall and by bodily location) of lower limb injuries
2. Severity of injury (as well as clinical diagnoses, other markers of severity such as changes in training intensity, time off for recovery, time to return to pre-injury level of activity)
3. Complication of intervention (fitness deficit, other injuries)
4. Compliance with intervention
5. Measures of service utilisation or resource use (medical visits, costs of orthotic devices)

SEARCH STRATEGY FOR IDENTIFICATION OF STUDIES

See: Bone, Joint and Muscle Trauma Group search strategy

We searched the The Cochrane Musculoskeletal Injuries Group specialised register (date of last search October 2000); The Cochrane Controlled Trials Register (The Cochrane Library, Issue 3, 1999); MEDLINE (from 1966); EMBASE (from 1980); ATLANTES (1980 -1996), Biosis, CINAHL, HERACLES (1975 -2000), SCISEARCH, SPORT Discus (1975 -2000), Current Contents, Index To Theses, and Dissertation Abstracts and reference lists of articles. Date of last search for these databases: May 2000.

In MEDLINE (Ovid Web) the first two levels of the optimum search strategy for randomised controlled trials (Clarke 2001) was used with the following specific search terms:

1 randomized controlled trial.pt.
2 controlled clinical trial.pt.
3 Randomized Controlled Trials/
4 Random Allocation/
5 Double Blind Method/
6 Single Blind Method/
7 or/1-6
8 Animal/ not Human/
9 7 not 8
10 clinical trial,pt.
11 exp Clinical Trials/
12 (clinic$ adj25 trials$).tw.
13 ((singl$ or doubl$ or trebl$ or tripl$) adj25 (blind$ or mask$)).tw.
14 Placebos/
15 placebo$.tw.
16 random$.tw.
17 Research Design/
18 or/10-17
19 18 not 8
20 19 not 9
21 or/9,20
22 exp Running/
23 Athletic Injuries/
24 Soft Tissue Injuries/
25 “sprains and strains”/ or cumulative trauma disorders/
26 hip injuries.mp
27 Knee Injuries/
28 Ankle Injuries/
29 Foot injuries/
30 Tendinitis/
31 Fasciitis/
32 Sports/
33 Sports Medicine/
34 “Physical Education and Training”/
35 Physical Fitness/
36 or/22-35
37 and/9,36
38 and/20,36
39 or/37-38

METHODS OF THE REVIEW

Methodological quality of all included trials was assessed by both reviewers using a piloted, subject-specific modification of the generic evaluation tool used by the Cochrane Musculoskeletal Injuries group. The following aspects of internal validity and external validity were assessed as below:

A. Was the assigned treatment adequately concealed prior to allocation?
3 = method did not allow disclosure of assignment
2 = small but possible chance of disclosure of assignment or unclear
1 = quasi-randomised or open list/tables

Cochrane Code: Adequate=A; Unclear=B; Inadequate=C.

B. Were the outcomes of patients who withdrew described and included in the analysis (intention to treat)?
3 = withdrawals well described and accounted for in analysis
2 = withdrawals described and analysis not possible
1 = no mention, inadequate mention, or obvious differences and no adjustment

C. Were the outcome assessors blinded to treatment status?
3 = effective action taken to blind assessors
2 = small or moderate chance of unblinding of assessors
1 = not mentioned or not possible

D. Were important baseline characteristics reported and comparable?
3 = good comparability of groups, or confounding adjusted for in analysis
2 = confounding small; mentioned but not adjusted for
1 = large potential for confounding, or not discussed

E. Were the subjects blind to assignment status after allocation?
3 = effective action taken to blind subjects
2 = small or moderate chance of unblinding of subjects
1 = not possible, or not mentioned (unless double-blind), or possible but not done
F. Were care programmes, other than the trial options, identical?
3 = care programmes clearly identical
2 = clear but trivial differences
1 = not mentioned or clear and important differences in care programmes

G. Were the inclusion and exclusion criteria clearly defined?
3 = clearly defined
2 = inadequately defined
1 = not defined

H. Were the outcome measures used clearly defined? (for the primary outcome measure)
3 = clearly defined
2 = inadequately defined
1 = not defined

I. Were diagnostic tests used in outcome assessment clinically useful? (for the primary outcome measure)
3 = optimal
2 = adequate
1 = not defined, not adequate

J. Was the duration of surveillance clinically appropriate? (for the primary outcome measure)
3 = optimal (observation extends beyond the period of intervention)
2 = adequate (observation is confined to the period of intervention)
1 = not defined, not adequate

Data collection:

The selection of studies for inclusion in the review involved multiple stages. The first stage involved assessing titles and abstracts to determine whether the articles met the predetermined eligibility criteria. All the citations were checked by both reviewers. If, given the information available, it was determined that an article definitely did not meet inclusion criteria, it was then excluded. If there was any doubt, the full text of the article was retrieved. Review of the full text led the reviewers to either exclude the study because it did not meet inclusion criteria or formally abstract the article.

Both reviewers independently used a pre-derived data extraction form. Agreement was measured using Kappa statistics. Disagreement was resolved by discussion, followed if necessary by scrutiny from a third reviewer. Studies were ranked by quality of allocation concealment (Cochrane score A, B, C). Categorical and overall quality scores were calculated to allow analysis of relationships between study quality or effect size. Sensitivity analyses were undertaken when indicated.

Data synthesis and statistical considerations:

Outcomes from included trials were combined using Review Manager 4.1(RevMan 2000) software. Heterogeneity between comparable trials was assessed both by inspection of graphical presentations and by performing the chi-square test available in MetaView, the statistical analysis package incorporated in Review Manager 4.1. Where appropriate, data was entered as negative values to conform to the Cochrane convention whereby effects that favour the intervention under review move to the left. For dichotomous outcomes the fixed effect model was used to estimate the individual and pooled relative risk (RR) and 95 per cent confidence intervals (95% CI). For continuous outcomes the weighted mean difference (WMD) was used to estimate the individual and pooled effect sizes and 95 per cent confidence intervals.

DESCRIPTION OF STUDIES

After the initial screening of the search yield, 118 relevant articles were identified (116 in English). The authors note that developing a search strategy that specifically looks at running injuries per se was difficult, as many sporting activities also involve running. To avoid missing any relevant trials, the reviewers have erred on the side of over inclusion during the search. As a result, many of the studies identified in the initial search were subsequently found not to be relevant. It is anticipated the search strategy will be modified in a future update of this review.

The full texts of the 118 articles were retrieved and subsequently evaluated by both reviewers using further, more strict criteria. Agreement among the reviewers regarding the quality of the articles was good (kappa = 0.663, p =0.00) and disagreement was resolved by consensus.

Ninety-seven articles were excluded, having been found on review of the complete text to be either unrelated to running injury, a review article or not a controlled trial. Twenty-one trials were considered for this review and 12 randomised controlled trials (RCTs) involving a total of 8,806 participants met the inclusion criteria. A further trial, Gardner 1988, which looked primarily at stress fractures in runners, was retrieved and has been placed in the ‘Studies awaiting assessment’ category for consideration in the first update of the review. The details of the nine excluded trials are provided in the Characteristics of Excluded Studies Table.

All 12 included trials were retrieved from the electronic database search of MEDLINE and CINAHL. The reviewers were not blinded to author(s), the institution or the title of the studies. All identified trials were English language publications. The details of each study are provided in the Characteristics of Included Studies table and are briefly summarized below:

Settings and subjects’ characteristics:

Eight studies (Andrish 1974; Hartig 1999; Milgrom 1992; Pope 1998; Pope 2000; Rudzki 1997; Schwellnus 1990; Smith 1985) involved military recruits in four countries. One study (Pollock 1977) involved male prison inmates. Apart from Smith 1985, all of these studies involved male subjects only and in Smith 1985,
the number of female subjects was not stated. In Fauno 1993, soccer referees were the subjects. The remaining two studies (BenGal 1997, van Mechelen 1993) drew runners from the general population and in these studies, the female participants were not included in the final analysis due to either the small number of respondents or a high dropout rate. The ages of the participants ranged from 17 to 36 years old.

Intervention period:

The intervention period varied between studies, from eight to 20 weeks, with one study (Fauno 1993) studying five days of refereeing in a soccer tournament. The intensity of training schedules in the different trials also varied. These are summarized in Table 01.

Intervention strategies:

Stretching exercises -

Five studies (Andrish 1974; Harrig 1999; Pope 1998; Pope 2000; van Mechelen 1993) evaluated the effect of stretching exercises in the prevention of injuries. Andrish 1974 and Pope 1998 assessed the effect of gastrocnemius and soleus stretching exercises, whereas Pope 2000 assessed the effect of stretching exercises on major lower limb muscle groups (hip/knee flexors and extensors, hip adductors and calf muscles). In addition to stretching exercises, van Mechelen 1993 also incorporated warm-up and cool-down exercises in the intervention procedure. In Hartig 1999, only hamstring muscles were involved in the stretching routine.

Modification of training schedule -

Three studies (Andrish 1974; Pollock 1977; Rudzi 1997) reported training schedule modifications. Pollock 1977 examined the effect of frequency (one, three and five days/week) and duration (15, 30 and 45 minutes/day) of training on the attrition and incidence of running-related injury. Andrish 1974 utilised a graduated running programme in one intervention group to examine the prevention of shin splints and in Rudzi 1997, the intervention group received a modified weight-loaded walking programme versus a running programme in the control group.

Use of orthoses/support -


Strengthening -

No trials of strengthening exercises were identified.

Outcomes:

The method of assessment of injury diagnosis was not stated in two studies (Andrish 1974, Pollock 1977). For the remaining 10 studies, diagnosis was made by self-reporting and subsequently confirmed by medical consultation. All studies reported the incidence of lower limb injuries either by location or by type. Andrish 1974 reported on the morbidity of shin splints and the incidence of recurrence. Pollock 1977 compared the attrition rate resulting from injury and Rudzi 1997 reported on morbidity and cost of medical services associated with injury. van Mechelen 1993 reported the change in knowledge and attitude with respect to warm-up, cool-down and stretching interventions.

**Methodological Quality**

Total quality scores were calculated for each paper based on the sum of the item scores. Of a total possible quality score of 30, the range of the overall scores was 17 to 24 with a mean score of 20.50.

A summary of the methodological quality score for each study is found in the following table:

<table>
<thead>
<tr>
<th>A B C D E F G H I J</th>
<th>Total Study Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1C 1 1 3 1 2 1 3 1 7</td>
<td>Andrish 1974</td>
</tr>
<tr>
<td>2B 1 3 3 1 2 3 2 2 2 2</td>
<td>BenGal 1997</td>
</tr>
<tr>
<td>1C 1 3 3 1 3 2 1 1 1 8</td>
<td>Fauno 1993</td>
</tr>
<tr>
<td>2C 1 3 1 3 1 2 2 2 2 0</td>
<td>Hartig 1999</td>
</tr>
<tr>
<td>2B 3 1 3 1 3 2 2 2 2 1 2</td>
<td>Milgrom 1992</td>
</tr>
<tr>
<td>2B 3 1 2 3 2 1 2 2 0</td>
<td>Pollock 1977</td>
</tr>
<tr>
<td>2C 1 2 3 2 3 3 3 2 2 3</td>
<td>Pope 1998</td>
</tr>
<tr>
<td>2C 3 2 3 1 3 3 2 2 4</td>
<td>Pope 2000</td>
</tr>
<tr>
<td>2C 1 2 3 1 3 2 3 3 2 3 2 0</td>
<td>Rudzi 1997</td>
</tr>
<tr>
<td>2B 3 2 3 1 3 3 3 2 2 4</td>
<td>Schwellnus 1990</td>
</tr>
<tr>
<td>2B 1 1 3 1 2 1 2 1 7 1 7</td>
<td>Smith 1985</td>
</tr>
<tr>
<td>2B 1 1 3 1 2 3 3 2 2 0</td>
<td>van Mechelen 1993</td>
</tr>
</tbody>
</table>

Randomisation procedures:

Only six studies gave full details of the method of randomisation. Three studies (Fauno 1993; Pope 1998; Pope 2000) utilised a quasi-randomised method of allocating participants. In Pope 1998 and Pope 2000, recruits were assigned to platoons by administrative staff based on their surnames, and then pairs of platoons were randomly allocated to control and intervention groups. In Fauno 1993, the allocation was based on the birth date. Hartig 1999 described the randomisation of subjects based on the army's routine assignment, whereas in Andrish 1974, randomisation was based on the results of scholastic and athletic scores. The allocation was assigned by drawing numbers from a hat in Rudzi 1997.

In four studies (van Mechelen 1992; BenGal 1997; Fauno 1993; Pollock 1977) both the unit of randomisation and the unit of analysis were the individual. In the other eight studies, which were all in a military context, (Andrish 1974; Harrig 1999; Milgrom 1992; Pope 1998; Pope 2000; Rudzi 1997; Schwellnus 1990; Smith 1985) allocation was by group (squad, platoon or company) but analysis was individual. Thus, these studies were cluster randomised, and ineligible for pooling using MetaView (RevMan 2000).
Two studies (BenGal 1997; Fauno 1993) took effective action in blinding the outcome assessors. In all other trials, the outcome was assessed by either doctors or physiotherapists but there was no mention if these assessors were blinded to the subjects’ assignment status. Only one study clearly established that subjects were blinded to intervention assignment (Pope 1998). All studies except two (Andrish 1974; Rudzki 1997) reported participants lost to follow up.

Intention to treat:

In five studies, losses were sufficient in number to lead to possible attrition bias. There were 21 subjects who failed to complete the prescribed training programme in Smith 1985, but it was unclear if the physical insufficiencies mentioned were related to injuries. In van Mechelen 1993, 94 participants did not return their training diaries which may have contained injury data and, subsequently, it was not possible to include them in the analysis. Thirty-three subjects in Fauno 1993 were excluded from the analysis due to non-attendance for the clinical examination or incomplete answering of the questionnaire. However, there was no mention as to whether or not these subjects were injured. Seventeen female subjects were deliberately excluded from the analysis by BenGal 1997 due to a high dropout rate for this group, while 48 subjects from the control group were withdrawn from the study towards the end of the first half of the training programme without stating reasons in Pope 1998. This approach in handling losses is likely to lead to attrition bias.

In Andrish 1974, it was stated that subjects who did not carry out the prophylactic regimens were placed in the control group for analysis. In the final analysis, the numbers reported were the same as before intervention. It was unclear, therefore, if all the subjects complied with the intervention or if the change in numbers were not accounted for in the analysis. There was only one study in which the data was analysed by intention to treat (Pope 2000) and the remaining five studies reported no loss to follow up (Hartig 1999; Milgrom 1992; Pollock 1977; Rudzki 1997; Schwellnus 1990).

In the military studies, comparability of intervention and control groups was assumed and a score of three was given. A score of three was also given to ‘care programmes’ for the military studies because of the uniformity in the training programme.

RESULTS

Reported incidence of injury (overall and by bodily location) was the principal outcome sought in these 12 studies. The incidence of injury by location is broadly divided into hip (e.g. groin injury), knee (e.g. patellofemoral pain, hamstring injury), lower leg (e.g. achilles tendonitis, calf strain, shin splints), and ankle and foot (e.g. ankle sprains, plantar fasciitis) regions. In presenting the results, comparisons were broadly arranged into three main preventive strategies: warm-up, cool-down and stretching exercises; modification of training schedule; and use of external devices such as braces and insoles. In addition, a combined intervention of stretching and use of insoles was also examined.

Comparison 1. Stretching exercises

a. Incidence of lower limb injuries

Five trials included this comparison (Andrish 1974; Hartig 1999; Pope 1998; Pope 2000; van Mechelen 1993). There were differences in the implementation of the stretching protocols, which are summarised in Table 02. In Andrish 1974 and Hartig 1999, stretching was performed outside the periods of the training. Neither of these trials showed evidence of protection against running injuries. In the other three studies (Pope 1998; Pope 2000; van Mechelen 1993), the stretching protocol was performed immediately before training.

Injury was defined differently between studies: Andrish 1974 - not mentioned; Hartig 1999 - based on the type of injury; Pope 1998, Pope 2000 - inability to resume full duties without signs and symptoms within three days; van Mechelen 1993 - forced to stop running, inability to run on the next occasion or to go to work, seeking medical attention and suffering pain for more than 10 days. These studies did not analyse the results according to the severity of injury.

As both the interventions and injury definitions were heterogeneous between studies, and as only van Mechelen 1993 was individually randomised, no data were pooled for this comparison, and there was no attempt to perform subgroup analysis. Exploratory analyses are, however, presented (comparison 01.01). Readers are reminded that analysis by individual in MetaView 4.1, after cluster randomisation, provides inappropriately narrow confidence intervals.

There was no overall evidence of significant protection against soft tissue injury from stretching exercises. Hartig 1999 reported the number of lower-limb overuse injuries was significantly less in the stretching intervention group (RR 0.57; 95% CI 0.37 to 0.89). Exploratory analyses of two cluster-randomised studies showed no evidence of significant protection (Andrish 1974, RR 1.27; 95% CI 0.66 to 2.43, our exploratory analysis; Pope 1998, RR 0.85; 95% CI 0.43 to 1.67, our exploratory analysis). van Mechelen 1993 found no evidence of reduction in soft tissue injury from the intervention studied (RR 1.19; 95% CI 0.71 to 1.99, our exploratory analysis). Pope 2000 reported that their pre-exercise stretching protocol did not produce a clinically useful (or statistically significant) reduction in risk of soft tissue injury (hazard ratio 0.83; 95% CI 0.63 to 1.09).

b. Compliance with intervention

Compliance with the intervention was mentioned in all five studies and is considered satisfactory. Compliance was ensured by regular
checks from platoon leaders (Andrish 1974, Hartig 1999), physical training instructors (Pope 1998) or by the research team (Pope 2000).

In van Mechelen 1993, compliance was assessed by analysing subjects’ self-reported daily diaries to determine if performance of the exercises was in accordance with those prescribed. It was found that 46.6 per cent in the intervention group and 4.8 per cent in the control group performed stretching exercises comparable to the prescribed intervention. The limited data in van Mechelen 1993 allowed for analysis of the compliance to the warm-up, cool-down and stretching routine within the intervention group. The results suggested that the subjects tended to comply more with the warm-up and cool-down exercises (RR 0.46; 95% CI 0.36 to 0.59; RR 0.54; 95% CI 0.43 to 0.69 respectively) than to the stretching routine (RR 1.15; 95% CI 0.92 to 1.43).

c. Knowledge and attitude towards the intervention

van Mechelen 1993 measured the knowledge and attitude towards warm-up, cool-down and stretching exercises between control and intervention groups. This was measured by a validated questionnaire and the scores were compared at the beginning and towards the end of the intervention. Using the fixed effects model, the overall results indicated no difference in both the knowledge and attitude, suggesting that there is no change in behaviour of the subjects with regard to warm-up, cool-down and stretching exercises.

Comparison 2. Modification of training schedule

a. Incidence of lower limb injuries

Three studies included in the analysis examined the training intensity on the risk of injury (Andrish 1974; Pollock 1977; Rudzki 1997). Andrish 1974 used a graduated running programme over two weeks prior to pursuing a full training routine, aiming to reduce shin splints injury. Pollock 1977 investigated the effects of frequency (one, three or five days/week) and duration (15, 30 and 45 minutes/day) of training on the incidence of overuse injury in a 20-week training programme. Lower back injuries accounted for three injuries in the frequency study and two injuries in the duration study, and it was not possible to differentiate which group these injuries occurred in. Therefore, the results from the study are used with the proviso that five of the 40 injuries reported were not in the area of interest.

In Rudzki 1997, running was substituted by a weight-load walking programme in the intervention group. The modification programme (substituting running with weight-load walking) resulted in a reduction of running distance of 16.5 km over 12 weeks in the intervention group. The running distance per week was available from two studies (Pollock 1977, Rudzki 1997) and is summarised in Table 03.

There was no attempt to conduct any pooled analyses because of the variation in the intensity, duration and frequency of the training programmes. Pollock 1977 reported data supporting significant reduction in the injury incidence by reducing frequency (RR 0.19; 95% CI 0.06 to 0.66) or duration (RR 0.41; 95% CI 0.21 to 0.79) of training. In Rudzki 1997, a reduction in the running distance significantly reduced overuse injuries (RR 0.70; 95% CI 0.54 to 0.91). In Andrish 1974, graduated introduction of the running programme was associated with a significant increase in the number of lower limb injuries (RR 2.07; 95% CI 1.13 to 3.80).

The severity of injuries was not stated in either Rudzki 1997 or Andrish 1974. Pollock 1977 reported a training related incident that prevented participant from jogging for at least one week. In Rudzki 1997, the morbidity associated with injuries was compared between the intervention and the control group. This morbidity could possibly be a reflection of the severity of injury. However, the limited data could not allow for a further analysis.

b. Compliance with intervention

The compliance with the intervention appeared satisfactory in these studies. The training administered to the subjects in Pollock 1977 was monitored closely during the entire 20-week programme. In Rudzki 1997, the intervention group was specifically forbidden to run during route marches to control the volume of running. In Andrish 1974, the group that entered into the graduated running programme performed other activities such as general calisthenics and upper-body conditioning in place of running. No data was available to allow for statistical analysis.

Comparison 3. Use of orthoses/support or footwear modifications

a. Incidence of lower limb injuries

Four studies provided outcome data that focused on the use of insoles in the prevention of lower limb injuries (Andrish 1974; Fauno 1993; Schwellnus 1990; Smith 1985). Andrish 1974 utilised heel pads made from thick foam rubber for all running activities in the reduction of shin splints, and Fauno 1993 compared the use of shock absorbing heel inserts in a group of soccer referees where they were exposed to five days of intensive running. Using cellular polyurethane or neoprene shock absorbing insoles, Schwellnus 1990 and Smith 1985 compared the incidence of overuse injuries with the control group following military training. The results showed no significant difference when the total number of lower limb injuries were analysed (RR 0.87; 95% CI 0.69 to 1.11). Available data from three studies (Andrish 1974; Schwellnus 1990; Smith 1985) providing incidence of lower limb injuries grouped by location (hip, knee, lower leg, ankle and foot) also demonstrated no significant difference in risk reduction.

Milgrom 1992 investigated the effect of improved shoe shock attenuation using modified basketball shoes compared with infantry boots. A comparison of the overall incidence of overuse injuries showed a significant difference between the intervention and the control group (RR 0.83; 95% CI 0.71 to 0.98, our exploratory
BenGal 1997 evaluated the use of knee braces with a silicon patellar ring support in preventing anterior knee pain. All subjects participated in an intensive eight week training regimen with six kilometres in the first week, then increasing each week up to 42 kilometres per week at week eight. Results demonstrate a statistically significant reduction in the incidence of anterior knee pain (RR 0.35; 95% CI 0.13 to 0.91).

The type, diagnosis and definition of injury differed between studies: Andrish 1974 - shin splints, roentgenograms on the affected limb; BenGal 1997 - anterior knee pain, positive passive/active patellar grinding tests and peripatellar tenderness; Fauno 1993 - soreness in the lower extremities, definition of injury not stated, diagnosed by medical personnel; Milgrom 1992 - overuse injuries, definition of injury not stated, diagnosed by medical personnel; Schwellnus 1990 - overuse injuries with no sudden precipitating event; overuse injuries that prevent return to normal activity for at least one day, confirmed by medical personnel; Smith 1985 - injuries caused by shock impact, definition of injury not stated.

The classification of severity of injury, rated by the number of days that the injury prevented a return to normal activities, was available in Schwellnus 1990. Injuries were rated as severe if the subject was prevented from returning to normal activities for four days or longer. Less severe injuries were classified if the subject was prevented from returning to normal activities for three days or less. The total injuries were expressed in mean incidence, injuries per 1000 subjects per week. The limited data did not allow for further analysis.

b. Compliance to intervention

Two studies provided information on compliance to the intervention. In Andrish 1974, records were kept as to how well subjects complied with the intervention and regular random inspections of footwear were performed on subjects in Schwellnus 1990. No data was available for analysis.

d. Recurrence

Andrish 1974 examined the effect of insoles on the rate of recurrence of shin splints. There was no significant difference between the control and the intervention group (RR 1.98; 95% CI 0.75 to 5.28).

Comparison 4. Combined intervention

Stretching exercises and the use of insoles as a combined preventive strategy was investigated in Andrish 1974 for the reduction of shin splint injuries. The results showed no difference in the incidence of shin splints between the control and the intervention group (RR 1.05; 95% CI 0.58 to 1.90).

**DISCUSSION**

The evidence from randomised controlled trials for the prevention of lower limb soft tissue injuries is derived from 12 trials which have a variety of settings, participants, interventions and outcome measures. The incidence of lower limb injuries is the main outcome reported. The methodological quality of the studies varies from low to moderate. Due to the diversity of the injuries, the principal focus of the current review examines the overall incidence of lower limb overuse injuries and their location.

It is evident from the review that the subjects included were mostly young, active male subjects. Only two studies have included female subjects, with one (BenGal 1997) excluding this group due to significant dropout. The other trial (Smith 1985) did not state the number of female subjects within the study population. The paucity of data for female athletes requires special consideration. The role of gender in the aetiology of running injuries is unknown (Hoeberigs 1992), although the anatomical and physiological differences between female and male athletes might account for unique patterns of musculoskeletal injury. More importantly, in relation to stress reactions/fractures of the bone, the association of endurance sports (like distance running) with menstrual dysfunction (Otis 1992), leading to premature skeletal demineralization in females, should not be taken lightly.

Eight studies included in the analyses were military studies in which the training programmes were very intensive when compared with the activity levels of the general population. This is reflected in the total number of hours of exposure. In interpreting the results, one should be aware of the variation in the participants, setting, duration, focus and the type of intervention administered.

Five trials were included for the evaluation of a stretching regimen in the reduction of overuse injuries. Four studies were considered to have moderate methodological quality with a rating over 20. Apart from van Mechelen 1993, the other trials drew their sample from the military population. The training intensity also varies in these trials. The subjects in van Mechelen 1993 ran an average of 2.7 times/week, for an 8.8 kilometre session at a speed of 12.4 kilometres per hour over 16 weeks. This training load reflects that this study group represents recreational rather than competitive runners. On the contrary, the subjects in the other four trials, being military recruits, were exposed to a high training load. Overall, results indicated no significant benefit in reducing injuries. However, it has to be noted that in two of the studies (Hartig 1999; Pope 1998), all the recruits (both control and intervention group) performed normal routine stretching prior to the physical training. In addition, in van Mechelen 1993, 90 per cent of runners...
Results of the three trials which focused on the modification of training showed evidence that a reduction in either the duration, frequency or the running distance could influence the risk of overuse injuries. These studies are of modest methodological quality. Pollock 1977 found that the incidence of injury was lower for a training load of one or three days/week with the duration of 15-30 minutes. Results from Rudzki 1997 also suggest that the reduction in running distance could reduce the incidence of injury; not surprising since the running distance is likely to increase along with the frequency and duration of training. Based on the limited data, it is not possible to suggest an optimal training load. The balance of how one can maximise the benefits from exercise, yet minimise the risk of injury remains to be established.

A sudden change in training habit or running distance have also been suggested as leading to injuries. Two trials (Andrish 1974; Rudzki 1997) have shed some light about training errors. It was noted that there was a peak period of injury at the beginning of the first two weeks of training, suggesting that the body requires time to accommodate to the change and an abrupt increase in stress on the musculoskeletal system is likely to lead to injury. In Rudzki 1997, there was another peak period for injury in the running group that occurred during the middle phase of training period (between week five and eight), when there was an increase in the volume of training.

Four studies were concerned with the use of shock absorbing insoles as the preventive strategy. Results showed no significant benefit with the use of insoles in the overall reduction of overuse soft tissue injuries. However, in a Cochrane review by Gillespie 2001 which looked at the prevention of stress fracture, the evidence seems to suggest that shock absorbing insoles are effective in reducing the incidence of stress fractures and stress reactions of bones. There appears to be a gradient of protection for more severe injuries.

The function of heel insoles are two-fold. They are designed to provide cushioning to absorb shock transmission to the lower extremity and compensate biomechanical deficiencies associated with running. The insoles described in these studies function as shock absorption only rather than as an attempt to modify structural abnormalities (e.g. leg-length discrepancy, excessive pronation) under the increased demands of running. Thus, the indication for orthotics/foot support for reducing running injuries related to malalignment problems is not clear from this review.

Knee braces appear to be effective in the prevention of anterior knee pain (BenGal 1997) but this implication is based on only one study. The limited data should only be considered as preliminary findings and further evidence is required.

A statistically significant benefit was achieved in Milgrom 1992 (our exploratory analysis) by the modification of footwear, but these results are specifically related to military training comparing infantry boots with modified basketball shoes and the study was cluster-randomised. Thus, the calculated confidence intervals are inappropriately narrow; caution needs to be exercised in extrapolating the results to different populations and other settings.

AUTHORS' CONCLUSIONS

Implications for practice

Based on evidence from randomised or pseudo-randomised clinical trials,

- the effectiveness of stretching exercises, and of insoles and footwear modification in the prevention of lower extremity soft tissue injuries associated with running is unknown.
- controlling the intensity of running (distance, frequency and duration) may be effective in the prevention of lower extremity soft tissue injuries associated with running.
- wearing a knee brace with a patellar support ring may be effective in the prevention of running-associated anterior knee pain.

Implications for research

Controlled investigations of running-related injuries are difficult due to the variation in the definition of injury, study population and outcome measures used. Well controlled RCTs are needed to shed light on the possible interventions for the prevention of lower limb soft tissue injuries in runners. The evaluation of interventions over a longer period and their effectiveness in reducing recurrence are also required. Studies are needed involving participants with differing levels of ability and more information is needed regarding the effectiveness of interventions in female runners.

The interacting effects of the training frequency, duration, distance and intensity in the prevention of running injuries should be considered and carefully addressed in the design of further studies. Research on the evaluation of the benefit of a progressive training programme should be assessed over a longer period. More data are required to confirm whether knee braces or footwear modification are effective in significantly reducing the incidence of overuse injury.

ACKNOWLEDGEMENTS

The authors thank Professor Bill Gillespie, Lesley Gillespie, Dr Helen Handoll and Leaann Morton for their valuable help and support throughout the preparation of the review.
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POTENTIAL CONFLICT OF INTEREST

None known.

SOURCES OF SUPPORT

External sources of support

• Health Services Research Committee HONG KONG

Internal sources of support

• No sources of support supplied

REFERENCES

References to studies included in this review

Andrish 1974 (published data only)

BenGal 1997 (published data only)

Fauno 1993 (published data only)

Hartig 1999 (published data only)

Milgrom 1992 (published data only)

Pollock 1977 (published data only)

Pope 1998 (published data only)

Pope 2000 (published data only)

Rudzki 1997 (published data only)

Schwellnus 1990 (published data only)

Smith 1985 (published data only)

van Mechelen 1993 (published data only)

References to studies excluded from this review

Clement 1984
Clement DB, Taunton JE, Smart GW. Achilles tendinitis and periten...

**Finestone 1993**


**Gudeman 1997**


**Herring 1990**


**Herring 1993**


**Jagoda 1981**


**Jakobsen 1994**


**Reynolds 1999**


**van Mechelen 1992**


**Wedderkopp 1999**


**References to studies awaiting assessment**

**Gardner 1988**


**Additional references**

**Baquie 1997**


**Clarke 2001**


**Heir 1996**


**Hoegerls 1992**


**Macera 1992**


**Marti 1988**


**Otis 1992**


**RevMan 2000**


**Vleck 1998**


**References to other published versions of this review**

**Yeung 2001**


* Indicates the major publication for the study
### Characteristics of included studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Method of randomisation: according to tested scholastic and athletic aptitudes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods</td>
<td>Method of randomisation: according to tested scholastic and athletic aptitudes</td>
</tr>
<tr>
<td>Blinding of subjects to assignment status: no</td>
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</tr>
<tr>
<td>Blinding of outcome assessors: not possible</td>
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<tr>
<td>Intention to treat analysis: not mentioned</td>
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</tr>
<tr>
<td>Comparability of treatment group at entry: not mentioned</td>
<td></td>
</tr>
<tr>
<td>Participants</td>
<td>Location: United States Naval Academy</td>
</tr>
<tr>
<td>Period of study: 1972-1973</td>
<td></td>
</tr>
<tr>
<td>Period of intervention: not stated</td>
<td></td>
</tr>
<tr>
<td>2777 first year midshipmen undergoing training</td>
<td></td>
</tr>
<tr>
<td>Exclusion criteria: not stated</td>
<td></td>
</tr>
<tr>
<td>Interventions</td>
<td>4 intervention groups:</td>
</tr>
<tr>
<td>1. Use of heel pad for running (n=344)</td>
<td></td>
</tr>
<tr>
<td>2. Stretching exercises to gastrocnemius and soleus (n=300)</td>
<td></td>
</tr>
<tr>
<td>3. Use of heel pad and stretching exercises (n=463)</td>
<td></td>
</tr>
<tr>
<td>4. Graduated running program (n=217)</td>
<td></td>
</tr>
<tr>
<td>5. Control group (n=1453)</td>
<td></td>
</tr>
<tr>
<td>Upon completion of treatment, subjects divided 2 groups:</td>
<td></td>
</tr>
<tr>
<td>1. Use of heel pads (n = 51)</td>
<td></td>
</tr>
<tr>
<td>2. Control group, no heel pads (n = 46)</td>
<td></td>
</tr>
<tr>
<td>Outcomes</td>
<td>1. Incidence of shin splints through self-reporting during training</td>
</tr>
<tr>
<td>2. Incidence of recurrence of shin splints</td>
<td></td>
</tr>
<tr>
<td>Notes</td>
<td>Data for stress fracture to tibia and foot excluded for analysis</td>
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### Study

<table>
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<tbody>
<tr>
<td>Methods</td>
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<td>Blinding of subjects to assignment status: not possible</td>
<td></td>
</tr>
<tr>
<td>Blinding of outcome assessors: yes</td>
<td></td>
</tr>
<tr>
<td>Loss to follow up: 20 (11 male and 9 female) dropped out</td>
<td></td>
</tr>
<tr>
<td>Intention to treat analysis: no</td>
<td></td>
</tr>
<tr>
<td>Comparability of treatment group at entry: not mentioned</td>
<td></td>
</tr>
<tr>
<td>Participants</td>
<td>Location: Israel</td>
</tr>
<tr>
<td>54 male and 26 female subjects (age 18-25) 8 weeks of an intensive physical training programme</td>
<td></td>
</tr>
<tr>
<td>Exclusion: inability to pass the preliminary fitness test, past history of anterior knee pain</td>
<td></td>
</tr>
<tr>
<td>Interventions</td>
<td>1. Knee brace (n=27)</td>
</tr>
<tr>
<td>2. No knee brace (n=33) (control group)</td>
<td></td>
</tr>
<tr>
<td>Outcomes</td>
<td>Incidence of anterior knee pain</td>
</tr>
<tr>
<td>Diagnosis made by:</td>
<td></td>
</tr>
<tr>
<td>1. Pain levels</td>
<td></td>
</tr>
<tr>
<td>2. Orthopaedic examination</td>
<td></td>
</tr>
<tr>
<td>3. Physical fitness test</td>
<td></td>
</tr>
</tbody>
</table>
**Characteristics of included studies (Continued)**

Measured at 1st and 8th week of training

Notes Female subjects not included in the analyses because of significant dropout (25%)

| Allocation concealment | B |

<table>
<thead>
<tr>
<th>Study</th>
<th>Fauno 1993</th>
</tr>
</thead>
</table>
| Methods | Randomization by birth date  
Loss to follow up: 30 (14 in intervention group, 16 in control group)  
Intention to treat analysis: no  
Blinding of outcome assessors: yes  
Blinding of subjects to assignment status: not possible |
| Participants | Location: Denmark  
Period of study: 1989  
121 soccer referees (age 17 to 65 years) undergoing 5 days of refereeing in a tournament  
Exclusion criteria: problems with lower limbs prior to intervention |
| Interventions | 1. Intervention group (n=62) - use of shock absorbing heel insoles  
2. Control group (n=59) |
| Outcomes | 1. Incidence of lower limb soreness  
Diagnosis made by the research team |
| Notes |  
Allocation concealment C |

<table>
<thead>
<tr>
<th>Study</th>
<th>Hartig 1999</th>
</tr>
</thead>
</table>
| Methods | Randomisation: “Army’s routine assignment”  
Loss to follow up: 28 (10 in control group, 18 in intervention group)  
Intention to treat analysis: not mentioned  
Blinding of outcome assessors: not mentioned  
Blinding of subjects to assignment status: not mentioned |
| Participants | Location: USA  
298 military basic trainees (average age 20 years) undergoing 13-week infantry basic training course  
Exclusion criteria: not mentioned |
| Interventions | 1. Intervention group (n=150) - 3 hamstring stretching sessions added to the fitness programme  
Stretching routine: 5 x 30 seconds  
2. Control group (n=148) |
| Outcomes | 1. Incidence of lower limb overuse injuries  
Diagnosis made by weekly review of the log-in sheets at the medical clinic |
| Notes |  
Allocation concealment C |

<table>
<thead>
<tr>
<th>Study</th>
<th>Milgrom 1992</th>
</tr>
</thead>
</table>
| Methods | Randomisation method not stated - Assignment by team  
Loss to follow up: none  
Blinding of outcome assessors: not mentioned  
Blinding of subjects to assignment status: not mentioned |
| Participants | Location: Israel  
Period of study: November 1988  
390 male infantry recruits undergoing 14 weeks of training  
Exclusion: clinical screening |
### Characteristics of included studies (Continued)

| Interventions | 1. Intervention group (n=187) - modified basketball shoes  
|               | 2. Control group (n=203) - standard training boots |
| Outcomes      | 1. Incidence of overuse injuries  
|               | Diagnosis made by doctors (reviewed every two weeks) |
| Notes         | Stress fracture data excluded for analysis |

#### Pollock 1977

| Study Methods | Randomisation method not stated  
|              | Loss to follow-up: 26 (study 1), 15 (study 2)  
|              | Intention to treat analysis: Yes  
|              | Blinding of outcome assessors: not mentioned  
|              | Blinding of subjects to assignment status: not mentioned |

| Study Participants | Location: Two USA jails  
|                    | Essentially 2 studies:  
|                    | Study 1 - 87 male prison (age 20-35) inmates undergoing training programmes of different duration for 20 weeks  
|                    | Study 2 - 70 male (age 20-35) prison inmates undergoing training programmes of different frequency for 20 weeks  
|                    | Inclusion: healthy, sedentary, free from drugs |

| Study Interventions | Study 1 - training 3 days/week for 20 weeks.  
|                     | Four groups:  
|                     | 1. Train 15 minutes/day (n=20)  
|                     | 2. Train 30 minutes/day (n=25)  
|                     | 3. Train 45 minutes/day (n=24)  
|                     | 4. Control group (n=18)  
|                     | Note: Exercise intensity at 85-90% maximal heart rate  
|                     | Study 2 - run on treadmill 30 minutes. Four groups:  
|                     | 1. 1 day/week (n=15)  
|                     | 2. 3 days/week (n=25)  
|                     | 3. 5 days/week (n=18)  
|                     | 4. Control group (n=13)  
|                     | Note: Progression of running to 9.75mph |

| Study Outcomes | 1. Incidence of training related injury which prevented participants from running for at least one week  
|                | 2. Attrition rate  
|                | 3. Cardiorespiratory fitness  
|                | Assessment of injury diagnosis - not stated |

| Study Notes | Analysis of incidence of injuries by body parts not possible |

| Study Allocation concealment | B |

#### Pope 1998

| Study Methods | Block randomisation  
|              | Allocation based on surnames of the subjects  
|              | Loss to follow-up: 210 (162 dropped out, 48 withdrawn at the end of first half of the training programme - reasons for withdrawal not mentioned)  
|              | Intention to treat analysis: no  
|              | Blinding of outcome assessors: yes |

| Study Participants | Location: Australia |
Characteristics of included studies (Continued)

1093 male army military recruits (age 17-35) undergoing 11 weeks of intensive training (average 47 hours per week)
Period of study: September 1992 to May 1993
Exclusion: previous injury between the time of the recruiting medical examination and arrival at the army site

Interventions
1. Intervention group (n=549) - stretches to the gastrocnemius and soleus muscles before training
2. Control group (n=544) - stretches to the wrist flexors and triceps muscle
Stretching routine: 2 x 20sec static stretches

Outcomes
1. Incidence of soft tissue injuries:
   a. Ankle sprains
   b. Achilles tendonitis
   c. Tibia periostitis
   d. Anterior compartment syndrome
   Self-report and diagnosis confirmed by regimental officer and physiotherapist’s examination
2. Range of ankle dorsiflexion (in degrees)

Notes
Data for stress fracture to tibia and foot excluded for analysis
Allocation concealment C

Study Pope 2000

Methods
Block randomisation
Method: allocation by surname
Loss to follow up: 353 (112 from intervention group, 241 from control group)
Intention to treat: yes
Blinding of subjects: no
Blinding of outcome assessors: yes

Participants
Location: Australia
1538 male military recruits (age 17-35) undergoing 11 weeks of training (40 sessions totaling 50 hours)
Period of study: January to December 1994
Exclusion criteria: absence of any significant injury, good general health

Interventions
1. Intervention group (n=735) - stretches to gastrocnemius, soleus, hamstrings, quadriceps, hip adductor and hip flexor muscle groups interspersed with 4 minutes warm up activities
   Stretching routine: 1 x 20sec stretch for each muscle group
2. Control group (n=803) - only warm up activities but no stretching exercises

Outcomes
Incidence of lower limb injuries by area and by type:
1. Joint injury
2. Ligament sprain
3. Muscle strain
4. Tendinitis
5. Periostitis
6. Compartment syndrome
7. Others
   Self-report and diagnosis confirmed by regimental medical officer

Notes
Allocation concealment C

Study Rudzki 1997

Methods
Randomisation method: drawn from a hat
Loss to follow up: none
Characteristics of included studies (Continued)

Intention to treat analysis: not mentioned
Blinding of outcome assessors: yes

Participants
Location: Australia
Recruitment period: March to April 1989
350 male military army recruits (age 17-31) undergoing 12 weeks of training
(average of 41.3 hours per week)
Exclusion: not mentioned

Interventions
1. Walk group (n=170) - substitute running with walking plus added weight
2. Run group (n=180) - uninterrupted programme of training
*Note - Difference in running distance of 16.5km between 2 groups

Outcomes
1. Incidence of lower limb and knee injuries
Diagnosis by clinical evaluation
2. Rate of injury per 1000 hours of physical training
3. Morbidity associated with injury
4. Medical centre visits
5. Cause of injuries

Notes
Injuries to upper limb, back and stress fractures are excluded from the analysis

Allocation concealment: C

Study
Schwellnus 1990

Methods
Randomisation method not mentioned
Loss to follow-up: 123 prior to intervention (control = 110, experimental = 13)
Intention to treat analysis: not mentioned
Blinding of outcome assessors: yes
Blinding of subjects to assignment status: not possible

Participants
Location: South African Army recruit training centre
1151 male military recruits (age 17-25) undergoing 9 weeks of training
Exclusion: gross biomechanical abnormalities, history of previous major injury or illness

Interventions
1. Neoprene insoles (n=1261)
2. No insoles (n=250)

Outcomes
1. Incidence of overuse injuries to the lower limb established by doctors (uniform diagnostic criteria established)
2. Mean incidence of injuries per 1000 recruits per week

Notes
Analysis excluded stress fractures, upper limb and back injuries

Allocation concealment: B

Study
Smith 1985

Methods
Method of randomisation not stated
Blinding of subjects to assignment status: not stated
Blinding of outcome assessors: no
Loss to follow up: 21
Intention to treat analysis: no

Participants
Location: USA Coast Guard Training Centre
90 subjects (both male and female but numbers not stated, age 17 to 25) undergoing 8 weeks of recruit training
Exclusion criteria: not stated

Interventions
1. Cellular polyurethane shock absorbing insoles (n=30)
2. Neoprene shock absorbing insoles (n=30)
### Characteristics of included studies (Continued)

3. Control group (n=30)

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Incidence of soft tissue injuries:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Heel contusion</td>
</tr>
<tr>
<td></td>
<td>2. Plantar fasciitis</td>
</tr>
<tr>
<td></td>
<td>3. Tibial stress syndrome</td>
</tr>
<tr>
<td></td>
<td>4. Metatarsalgia</td>
</tr>
<tr>
<td>Assessment of injury diagnosis</td>
<td>- not stated</td>
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</table>

<table>
<thead>
<tr>
<th>Notes</th>
<th>Data for calluses and blisters excluded</th>
</tr>
</thead>
</table>

| Allocation concealment            | B                                       |

#### Study: van Mechelen 1993

<table>
<thead>
<tr>
<th>Methods</th>
<th>Randomisation method not stated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loss to follow-up: 95 (dropped out)</td>
</tr>
<tr>
<td></td>
<td>Intention to treat analysis: not possible</td>
</tr>
<tr>
<td></td>
<td>Blinding of outcome assessors: not possible</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Participants</th>
<th>Location: Amsterdam, Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Period of study: September 1988 - January 1989</td>
</tr>
<tr>
<td></td>
<td>421 male civil servants (recreational runners)</td>
</tr>
<tr>
<td></td>
<td>Age range: not stated</td>
</tr>
<tr>
<td></td>
<td>Inclusion: healthy, no current injury, not home from work on sick leave, running at least 10km/week all year round, not performing sports as their profession</td>
</tr>
</tbody>
</table>

| Interventions                     | 1. Intervention group (n=210) - information on warm up / cool down and stretching exercises, explained by coach and performance of these exercises before and after each running session |
|                                   | Protocol: 6 minutes of running as warm-up exercises, 3 minutes of loosening exercises, 10 minutes of stretching exercises to major lower limb muscles (3 x 10 sec static stretches) |
|                                   | 2. No intervention (n=211)               |

| Outcomes                          | 1. Lower limb soft tissue injury incidence per 1000 hours of running |
|                                   | Self report (if matched with the running injury definition), followed by physicians' confirmation of medical diagnosis |
|                                   | 2. Knowledge and attitude scores towards the intervention programme |

<table>
<thead>
<tr>
<th>Notes</th>
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| Allocation concealment            | B                                       |

### Characteristics of excluded studies

<table>
<thead>
<tr>
<th>Clement 1984</th>
<th>Not RCT</th>
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<tbody>
<tr>
<td></td>
<td>Use of different modalities in the treatment of achilles tendinitis with peritendinitis.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Finestone 1993</th>
<th>RCT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effect of knee braces in the treatment of subjects that had already developed patellofemoral pain - not a preventive strategy.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gudeman 1997</th>
<th>RCT</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Use of iontophoresis of 0.4% of dexamethasone on the treatment of plantar fasciitis. It is not stated if the subjects’ symptoms are caused by running.</td>
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</table>

<table>
<thead>
<tr>
<th>Herring 1990</th>
<th>Longitudinal double-blind study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effect of sock fiber composition in the prevention of friction blisters in long distance runners - not related to soft tissue injury.</td>
</tr>
</tbody>
</table>

| Herring 1993                      | Longitudinal single-blind study          |

---

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Characteristics of excluded studies (Continued)

Effect of sock fiber composition in the prevention of friction blisters in long distance runners - not related to soft tissue injury.

<table>
<thead>
<tr>
<th>Study title</th>
<th>Intervention type</th>
<th>Study details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jagoda 1981</td>
<td>RCT</td>
<td>Comparison of different socks in the prevention of friction blisters - not related to soft tissue injury.</td>
</tr>
<tr>
<td>Jakobsen 1994</td>
<td>Not RCT</td>
<td>Effects of prevention and training programmes in the reduction of injury incidence.</td>
</tr>
<tr>
<td>Reynolds 1999</td>
<td>Not RCT</td>
<td>Survey questionnaire that examined the incidence of injuries over a 100 mile march.</td>
</tr>
<tr>
<td>Wedderkopp 1999</td>
<td>RCT</td>
<td>Intervention programme designed to reduce the number of injuries in young female players in European handball. Running is not the primary focus of the sport.</td>
</tr>
<tr>
<td>van Mechelen 1992</td>
<td>Case-control study, not RCT</td>
<td>The relationship between hip and ankle joint range of movement and running injuries.</td>
</tr>
</tbody>
</table>

### ADDITIONAL TABLES

#### Table 01. Intervention period

<table>
<thead>
<tr>
<th>Study title</th>
<th>Period of intervention (weeks)</th>
<th>Hours of exposure/week</th>
<th>Total hours of exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrish 1974</td>
<td>not stated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BenGal 1997</td>
<td>8</td>
<td>36</td>
<td>288</td>
</tr>
<tr>
<td>Fauno 1993</td>
<td>5</td>
<td>not stated</td>
<td>14.5</td>
</tr>
<tr>
<td>Hartig 1999</td>
<td>13</td>
<td>not stated</td>
<td>not stated</td>
</tr>
<tr>
<td>Milgrom 1992</td>
<td>14</td>
<td>not stated</td>
<td>not stated</td>
</tr>
<tr>
<td>Pollock 1997</td>
<td>20</td>
<td>0.75-2.50</td>
<td>15-50</td>
</tr>
<tr>
<td>Pope 1998</td>
<td>11</td>
<td>47</td>
<td>517</td>
</tr>
<tr>
<td>Pope 2000</td>
<td>11</td>
<td>50</td>
<td>550</td>
</tr>
<tr>
<td>Rudzki 1997</td>
<td>12</td>
<td>41.3</td>
<td>495.6</td>
</tr>
<tr>
<td>Schwellnus 1990</td>
<td>9</td>
<td>0.5 - 7</td>
<td>4.5 - 63</td>
</tr>
<tr>
<td>Smith 1985</td>
<td>8</td>
<td>not stated</td>
<td>not stated</td>
</tr>
<tr>
<td>van Mechelen 1993</td>
<td>16</td>
<td>1.74 ±1.32 - 1.85 ± 1.24</td>
<td>27.85 ± 21.15 - 29.58 ± 19.89</td>
</tr>
</tbody>
</table>

#### Table 02. Stretching protocol

<table>
<thead>
<tr>
<th>Study title</th>
<th>Target muscle group</th>
<th>Stretch protocol (experimental)</th>
<th>Stretch protocol (control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrish 1974</td>
<td>gastrocnemius and soleus</td>
<td>3 min, 3x/day, outside training session</td>
<td>not available</td>
</tr>
<tr>
<td>Hartig 1999</td>
<td>hamstrings</td>
<td>5x30 sec, 3x/day, outside training session</td>
<td>all recruits had normal routine stretching</td>
</tr>
<tr>
<td>Pope 1998</td>
<td>gastrocnemius and soleus</td>
<td>2x20 sec, before training</td>
<td>stretching other muscle groups</td>
</tr>
</tbody>
</table>
Table 02. Stretching protocol (Continued)

<table>
<thead>
<tr>
<th>Source Year</th>
<th>Muscles</th>
<th>Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pope 2000</td>
<td>Hip adductors, hip flexors, quadriceps, hamstrings, gastrocnemius and soleus</td>
<td>1x20 sec, before training</td>
<td>only warm up exercises, no stretching</td>
</tr>
<tr>
<td>van Mechelen 1993</td>
<td>Iliopsoas, quadriceps, hamstrings, gastrocnemius and soleus</td>
<td>3x10 sec for 10 min, before running</td>
<td>some form of daily stretching performed</td>
</tr>
</tbody>
</table>

Table 03. Running distance per week

<table>
<thead>
<tr>
<th>Study title</th>
<th>Distance (km) per week</th>
<th>Total distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollock 1977</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/week</td>
<td>4.56 - 9.68</td>
<td>91.16 - 193.38</td>
</tr>
<tr>
<td>3 days/week</td>
<td>13.67 - 29.00</td>
<td>273.48 - 580.13</td>
</tr>
<tr>
<td>5 days/week</td>
<td>22.79 - 48.34</td>
<td>455.80 - 966.88</td>
</tr>
<tr>
<td>Duration group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 mins/day</td>
<td>2.41 - 2.81</td>
<td>48.27 - 56.31</td>
</tr>
<tr>
<td>30 mins/day</td>
<td>4.66 - 5.23</td>
<td>93.2 - 104.58</td>
</tr>
<tr>
<td>45 mins/day</td>
<td>6.60 - 8.21</td>
<td>131.94 - 164.12</td>
</tr>
<tr>
<td>Rudzki 1997</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Run group</td>
<td>23.33</td>
<td>280</td>
</tr>
<tr>
<td>Walk group</td>
<td>6.83</td>
<td>82</td>
</tr>
</tbody>
</table>

**GRAPHS**

Comparison 01. Stretching exercises vs control

<table>
<thead>
<tr>
<th>Outcome title</th>
<th>No. of studies</th>
<th>No. of participants</th>
<th>Statistical method</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Overall lower limb injuries</td>
<td></td>
<td></td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>Totals not selected</td>
</tr>
<tr>
<td>02 Compliance with intervention</td>
<td></td>
<td></td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>Subtotals only</td>
</tr>
<tr>
<td>03 Knowledge and attitude</td>
<td></td>
<td></td>
<td>Weighted Mean Difference (Fixed) 95% CI</td>
<td>Totals not selected</td>
</tr>
</tbody>
</table>

Comparison 02. Modification of training schedule

<table>
<thead>
<tr>
<th>Outcome title</th>
<th>No. of studies</th>
<th>No. of participants</th>
<th>Statistical method</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Overall lower limb injuries</td>
<td></td>
<td></td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>Subtotals only</td>
</tr>
<tr>
<td>02 Reduction in running distance</td>
<td></td>
<td></td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>Subtotals only</td>
</tr>
</tbody>
</table>
### Comparison 03. Insoles vs control (no insoles)

<table>
<thead>
<tr>
<th>Outcome title</th>
<th>No. of studies</th>
<th>No. of participants</th>
<th>Statistical method</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Incidence of overall lower limb injuries</td>
<td>4</td>
<td>3344</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>0.87 [0.69, 1.11]</td>
</tr>
<tr>
<td>02 Hip injuries</td>
<td>1</td>
<td>1388</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>1.62 [0.53, 4.98]</td>
</tr>
<tr>
<td>03 Knee injuries</td>
<td>1</td>
<td>1388</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>0.82 [0.54, 1.23]</td>
</tr>
<tr>
<td>04 Lower leg injuries</td>
<td>3</td>
<td>3253</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>0.91 [0.59, 1.42]</td>
</tr>
<tr>
<td>05 Ankle and foot injuries</td>
<td>2</td>
<td>1456</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>1.27 [0.71, 2.29]</td>
</tr>
<tr>
<td>06 Recurrence of shin splints</td>
<td>1</td>
<td>97</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>1.98 [0.75, 5.28]</td>
</tr>
</tbody>
</table>

### Comparison 04. Modification of shoewear

<table>
<thead>
<tr>
<th>Outcome title</th>
<th>No. of studies</th>
<th>No. of participants</th>
<th>Statistical method</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Incidence of overall lower limb injuries</td>
<td>1</td>
<td>390</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>0.83 [0.71, 0.98]</td>
</tr>
<tr>
<td>02 Knee injuries</td>
<td>1</td>
<td>390</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>0.93 [0.62, 1.39]</td>
</tr>
<tr>
<td>03 Lower leg injuries</td>
<td>1</td>
<td>390</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>1.26 [0.82, 1.93]</td>
</tr>
<tr>
<td>04 Foot injuries</td>
<td>1</td>
<td>390</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>0.53 [0.36, 0.79]</td>
</tr>
</tbody>
</table>

### Comparison 05. Knee brace vs control (no brace)

<table>
<thead>
<tr>
<th>Outcome title</th>
<th>No. of studies</th>
<th>No. of participants</th>
<th>Statistical method</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Anterior knee pain</td>
<td>1</td>
<td>43</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>0.35 [0.13, 0.91]</td>
</tr>
</tbody>
</table>

### Comparison 06. Combined insoles and stretching exercises

<table>
<thead>
<tr>
<th>Outcome title</th>
<th>No. of studies</th>
<th>No. of participants</th>
<th>Statistical method</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Incidence of shin splints</td>
<td>1</td>
<td>1916</td>
<td>Relative Risk (Fixed) 95% CI</td>
<td>1.05 [0.58, 1.90]</td>
</tr>
</tbody>
</table>

### INDEX TERMS

**Medical Subject Headings (MeSH)**

Cumulative Trauma Disorders [prevention & control]; Leg Injuries [prevention & control]; Orthotic Devices; Randomized Controlled Trials; Running [injuries]; Soft Tissue Injuries [prevention & control]

**Medical MeSH check words**

Humans

### COVER SHEET

**Title**

Interventions for preventing lower limb soft-tissue injuries in runners

**Authors**

Yeung EW, Yeung SS

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Contribution of author(s)  
Both reviewers, Ella Yeung and Simon Yeung, initiated and designed the review. Both reviewers located the review studies, performed independent quality assessment and data extraction of the included trials. Ella Yeung checked the data entry, completed the first draft of the review and is the guarantor of the review.

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1998/4

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2001/3

Date of most recent amendment  
16 December 2004

Date of most recent SUBSTANTIVE amendment  
16 February 2001

What's New  
Information not supplied by author

Date new studies sought but none found  
Information not supplied by author

Date new studies found but not yet included/excluded  
Information not supplied by author

Date new studies found and included/excluded  
Information not supplied by author

Date authors' conclusions section amended  
Information not supplied by author

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### Graphs and Other Tables

#### Fig. 1. Comparison 01. Stretching exercises vs control

**01.01 Overall lower limb injuries**

Review: Interventions for preventing lower limb soft-tissue injuries in runners

Comparison: 01 Stretching exercises vs control

Outcome: 01 Overall lower limb injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention n/N</th>
<th>Control n/N</th>
<th>Relative Risk (Fixed) 95% CI</th>
<th>Relative Risk (Fixed) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrich, 1974</td>
<td>11/300</td>
<td>42/1453</td>
<td>1.27 [0.66, 2.43]</td>
<td></td>
</tr>
<tr>
<td>Hartig, 1999</td>
<td>25/150</td>
<td>43/148</td>
<td>0.57 [0.37, 0.89]</td>
<td></td>
</tr>
<tr>
<td>Pope, 1998</td>
<td>15/451</td>
<td>17/432</td>
<td>0.85 [0.43, 1.67]</td>
<td></td>
</tr>
<tr>
<td>van Mechelen, 1993</td>
<td>26/159</td>
<td>23/167</td>
<td>1.19 [0.71, 1.99]</td>
<td></td>
</tr>
</tbody>
</table>

#### Fig. 2. Comparison 01. Stretching exercises vs control

**01.02 Compliance with intervention**

Review: Interventions for preventing lower limb soft-tissue injuries in runners

Comparison: 01 Stretching exercises vs control

Outcome: 02 Compliance with intervention

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention n/N</th>
<th>Control n/N</th>
<th>Relative Risk (Fixed) 95% CI</th>
<th>Weight (%)</th>
<th>Relative Risk (Fixed) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Warm-up exercises</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>van Mechelen, 1993</td>
<td>50/159</td>
<td>109/159</td>
<td>0.46 [0.36, 0.59]</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>159</td>
<td>159</td>
<td></td>
<td>1000</td>
<td>0.46 [0.36, 0.59]</td>
</tr>
<tr>
<td>Total events: 50 (Intervention), 109 (Control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for heterogeneity: not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect z=6.05 p&lt;0.00001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 02 Cool-down exercises |
| van Mechelen, 1993 | 56/159           | 103/159     | 0.54 [0.43, 0.69]            | 1000       |                              |
| Subtotal (95% CI) | 159              | 159         |                              | 1000       | 0.54 [0.43, 0.69]            |
| Total events: 56 (Intervention), 103 (Control) |
| Test for heterogeneity: not applicable |
| Test for overall effect z=4.98 p<0.00001 |

| 03 Stretching exercises |
| van Mechelen, 1993 | 85/159           | 74/159      | 1.15 [0.92, 1.43]            | 1000       |                              |
| Subtotal (95% CI) | 159              | 159         |                              | 1000       | 1.15 [0.92, 1.43]            |

(Continued...)
### Comparison 01. Stretching exercises vs control

#### 01.03 Knowledge and attitude

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Weighted Mean Difference (Fixed)</th>
<th>Weighted Mean Difference (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean(SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>01</td>
<td>Knowledge towards warm-up exercises</td>
<td>157</td>
<td>0.40 (1.33)</td>
<td>168</td>
</tr>
<tr>
<td>van Mechelen 1993</td>
<td>02</td>
<td>Knowledge towards stretching exercises</td>
<td>156</td>
<td>-0.04 (1.36)</td>
</tr>
<tr>
<td>van Mechelen 1993</td>
<td>03</td>
<td>Knowledge towards cool-down exercises</td>
<td>158</td>
<td>0.74 (1.33)</td>
</tr>
<tr>
<td>van Mechelen 1993</td>
<td>04</td>
<td>Attitude towards warm-up exercises</td>
<td>159</td>
<td>0.16 (1.55)</td>
</tr>
<tr>
<td>van Mechelen 1993</td>
<td>05</td>
<td>Attitude towards cool-down exercises</td>
<td>159</td>
<td>0.13 (0.87)</td>
</tr>
</tbody>
</table>

---

**Fig. 3.** Comparison 01. Stretching exercises vs control

Review: Interventions for preventing lower limb soft-tissue injuries in runners

Comparison: 01 Stretching exercises vs control

Outcome: 03 Knowledge and attitude
**Fig. 4. Comparison 02. Modification of training schedule**

02.01 Overall lower limb injuries

**Review:** Interventions for preventing lower limb soft-tissue injuries in runners

**Comparison:** 02 Modification of training schedule

**Outcome:** 01 Overall lower limb injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Relative Risk (Fixed)</th>
<th>Weight</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td>(%)</td>
<td>95% CI</td>
</tr>
</tbody>
</table>

- **01 Reduction in frequency of training (1-3 days/week vs 5 days/week)**
  - Pollock 1977: 3/40 vs 7/18
    - Relative Risk: 0.19 [0.06, 0.66]
    - Test for overall effect: z=2.62 p=0.009

- **02 Reduction in the duration of training (15-30 minutes/day vs 45 minutes/day)**
  - Pollock 1977: 10/45 vs 13/24
    - Relative Risk: 0.41 [0.21, 0.79]
    - Test for overall effect: z=2.65 p=0.008

- **03 Reduction in running distance**
  - Rudski 1997: 56/170 vs 85/180
    - Relative Risk: 0.70 [0.54, 0.91]
    - Test for overall effect: z=2.67 p=0.008

- **04 Graduated running program**
  - Andrish 1974: 13/217 vs 42/1453
    - Relative Risk: 2.07 [1.13, 3.80]
    - Test for overall effect: z=2.36 p=0.02

---

*Interventions for preventing lower limb soft-tissue injuries in runners (Review)*

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Fig. 5. Comparison 02. Modification of training schedule

02.02 Reduction in running distance

Review: Interventions for preventing lower limb soft-tissue injuries in runners
Comparison: 02 Modification of training schedule
Outcome: 02 Reduction in running distance

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Relative Risk (Fixed)</th>
<th>Weight (%)</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Hip injuries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rudzki 1997</td>
<td>9/170</td>
<td>11/180</td>
<td>0.87 [0.37, 2.04]</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>170</td>
<td>180</td>
<td></td>
<td>100.0</td>
<td>0.87 [0.37, 2.04]</td>
</tr>
<tr>
<td>Test for overall effect</td>
<td>z=0.33</td>
<td>p=0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total events: 9 (Intervention), 11 (Control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for heterogeneity:</td>
<td>not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect z=0.33</td>
<td>p=0.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>03 Knee injuries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rudzki 1997</td>
<td>15/170</td>
<td>35/180</td>
<td>0.45 [0.26, 0.80]</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>170</td>
<td>180</td>
<td></td>
<td>100.0</td>
<td>0.45 [0.26, 0.80]</td>
</tr>
<tr>
<td>Test for overall effect</td>
<td>z=2.73</td>
<td>p=0.006</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total events: 15 (Intervention), 35 (Control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for heterogeneity:</td>
<td>not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect z=2.73</td>
<td>p=0.006</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>04 Lower leg injuries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rudzki 1997</td>
<td>8/170</td>
<td>6/170</td>
<td>1.33 [0.47, 3.76]</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>170</td>
<td>170</td>
<td></td>
<td>100.0</td>
<td>1.33 [0.47, 3.76]</td>
</tr>
<tr>
<td>Test for overall effect</td>
<td>z=0.54</td>
<td>p=0.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total events: 8 (Intervention), 6 (Control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for heterogeneity:</td>
<td>not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect z=0.54</td>
<td>p=0.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>05 Ankle and foot injuries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rudzki 1997</td>
<td>24/170</td>
<td>33/180</td>
<td>0.77 [0.48, 1.25]</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>170</td>
<td>180</td>
<td></td>
<td>100.0</td>
<td>0.77 [0.48, 1.25]</td>
</tr>
<tr>
<td>Test for overall effect</td>
<td>z=1.06</td>
<td>p=0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total events: 24 (Intervention), 33 (Control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for heterogeneity:</td>
<td>not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect z=1.06</td>
<td>p=0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig. 6.  Comparison 03.  Insoles vs control (no insoles)

03.01 Incidence of overall lower limb injuries

Review: Interventions for preventing lower limb soft-tissue injuries in runners
Comparison: 03 Insoles vs control (no insoles)
Outcome: 01 Incidence of overall lower limb injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Relative Risk (Fixed)</th>
<th>Weight</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td>(%)</td>
<td>95% CI</td>
<td></td>
</tr>
<tr>
<td>Andrish 1974</td>
<td>15/344</td>
<td>42/1453</td>
<td>13.3</td>
<td>1.51 [0.85, 2.69]</td>
<td></td>
</tr>
<tr>
<td>Fauno 1993</td>
<td>4/48</td>
<td>7/43</td>
<td>6.1</td>
<td>0.51 [0.16, 1.63]</td>
<td></td>
</tr>
<tr>
<td>Schwellnus 1990</td>
<td>45/237</td>
<td>259/1151</td>
<td>73.1</td>
<td>0.84 [0.64, 1.12]</td>
<td></td>
</tr>
<tr>
<td>Smith 1985</td>
<td>4/44</td>
<td>7/24</td>
<td>7.5</td>
<td>0.31 [0.10, 0.96]</td>
<td></td>
</tr>
</tbody>
</table>

Total (95% CI) 673 2671
Total events: 68 (Intervention), 315 (Control)
Test for heterogeneity chi-square=7.54 df=3 p=0.06 I² =60.2%
Test for overall effect z=1.12 p=0.3

Fig. 7.  Comparison 03.  Insoles vs control (no insoles)

03.02 Hip injuries

Review: Interventions for preventing lower limb soft-tissue injuries in runners
Comparison: 03 Insoles vs control (no insoles)
Outcome: 02 Hip injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Experimental</th>
<th>Control</th>
<th>Relative Risk (Fixed)</th>
<th>Weight</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td>(%)</td>
<td>95% CI</td>
<td></td>
</tr>
<tr>
<td>Schwellnus 1990</td>
<td>4/237</td>
<td>12/1151</td>
<td>100.0</td>
<td>1.62 [0.53, 4.98]</td>
<td></td>
</tr>
</tbody>
</table>

Total (95% CI) 237 1151
Total events: 4 (Experimental), 12 (Control)
Test for heterogeneity: not applicable
Test for overall effect z=0.84 p=0.4
### Fig. 8. Comparison 03. Insoles vs control (no insoles)

#### 03.03 Knee injuries

Review: Interventions for preventing lower limb soft-tissue injuries in runners  
Comparison: 03 Insoles vs control (no insoles)  
Outcome: 03 Knee injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Relative Risk (Fixed)</th>
<th>Weight</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schwellnus 1990</td>
<td>24/237</td>
<td>143/1151</td>
<td>100.0</td>
<td>0.82</td>
<td>[0.54, 1.23]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>237</td>
<td>1151</td>
<td>100.0</td>
<td>0.82</td>
<td>[0.54, 1.23]</td>
</tr>
<tr>
<td>Total events</td>
<td>24 (Experimental), 143 (Control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Test for heterogeneity: not applicable  
Test for overall effect: z=0.98  p=0.3

### Fig. 9. Comparison 03. Insoles vs control (no insoles)

#### 03.04 Lower leg injuries

Review: Interventions for preventing lower limb soft-tissue injuries in runners  
Comparison: 03 Insoles vs control (no insoles)  
Outcome: 04 Lower leg injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Relative Risk (Fixed)</th>
<th>Weight</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andrisch 1974</td>
<td>15/344</td>
<td>42/1453</td>
<td>38.9</td>
<td>1.51</td>
<td>[0.85, 2.69]</td>
</tr>
<tr>
<td>Schwellnus 1990</td>
<td>7/237</td>
<td>73/1151</td>
<td>60.3</td>
<td>0.47</td>
<td>[0.22, 1.00]</td>
</tr>
<tr>
<td>Smith 1985</td>
<td>1/24</td>
<td>0/44</td>
<td>0.9</td>
<td>5.40</td>
<td>[0.23, 127.67]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>605</td>
<td>2648</td>
<td>100.0</td>
<td>0.91</td>
<td>[0.59, 1.42]</td>
</tr>
<tr>
<td>Total events</td>
<td>23 (Intervention), 115 (Control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Test for heterogeneity: chi-square=7.10  df=2  p=0.03  I² =71.8%  
Test for overall effect: z=0.40  p=0.7

Interventions for preventing lower limb soft-tissue injuries in runners (Review)  
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Fig. 10. Comparison 03. Insoles vs control (no insoles)

03.05 Ankle and foot injuries

Review: Interventions for preventing lower limb soft-tissue injuries in runners
Comparison: 03 Insoles vs control (no insoles)
Outcome: 05 Ankle and foot injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Relative Risk (Fixed)</th>
<th>Weight</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td>(%)</td>
<td>95% CI</td>
</tr>
<tr>
<td>Schwellnus 1990</td>
<td>9/237</td>
<td>44/1151</td>
<td>84.2</td>
<td>0.99 [ 0.49, 2.01 ]</td>
<td></td>
</tr>
<tr>
<td>Smith 1985</td>
<td>6/24</td>
<td>4/44</td>
<td>15.8</td>
<td>2.75 [ 0.86, 8.80 ]</td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>261</td>
<td>1195</td>
<td>100.0</td>
<td>1.27 [ 0.71, 2.29 ]</td>
<td></td>
</tr>
</tbody>
</table>

Total events: 15 (Intervention), 48 (Control)
Test for heterogeneity chi-square=2.16 df=1 p=0.14 I² =53.8%
Test for overall effect z=0.80  p=0.4

Fig. 11. Comparison 03. Insoles vs control (no insoles)

03.06 Recurrence of shin splints

Review: Interventions for preventing lower limb soft-tissue injuries in runners
Comparison: 03 Insoles vs control (no insoles)
Outcome: 06 Recurrence of shin splints

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Relative Risk (Fixed)</th>
<th>Weight</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td>(%)</td>
<td>95% CI</td>
</tr>
<tr>
<td>Andris 1974</td>
<td>11/51</td>
<td>5/46</td>
<td>100.0</td>
<td>1.98 [ 0.75, 5.28 ]</td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>51</td>
<td>46</td>
<td>100.0</td>
<td>1.98 [ 0.75, 5.28 ]</td>
<td></td>
</tr>
</tbody>
</table>

Total events: 11 (Intervention), 5 (Control)
Test for heterogeneity: not applicable
Test for overall effect z=1.37  p=0.2
### Fig. 12. Comparison 04. Modification of shoewear

#### 04.01 Incidence of overall lower limb injuries

**Review:** Interventions for preventing lower limb soft-tissue injuries in runners  
**Comparison:** 04 Modification of shoewear  
**Outcome:** 01 Incidence of overall lower limb injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Relative Risk (Fixed)</th>
<th>Weight</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td>(%)</td>
<td>95% CI</td>
</tr>
<tr>
<td>Milgrom 1992</td>
<td>102/187</td>
<td>133/203</td>
<td>100.0</td>
<td>0.83 [ 0.71, 0.98 ]</td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>187</td>
<td>203</td>
<td>100.0</td>
<td>0.83 [ 0.71, 0.98 ]</td>
<td></td>
</tr>
</tbody>
</table>

Total events: 102 (Intervention), 133 (Control)  
Test for heterogeneity: not applicable  
Test for overall effect $z=2.18$  
$p=0.03$

### Fig. 13. Comparison 04. Modification of shoewear

#### 04.02 Knee injuries

**Review:** Interventions for preventing lower limb soft-tissue injuries in runners  
**Comparison:** 04 Modification of shoewear  
**Outcome:** 02 Knee injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Relative Risk (Fixed)</th>
<th>Weight</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td>(%)</td>
<td>95% CI</td>
</tr>
<tr>
<td>Milgrom 1992</td>
<td>36/187</td>
<td>42/203</td>
<td>100.0</td>
<td>0.93 [ 0.62, 1.39 ]</td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>187</td>
<td>203</td>
<td>100.0</td>
<td>0.93 [ 0.62, 1.39 ]</td>
<td></td>
</tr>
</tbody>
</table>

Total events: 36 (Intervention), 42 (Control)  
Test for heterogeneity: not applicable  
Test for overall effect $z=0.35$  
$p=0.7$
**Fig. 14. Comparison 04. Modification of shoewear**

**04.03 Lower leg injuries**

**Review:** Interventions for preventing lower limb soft-tissue injuries in runners

**Comparison:** 04 Modification of shoewear

**Outcome:** 03 Lower leg injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention n/N</th>
<th>Control n/N</th>
<th>Relative Risk (Fixed)</th>
<th>Weight (%)</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milgrom 1992</td>
<td>37/187</td>
<td>32/203</td>
<td>1.26 [0.82, 1.93]</td>
<td>100.0</td>
<td>1.26 [0.82, 1.93]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>187</td>
<td>203</td>
<td>100.0</td>
<td>1.26 [0.82, 1.93]</td>
<td></td>
</tr>
</tbody>
</table>

Test for heterogeneity: not applicable

Test for overall effect: z=1.04 p=0.3

---

**Fig. 15. Comparison 04. Modification of shoewear**

**04.04 Foot injuries**

**Review:** Interventions for preventing lower limb soft-tissue injuries in runners

**Comparison:** 04 Modification of shoewear

**Outcome:** 04 Foot injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention n/N</th>
<th>Control n/N</th>
<th>Relative Risk (Fixed)</th>
<th>Weight (%)</th>
<th>Relative Risk (Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milgrom 1992</td>
<td>29/187</td>
<td>59/203</td>
<td>0.53 [0.36, 0.79]</td>
<td>100.0</td>
<td>0.53 [0.36, 0.79]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>187</td>
<td>203</td>
<td>100.0</td>
<td>0.53 [0.36, 0.79]</td>
<td></td>
</tr>
</tbody>
</table>

Test for heterogeneity: not applicable

Test for overall effect: z=3.10 p=0.002
Fig. 16. Comparison 05. Knee brace vs control (no brace)

05.01 Anterior knee pain

Review: Interventions for preventing lower limb soft-tissue injuries in runners
Comparison: 05 Knee brace vs control (no brace)
Outcome: 01 Anterior knee pain

<table>
<thead>
<tr>
<th>Study</th>
<th>Experimental n/N</th>
<th>Control n/N</th>
<th>Relative Risk (Fixed) 95% CI (%)</th>
<th>Weight (%)</th>
<th>Relative Risk (Fixed) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>BenGal 1997</td>
<td>4/21</td>
<td>12/22</td>
<td>100.0</td>
<td>0.35</td>
<td>0.35 [0.13, 0.91]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>21</td>
<td>22</td>
<td>100.0</td>
<td>0.35</td>
<td>0.35 [0.13, 0.91]</td>
</tr>
</tbody>
</table>

Total events: 4 (Experimental), 12 (Control)
Test for heterogeneity: not applicable
Test for overall effect z=2.15  p=0.03

Fig. 17. Comparison 06. Combined insoles and stretching exercises

06.01 Incidence of shin splints

Review: Interventions for preventing lower limb soft-tissue injuries in runners
Comparison: 06 Combined insoles and stretching exercises
Outcome: 01 Incidence of shin splints

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention n/N</th>
<th>Control n/N</th>
<th>Relative Risk (Fixed) 95% CI (%)</th>
<th>Weight (%)</th>
<th>Relative Risk (Fixed) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andish 1974</td>
<td>14/463</td>
<td>42/1453</td>
<td>100.0</td>
<td>1.05</td>
<td>1.05 [0.58, 1.90]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>463</td>
<td>1453</td>
<td>100.0</td>
<td>1.05</td>
<td>1.05 [0.58, 1.90]</td>
</tr>
</tbody>
</table>

Total events: 14 (Intervention), 42 (Control)
Test for heterogeneity: not applicable
Test for overall effect z=0.15  p=0.9