Review

A systematic review of interventions to prevent lower limb soft tissue running injuries

E W Yeung, S S Yeung

Abstract

***Objectives*—To assess the available evidence for preventive strategies for lower limb soft tissue injuries caused by running.**

***Methods*—An electronic database search was conducted using The Cochrane Musculoskeletal Injuries Group Specialised Register, The Cochrane Controlled Trials Register, Medline, Embase, Sport Discus, Heracles, Atlantes, Biosis, Cinahl, Scisearch, Current Contents, Index To Theses and Dissertation Abstracts. Any randomised or quasi-randomised trials evaluating interventions to prevent running injuries to lower limb soft tissue were included. The eligibility of trials for inclusion and the quality of the trials were independently assessed by two reviewers.**

***Results*—Exposure to a high training load (duration, frequency, or running distance) increases the risk of injury, and thus modification of the training schedule can reduce the incidence of injury. The effectiveness of stretching exercises and of insoles in the prevention of lower extremity soft tissue injuries caused by running is not known. Wearing a knee brace with a patellar support ring may be effective in the prevention of anterior knee pain caused by running.**

***Conclusions*—This review provides evidence for the effectiveness of the modification of training schedules in reducing lower limb soft tissue running injuries. More studies are required to quantify the optimal training loads and to confirm that knee braces can prevent knee pain. It is important to note that the studies included in this review had few female participants therefore the results may not be generalisable.**

Keywords: running; lower limb; soft tissue; knee; ankle

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Participation in sports and physical activity is increasingly popular. In a survey conducted in Hong Kong on 2652 respondents, an average of 54% of the Hong Kong adult population participated in at least one sports activity during the year of 1998.[1] This was higher than in 1996.[2] Of the top five major sporting activities, running is one of the most popular. The results suggested that there was an increase in participation in running from 9.6% in 1996 to 12.5% in 1998. A similar trend was found in other countries, such as North America, Canada, and the Netherlands.[3 4]

Despite the health benefits associated with running, concerns have been raised about the high incidence of musculoskeletal injuries, primarily of the lower limbs. In a survey conducted at the Hong Kong Tsing Ma Bridge International Marathon and 10 km run in 1997, with a total of 5500 participants,[5] the incidence of injury (1.3%) requiring physiotherapy was comparable to that in other overseas running competitions.[6 7] Several risk factors appear to be associated with injury incidence, such as weekly mileage, history of previous running injuries, number of years in running, training characteristics (speed, frequency, surface, timing), training surface, and footwear.[8 9] The most commonly diagnosed lower limb soft tissue injuries caused by distance running were iliotibial band syndrome, tibial stress syndrome, patellofemoral pain syndrome, Achilles tendinitis, and plantar fasciitis.[10 11] These injuries range from inflammation to structural degeneration. Preventive strategies include modifying the training schedule, stretching, or changing the footwear.

To address the modifiable risk factors associated with running injuries, available evidence should be systematically reviewed in order to efficiently integrate valid information. The aim of this study was to perform a systematic search of the available evidence for randomised and quasi-randomised studies that dealt with prevention of running injuries. The integration of such valid information should provide a basis for decision making, thus reducing random errors and providing more reliable results from which to draw conclusions and make decisions.

Methods

SEARCH STRATEGY AND STUDY IDENTIFICATION

An electronic database search included: 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 (Ovid Web, from 1966); Embase (from 1980); Atlantes (1980–1996); Biosis, Cinahl, Heracles (1975–2000); Sciscearch, Sport Discus (1975–2000); Current

Table 1 The search strategy used in Medline (Ovid Web)

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

Contents; Index To Theses; and Dissertation Abstracts. The date of the last search for these databases was May 2000.

In Medline, the first two levels of the optimum search strategy were used.[12] The date of the last search was May 2000. Randomised or quasi-randomised controlled studies of strategies for preventing lower limb soft tissue running injuries were included. Studies involving subjects of either sex from adolescence to middle age were included. No language restriction was applied. Studies that involved laboratory based measures that had no proven relation to clinical outcomes were excluded. Also excluded were studies that involved surgical intervention or those that targeted prevention of stress fractures alone.

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, we have erred on the side of overinclusion during the search. As a result, many of the studies identified in the initial search were subsequently found to be not relevant. The specific search terms included were running, athletic injuries, soft tissue injuries, sprains and strains, hip injuries, knee injuries, ankle injuries, foot injuries, tendinitis, fasciitis, cumulative trauma disorders, sports, sports medicine, physical education and training, and physical fitness. Table 1 outlines the search strategy.

ASSESSMENT OF METHODOLOGICAL QUALITY

The selection of studies for inclusion involved multiple stages. The first stage involved assessing titles and abstracts to determine whether the studies met the predetermined eligibility criteria. All the citations were checked by both of us. If, given the information available, it was determined that the article definitely did not meet inclusion criteria, it was then excluded. If the title or abstract left room for doubt that the article could not definitely be excluded, the full text of the article was retrieved. Review of the full text may then have led to the study's exclusion because it did not meet the inclusion criteria. If the article was not excluded, it was then formally abstracted.

All identified studies were then independently assessed and coded by the two of us using a data extraction form previously derived. Agreement was measured using the weighted κ statistic. The following criteria were used to assess the methodological quality:

- Was the assigned treatment adequately concealed before allocation?
- Were the outcomes of patients who withdrew described and included in the analysis?
- Were the outcome assessors blinded to treatment status?
- Were important baseline characteristics reported and comparable?
- Were the subjects blind to assignment status after allocation?
- Were care programmes, other than the trial options, identical?
- Were the inclusion and exclusion criteria clearly defined?
- Were the outcome measures used clearly defined?
- Were diagnostic tests used in outcome assessment clinically useful?
- Was the duration of surveillance clinically appropriate?

STATISTICAL ANALYSIS

Outcomes from included studies 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 χ^2 tests. For dichotomous outcomes, the fixed effect model was used to estimate the individual and pooled relative risk (RR) and 95% confidence intervals (CI). For continuous outcomes the weighted mean difference was used to estimate the individual and pooled effect sizes and 95% CI.

Results

After the initial search and examination of the title and abstracts, 118 articles (116 in English and two foreign language publications) were identified as relevant. The full texts of these articles were retrieved and subsequently evaluated by both of us. Review of the complete text excluded 106 articles, because they were unrelated to the running injury, a review article, or not a controlled trial. Twelve studies met the criteria for inclusion.[13–25] In one prevention study, the findings were reported separately in two different articles.[14 15] All included studies were English language publications and were retrieved from the electronic database search of Medline and Cinahl. Agreement among the

Table 2 Characteristics of the studies on modification of training schedule

	Pollock et al.[13] (n=157)	*Rudzki[14 15] (n=350)*	*Andrish et al.[16] (n=1670)*
Methodological quality score	20	20	17
Sex	Male	Male	Male
Age (years)	20–35	17–31	NA
Population	Prison inmates	Military recruits	Military recruits
Intervention	Effects of duration and frequency of training	Reduction in running distance	Graduated running
Protocol	Duration group: train 15, 30, 45 minutes/day frequency group: train 1, 3, 5 days/week	Substitute running with walking plus added weight	Graduated running programme for the first 2 weeks
Period of intervention (weeks)	20	12	2
Hours of exposure to running/week	0.75–2.50	41.3	NA
Definition of injury	Training related injury that prevented subjects from running for at least one week	Medical confirmation	Medical confirmation

NA, Not available.

reviewers on the quality of the articles was good (κ = 0.663, p = 0.00); disagreement was resolved by consensus.

CHARACTERISTICS OF THE STUDIES

Twelve trials with 8806 participants were included. These trials were concerned with three main preventive strategies for running injuries: modification of training schedule, stretching exercises, and use of external support or modification of footwear. The total quality scores were calculated for each trial based on the sum of the item scores (maximum = 3). Of a total possible quality score of 30, the range of overall score was 17–24. Tables 2–4 present the details of the study characteristics.

Eight studies[14–19 22–24] involved military recruits and one study involved prison inmates as subjects.[13] The remaining three studies drew subjects from the general population (civil servants,[20] amateur athletes,[25] soccer referees[21]). Only three studies involved female subjects. However, in these studies, either the female subjects were not included in the final analysis because of the small number or a high drop out rate,[20 25] or the number of female subjects was not stated.[23] The intervention period varied between studies, from eight to 20 weeks, with one studying five days of refereeing in a soccer tournament.

Of the 12 studies included, only six trials gave full details of randomisation.[14–19 21] In four studies,[13 20 21 25] both the unit of randomisation

Table 3 Characteristics of the studies on stretching exercises

	Andrish et al.[16] (n=1753)	*Hartig and Henderson[17] (n=298)*	*Pope et al.[18] (n=1093)*	*Pope et al.[19] (n=1538)*	*van Mechelen et al.[20] (n=421)*
Methodological quality score	17	20	23	24	20
Sex	Male	Male	Male	Male	Male/female
Age (years)	NA	20 (mean)	17–35	17–35	NA
Population	Military recruits	Military recruits	Military recruits	Military recruits	Civil servants
Target muscles	Gastrocnemius and soleus	Hamstrings	Gastrocnemius and soleus	Hip adductors, hip flexors, quadriceps, hamstrings, gastrocnemius and soleus	Iliopsoas, quadriceps, hamstrings, gastrocnemius and soleus
Stretching protocol	NA	5 × 30 s	2 × 20 s	1 × 20 s	3 × 10 s
Period of intervention (weeks)	NA	13	11	11	16
Hours of exposure to running/week	NA	NA	47	50	1.74 (1.32)—1.85 (1.24)
Definition of injury	Medical confirmation	Medical confirmation	Inability to resume full duties without signs and symptoms within 3 days	Inability to resume full duties without signs and symptoms within 3 days	Stop running; cannot run on the next occasion; cannot go to work; medical attention; suffer pain for more than 10 days

NA, Not available.

Table 4 Characteristics of the studies on the use of braces or insoles/footwear modification

	Andrish et al.[16] (n=1797)	*Fauno et al.[21] (n=121)*	*Schwellnus et al.[22] (n=1511)*	*Smith et al.[23] (n=90)*	*Milgrom et al.[24] (n=390)*	*BenGal et al.[25] (n=60)*
Methodological quality score	17	18	24	17	21	22
Sex	Male	Male	Male	Male/female	Male	male/female
Age (years)	NA	17–65	17–25	17–25	NA	18–25
Population	Military recruits	Soccer referees	Military recruits	Military recruits	Military recruits	amateur athletes
Intervention	Heel pads	Shock absorbing insoles	Shock absorbing insoles	Shock absorbing insoles	Shoewear modification	knee brace
Period of intervention (weeks)	NA	5 days	9	8	14	8
Hours of exposure to running/week	NA	14.5*	0.5–7	NA	NA	36
Definition of injury	Medical confirmation	Medical confirmation	Medical confirmation	NA	Medical confirmation	Medical confirmation

NA, Not available.
*Total hours of exposure.

Table 5 Analysis of the included studies

Intervention	Relative risk (95% CI)
Modification of training schedule	
Reduction in frequency of training[13]	0.19 (0.06 to 0.66)*
Reduction in duration of training[13]	0.41 (0.21 to 0.79)*
Reduction in running distance[14 15]	0.70 (0.54 to 0.91)*
Hip injuries	0.87 (0.37 to 2.04)
Knee injuries	0.45 (0.26 to 0.80)*
Lower leg injuries	1.33 (0.47 to 3.76)
Ankle and foot injuries	0.77 (0.48 to 1.25)
Graduated running programme[16]	2.07 (1.13 to 3.80)
Stretching exercises (data not pooled for analysis)	
Stretching outside training session[16 17]	
Andrish *et al.*[16]	1.27 (0.66 to 2.43)
Hartig and Henderson[17]	0.57 (0.37 to 0.89)*
Stretching immediately before training session[18–20]	
Pope *et al.*[18]	0.85 (0.43 to 1.67)
Pope *et al.*[19]	0.83 (0.63 to 1.09)
van Mechelen *et al.*[20]	1.19 (0.71 to 1.99)
Use of external support or footwear modification	
Use of shock absorbing insoles[16 21–23]	0.87 (0.69 to 1.11)
Hip injuries[22]	1.62 (0.53 to 4.98)
Knee injuries[22]	0.82 (0.54 to 1.23)
Lower leg injuries[16 22 23]	0.91 (0.59 to 1.42)
Ankle and foot injuries[22 23]	1.27 (0.71 to 2.29)
Footwear modification[24]	0.83 (0.71 to 0.98)*
Knee injuries	0.93 (0.62 to 1.39)
Lower leg injuries	1.26 (0.82 to 1.93)
Foot injuries	0.53 (0.36 to 0.79)*
Use of knee brace[25]	0.35 (0.13 to 0.91)*

*Effect favours intervention.

and the unit of analysis were the individual. In the other eight studies, allocation was by group (squad, platoon, or company) but the analysis was by individual. Thus these studies were cluster randomised and ineligible for pooling of analysis. In five studies,[18 20 21 23 25] subjects were excluded from the final analysis for various reasons, such as a high drop out rate or the losses were sufficient in number to lead to attrition bias. There was only one study[19] in which the data were analysed by intention to treat.

Reported incidence of injury (overall and by location) was the principal outcome sought in these 12 studies. Where possible, injury severity and compliance to intervention were also explored in these studies. Comparisons were broadly arranged into these three main preventive strategies: modification of training schedule; stretching exercises; use of external support. Table 5 summarises the results.

EFFECT OF MODIFICATION OF THE TRAINING SCHEDULE

Modification of the training schedule was used as an intervention in three studies (514 participants in intervention groups, 1663 controls).[13–16] These studies examined the effect of different modifications of the volume of training (frequency and duration,[13] reduction in running distance,[14 15] graduated running programme[16]) on the incidence of injury. Because of the variation in the intensity, duration, and frequency of the training programmes, no attempt was made to pool analyses (table 2).

The results suggest that people who train one to three days a week are less likely to be injured than those training five days a week (RR 0.19; 95% CI 0.06 to 0.66). Similarly with the duration of training, the results indicate that people who train 15–30 minutes a day have a significantly lower injury incidence than those training 45 minutes a day (RR 0.41; 95% CI 0.21 to 0.79). 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 in which group these injuries occurred. 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.

There is also evidence to suggest that a reduction in the running distance (280 km compared with 82 km over 12 weeks) is significant in the reduction of overuse injuries (RR 0.70; 95% CI 0.54 to 0.91). A further analysis of injuries at different body locations suggests that this reduction in weekly running distance results in a risk reduction in knee injuries (RR 0.45; 95% CI 0.26 to 0.80).

The results showed no significant difference in prevention of injuries using a graduated running programme (RR 2.07; 95% CI 1.13 to 3.80). It should be noted that the graduated programme was for the first two weeks of the training only.

EFFECT OF STRETCHING INTERVENTION

Analysis of the five studies (1944 participants in intervention groups, 3159 controls)[16–20] that focused on stretching exercises showed differences in the way the stretching protocol was implemented (table 3). Two studies evaluated the effect of stretching outside the training sessions.[16 17] The remaining three studies examined the effectiveness of stretching immediately before training.[18–20]

As both the interventions and injury definitions were heterogeneous between studies, and as only one study[20] was individually randomised, no data were pooled for this comparison, and there was no attempt to perform subgroup analysis. Exploratory analyses are, however, presented.

There is insufficient evidence to suggest whether stretching exercises are effective in preventing lower limb injuries. In the study by Hartig and Henderson,[17] the number of lower limb overuse injuries was significantly smaller in the stretching intervention group (RR 0.57; 95% CI 0.37 to 0.89). Exploratory analyses of the two cluster randomised studies[16 18] showed no evidence of significant protection (Andrish *et al*[16] (RR 1.27; 95% CI 0.66 to 2.43) and Pope *et al*[18] (RR 0.85; 95% CI 0.43 to 1.67)). Pope *et al*[19] reported that their protocol of stretching before exercise did not produce a clinically useful (or statistically significant) reduction in the risk of soft tissue injuries (hazard ratio 0.83; 95% CI 0.63 to 1.09). Furthermore, van Mechelen *et al*[20] found no evidence of reduction in soft tissue injury from the intervention studied (RR 1.14; 95% CI 0.67 to 1.92).

EFFECT OF THE USE OF EXTERNAL SUPPORT OR FOOTWEAR MODIFICATION

Six studies investigated the effects of the use of external support as an intervention strategy (table 4). Four studies (716 participants in intervention groups, 2803 controls) provided evidence on the use of insoles in the prevention of lower limb injuries.[16 21–23] The other two studies focused on the intervention by modified shoewear (187 participants in intervention groups, 203 controls)[24] and knee braces (27 participants in intervention groups, 33 controls).[25]

Andrish *et al*[16] used heel pads made from thick foam rubber for all the running activities in the reduction of shin splints, and Fauno *et al*[21] compared the use of shock absorbing heel inserts in a group of soccer referees exposed to five days of intensive running. Using cellular polyurethane or neoprene shock absorbing insoles, Schwellnus *et al*[22] and Smith *et al*[23] compared the incidence of overuse injuries with the control group after 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[16 22 23] providing incidence of lower limb injuries grouped by location (hip, knee, lower leg, ankle, and foot) also showed no significant difference in risk reduction.

Milgrom *et al*[24] 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 small but significant lower incidence rate in the intervention group in a 14 week military training period (RR 0.83; 95% CI 0.71 to 0.98). Analysis based on location of the injuries showed a protective effect on foot injuries (RR 0.53; 95% CI 0.36 to 0.79).

The effect of a knee brace with a silicon patellar ring in preventing anterior knee pain for an intensive eight week training programme was investigated.[25] The training regimen consisted of a run of 6 km in the first week, then increasing each week up to 42 km/week at week 8. The results showed a significant reduction in the incidence of anterior knee pain (RR 0.35; 95% CI 0.13 to 0.91).

Discussion

Running injuries, primarily of the lower limb, are commonly treated sports related injuries in medical and physiotherapy clinics. Prevention of these injuries would allow the positive benefits of running to be enjoyed (improved cardiorespiratory function, general wellbeing, etc). This review systematically examines the evidence for prevention of running injuries.

EFFECT ON THE MODIFICATION OF TRAINING SCHEDULE

Results of the trials that focused on the modification of training showed strong evidence that a change in either the duration or frequency could influence the risk towards overuse injuries.[13] It would seem obvious that a reduction in the training load should reduce the incidence of injury. However, given that the subjects in this study are novice runners, the results have implications for exercise prescription when one needs to consider the balance in terms of benefits of exercise and risk of injury. The evidence suggests that the incidence of injury is lower for a training load of one to three days a week with a duration of 15–30 minutes. In addition, this training programme, exercising at an intensity of 85–90% maximal heart rate three days a week for 30 minutes duration, produces a similar cardiorespiratory improvement to training for five days a week for 45 minutes duration.

In addition, results from the military studies indicate that a reduction in running distance/volume could reduce the incidence of injury.[14 15] This is not surprising as the running distance correlates with the frequency and duration of training. It has been reported that injury rate increases with increasing weekly mileage above about 32 km a week.[8 9] The studies included[14 15] had a training load less than 32 km a week (both control and intervention group), but it should be noted that these participants were exposed to a sudden increase in distance and intensity. This abrupt change may not allow the body to adapt physiologically so that injury may result.

The results of the included trials for training characteristics must be interpreted with caution because of the limited number of trials and the variability of the settings and participants. From the limited data in this review, it is not possible to suggest an optimal training load.

EFFECT OF A STRETCHING INTERVENTION

Stretching is perhaps the most common routine advocated by sports coaches and sports medicine professionals. In this study, no evidence for its effectiveness in the prevention of sport related injury was found.

The current review identified five eligible trials that examined the effect of a stretching regimen on lower limb injuries. Suggested stretching routines varied between one and five stretches and holding for 20–30 seconds for major lower limb muscle groups. Closer examination of the trials also found differences in the way the stretching protocol was performed.

Apart from one study,[20] all the trials drew their sample from the military population. The training intensity also varied in that the subjects in the study by van Mechelen *et al*[20] ran an average of 2.7 times a week, 8.8 km per session at a speed of 12.4 km per hour, over 16 weeks. This training load reflects the fact that this group represents recreational rather than competitive runners. In contrast, the subjects in the other four trials,[16–19] being military recruits, were exposed to a much higher training load. Overall, the results indicate no significant benefit in reducing injuries.

It should be noted, however, that in two of the military studies,[17 18] all the participants—that is, both control and intervention groups—performed normal routine stretching before the physical training. A similar observation was reported in another trial[20]: 90% of runners from both the control and intervention group performed some form of warm up and cool down exercises and 58% performed stretching exercises. This suggests that the magnitude of the effect of intervention would be diminished to a great extent. Consequently the effect of stretching exercises in the prevention of running injuries may well be underrepresented.

EFFECT OF THE USE OF EXTERNAL SUPPORT OR FOOTWEAR MODIFICATION

Although sports shoe companies continue to develop different models of running shoes and advocate their effectiveness in shock absorption and prevention of running injuries, the current search did not find a single randomised trial that investigated the effectiveness of different models of running shoe in injury prevention. Of the six trials included, four were concerned with the use of shock absorbing insoles.[16 21–23] The other two studies investigated the role of modified shoe wear in army recruits[24] and the use of knee braces in the prevention of anterior knee pain.[25] The results showed no significant benefit with the use of insoles in the reduction of overuse soft tissue injuries. However, in a recent Cochrane review,[26] which focused on the prevention of stress fractures, 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. Heel insoles are designed to have a dual purpose. They are intended 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 absorbers only, rather than attempting to modify structural abnormalities—for example, leg length discrepancy, excessive pronation—under the increased demands of running. Thus the indication for the use of orthotics/foot support to reduce running injuries related to malalignment problems is not clear from this review.

A statistically significant benefit was achieved in the study[24] on the modification of footwear. The 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. A knee brace appears to be effective in the prevention of anterior knee pain,[25] but this is based on only one study. The limited data should only be considered as preliminary findings and further evidence is required.

It is evident from the review that the subjects included were mainly young, active, and male. Three studies included female subjects, with two[23 25] excluding the results for this group because of the small number or a significant rate of drop out. The other trial[23] 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 sex in the incidence of running injuries is not known,[27] although the anatomical and physiological differences between female and male athletes may account for unique patterns of musculoskeletal injury. More importantly, in relation to stress reactions/fractures of the bone, the association of endurance sports, such as distance running, with menstrual dysfunction[28] leading to premature skeletal demineralisation in women should not be taken lightly.

Eight studies included in the analyses were of military personnel, and the training programmes were very intensive compared with the activity levels of the general population. This is reflected in the total number of hours of exposure. Therefore, in discussing the results and considering the general application of these results to a wider population, one should be aware of the variation in the participants, setting, duration, focus, and type of intervention administered.

Conclusion

Despite the numerous intervention strategies suggested by investigators in the prevention of lower limb soft tissue injuries in runners, this meta-analysis reveals that most of the strategies suggested lack convincing evidence from randomised controlled trials of their effects. Strong evidence is presented that injury incidence can be decreased by reducing the frequency, duration, and distance. It appears that a training load of one to three days a week with a duration of 15–30 minutes results in a lower incidence of overuse injury than one of five days a week with a duration of 45 minutes. However, the current literature does not provide an optimum training load that can minimise injuries yet achieve the beneficial effects of exercise.

From the collated analysis of the five studies evaluating stretching regimens, it is not known whether protection against injuries is afforded. The stretching routines suggested varied between one and five stretches and holding for 20–30 seconds for major lower limb muscle groups.

The application of shock absorbing insoles is not effective in reducing soft tissue injuries but the role of corrective insoles for malalignment is not clear. The use of knee braces and the modification of footwear (from infantry boots to modified basketball shoes) appear to be effective in reducing knee and foot injuries respectively. However, in view of the limited number of studies, more data are required to confirm this effect.

Implications for further research

Controlled investigations of running related injuries are difficult because of the variation in the definition of injury, study population, and outcome measures used. Furthermore, well controlled randomised controlled trials are needed to shed light on the possible interventions for the prevention of lower limb soft tissues injuries in runners. Evaluation of interventions over a longer period and their effectiveness in reducing recurrence are also required. Studies are needed of participants with differing levels of ability, and more information is required on the effectiveness of interventions in female runners.

The interacting effects of 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 the effectiveness of knee braces or footwear modification in reducing the incidence of running injuries.

A more detailed version of this review has been published in the Cochrane Database of Systematic Reviews. Cochrane systematic reviews are regularly updated to include new research and in response to comments and criticisms from readers.

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Take home message

Lower limb soft tissue injuries are common in runners. This review shows that injuries from running can be reduced by modifying training schedules, but no guidelines are available from trials on optimum training load. Wearing a knee brace with a patellar support ring may be effective in preventing anterior knee pain provoked by running.