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Risk and protective factors for middle- and long-distance running-related injury:

A systematic review

Running head: Risk and protective factors for distance running injury

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Abstract

Background Despite a rapidly growing body of research, a systematic evidence compilation of the risk and protective factors for middle- and long-distance running-related injury (RRI) is currently lacking.

Objectives To compile the evidence about modifiable and non-modifiable training-related and behavioural risk and protective factors.

Data sources Five databases (PubMed; CINAHL; MEDLINE; SPORTDiscus; and PsycINFO) were searched for the dates 01 January 1970 to 31 December 2015, inclusive, for original peer-reviewed articles.

Study selection The eligible designs were cross-sectional, case-control, longitudinal observational studies, and randomised controlled trials involving runners competing at distances from ≥800m to ≤42.2km. Outcomes were any specific and/or general RRI, and exposures included training-related and behavioural factors.

Study appraisal and synthesis methods Authors and date, study design, injury type(s), descriptors and comparators for each exposure, and results and measures of association were extracted from the selected studies. Methodological quality was independently appraised using two separate checklists; a modified checklist for observational study designs, and the PEDro scale for randomised controlled trials.

Results Among 73 eligible articles for inclusion, 19 (26.0%) and 30 (41.0%) were of high or satisfactory methodological quality, respectively. As a non-modifiable exposure, a history of previous injury was found to be associated with an increased risk of both general and specific RRI. In terms of modifiable exposures, irregular and/or absent menstruation was found to be associated with an increased risk of stress fracture development, whereas the use of oral contraceptives was found to be associated with a decreased risk.

Limitations Due to high clinical, methodological, and statistical heterogeneity, it was not feasible to estimate a pooled effect size across similar studies.

Conclusions A history of previous injury was associated with an increased risk of both general and specific RRI. The use of oral contraceptives was found to be associated with a decreased risk of skeletal stress fracture. Conversely, irregular and/or absent menstruation was associated with an increased risk. The varied effect directions

and/or a number of statistically insignificant results associated with the majority of factors hindered the ability to draw any definitive conclusions about their relationship to RRI risk.

Key points

#1 The identification of modifiable and non-modifiable risk and protective factors for distance running-related injury is a necessary step for better understanding how to design and deliver injury prevention interventions.

#2 A history of previous injury is a strong non-modifiable risk factor for distance running-related injury. Future studies are required to better understand why and how previous injury contributes to the development of subsequent injury.

#3 The use of oral contraceptives is a modifiable protective factor for stress fracture development in female runners. Irregular or absent menstruation increased the risk of the same injury. More studies are required to investigate how key exposures associated with the female athlete triad interact and affect the risk of distance running-related injury.

4 Varied effect directions and a number of statistically insignificant results associated with the majority of factors hindered the ability to draw any definitive conclusions about their relationship to running-related injury risk.

1.0 Introduction

Distance running is an ideal form of exercise for many able-bodied individuals in a variety of locations. Indeed, the physiological and psychological benefits associated with running are well accepted [1]. Unfortunately, the positives of this activity are offset by the risk of sustaining a running-related injury (RRI). Depending on the population sample and length of follow-up, the RRI incidence rate reportedly ranges from 2.5 to 33.0 injuries per 1000 hours of running [2]. Over a lifetime recall period, the pain-related injury incidence proportion for cross-country runners has recently been found to reach 94.4% [3].

The increasing popularity of running, combined with reports of a high risk of sustaining a RRI, has inspired many scientific investigations over the last forty-five years. Several descriptive [4-10] and systematic reviews [1, 11-17] have attempted to summarise the available evidence on factors that are associated with RRI. The first major systematic review included 17 studies [11]. Unlike subsequent papers [13, 15, 16], that review did not adapt its methodological quality checklist to the target context. A later review that included 31 articles did not include middle-distance running samples, and only commented on a limited number of training-related and behavioural risk factors [13]. More recently, Saragiotto et al [15] identified 60 different predictive factors for RRI across 11 articles, but did not include studies that had investigated specific musculoskeletal pathologies. The most recent systematic reviews have been very focused, addressing the influence of sex [16] and vertical ground reaction forces on RRI risk [17].

In light of existing research investigating RRI aetiology, there is a need for a review that does not exclude particular study designs or injuries. Even though certain epidemiological study designs are temporally ambiguous regarding causality, including them is now required in order to consider the whole body of evidence in the area so that novel theories and hypotheses can be generated. An appropriate starting point for such an effort is to compile the evidence on the effect of training-related and behavioural factors on RRI risk. This would mean excluding kinetic, kinematic and isokinetic factors, each of which instead necessitate their own systematic reviews with a specific and well-defined research question e.g. [12, 17]. With biomechanical factors excepted, it is possible to categorise training-related and behavioural factors according to whether or not they are amenable to modification. Such a delineation has important theoretical and practical implications for the type of population-based RRI prevention program or strategy that is to be implemented or used [18]. Therefore,

the purpose of this systematic review was to compile the evidence about modifiable and non-modifiable training-related and behavioural risk and protective factors.

2.0 Methods

2.1 Electronic search

Five databases (PubMed; CINAHL; MEDLINE; SPORTDiscus; and PsycINFO) were searched by the first author for the dates 01 January 1970 to 31 December 2013, inclusive. Updated searches across all databases were later conducted to retrieve further potential articles published between 01 January 2014 to 31 December 2015. Citation software (EndNote for Windows 6.0.1) and advice from a university librarian facilitated the searching process. Database search strategies, including key words and Medical Subject Heading (MeSH) terms, can be viewed in the Electronic Supplementary Material (ESM) Table S1.

2.2 Eligibility criteria

Eligible running distances studied ranged from ≥800m to ≤42.2km in accordance with the International Association of Athletics Federation's (IAAF) middle- and long-distance running definitions [19]. These events distinguish middle- and long-distance running from other similar athletic disciplines, including both sprinting and extreme endurance running (i.e. ultra-marathons).

2.2.1 Inclusion and exclusion criteria

To be eligible for inclusion, the studies had to comply with the following criteria: (i) study designs were cross-sectional, case-control, or longitudinal (i.e. both retrospective and prospective cohort studies) along with randomised controlled trials (RCTs); (ii) the study sample represented middle- and long-distance runners as per the above IAAF definition (section 2.2); (iii) exposures included training-related and/or behavioural factors; (iv) the outcome was any specific and/or general RRI; (v) inferential statistical analyses with measures of association between exposures and RRI were reported (e.g. crude and/or adjusted analyses including, but not limited to, mean/median statistical difference, odds ratio (OR), relative risk (RR), cumulative risk difference (cRD), hazard ratio (HR) with 95% confidence intervals); and, (vi) original peer-reviewed academic journal articles published in English.

After executing a primary search and implementing the above eligibility criteria, one author (AH) inspected the titles and abstracts of all retrieved articles. For the remaining eligible articles, the bibliography within each article was manually hand searched to identify potential new articles that were missed via the primary search strategy. Two authors (AH and RN) independently evaluated the suitability of each article in accordance with the above criteria. Disagreements were resolved via a consensus meeting.

2.3 Data extraction and evidence interpretation

The following information and data were extracted from eligible studies: (i) authors and date; (ii) study design; (iii) injury type; (iv) descriptors and comparators for each exposure; and, (v) results and measures of association. All data were extracted by one author and re-examined by all authors, each of whom had been allocated a unique role to ensure data accuracy. Regarding the interpretation of both statistically significant and non-significant data, we assessed the strength of epidemiological association risk ratios according to the criteria in Table 1 (apply only to relative and not absolute measures of association).

Table 1 Criteria for assessing the strength of epidemiological associations. Adapted from Craun and Calderon for the World Health Organisation [20], with permission.

Risk ratio (increased risk)	**Risk ratio (decreased risk)**	**Strength of association**
1.0	1.0	(Reference)
1.01-1.20	0.80-0.99	Weak
1.21-1.50	0.50-0.79	Moderate
>1.51	<0.49	Strong

2.4 Quality assessment

Two checklists were used for assessing the methodological quality of included articles: (i) a modified version of an existing methodological quality assessment checklist for observational study designs [13]; and (ii) the Physiotherapy Evidence Database (PEDro) scale for RCTs [21]. The former checklist includes 12 items across four categories: (i) study objective; (ii) study population; (iii) outcome measurements; and, (iv) data presentation and analyses. There were 10, 11 and 12 items according to whether the study design was case-control, cross-sectional, or cohort, respectively (ESM Table S2). The PEDro scale was expanded with the addition of a single

item, which was concerned with RRI definitions (ESM Table S3). We considered a score of ≥50.0% as an indication of satisfactory methodological quality, whereas a score of ≥75.0% was deemed high quality [3, 22]. Two authors (AH and EV) independently assessed the quality of each article and awarded each item a positive (+) or negative (-) score. In cases of disagreement, a consensus meeting resolved any discrepancies.

3.0 Results

3.1 Full-text selection

After searching five databases, a total of 3,572 articles were identified. After removing 561 duplicates and examining 3,011 titles and abstracts, 97 potentially relevant full-text articles were retained. A manual search of the 97 reference lists produced a further 48 articles, and these were added to the search process. Closely inspecting 145 full-texts excluded another 79 articles. The literature search resulted in a total of 73 articles for the evidence compilation (Figure 1).

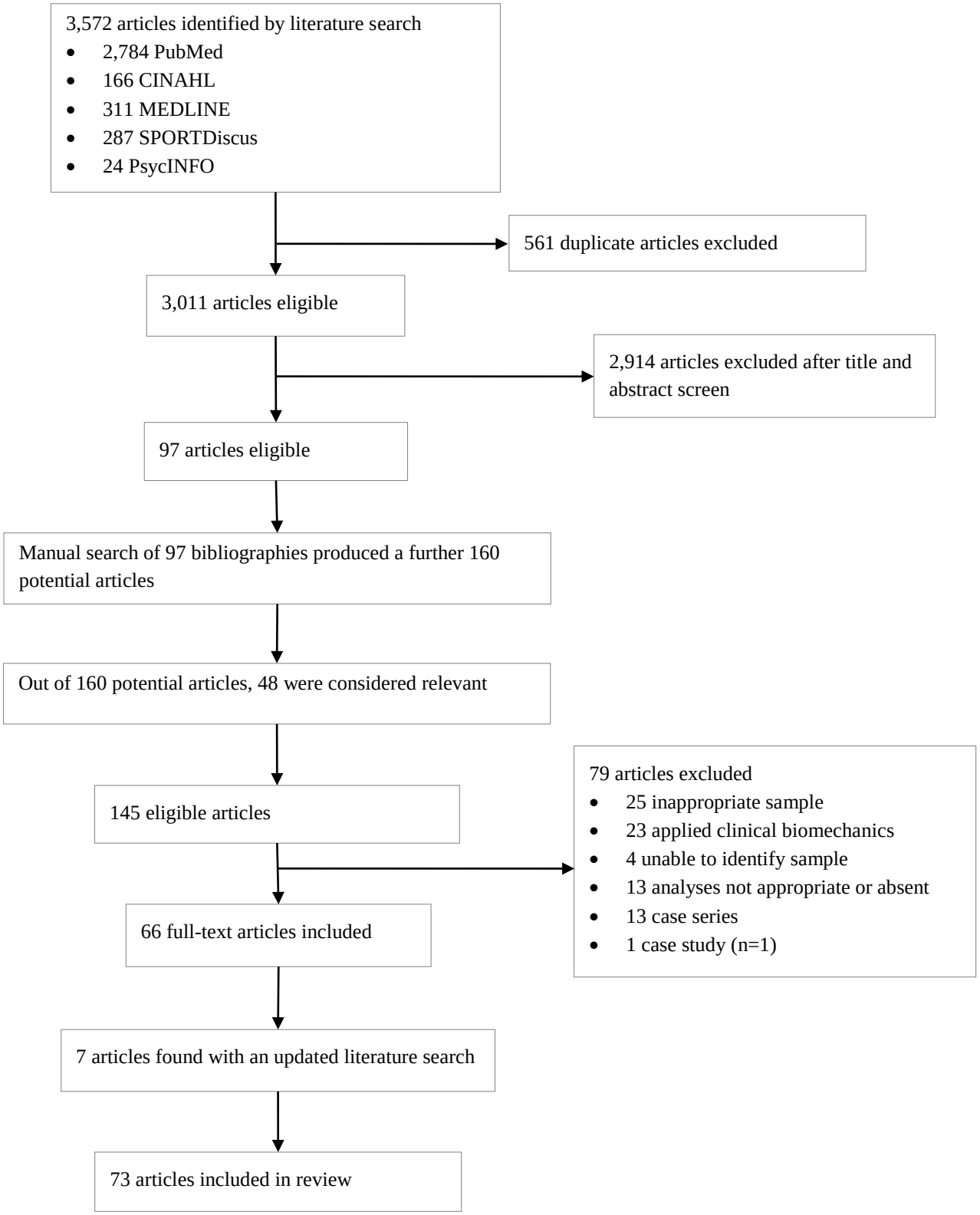

Figure 1 Visualisation of the systematic searching process

3.2 Study characteristics

The composition of the included study designs was as follows: (i) eight RCTs; (ii) 26 prospective cohorts; (iii) three retrospective cohorts; (iv) three case-control studies; (iv) 27 cross-sectional two group comparisons; and, (v) six cross-sectional three group comparisons. In terms of publication distribution over time, no eligible articles were published between 1970 to 1979, but 25 were published during 1980 to 2000, inclusive. In the most recent 15 years, 48 articles were published.

3.3 Quality assessment

Across the 73 included studies, the level of inter-rater agreement of quality assessment was high, kappa statistic (k) = 0.92. The respective mean and median quality score for each study design was as follows: (i) RCT = 63.5% and 66.6% (range: 41.6% to 91.6%); (ii) prospective cohort = 73.3% and 75.0% (range: 33.3% to 91.6%); (iii) retrospective cohort = 58.3% and 50.0% (range: 41.6% to 83.3%); (iv) case-control = 40.0% and 40.0% (range: 30.0% to 50.0%); (v) cross-sectional two group comparison = 52.8% and 54.5% (range: 18.1% to 81.8%); and, (vi) cross-sectional three group comparison = 49.9% and 54.5% (range: 27.2% to 63.6%). Overall, 19 (26.0%) and 30 (41.0%) studies were of high (≥75.0%) and satisfactory (≥50.0%) methodological quality, respectively (Table 2).

For RCTs, items five, six and seven generally received the lowest scores, and represent whether participants, therapists and/or assessors were blind with regard to intervention allocation. For the prospective cohort study designs, a lower overall score was found for item eight, in that the follow-up period was <12 months. Overall, case-control study designs did not meet the satisfactory level of quality due to low scores for items nine and 10, indicating that the recall period was not reported, nor was a clear definition of injury provided. The unanimously low score for item 11 indicates that therapists and statistical analysts were aware of the injury status or variable coding when performing physical examinations or working with data, respectively.

Table 2 Observational study quality scores ordered by decreasing rank

		Methodological quality criteria [a]													
Study	**Design**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Score (%)**
Macera et al (1989) [23]	PC	+	+	+	+	+	+	+	+	n/a	+	-	+	+	11/12 (91.6)
Walter et al (1989) [24]	PC	+	+	+	+	+	+	+	+	n/a	+	-	+	+	11/12 (91.6)
Kelsey et al (2007) [25]	PC	+	+	+	+	+	+	+	+	n/a	+	-	+	+	11/12 (91.6)
Nielsen et al (2013) [26]	PC	+	+	+	+	+	+	+	+	n/a	+	-	+	+	11/12 (91.6)
Nielsen et al (2013) [27]	PC	+	+	+	+	+	+	+	+	n/a	+	-	+	+	11/12 (91.6)
Nielsen et al (2014) [28]	PC	+	+	+	+	+	+	+	+	n/a	+	-	+	+	11/12 (91.6)
Wen et al (1998) [29]	PC	+	+	+	+	+	+	+	-	n/a	+	-	+	+	10/12 (83.3)
Van Middelkoop et al (2008) [30]	PC	+	+	+	+	+	+	+	-	n/a	+	-	+	+	10/12 (83.3)
Buist et al (2010) [31]	PC	+	+	+	+	+	+	+	-	n/a	+	-	+	+	10/12 (83.3)
Hirschmüller et al (2012) [32]	PC	+	-	+	+	+	+	+	+	n/a	+	-	+	+	10/12 (83.3)
Bredeweg et al (2013) [33]	PC	+	+	+	+	+	+	+	-	n/a	+	-	+	+	10/12 (83.3)
Van Middelkoop et al (2007) [34]	PC	+	+	+	+	+	-	+	-	n/a	+	-	+	+	9/12 (75.0)
Hespanhol Junior et al (2013) [35]	PC	+	-	+	+	+	+	+	-	n/a	+	-	+	+	9/12 (75.0)
Malisoux et al (2013) [36]	PC	+	+	+	+	+	-	+	-	n/a	+	-	+	+	9/12 (75.0)
Nielsen et al (2014) [37]	PC	+	+	+	+	+	+	+	-	n/a	-	-	+	+	9/12 (75.0)

Kluitenberg et al (2015) [38]	PC	+	-	+	+	+	+	+	-	n/a	+	-	+	+	9/12 (75.0)
Bennett et al (2012) [39]	PC	+	+	-	+	+	-	+	-	n/a	+	-	+	+	8/12 (66.6)
Fields et al (1990) [40]	PC	+	-	-	+	+	+	+	+	n/a	+	-	+	-	8/12 (66.6)
Buist et al (2010) [41]	PC	+	+	+	+	+	-	-	-	n/a	+	-	+	+	8/12 (66.6)
Taunton et al (2003) [42]	PC	+	+	-	-	+	+	+	-	n/a	+	-	+	+	8/12 (66.6)
Satterthwaite et al (1999) [43]	PC	+	+	-	+	+	+	-	-	n/a	-	-	+	+	7/12 (58.3)
Reinking et al (2007) [44]	PC	+	+	+	+	+	-	+	-	n/a	-	-	+	-	7/12 (58.3)
Thijs et al (2011) [45]	PC	+	+	-	+	-	+	+	-	n/a	+	-	+	-	7/12 (58.3)
Van Ginckel et al (2009) [46]	PC	+	-	-	+	+	-	+	-	n/a	+	-	+	-	6/12 (50.0)
Ghani Zadeh Hesar et al (2009) [47]	PC	+	-	-	+	-	+	+	-	n/a	-	-	+	-	5/12 (41.6)
Thijs et al (2008) [48]	PC	+	-	-	-	+	-	+	-	n/a	-	-	+	-	4/12 (33.3)
Hootman et al (2002) [49]	RC	+	+	+	+	+	+	+	+	n/a	+	-	+	+	10/12 (83.3)
Taunton et al (2002) [50]	RC	-	+	-	+	-	-	-	+	n/a	+	-	+	+	6/12 (50.0)
Warren & Davis (1988) [51]	RC	+	+	+	-	-	-	+	-	n/a	-	-	+	-	5/12 (41.6)
Myburgh et al (1990) [52]	CC	+	+	+	+	n/a	n/a	+	n/a	-	-	-	-	-	5/10 (50.0)
Miller et al (2007) [53]	CC	+	-	-	+	n/a	n/a	+	n/a	-	-	-	+	-	4/10 (40.0)
Fredericson et al (2000) [54]	CC	+	-	-	+	n/a	n/a	+	n/a	-	-	-	-	-	3/10 (30.0)
Henriksson et al (2000) [55]	CS 3 group	+	+	-	+	+	n/a	+	n/a	+	-	-	+	-	7/11 (63.6)

Barrow & Saha (1988) [56]	CS 3 group	+	+	+	+	+	n/a	-	n/a	+	-	-	-	-	6/11 (54.5)
Ribeiro et al (2011) [57]	CS 3 group	+	+	+	+	-	n/a	+	n/a	-	-	-	+	-	6/11 (54.5)
Ribeiro et al (2011) [58]	CS 3 group	+	+	+	+	-	n/a	+	n/a	-	-	-	+	-	6/11 (54.5)
Ekenman et al (2001) [59]	CS 3 group	+	+	-	-	+	n/a	+	n/a	-	-	-	+	-	5/11 (45.4)
Messier & Pittala (1988) [60]	CS 3 group	+	-	-	-	-	n/a	+	n/a	-	-	-	+	-	3/11 (27.2)
Wen et al (1997) [61]	CS 2 group	+	-	+	+	+	n/a	+	n/a	+	+	-	+	+	9/11 (81.8)
Parker et al (2011) [62]	CS 2 group	+	+	-	+	+	n/a	+	n/a	+	+	-	+	+	9/11 (81.8)
Marti (1988) [63]	CS 2 group	+	+	-	+	+	n/a	+	n/a	+	+	-	+	-	8/11 (72.7)
Marti et al (1988) [64]	CS 2 group	+	+	-	+	+	n/a	+	n/a	+	+	-	+	-	8/11 (72.7)
Rasmussen et al (2013) [65]	CS 2 group	+	+	-	+	+	n/a	+	n/a	-	+	-	+	+	8/11 (72.7)
Lloyd et al (1986) [66]	CS 2 group	+	+	+	+	+	n/a	+	n/a	-	-	-	+	+	8/11 (72.7)
McKean et al (2006) [67]	CS 2 group	+	+	-	+	+	n/a	+	n/a	+	-	-	+	+	8/11 (72.7)
McKelvie & Valliant (1985) [68]	CS 2 group	+	+	-	+	+	n/a	+	n/a	+	-	-	+	-	7/11 (63.6)
Jacobs & Berson (1986) [69]	CS 2 group	+	+	-	+	+	n/a	+	n/a	+	+	-	-	-	7/11 (63.6)
Gerlach et al (2005) [70]	CS 2 group	+	-	-	+	+	n/a	+	n/a	+	+	-	+	-	7/11 (63.6)
Chang et al (2012) [71]	CS 2 group	+	+	-	+	+	n/a	+	n/a	-	-	-	+	+	7/11 (63.6)
Haglund-Åkerlind et al (1993) [72]	CS 2 group	+	-	+	+	+	n/a	+	n/a	-	-	-	+	-	6/11 (54.5)
Duffey et al (2000) [73]	CS 2 group	+	-	+	+	-	n/a	+	n/a	-	+	-	+	-	6/11 (54.5)

Bennell et al (2004) [74]	CS 2 group	+	-	+	+	-	n/a	+	n/a	+	-	-	+	-	6/11 (54.5)
Lopes et al (2011) [75]	CS 2 group	+	+	+	+	+	n/a	+	n/a	-	-	-	-	-	6/11 (54.5)
Valliant (1981) [76]	CS 2 group	+	+	-	-	+	n/a	+	n/a	-	-	-	+	-	5/11 (54.5)
Messier et al (1995) [77]	CS 2 group	+	-	-	+	-	n/a	+	n/a	-	+	-	+	-	5/11 (54.5)
Niemuth et al (2005) [78]	CS 2 group	+	+	-	+	-	n/a	+	n/a	-	-	-	+	-	5/11 (54.5)
Marti & Rehmann (1987) [79]	CS 2 group	-	+	-	-	+	n/a	+	n/a	+	-	-	-	-	4/11 (36.3)
Grimston et al (1991) [80]	CS 2 group	+	-	-	-	-	n/a	+	n/a	+	-	-	-	+	4/11 (36.3)
Messier et al (1991) [81]	CS 2 group	+	-	-	+	-	n/a	+	n/a	-	-	-	+	-	4/11 (36.3)
Reinking & Hayes (2006) [82]	CS 2 group	+	-	-	-	-	n/a	+	n/a	+	-	-	+	-	4/11 (36.3)
McQuade (1986) [83]	CS 2 group	+	-	-	-	+	n/a	-	n/a	-	-	-	+	-	3/11 (27.2)
McCrory et al (1999) [84]	CS 2 group	+	-	-	-	-	n/a	+	n/a	-	-	-	+	-	3/11 (27.2)
Knobloch et al (2008) [85]	CS 2 group	-	-	+	-	-	n/a	-	n/a	-	+	-	+	-	3/11 (27.2)
Caselli & Longobardi (1997) [86]	CS 2 group	-	+	-	-	+	n/a	-	n/a	-	-	-	-	-	2/11 (18.1)
Fonseca et al (2015) [87]	CS 2 group	-	+	-	-	-	n/a	-	n/a	+	-	-	-	-	2/11 (18.1)

PC, prospective cohort; RC, retrospective cohort; CC, case-control; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; +/-, item scored positive or negative for a given study; n/a, not applicable; [a] quality assessment criteria: (1), study had a clearly defined purpose; (2), setting, locations, dates, and periods of recruitment reported; (3), main demographic features of the population reported; (4), eligibility criteria, and sampling methods/strategy reported; (5) numbers at each stage of the study were reported; (6), if participation at follow-up was >80% for periods of ≤6 months, or >60% for periods of ≥7 months; (7), methods used to collect data were reported (i.e. surveys, physical examinations procedure); (8), prospective observational follow-up period ≥12 months; (9), participants' recall periods reported; (10), the injury definition and associated physical impairments were reported and discernible; (11), if the statistical analyses and/or exposure assessment occurred under blinding (i.e. blind physical assessment and concealed group coding); (12), if the statistical approach used was transparently reported; (13), adequate adjustment for covariates occurred via the use of a multivariable technique. Further information: item 9 was not applicable for PC studies; items 5,6 and 8 were not applicable for CC studies; and items 6 and 8 were not applicable for CS studies. A more detailed explanation for each item can be found in Electronic Supplementary Material Table S2

Table 3 PEDro quality of scores for randomised controlled trials ordered by decreasing rank

	Criteria for assessing methodological quality [a]												
Study	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Score (%)**
Theisen et al (2013) [88]	+	+	+	+	+	+	+	+	-	+	+	+	11/12 (91.6)
Cobb et al (2007) [89]	+	+	+	+	-	-	-	+	+	+	+	+	9/12 (75.0)
Buist et al (2008) [90]	+	+	+	+	-	-	-	+	+	+	+	+	9/12 (75.0)
Bredeweg et al (2012) [91]	+	+	+	+	-	-	-	-	+	+	+	+	8/12 (66.6)
Ryan et al (2014) [92]	+	+	-	+	-	-	-	+	+	+	+	+	8/12 (66.6)
Ryan et al (2010) [93]	-	+	+	+	-	-	-	-	-	+	+	+	6/12 (50.0)
Van Mechelen et al (1993) [94]	+	-	-	+	-	-	-	-	-	+	+	+	5/12 (41.6)
Jakobsen et al (1994) [95]	-	-	-	+	-	-	-	+	+	+	-	+	5/12 (41.6)

+/-, item scored positive or negative for a given study; [a] quality assessment criteria: (1), eligibility criteria were specified; (2), random allocation to groups; (3), allocation was concealed; (4), groups were similar at baseline; (5), blinding of participants; (6), blinding of therapists who administered the intervention; (7), blinding of assessors who measured at least one key outcome; (8), measures of at least one key outcome were obtained for >85% of participants initially allocated to groups; (9), intention-to-treat analyses were used; (10), the results of between-group statistical comparisons were reported; (11), the study provided both point measures and measures of variability for at least one key outcome; (12), the injury definition and associated physical impairments were reported and discernible. A more detailed explanation for each item can be found in Electronic Supplementary Material Table S3

3.4 Modifiable risk and protective factors

In the modifiable factor category, 12 sub-categories were identified: (i) distance; (ii) duration; (iii) frequency; (iv) pace and intervals; (v) weight; (vi) body mass index (BMI); (vii) diet and hormonal; (viii) footwear, insoles, and orthotics; (ix) terrain and surface; (x) stretching, warm-up, and cool down; (xi) psychological; and, (xii) other modifiable (i.e. factors that could not be appropriately sub-categorised) (Table 4).

3.4.1 Distance

Thirty-six studies examined distance or factors associated with distance (ESM Table S4). The median methodological quality score for these studies was 63.6% (range: 18.1% to 91.6%) with two RCTs and nine prospective cohort studies scoring ≥75.0%. Running distance data were handled differently across studies, and either dichotomised (e.g. high vs. low), categorised, or expressed as a discrete unit change (i.e. increase or decrease in 1.0km or 10.0km per week). In total, 17 studies found a statistically significant relationship between increasing and/or decreasing distance and either general [22-24, 36, 65, 66, 69, 76, 79, 83, 86] or specific RRI [43, 61, 72, 77, 81, 85].

The RCT by Theisen et al [88] did not find a statistically significant association between a 1.0km unit increase per week and general RRI in their adjusted analyses. Similarly, Kelsey et al [25] analysed the effect of absolute distance on stress fracture development in female runners and found little evidence that a 10.0km unit increase per week significantly affected risk. The high quality prospective cohort studies by Macera et al [23] and Walter et al [24] both provide strong evidence that a weekly distance of ≥64km increases the risk of RRI. The latter study also found a 2.5 fold greater risk for males running >8km during their weekly long run versus <8km. Conversely, the high quality prospective investigation by Malisoux et al [36] found weak evidence that a 1.0km unit increase in distance per session significantly decreased the risk of RRI after covariate adjustment. Likewise, a 10.0km unit decrease per week significantly increased the risk of knee pain [43], and a weekly distance of <30km (reference 30-60km) doubled the risk of general RRI [65]. The two studies to examine relative changes in distance over time were clinically interesting given that both found a greater risk of injury if the running distance increased by >10% and >30% over a 13 week and two week period, respectively [28, 90].

Despite four prospective cohort studies and 10 cross-sectional studies supporting that higher distances increase general and specific RRI risk [22-24, 43, 61, 66, 69, 72, 76, 77, 79, 81, 83, 85], a number of high quality longitudinal investigations found that either there was no relationship, or that higher distances had a protective

effect [25, 28, 30, 32, 35, 43, 88, 90]. Accordingly, there is no compelling evidence to support whether higher or lower absolute running distances affect RRI risk.

3.4.2 Duration

Eight studies examined duration, which was expressed as either a discrete unit increase (i.e. per session or per week 1.0/10.0min or 1.0hr, respectively), cumulative hours per week of running, or as a minute per session comparison [22, 32, 35, 36, 49, 50, 52, 71, 88] (ESM Table S5). The median methodological quality score for these studies was 75.0% (range: 50.0% to 91.6%) with five studies scoring ≥75.0% [32, 35, 36, 49, 88]. Four studies found statistically significant associations indicating that higher running durations increased the risk of RRI [35, 49, 50, 71].

The study by Hespanhol Junior et al [35] found that increasing the duration of running by 10 minutes per session marginally increased the risk of general RRI. The cross-sectional study by Chang et al [71] provided both moderate and strong evidence that 30-60min vs. <30min, and >60 vs. <30min per session significantly increased the risk of foot injuries, respectively. Conversely, the same study found that a higher duration per session (>60min vs. <30min) strongly decreased the risk of hip injuries [71]. In contrast, a moderate decreased risk of patellofemoral pain syndrome was found for females who ran a lower cumulative weekly duration (5.0hr (reference) <5.0hr) [50]. The other prospective and retrospective cohort studies found weak evidence that an increased running duration of 10.0min per session and a higher number of weight bearing physical activity hours per week significantly increased the risk of general RRI [35, 49]. A number of studies found no statistically significant relationships between RRI and duration [32, 36, 50, 52, 71, 88], and so conclusions remain open to speculation for this modifiable exposure.

3.4.3 Frequency

Fifteen studies assessed whether frequency of running training and/or competitive practice affected the risk of RRI [23, 24, 35, 36, 42, 43, 49, 52, 66, 67, 69, 72, 75, 88] (ESM Table S6). The median methodological quality score for the eight longitudinal study designs, including one RCT, was 79.2% (range: 58.3% to 91.6%). The case-control and cross-sectional designs (n=7) had a median quality score of 54.5% (range: 27.2% to 72.7%). Six studies found statistically significant results [24, 42, 43, 67, 69, 85].

A higher frequency significantly increased the risk of general RRI, and injuries to the front thigh in two prospective cohort studies [24, 43]. The same effect direction was found in three cross-sectional studies [67, 69, 85]. Conversely, a lower frequency (1.0 vs. >1.0d/wk) strongly increased the risk of injury in a prospective cohort study of satisfactory methodological quality [42]. The study by Walter et al [24] provides evidence that an incremental addition of one weekly running session strongly increases the risk of RRI for males. In the same study, however, only the 7.0d/wk category for females significantly increased the risk. A number of high quality prospective cohort studies found no statistically significant relationships for frequency [23, 35, 36, 49, 88]. Accordingly, it is not possible to definitively conclude that running frequency is an important factor in injury causation.

3.4.4 Pace and interval

Twenty studies were included in the pace and interval sub-category (ESM Table S7). The median methodological quality score was 68.1% (range: 27.2% to 91.6%) with eight studies scoring ≥75.0% [24, 29, 30, 35, 36, 49, 61, 88]. A total of eight studies found statistically significant differences in injured and non-injured groups [29, 35, 49, 61, 63, 69, 77, 84, 96].

The high quality prospective study by Hespanhol Junior et al [35] found that a 1.0d/wk increase of speed training moderately increased the risk of RRI. The same authors found that increasing interval-based training by 1.0d/wk had a moderate protective effect. In the prospective cohort studies by Malisoux et al [36] and Theisen et al [88], mean running speed (per 1.0kph unit increase) was statistically insignificant in unadjusted analyses. Many other studies did not find that pace and/or interval-based training affected general or specific RRI risk [24, 30, 52, 53, 60, 66, 72, 73, 81, 83]. Based on the contrasting results and limited evidence available for the effect of running pace and interval training on RRI risk, it was not possible to form any definitive conclusions for these exposures.

3.4.5 Weight

Twenty-three studies examined whether body weight affected RRI risk (ESM Table S8). Even though the majority of articles were cross-sectional in nature (n=14), there were eight prospective cohort investigations with a median quality score of 54.1% (range: 33.3% to 91.6%) [25, 29, 32, 45-48, 50]. Across the latter studies, only two studies found statistically significant associations between weight and injuries to the foot and plantar fascia [29, 50]. The significant findings in two other cross-sectional studies offered contrasting effect

directions, and should be subject to careful interpretation [73, 76]. In total, four studies found statistically significant varied effect directions or differences between groups. There is inadequate evidence to support that either higher or lower body weight significantly influences RRI risk.

3.4.6 Body mass index

The assessment of BMI featured in 25 studies, which had a median methodological quality score of 75.0% (range: 33.3% to 91.6%) (ESM Table S9). The mean quality score for the prospective cohort studies was 69.9%, with 10 being of high quality [23, 25, 26, 31-33, 36-38, 61]. There were nine studies that found a statistically significant difference between BMI values between injured and non-injured runners, of which two reported a strong effect size [42, 50].

In terms of specific results, there was a fivefold greater risk of spinal injuries and a 2.4 fold increased risk of tibial stress fracture in female runners with a BMI of <21kg/m^2 compared to a 21.0kg/m^2 reference [50]. Likewise, a BMI of >26kg/m^2 strongly decreased the risk of RRI in a prospective investigation of satisfactory quality [42]. These were unique observations, as most investigations found that a higher BMI increased RRI, including an RCT and prospective cohort study which both used a 1kg/m^2 per unit increase exposure [31, 88]. A higher BMI significantly increased the risk of general and specific injures in five more prospective cohort investigations [31, 37, 38, 41, 61]. Given that 17 investigations did not find a statistically significant effect for BMI, of which 10 were longitudinal by design, it does not seem that either a higher or lower BMI is an important exposure in a given RRI causal mechanism.

3.4.7 Diet and hormonal

There were nine studies that had examined factors related to dietary practice and medication use [25, 43, 52, 55, 56, 66, 70, 74, 89] (ESM Table 10). The median methodological quality score for these studies was 63.6% (range: 50.0% to 91.6%) with an RCT [89] and prospective cohort [25] study scoring 75.0% and 91.6%, respectively. Regarding dietary practices, the prospective investigation by Kelsey et al [25] found that low calcium intake increased the risk of stress fracture in female runners, albeit this association was not statistically significant. Likewise, the case-control study by Myburgh et al [52] found a statistically significant difference in daily calcium intake and dairy product consumption between runners afflicted with and without stress fracture in crude analyses. In the same study, no other macro and micronutrients and vitamins discriminated injured from non-injured runners [52].

In terms of medication use, the use of oral contraceptives (OCs) was associated with a decreased risk of stress fracture development in female distance runners across a number of studies [25, 52, 56, 66, 89]. In the RCT by Cobb et al [89], only the treatment-received (i.e. per protocol) analyses for ≥1 month's continued OC use produced a strong statistically significant reduction in risk by 77%. The intention-to-treat analysis in the same study resulted in 43% reduction in risk, albeit this was not statistically significant. Likewise, the high quality prospective cohort study by Kelsey et al [25] found a strong, albeit insignificant, 2.2 fold increased risk of stress fracture incidence associated with reporting never having used OCs.

The five studies that assessed the effects of menstruation on stress fracture development indicated that irregular or absent menstruation was associated with an increased risk [25, 52, 55, 56, 66]. In the only prospective study to examine menarche and menstrual patterns, a younger age at menarche (per 1.0yr unit decrease) nearly doubled the risk of stress fracture. Even though no statistically significant relationship was found for a history of menstrual irregularity over a lifetime recall in the same study, the greater than threefold risk increase is clinically interesting [25]. A case-control [52] and two cross-sectional studies [56, 66] found that a significantly higher proportion of injured runners had irregular or absent menstrual cycles. Overall, there is a paucity of literature which has examined diet and hormonal exposures as they relate to the development of RRI. Even so, the evidence provided here supports a protective effect of OC use on stress fracture development, whereas absent or irregular menstrual patterns increased the risk.

3.4.8 Footwear, insoles, and orthotics

Fifteen studies examined exposures relating to footwear, insoles and orthotics (ESM Table S11). The median quality score for these studies was 66.6% (range: 50.0% to 91.6%). The use of shoe insoles and orthoses was strongly associated with an increased risk of developing any given RRI in four cross-sectional studies, however the temporality of causal effects remain subject to informed judgement [61, 63, 67, 71]. Wearing running shoes for longer before discarding them was associated with a decreased risk of general injury and anterior knee pain [61, 73]. The high quality prospective cohort study by Kluitenberg et al [38] suggested that footwear condition, whether used or new, does not significantly affect the risk of RRI. The same study also found similar effects for footwear that was <3.0 months old compared to footwear aged between 3.0-12.0 months [38]. Wearing soft insoles and rotating running footwear both produced a moderate decrease in risk for knee and general injury, respectively [36, 71].

Three RCTs with a mean quality score of 69.4% (range: 50.0% to 91.6%) investigated whether different foot and/or running shoe types could predict the incidence and/or severity of RRI [88, 92, 93]. One RCT found that wearing motion control footwear in both neutral and pronated foot types significantly increased self-reported pain scores in female runners when compared to both stability and neutral footwear [93]. Another RCT found that compared to non-compliant midsoles, cushioned midsoles did not significantly reduce the incidence of RRI [88]. The third RCT found that both the part and full minimalist footwear conditions strongly increased the RRI incidence rate per 1000hrs when compared to a conventional neutral trainer [92]. The diversity of questions and trialled footwear types and conditions suggests that more research needs to be conducted for this particular modifiable sub-category.

3.4.9 Terrain and surface

Nineteen studies assessed whether topographic features and the compliancy of particular surfaces affected RRI risk (ESM Table S12). The median quality score for the seven longitudinal investigations was 91.6% (range: 66.6% to 91.6%), whereas the case-control and 11 cross-sectional studies scored 54.5% (range: 18.1% to 81.8%). One high quality prospective cohort investigation found that running 2/3^{rds} of the time on non-compliant surfaces, such as concrete, significantly increased the risk of general injury for female runners, but not males [23]. In agreement, the study by Wen et al [61] found that a lower time spent running on concrete decreased the risk of thigh and back injuries. Despite being of high quality, this study used a cross-sectional design, and so the temporality of this effect is unknown. Given the number of studies that found no statistically significant association for terrain and/or surface, including a number of high quality prospective cohort investigations [24, 25, 35, 36, 42], the evidence does not support that these modifiable training-related factors affect RRI risk.

3.4.10 Stretching, warm-up, and cool-down

Limited data were available for stretching, warm-up and cool-down practices [24, 30, 34, 49, 69, 73, 76, 83, 94] (ESM Table S13). The median methodological quality score for the nine studies was 63.6% (range 27.2% to 91.6%), of which the median score for five longitudinal investigations was 83.3% (range: 41.6% to 91.6%) [24, 30, 34, 49, 94]. The cross-sectional studies that assessed the frequency and duration of stretching generally found that a higher proportion of injured runners stretched [69, 73, 83]. The only RCT in this sub-category, which tested the effect of an individualised program involving stretching, warm-up and cool-down practices,

found no statistically significant difference in the RRI incidence rate per 1000hrs between its two groups [94]. Two prospective cohort studies found no statistically significant association between warming-up and cooling-down, and general RRI [30, 34]. The high quality prospective cohort study by Walter et al [24] found a significant 60% increased risk associated with 'always stretching', versus 'sometimes stretching' for male runners, but not females. According to the varied effect directions, it is not possible to determine whether stretching, warm-up, and cool-down practices increase or decrease the risk of RRI.

3.4.11 Psychological factors

There were 11 studies in the psychological sub-category (ESM Table S14). The median methodological quality score for these studies was 69.6% (range: 36.3% to 91.6%). There were six prospective cohort [24, 26, 31, 35, 40, 41] and five cross-sectional studies [59, 62, 63, 76, 79]. In total, eight studies found a significant relationship between personality type and RRI risk [24, 26, 31, 40, 59, 62, 63, 79], with type A opposed to type B-related personality generally increasing the risk. When compared to a type B personality disposition, type A persons are generally more competitive, outgoing, ambitious, impatient, and aggressive. Even so, many studies only reported proxy variables that tenuously suggest personality type, such as training only to be competitive rather than running only for fitness or recreational purposes [24, 59, 63, 79]. One early cross-sectional study used a distinctive personality inventory, and so it was not fully understood how particular items such as being less 'forthright' and less 'toughminded' had affected the differences in risk between injured and non-injured runners [76]. A number of equivocal relationships emerged across sexes and between items in another cross-sectional study [59]. Specifically, Ekenman et al [59] found that a higher sense of impatience, time urgency, and conviction to exercise significantly discriminated females afflicted with tibial stress fracture versus healthy controls. Two prospective cohort investigations have since found that either there is no relationship between personality type and RRI [31], or that type B actually increases the risk [26]. On the whole, few scientific investigations have examined whether personality characteristics and/or behavioural patterns affect the risk of RRI. Because of this, no definitive conclusions can be drawn.

3.4.12 Other modifiable factors

The other modifiable sub-category included investigations that had examined the effect of preconditioning and custom training plans on RRI risk, as well as exposures relating to strength training and running discipline/events (ESM Table S15). Across 13 studies, the median methodological quality score was 66.6%

(range: 27.2% to 91.6%). One RCT found that for competition-related injuries, an individualised injury prevention running program significantly decreased the RRI incidence rate per 1000hrs [95]. In the same trial, however, no statistically significant difference was found for the training-related injury incidence rate per 1000hrs. Another RCT examined the effects of a preconditioning program that aimed to facilitate gradual musculoskeletal adaptation prior to a running program [91]. The preconditioning intervention did not significantly differentiate the RRI incidence rate per 1000hrs between injured and non-injured runners [91]. A retrospective cohort study found a moderate decrease in injury risk for female runners if they engaged in weight training on two days per week, but no significant relationship was found for males [49]. A strong increased risk of competition-related injury in female runners was strongly associated with group-based training, rather than running solo [62]. The risk of sustaining a training-related injury was also moderately increased for the group-based training condition, although this association was not statistically significant [62]. The use of specific conditioning programs was not protective against the development of RRI in the two RCTs that examined this. Further research is required to determine whether strength-based resistance training protects against injury in the distance running context directly.

Table 4 Overview of select modifiable results across 12 exposure sub-categories. The total number of studies within each sub-category, the outcome, study design and median quality assessment score are presented

Exposure	Total no. of studies (N)	Focus on general (n)/specific (n) injury	Reported study designs (n)	Median (range) quality score
Distance	36	17/19	RCT, 2; PC, 12; RC, 2; CC, 2; CS 19	63.6 (18.1-91.6)
Duration	8	4/4	RCT, 1; PC, 3; RC, 2; CC, 1; CS, 1	75.0 (50.0-91.6)
Frequency	15	10/5	RCT, 1; PC, 6; RC, 1; CC, 1; CS, 6	72.7 (27.2-91.6)
Pace/interval	20	10/10	RCT, 1; PC, 5; RC, 1; CC, 2; CS, 11	68.1 (27.2-91.6)
Weight	23	5/18	PC, 8; CC, 1; CS, 14	54.5 (27.2-91.6)
BMI	25	13/12	RCT, 1; PC, 16; RC, 2; CS, 6	75 (33.3 to 91.6)
Diet and hormonal	9	2/7	RCT, 1; PC, 2; CC, 1; CS, 5	63.6 (50.0-91.6)
Footwear/insoles/orthotics	15	8/7	RCT, 3; PC, 3; CC, 1; CS, 8	66.6 (50.0-91.6)
Terrain/surface	19	9/10	RCT, 1; PC, 6; CC, 1; CS, 11	65.1 (18.1-91.6)

Stretching/warm-up/cool-down	9	8/1	RCT, 1; PC, 3; RC, 1; CS, 4	63.6 (27.2-91.6)
Psychological	11	10/1	PC, 6; CS, 5	69.6 (36.3-91.6)
Other modifiable	13	11/2	RCT, 3; PC, 3; RC, 1; CS, 6	66.6 (27.2-91.6)

BMI, body mass index; CC, case-control; CS, cross-sectional; PC, prospective cohort; RC, retrospective cohort; RCT, randomised controlled trial

3.5 Non-modifiable risk and protective factors

In the non-modifiable category, there were seven sub-categories comprising individual factors identified in the retrieved literature: (i) age; (ii) sex; (iii) height; (iv) experience; (v) previous injury; (vi) biomedical; and; (vii) other non-modifiable (i.e. factors that could not be appropriately sub-categorised) (Table 5).

3.5.1 Age

Thirty-four studies reported the effects of age on RRI risk (ESM Table S16). The median quality score for these studies was 60.8% (range: 27.2% to 91.6%) with three investigations scoring 91.6% [25, 26, 88]. Thirteen of 15 prospective cohort studies received scores of ≥50.0% [25, 26, 29, 31-33, 36, 38, 41-43, 45, 46]. Two retrospective cohort studies scored 83.3% [49] and 50.0% [50], and 11 of 16 cross-sectional designs were of satisfactory methodological quality [57, 58, 61-63, 66, 68, 70, 72, 74, 77]. In total, nine studies reported a statistically significant association with age [25, 38, 41-43, 49, 50, 68, 80]. In five of nine, the direction of the effect between age and general RRI was inconsistent, and was further modified by sex [38, 41, 42, 49, 68].

In terms of specific injury, a strong increased risk of front thigh injury was found for the age bracket 30-34yrs versus <25yrs, but not for ages either side of this (≤29yrs or ≥35yrs) [43]. Conversely, being aged 30-34yrs and ≥40yrs strongly decreased the risk of calf injury, but no statistically significant association was found for ≤29yrs and 35-39yrs [43]. The study by Taunton et al [42] found a strong decreased risk of new injury, but only for female runners who were aged <31yrs. A high quality prospective cohort investigation found that a younger age (per 1.0yr unit decrease) moderately increased the risk of stress fracture in female runners by 42.0% [25]. Conversely, Kluitenberg et al [38] found weak evidence to support that a higher age increased the risk of general injury in multivariable survival analyses. Other high quality longitudinal investigations did not find a statistically significant relationship between age and general or specific RRIs [26, 29, 31-33, 36], including an RCT after multivariable adjustment [88]. Taken as a whole, there is little scientific evidence to support that age is an important factor for RRI development.

3.5.2 Sex

Sixteen directly compared the risk of RRI across sexes (ESM Table S17). The median quality score for these studies was 66.0% (range: 41.6% to 91.6%), with five studies scoring ≥75.0% [26, 32, 36, 38, 88]. The majority of studies, including those of a higher quality, did not find statistically significant differences in RRI risk across

sex. The multivariable adjusted analysis in the prospective cohort study by Buist and colleagues [41] found a moderately significant increased risk of general injury among males when compared to females. Another study, albeit cross-sectional by design, also found that male runners aged <40yrs had a moderately significant higher odds of sustaining a given injury when compared to their female counterparts [67]. In contrast, Lopes et al [75] found that the presence of pain was significantly greater in females than males. Similarly, females were at a strong increased risk of hip injuries, but not injuries to the hamstring or calf [43]. Many studies did not support a sex based risk difference hypothesis [26, 32, 36, 38, 39, 44, 46, 47, 65, 69, 77, 88]. On balance, there is little evidence to support any conceivable sex-based risk difference hypothesis.

3.5.3 Height

Height was examined in 20 investigations comprising seven prospective cohort studies, one retrospective cohort study, and 12 cross-sectional study designs (ESM Table S18). The median quality score for these studies was 54.0% (range: 27.2% to 91.6%). Five investigations found statistically significant associations with height [24, 50, 73, 76, 77], with two utilising multivariable analyses [24, 50]. The measures of association in one study were particularly strong, indicating that both male and female runners of <157cm in height had a significantly increased risk of sustaining injuries to the plantar fascia and anterior aspect of the knee when compared to a 157cm reference group, respectively [50]. No relationships were found for a number of other specific injuries. According to these data, and given the absence of statistically significant differences in 15 studies, the evidence to support height as a risk factor is very weak.

3.5.4 Experience

Thirty-eight studies examined whether factors related to running experience affected the risk of RRI (ESM Table S19). Across 16 longitudinal study designs, including one RCT, the median methodological quality score was 79.1% (range: 50.0% to 91.6%). The median quality for the two case-control and 20 cross-sectional studies was 54.5% (range: 27.2% to 81.8%). Measures used in the studies ranged from absolute or cumulative monthly or yearly units of running to other historical measures, such as years of axial loading and years engaged in competitive running. The high quality prospective cohort study by Buist et al [31] found that a history of non-axial loading doubled the risk of injury in males, but not females. The opposite picture emerged in another prospective cohort study whereby a history of non-axial loading strongly increased the risk of injury in females, but not males [41]. One high quality RCT found no significant evidence to support the association between

experience, or the number of weekly competitions, and RRI, but it did find a strong protective effect associated with reporting having run regularly in the prior 12 months [88]. Conversely, running year round was shown to strongly increase the risk of general RRI in another prospective cohort study for both males and females [24]. A number of investigations with varied study designs found higher training and/or competition-related experience to be associated with an significantly increased risk of general and specific RRI [29, 49, 66, 69, 72, 75, 84, 85], but this was not the common rule [23, 31, 38, 41, 43, 50, 61, 62, 65, 77]. Consideration of the overall evidence and the number of studies that found no statistical relationship suggests that running experience does not affect the development of RRI.

3.5.5 Previous injury

A total of 22 studies examined the association between previous injury and the development of a subsequent RRI (ESM Table S20). There was one RCT [88], 15 prospective cohort studies [23-26, 29, 31, 32, 34-36, 38, 39, 41, 44], two retrospective cohort studies [49, 50], and four cross-sectional studies [62-65] in this sub-category. The median methodological quality scores for these studies was 78.4% (range: 50.0% to 91.6%). Overall, only three investigations failed to find statistically significant effects for previous injury [34, 41, 50]. The measures of association for the remaining 19 studies were universally strong and statistically significant. Based on this evidence, previous injury is a strong risk factor for RRI development.

3.5.6 Biomedical factors

Six studies tested the association between select biomedical factors and RRI [25, 32, 43, 52, 74, 80] (ESM Table S21). The median methodological quality score for these studies was 56.4% (range: 36.3% to 91.6%). There were three prospective cohort studies [25, 32, 43], one case-control study [52], and two cross-sectional studies [74, 80]. In the high quality prospective cohort study by Kelsey et al [25], a lower whole-body bone mineral content (BMC) strongly increased the risk of stress fracture in female runners. In corroboration, the case-control study by Myburgh et al [52] found runners with stress fracture had a significantly lower bone mineral density (BMD) in a number of anatomical locations when compared to healthy controls. Conversely, the cross-sectional study by Grimston et al [80] found that females without stress fracture had significantly lower BMD values in the lumbar spine and femoral neck compared to runners with stress fracture. A later cross-sectional study found no statistically significant differences in BMD values between injured and non-injured female runners with tibial stress fracture across a range of bodily locations [74]. In the only histopathological

investigation, a significantly strong increased risk of Achilles tendinopathy development in the presence of higher intratendinous microvascular networks was found [32]. More studies are required to investigate biomedical exposures as they relate specifically to their effect on RRI risk.

3.5.7 Other non-modifiable factors

Other non-modifiable factors were related to demographic characteristics (ESM Table S22). There were five studies in this sub-category with a median methodological quality score of 63.6% (range: 36.3% to 83.3%). In the high quality prospective cohort study by Van Middelkoop et al [30], a high level of education decreased the risk of RRI, albeit the effect was weak and non-significant. Fitness level, number of children, marital status, occupation and income in a number of cross-sectional studies also did not dictate injury status [66, 69, 70, 79].

Table 5 Overview of select non-modifiable results across seven exposure sub-categories. The total number of studies within each sub-category, the outcome, study design and median quality assessment score are presented

Exposure	Total no. of studies (N)	Focus on general (n)/specific (n) injury	Reported study designs (n)	Median (range) quality score
Age	34	15/19	RCT, 1; PC, 15; RC, 2; CS, 16	60.8 (27.2-91.6)
Sex	16	9/7	RCT, 1; PC, 9; CS, 6	66.0 (41.6-91.6)
Height	20	5/15	PC, 7; RC, 1; CS, 12	54.0 (27.2-91.6)
Experience	38	17/21	RCT, 1; PC, 13; RC, 2; CC, 2; CS, 20	65.1 (27.2-91.6)
Previous injury	22	12/10	RCT, 1; PC, 15; RC, 2; CS, 4	78.4 (50.0-91.6)
Biomedical	6	0/6	PC, 3; CC, 1; CS, 2	56.4 (36.3-91.6)
Other non-modifiable	5	5/0	PC, 1; CS, 4	63.6 (36.3-83.3)

CC, case-control; CS, cross-sectional; PC, prospective cohort; RC, retrospective cohort; RCT, randomised controlled trial

4.0 Discussion

The purpose of this systematic review was to compile the evidence about modifiable and non-modifiable training-related and behavioural risk and protective factors on the risk of developing middle- and long-distance RRI. This is important because knowledge about whether or not the modification of certain factors will reduce the risk of RRI is valuable information for a number of persons and organisations, including but not limited to, runners, coaches, academic researchers, community-based healthcare professionals, and athletic governing bodies.

In terms of methodological quality, the mean score associated with the reviewed RCTs was satisfactory (63.5%). The PEDro scale mainly showed that a number of included RCTs did not meet criteria for blinding with regard to intervention allocation. However, it is not always ethically or practically possible to blind participants, therapists, and/or research staff to sports medicine interventions, and so this finding is not unexpected. Regarding the cohort studies, the mean quality score was satisfactory (72.8%), albeit the ratings of the observational follow-up period received a low overall score because few studies were more than 12 months in duration. Among the cross-sectional and case-control study designs, 58.3% did not report the recall period for injury history and/or training-related practices, and even fewer studies reported a clear definition of injury (28.%). Contrastingly, 84% of longitudinal study designs clearly defined the study's outcome. Despite this discrepancy, a detailed and discernible injury definition was still reported in only a limited number of retrospective studies that aimed to determine the risk factors for a specific injury selected and diagnosed *a priori.* For example, certain cross-sectional and case-control studies used their injury definition to identify runners who had experienced comparable impairments to training-related practices, but only because they shared the same pathological features of a suspected injury e.g. [73, 77, 81]. This took place prior to a formal diagnostic procedure to confirm either inclusion or exclusion. Therefore, irrespective of study design, future investigations should clearly state and operationalise the consensus-based standardised definition for reporting a RRI event [97].

Regarding the compiled evidence on modifiable factors, limited evidence suggested that irregular or absent menstruation, and never having used OCs, were associated with an increased risk of stress fracture development [25, 52, 55, 56, 66, 89]. Because these two factors are related to the female athlete triad, more research is now required to clarify how precisely hormone imbalances (as displayed by menstrual irregularities), along with

other factors, affect the risk of stress fracture development in female distance runners. Varied effect directions and/or a number of statistically insignificant results for a given exposure were found for distance, duration, frequency, pace and intervals, weight, BMI, footwear, insoles and orthotics, terrain and surface, stretching, warm-up and cool-down practices, psychology, and individualised training programs. Regarding non-modifiable factors, varied effect directions and/or a number of statistically insignificant results for a given exposure were found for age, sex, height, experience, and certain exposures in the biomedical sub-category such as BMD and BMC. The only factor that consistently increased the risk of RRI was reporting a history of previous injury [4, 5, 8, 9, 11, 13, 15].

Saragiotto et al [15] have described how runners might adopt different biomechanical patterns when running in response to an existing or previous pain stimulus. In particular, runners will attempt to protect themselves from further physical harm or re-injury by modifying their running gait cycle. Whilst previous injury is not modifiable itself, it might be possible to influence outcomes associated with injury history such as through improved rehabilitation programs. Therefore, the next step for research is to further investigate why and how previous injury contributes to the development of subsequent injury [8, 15]. This enhanced information would provide clinical staff and physical therapists with additional knowledge about how to protect previously injured runners from sustaining a subsequent injury, be it via physical screening or tailoring training-related advice accordingly (e.g. instructing about the risk of rapidly increasing weekly running distances). Given that previous injury is a non-modifiable, runner-intrinsic factor, its effect on increasing subsequent injury risk necessitates both clinical expertise and high quality epidemiological data. It is essential to recognise that repeat, recurrent, and multiple injuries are not synonymous, and because of this, the subsequent injury categorisation (SIC) model should now be used to inform and guide the design of future RRI epidemiological investigations [98].

Contrary to the conclusions offered in previous reviews [4, 5, 9-11], we did not find adequate evidence to support that a higher weekly running distance increased the risk of RRI. Indeed, the term ‘higher’ is entirely relative to the individual runner and his/her underlying physiology [99, 100]. Accordingly, Nielsen et al [13] identified that a complex relationship involving distance, frequency, duration and pace, has not been sufficiently accounted for, whether methodologically or analytically, in the majority of studies to date. For example, even though it has been traditional practice to quantify running distance as a time-fixed exposure, it is more accurate to examine how distance changes over time in relation to injury risk [8, 28, 37, 90, 101]. The only two investigations to compare differences in running distance progression were both statistically insignificant yet

clinically interesting [28, 90]. Specifically, the mean survival time for runners randomised to a 10% graded program over a 13 week period was 212 minutes compared to 167 minutes for runners left to their own devices over an 8 week period [90]. Likewise, novice runners who increased their weekly distance by more than 30% over a fortnightly period were at a 60% increased risk of sustaining a RRI when compared to a group who increased their distance by less than 10% [28]. Based on these results, future research should aim to determine how much running the musculoskeletal system can tolerate given the presence of other pertinent time-dependent exposures. Theoretically, this means hypotheses should formally prioritise running participation in relation to other time-varying factors. From an analytical standpoint, this requires adoption of time-to-event statistical analyses which better account for the dynamic nature of risk [102]. Recent interest and new developments surrounding the relationship between rapidly increasing training loads and injury should now be extended to the distance RRI context [103].

A limited number of studies examined diet and hormonal factors. The available evidence was insufficient to support whether or not overall energy intake, macro and micronutrients, or general medication use were associated with RRI. On the other hand, despite few studies of varied design, OC use was found to be associated with a decreased risk of stress fracture development [25, 52, 56, 66, 89]. Further research is now required to elucidate how OC use protects against stress fracture development in female athletes. In particular, the need to use OCs is likely attributable to a number of specific deleterious physiological effects associated with the female athlete triad. This well-known phenomenon is characterised by the tight interplay between amenorrhea, suboptimal energy availability, and reduced BMD [104]. Together, these factors manifest and not only detrimentally affect sporting performance, but also pose a serious risk to the athlete's overall health [104, 105]. Given that this systematic review also found that irregular or absent menstruation was associated with a significantly increased risk of stress fracture development [25, 52, 55, 56, 66], more research should now investigate how key exposures associated with the female athlete triad interact and ultimately affect the risk of distance RRI. However, this could prove challenging as the feasibility of conducting experimental trials in this area has been questioned [89].

Whether a product of intuition or due to the practicalities of ascertainment and quantification, age, running distance, BMI, and running experience, have featured recurrently in the RRI literature (Table 4 and Table 5). Despite heightened interest surrounding these factors, conclusions pertaining to their effect on RRI development remain speculative at best. This is primarily due to methodological and analytical heterogeneity, including the

way in which exposures have been quantified and measured, the sampling of varied populations, different lengths of follow-up, and the use of a range of injury definitions and statistical techniques. The results from this systematic review do not reflect the first-hand experiences of recreational distance runners about what factors they personally believe cause RRI [106]. Further qualitative studies are now required to confirm whether or not there is a wider disconnect between the evidence generated via highly controlled epidemiological inquiry, and runners' opinions and beliefs about RRI causation [107]. Likewise, more research utilising a longitudinal study design needs to investigate the effect of personality type, behavioural patterns, and motivation on the risk of RRI development [26, 31]. The same line of reasoning applies to the paucity of literature that has examined different dietary practices and regimes of nutritional supplementation [52]. In terms of exposures relating to preparatory practices and athletic recovery, this systematic review was limited in scope given that it could only identify few studies reporting the effects of warm-up, cool-down and/or stretching routines in relation to injury susceptibility. Therefore, future RRI prevention research should both increase its depth and widen its breadth in terms of refining existing knowledge and exploring new topics. It is now time to investigate new research areas and introduce novel hypotheses in the RRI context.

4.1 Limitations

A number of limitations in this review should be noted. Starting with the search strategy itself, there is a possibility that potentially eligible articles were not retrieved, particularly given that one author independently examined the eligibility of identified articles during the first round screening process. However, when the decision to include an article was not clear, consultation with another author occurred. In terms of the inclusion criteria, the direction of a causal effect between a given exposure and RRI cannot be directly ascertained when using case-control and cross-sectional study designs. Even though a strength of such study designs lies with their ability to collect and analyse a multitude of exposures simultaneously, their inclusion in this review does mean that some lower quality evidence was included. In a similar way, results would have greater external validity if risk and protective factors were identified for specific injury types so as to avoid the over- and under-representation of certain exposures [15]. However, summarising the factors for a specific injury is not currently possible because of the shortage of original research. Similarly, caution should be exercised when making comparisons across studies given the use of varying injury definitions and diverse population samples. Regarding data extraction and their interpretation, the diversity of the included articles meant that it was not feasible to obtain a common pooled estimate across similar studies in which to perform a meta-analysis.

Therefore, the interpretation of association measures was based on whether or not an exposure was statistically significant according to the confidence interval. Clinical significance was considered where possible, but many studies simply did not report measures of association when their results were not statistically significant. Regarding the methodological quality assessment, if a given study did not disclose which exposures were adjusted for in the analyses, yet stated that multivariable model was used, the corresponding item was scored positive. It might have been better to appraise a given study according to whether or not the statistical model accounted for important covariates to enhance the interpretation of results.

5.0 Conclusions

This systematic review found that a history of previous injury was associated with an increased risk of both general and specific RRI. Determining precisely why and how previous injury increases the risk of subsequent injury now requires the use of existing epidemiological concepts such as the SIC model to inform and guide the design of future RRI investigations [98]. In terms of modifiable exposures, irregular or absent menstruation, and never having used OCs, were associated with an increased risk of stress fracture development. More research should now investigate how key exposures associated with the female athlete triad interact and ultimately affect the risk of distance RRI. The quality of the reviewed studies means that no definitive conclusions were able to be made for the other modifiable and non-modifiable factors in terms of their relationship to RRI. Further studies of rigorous design and conduct are needed to rule out the existence, or not, of such effects.

Compliance with ethical standards

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Conflicts of Interest

Adam Hulme, Rasmus Nielsen, Toomas Timpka, Evert Verhagen and Caroline Finch declare that they have no conflicts of interest relevant to the content of this review.

Author Information

Adam Hulme undertook this work as part of his PhD studies under the supervision of Caroline Finch. Caroline Finch is the Director of the Australian Collaboration for Research into Injury in Sport and its Prevention (ACRISP). ACRISP is one of nine research centres worldwide to be selected by the International Olympic Committee (IOC) as a member of the IOC Medical Research Network.

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Article title: Risk and protective factors for middle- and long-distance running-related injury: A systematic review

Journal: Sports Medicine

Author(s): Adam Hulme, Rasmus Oestergaard Nielsen, Toomas Timpka, Evert Verhagen, Caroline Finch.

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Electronic Supplementary Material Table S1 Search strategy for PubMed, CINAHL, MEDLINE, SPORTDiscus, and PsycINFO

	PubMed database	Articles (N)
#22	Search 4 AND 14 AND 21	2784
#21	Search 15 OR 16 OR 17 OR 18 OR 19 OR 20	81147
#20	Search athlet*[Title/Abstract]	36061
#19	Search jogg*[Title/Abstract]	1400
#18	Search runn*[Title/Abstract]	43654
#17	Search athlete[MeSH Terms]	3289
#16	Search jogging[MeSH Terms]	687
#15	Search running[MeSH Terms]	13218
#14	Search 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13	3571420
#13	Search epidemiolog*[Title/Abstract]	258325

#12	Search antecedent*[Title/Abstract]	11744
#11	Search determinant*[Title/Abstract]	162866
#10	Search factor*[Title/Abstract]	2194044
#9	Search predict*[Title/Abstract]	932553
#8	Search etiolog*[Title/Abstract]	188477
#7	Search "risk factor"[Title/Abstract]	120418
#6	Search etiology[MeSH Terms]	552876
#5	Search risk factor[MeSH Terms]	542901
#4	Search 1 OR 2 OR 3	544507
#3	Search injur*[Title/Abstract]	527262
#2	Search overuse injury[MeSH Terms]	10732
#1	Search athletic injury[MeSH Terms]	20190
	CINAHL	
#22	S4 AND S14 AND S21	166
#21	S15 OR S16 OR S17 OR S18 OR S19 OR S20	21,946
#20	TI jogg*	113
#19	TI athlet*	9,048
#18	TI runn*	3,931

#17	(MH "Jogging")	97
#16	(MH "Athletes, Amateur") OR (MH "Athletes, College") OR (MH "Athletes, Elite") OR (MH "Athletes, Female") OR (MH "Athletes, High School") OR (MH "Athletes, Male") OR (MH "Athletes, Master") OR (MH "Athletes, Professional")	7,524
#15	(MH "Running+") OR (MH "Running, Distance")	7,008
#14	S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13	218,615
#13	TI aetiolog*	901
#12	TI epidemiolog*	11,787
#11	TI antecedent*	568
#10	TI determinant*	6,608
#9	TI predict*	46,977
#8	TI etiolog*	2,645
#7	TI factor*	66,429
#6	TI "risk factor*"	20,594
#5	(MH "Risk Factors+")	109,017
#4	S1 OR S2 OR S3	57,409
#3	TI injur*	55,722
#2	TI "overuse injur*"	181
#1	(MH "Athletic Injuries+")	3,010

	MEDLINE	
#21	S4 AND S13 AND S20	311
#20	S14 OR S15 OR S16 OR S17 OR S18 OR S19	33,112
#19	TI jogg*	414
#18	TI athlet*	15,235
#17	TI runn*	9,561
#16	(MH "Jogging")	687
#15	(MH "Athletes")	3,289
#14	(MH "Running+")	13,218
#13	S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12	868,007
#12	TI aetiolog*	7,529
#11	TI epidemiolog*	92,111
#10	TI antecedent*	2,065
#9	TI determinant*	35,984
#8	TI predict*	178,606
#7	TI etiolog*	37,796
#6	TI "risk factor*"	72,742
#5	(MH "Risk Factors")	542,899

#4	S1 OR S2 OR S3	226,219
#3	TI injur*	213,430
#2	TI "overuse injur*"	243
#1	(MH "Athletic Injuries")	20,190
	SPORTDiscus	
#16	S1 AND S11 AND S15	287
#15	S12 OR S13 OR S14	69,303
#14	TI athlet*	49,093
#13	TI jogg*	828
#12	TI runn*	20,017
#11	S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10	28,194
#10	TI aetiolog*	165
#9	AB epidemiolog*	5,255
#8	TI epidemiolog*	1,964
#7	TI antecedent*	302
#6	TI determinant*	2,121
#5	TI predict*	9,184
#4	TI etiolog*	462

#3	AB "risk factor*"	9,969
#2	TI "risk factor*"	2,729
#1	TI injur*	31,159
	PsycINFO	
#15	S1 AND S11 AND S14	24
#14	S12 OR S13	167
#13	TI athlet*	50
#12	TI runn*	117
#11	S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10	10,086
#10	AB epidemiolog*	639
#9	TI epidemiolog*	99
#8	TI antecedent*	262
#7	TI determinant*	841
#6	TI predict*	3,854
#5	TI etiolog*	148
#4	TI factor*	3,698
#3	AB "risk factor*"	1,204
#2	TI "risk factor*"	224

#1	TI injur*	758

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Electronic Supplementary Material Table S2 Observational study design quality assessment checklist

Study objective	**Explanation**
1. Positive – if the study had a clearly defined purpose [CS/CC/PC]	• Explain the scientific background in a formal review of literature • Provide a rationale for the investigation and report the purpose • Where suitable, include a priori expectations, predictions/hypotheses
Study population	**Explanation**
2. Positive – if the setting, locations, and relevant dates, including periods of recruitment are described [CS/CC/PC]	• If recruiting runners from a racing event, include the location, date and how long recruitment spanned • Indicate where (geographic area) the runners were recruited from
3. Positive – if the main demographic and training-related features of the study population are described [CS/CC/PC]	• External validity is compromised if no details are provided for this item • Details should include past and/or current training-related history/habits (e.g. average distance per week, usual pace/intensity of training and/or racing, frequency of running per week, predominant running surfaces, experience or

	years running, number of races in previous year etc.) • Tabularisation of these descriptive data preferred but not required for approval (this item is subject to some interpretation, that is, enough detail has to be reported to appreciate the characteristics of the sample in which to generalise findings) • One of the earliest examples to score positive for this item is Macera et al's (1989) study which provided the minimum required detail in order to comprehend the population
4. Positive – if the eligibility criteria and sampling methods/strategy for selecting participants are reported [CS/CC/PC]	• Provide eligibility criteria and the sources and methods of selecting participants (e.g. 'runners aged between 18 and 65 years who were running at least three times per week were approached in their usual training grounds/athletic clubs and provided with a questionnaire', or, 'questionnaires were included in every marathon entrants' race pack and distributed on one of three days before the start of the event') • Regarding comparative trials or case-control studies: (i) how long have injured/cases been symptomatic; (ii) what was the rationale for selecting cases; (iii) has there been a satisfactory description of the clinical examination in which to establish a diagnosis; (iv) what measures were taken to rule out differential diagnoses; (v) how were non-injured/controls selected and recruited; (vi) for matched studies, give matching criteria and number of non-injured/controls per case
5. Positive – if numbers at each stage of the study are reported [CS/PC]	• Potentially eligible, examined for eligibility, confirmed eligible, included, and analysed • It might not always be possible to report numbers included, but an attempt must be made to report the numbers enrolled and analysed

	• A flow diagram is desirable but is not required for approval • This item applies to enrolment for prospective cohort studies
6. Positive – if the participation rate at the main moment of follow-up is at least 80% for observation periods of ≤6 months, or at least 60% for observation periods of ≥7 months [PC]	• The longer the follow-up period, the greater the probability that participants will drop-out of the study
Outcome measurements	**Explanation**
7. Positive – if the methods used to collect data are reported [CS/CC/PC]	• Include information on self-administered questionnaires • It is enough to report that 'a questionnaire was used to obtain training-related habits', but ideally, justification for the questionnaire or satisfactory detail of solicited information should be provided • Whether or not the questionnaire has been pilot tested and the number of questionnaire items/modifications to existing instruments is desired but is not required for approval • For case-control studies, or where a physical examination is reported (i.e. in certain cases for cohorts and cross-sectional studies), indicate the exact clinical examination procedures used (for purposes of replication in subsequent studies), and, ideally, disclose the experience/qualification of clinicians (latter desired but not required for approval)
8. Positive – if the prospective observational period was ≥12 months [PC]	• Injury risk will vary according to seasonal cycles • Even in the case of amateur runners who might not adhere to a training program, seasonal variation in terms of

	weather patterns and calendar dates might affect injury patterns
9. Positive – if the retrospective recall period is reported [CS/CC]	• Study designs with a retrospective focus (CS/CC) should report participants' recall period pertaining to their training-related history/habits or injury history (i.e. is the training-related information derived over a lifetime recall, current practice, or the previous three months, and, have participants reported any injuries sustained over their running career or only in the previous year etc.)
10. Positive - if the injury definition and self-reported physical impairment concepts are reported [CS/CC/PC]	• Injury definitions such as, for example, 'an injury had to interfere with the ability to run' are ambiguous and do not indicate if runners were involuntarily incapacitated (time-loss), or, they were compromised to a degree (i.e. forced involuntary reduction or modification of distance and/or pace etc.) • The consequences of the injury that resulted in a diagnosis (symptoms associated with injury), rather than only reporting the injury assessment itself (signs), is to be scored positive, even for clinical retrospective investigations • An appropriate definition would be: 'a running-related injury was defined as complete involuntary cessation of running (i.e. forced time-loss) due to musculoskeletal pain directly attributable to distance running' • Physical impairments include: pain, and/or restriction/modification, and/or time-loss, and/or medical intervention
Analysis and data presentation	**Explanation**
11. Positive – if the analysis/physical assessment is reported to have occurred under blinded conditions [CS/CC/PC]	• Analysts are to be blinded when working with data regarding group allocation (e.g. anonymous data, or a mention of a third party analyst) • It is desirable to have two analysts independently follow the same procedural statistical technique • Where a retrospective physical exam is performed, practitioners should not know injury status

	• For a fair and objective analysis, statistical analysts should not know the coding details for injury status when working with statistical software
12. Positive – if the statistical analyses and methods used are transparently reported [CS/CC/PC]	• The statistical package and version used (desired but not required for approval) • Specific statistical analyses used • Separate statistical methods section at the end of methods (preferred but not required for approval)
13. Positive – if analyses adequately adjusted for confounders whether individual factors (e.g. age, sex, BMI, previous injury) and/or training-related (e.g. volume, pace) [CS/CC/PC]	• Studies will be scored positive if there is indication that potential confounders were adjusted in a multivariate regression model • Adjusted measures of association are reported • Ideally, justification should be given for why certain confounders were included and adjusted for (not required for approval)

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A full description of each item can be found at: http://www.pedro.org.au/english/downloads/pedro-scale/

Electronic Supplementary Material Table S3 PEDro quality assessment checklist for randomised controlled trials

1. Eligibility criteria were specified
2. Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)
3. Allocation was concealed
4. The groups were similar at baseline regarding the most important prognostic indicators
5. There was blinding of all subjects
6. There was blinding of all therapists who administered the therapy
7. There was blinding of all assessors who measured at least one key outcome
8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups
9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by “intention to treat”

10. The results of between-group statistical comparisons are reported for at least one key outcome

11. The study provides both point measures and measures of variability for at least one key outcome

12. Self-reported physical impairment concepts are reported [a]

Injury definitions such as, for example, ‘an injury had to interfere with the ability to run’ are ambiguous and do not indicate if runners were incapacitated (time-loss), or, they were compromised to a degree (i.e. forced involuntary reduction of volume or pace etc.). The consequences of the injury that resulted in a diagnosis (symptoms associated with injury), rather than only reporting the injury assessment itself (signs), is to be scored positive e.g. ‘A running-related injury was defined as complete involuntary cessation of running (i.e. forced time-loss) due to musculoskeletal pain directly attributable to distance running’. Physical impairments include: pain, and/or restriction/modification, and/or time-loss, and/or medical intervention

[a] PEDro expanded with single item

Electronic Supplementary Material Table S4 through to Table S22

Article title: Risk and protective factors for middle- and long-distance running-related injury: A systematic review

Journal: Sports Medicine

Author(s): Author(s): Adam Hulme, Rasmus Oestergaard Nielsen, Toomas Timpka, Evert Verhagen, Caroline Finch.

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<tables found below in sequential order>

Electronic Supplementary Material Table S4 Extracted information on running-related injury studies that had considered distance as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	Per 1.0km ↑	-	-
Buist et al (2008)	RCT	75.0	General	Standard vs. graded (10%) running program (20.8% IIP vs. 20.3% IIP)	OR = 0.6; 95% CI: 0.6-1.3; p = 0.90	-
				212min to injury vs. 167min to injury (45min diff.)	-	-
Kelsey et al (2007)	PC	91.6	SFX	Mean dist. p/w past 12mo (per 10.0km ↑) (♀)	HR = 1.08; 95% CI: 0.81-1.45 (†)	-
Macera et al (1989)	PC	91.6	General	0-15.8 (ref) 16.0-31.8km (♂)	-	-
				0-15.8 (ref) 32.0-47.8km (♂)	-	-
				0-15.8 (ref) 48.0-63.8km (♂)	-	-
				0-15.8 (ref) >64.0km (♂)	OR = 2.9; 95% CI: 1.1-7.5 (†)	Higher dist. ↑ risk

				0-15.8 (ref) 16.0-31.8km (♀)	-	-
				0-15.8 (ref) 32.0-47.8km (♀)	-	-
				0-15.8 (ref) 48.0-63.8km (♀)	-	-
				0-15.8 (ref) >64.0km (♀)	-	-
Nielsen et al (2014b)	PC	91.6	Multiple varied injuries	% change in wk dist. (<10% (ref) 10%-30%)	HR = 1.03; 95% CI: 0.37-2.90; p = 0.96	-
				% change in wk dist. (<10% (ref) >30%)	HR = 1.59; 95% CI: 0.96-2.66; p = 0.07	-
Walter et al (1989)	PC	91.6	General	<16.0 (ref) 16.0-31.8km (♂)	-	-
				<16.0 (ref) 32.0-46.4km (♂)	-	-
				<16.0 (ref) 48.0-62.4km (♂)	-	-
				<16.0 (ref) >64.0km (♂)	RR = 2.22; 95% CI: 1.30-3.68 (†)	Higher dist. ↑ risk
				<16.0 (ref) 16.0-31.8km (♀)	-	-

				<16.0 (ref) 32.0-46.4km (♀)	-	-
				<16.0 (ref) 48.0-62.4km (♀)	-	-
				<16.0 (ref) >64.0km (♀)	RR = 3.42; 95% CI: 1.42-7.85 (†)	Higher dist. ↑ risk
				Longest run per wk >8km (y vs. n) (♂)	RR = 2.49; 95% CI: 1.64-3.71 (†)	Long run >8km ↑ risk
				Longest run per wk >8km (y vs. n) (♀)	RR = 1.78; 95% CI: 0.99-3.13) (†)	-
Hirschmüller et al (2012)	PC	83.3	AT	56.8 vs. 54.3km	-	-
Van Middelkoop et al (2008)	PC	83.3	General	Long dist. training (always)	OR = 0.76: 95% CI: 0.54-1.07; p = 0.12 (†)	-
Wen et al (1997)	PC	81.8	Hamstring	-	OR = 1.11; p = 0.005 (†)	Higher dist. ↑ risk
Hespanhol Junior et al (2013)	PC	75.0	General	Per 1.0km ↑	OR = 1.00; 95% CI: 0.99-1.01; p = 0.920	-

Malisoux et al (2013)	PC	75.0	General	Mean session distance (per 1.0km ↑)	HR = 0.79; 95% CI: 0.73-0.87 (†)	Higher dist. ↓ risk
Reinking et al (2007)	PC	58.3	ERLP	<64.0 (ref) ≥64.0km	RR = 1.44; 95% CI: 0.79-2.62	-
				≥64.0 (ref) <64.0km	RR = 0.69; 95% CI: 0.38-1.27	-
Satterthwaite et al (1999)	PC	58.3	Hamstring	Per 10.0km ↑	OR = 1.07; 95% CI: 1.02-1.13; p <0.008 (†)	Higher dist. ↑ risk
			Knee	Per 10.0km ↓	OR = 1.13; 95% CI: 1.04-1.23; p <0.003 (†)	Lower dist. ↑ risk
Hootman et al (2002)	RC	83.3	General	<32.0 vs. >32.0km	-	-
Warren & Davis	RC	41.6	Multiple varied injuries	-	-	-
Myburgh et al (1990)	CC	50.0	SFX	53.0 vs. 45.0km	-	-

Miller et al (2007)	CC	40.0	ITBFS	38.1 vs. 19.0km	p = 0.06	-
Lloyd et al (1986)	CS 2 group	72.7	General	10.1 vs. 8.7km (timeframe not reported) (♀)	p <0.001	Inj. had a higher dist.
Marti et al (1988b)	CS 2 group	72.7	General	26.3 vs. 22.0km	P <0.001	-
McKean et al (2006)	CS 2 group	72.7	Multiple varied injuries	-	-	-
Rasmussen et al (2013)	CS 2 group	72.7	General	30.0-60.0 (ref) 0.0-30.0km	RR = 2.02; 95% CI: 1.26-3.24; p <0.01 (†)	Lower dist. ↑ risk
				30.0-60.0 (ref) >60.0km	RR = 1.13; 95% CI: 0.45-2.79; p = 0.80 (†)	-
				Longest dist. 6wk prior to marathon (>30.0 (ref) 25.0-30.0km)	RR = 1.18; 95% CI: 0.68-2.08; p = 0.55	-
				Longest dist. 6wk prior to marathon (>30.0 (ref) <25.0km)	RR = 1.27; 95% CI: 0.71-2.26; p = 0.42	-

Gerlach et al (2005)	CS 2 group	63.6	Multiple varied injuries	-	-	-
Jacobs & Berson (1986)	CS 2 group	63.6	General	>~48.3km (~67.0% inj. vs. 48.0%) (histogram)	p <0.001	Higher % of inj. higher dist.
Bennell et al (2004)	CS 2 group	54.5	TSFX	54.2 vs. 48.8km (♀)	p = 0.39	-
Duffey et al (2000)	CS 2 group	54.5	AKP	40.5 vs. 42.6km	-	-
Haglund-Åkerlind et al (1993)	CS 2 group	54.5	AT	106.0 vs. 85.8km	p <0.05	Inj. had a higher dist.
Messier et al (1995)	CS 2 group	54.5	ITBFS	50.3 vs. 42.5km	p = 0.01	Inj. had a higher dist.
Valliant (1981)	CS 2 group	54.5	General	76.4 vs. 47.6km	p <0.01	Inj. had a higher dist.
Grimston et al	CS 2	36.3	SFX	60.7 vs. 57.4km (♀)	-	-

(1991)	group					
Marti & Rehmann (1987)	CS 2 group	36.3	General	Habitual dist. wk (values not reported)	SRC 0.57; p = .000 (†)	Higher dist. ↑ risk
Messier et al (1991)	CS 2 group	36.3	PFPS	33.7 vs. 48.8km	t = 2.82; p <0.008	Inj. had a higher dist.
McCrory et al (1999)	CS 2 group	27.2	AT	52.1 vs. 44.5km	-	-
McQuade (1986)	CS 2 group	27.2	General	32.1 vs. 24.1km	t = 2.44, p <0.02	Inj. had a higher dist.
Messier & Pittala (1988)	CS 3 group	27.2	General	Control = 48km; MTSS = 39km; ITBFS = 46km; PF = 52km	-	-
Knobloch et al (2008)	CS 2 group	27.2	Back	>65.0km (ref not reported)	OR = 2.3; 95% CI: 1.13-4.65; p = 0.019	Higher dist. ↑ risk
Caselli & Longobardi (1997)	CS 2 group	18.1	General	-	r^2 = .92 (histogram)	Inj. had a lower dist.

AT, Achilles tendinopathy; AKP, anterior knee pain; CI, confidence interval; CC, case-control; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; ERLP, exercise-related leg pain; HR, hazard ratio; IIP, injury incidence proportion; ITBFS, iliotibial band friction syndrome; MTSS, medial tibial stress syndrome; OR, odds ratio; PC, prospective cohort; PFPS, patellofemoral pain syndrome; RC, retrospective cohort; RCT, randomised controlled trial; RR, relative risk; SFX, stress fracture; TSFX, tibial stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S5 Extracted information on running-related injury studies that had considered duration as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	Per session (per 1.0min ↑)	HR = 0.99; p = 0.34	-
				Per wk (per 1.0hr ↑)	-	-
Hirschmüller et al (2012)	PC	83.3	AT	Per wk (3.6 vs. 3.4hr)	-	-
Hespanhol Junior et al (2013)	PC	75.0	General	Per session (per 10.0min ↑)	OR = 1.01; 95% CI: 1.00-1.02; p = 0.008 (†)	Higher duration ↑ risk
Malisoux et al (2013)	PC	75.0	General	Per session (per 1.0min ↑)	-	-
Hootman et al (2002)	RC	83.3	General	Weight baring PA/wk (hr); values not reported (♂)	OR = 1.11; 95% CI: 1.06-1.17; p = 0.0001 (†)	Higher duration ↑ risk
				Weight baring PA/wk (hr); values not reported (♀)	-	-

Taunton et al (2002)	RC	50.0	Multiple varied injuries	Per wk (5.0 (ref) <5.0hr) (♂)	-	-
			PFPS	Per wk (5.0 (ref) <5.0hr) (♀)	OR = 0.54; 95% CI: 0.34-0.84 (†)	Lower duration ↓ risk
			Multiple varied injuries	Per wk (5.0 (ref) <5.0hr) (♀)	-	-
Myburgh et al (1990)	CC	50.0	SFX	Per wk (6.0 vs. 5.0hr)	-	-
Chang et al (2012)	CS 2 group	63.6	Hip	Per session (30-60 vs. <30min)	OR = 1.10; 95% CI: 0.38-3.16; p = 0.860 (†)	-
				Per session (>60 vs. <30min)	OR = 0.34; 95% CI: 0.13-0.86; p = 0.020 (†)	Higher duration ↓ risk
			Foot	Per session (30-60 vs. <30min)	OR = 1.43; 95% CI: 0.73-2.83; p = 0.300 (†)	-
				Per session (>60 vs. <30min)	OR = 3.04; 95% CI: 1.47-6.28; p =	Higher duration ↑

		0.003 (†)	risk

AT, Achilles tendinopathy; CC, case-control; CI, confidence interval; CS 2 group, cross-sectional two group comparison; HR, hazard ratio; OR, odds ratio; PC, prospective cohort; PFPS, patellofemoral pain syndrome; RC, retrospective cohort; RCT, randomised controlled trial; RR, relative risk; SFX, stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S6 Extracted information on running-related injury studies that had considered frequency as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	Per 1.0d/wk ↑	-	-
Macera et al (1989)	PC	91.6	General	6.0 or 7.0d/wk (comparator not reported) (♂)	OR = 1.4; 95% CI: 0.8-2.5 (†)	-
				6.0 or 7.0d/wk (comparator not reported) (♀)	OR = 0.5; 95% CI: 0.1-2.1 (†)	-
Walter et al (1989)	PC	91.6	General	0.0-2.0d (ref) 3.0d/wk (♂)	RR = 2.93; 95% CI: 1.27-6.20 (†)	Higher freq. ↑ risk
				0.0-2.0 (ref) 4.0d/wk (♂)	RR = 2.49; 95% CI: 1.08-5.26 (†)	Higher freq. ↑ risk
				0.0-2.0 (ref) 5.0d/wk (♂)	RR = 3.13; 95% CI: 1.38-6.46 (†)	Higher freq. ↑ risk
				0.0-2.0 (ref) 6.0d/wk (♂)	RR = 3.66: 95% CI: 1.62-7.50 (†)	Higher freq. ↑ risk

				0.0-2.0 (ref) 7.0d/wk (♂)	RR = 5.92; 95% CI: 2.49-12.75 (†)	Higher freq. ↑ risk
				0.0-2.0d (ref) 3.0d/wk (♀)	-	-
				0.0-2.0 (ref) 4.0d/wk (♀)	-	-
				0.0-2.0 (ref) 5.0d/wk (♀)	-	-
				0.0-2.0 (ref) 6.0d/wk (♀)	-	-
				0.0-2.0 (ref) 7.0d/wk (♀)	RR = 5.50; 95% CI: 1.44-17.39 (†)	Higher freq. ↑ risk
Hespanhol Junior et al (2013)	PC	75.0	General	Per 1.0d/wk ↑	OR = 1.01; 95% CI: 0.87-1.18; p = 0.856	-
Malisoux et al (2013)	PC	75.0	General	Per 1.0d/wk ↑	-	-
Taunton et al (2003)	PC	66.6	General overall	1.0d/wk (♀)	OR = 3.65; 95% CI: 1.08-12.29 (†)	Lower freq.↑ risk
				1.0d/wk (♂)	-	-

				2.0d/wk	-	-
				3.0d/wk	-	-
				4.0d/wk	-	-
				5.0d/wk	-	-
Satterthwaite et al (1999)	PC	58.3	Front thigh	Per 1d/wk ↑	OR = 1.19; 95% CI: 1.05-1.34; p <0.008 (†)	Higher freq. ↑ risk
Hootman et al (2002)	RC	83.3	General	<6 vs. >6d/wk	-	-
Myburgh et al (1990)	CC	50.0	SFX	-	-	-
Lloyd et al (1986)	CS 2 group	72.7	General	5.1 vs. 4.8d/wk (♀)	-	-
McKean et al (2006)	CS 2 group	72.7	Multiple varied injuries	1.0-3.0 (ref) 4.0-5.0d/wk (<40yr)	OR = 1.32; 95% CI: 1.07-1.62; p = 0.009 (†)	Higher freq. ↑ risk
				1.0-3.0 (ref) >6d/wk (<40yr)	OR = 1.77; 95% CI: 1.25-2.53; p =	Higher freq. ↑

					0.002 (†)	risk
				1.0-3.0 (ref) 4.0-5.0d/wk (>40yr)	-	-
				1.0-3.0 (ref) >6.0d/wk (>40yr)	OR = 2.24; 95% CI: 1.46-3.45; p <0.001 (†)	Higher freq. ↑ risk
Jacobs & Berson (1986)	CS 2 group	63.6	General	>5d/wk (~50% vs. ~32%) (histogram)	p <0.001	Higher % inj.
Haglund-Åkerlind et al (1993)	CS 2 group	54.5	AT	7.9 vs. 7.0d/wk	-	-
Lopes et al (2011)	CS 2 group	54.5	General	3.0d/wk (IQR = 3.0-4.0d/wk vs. 3.0d/wk (IQR = 3.0-4.0d/wk)	p = 0.793	-
Knobloch et al (2008)	CS 2 group	27.2	MTSS	>4.0d/wk (comparator not reported)	OR = 2.3; 95% CI: 1.09-4.96; p = 0.025	>4d/wk ↑ risk

AT, Achilles tendinopathy; CI, confidence interval; CC, case-control; CS 2 group, cross-sectional two group comparison; IQR, interquartile range; MTSS, medial tibial stress syndrome; OR, odds ratio; PC, prospective cohort; RC, retrospective cohort; RCT, randomised controlled trial; RR, relative risk; SFX, stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S7 Extracted information on running-related injury studies that had considered pace and intervals as exposures

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	Per 1.0kph ↑	HR = 0.91; p = 0.29	-
Walter et al (1989)	PC	91.6	General	Usual training pace (values not reported)	-	-
Van Middelkoop et al (2008)	PC	83.3	General	Intervals (always)	OR = 0.76: 95% CI: 0.54-1.07; p = 0.12 (†)	-
Wen et al (1998)	PC	83.3	Shin	% time intervals (inj./weeks accumulated)	RIIR = 14.89; 95% CI: 0.50-147.32; p <0.05 (†)	Interval ↑ risk
Hespanhol Junior et al (2013)	PC	75.0	General	Speed training (per 1.0d/wk ↑)	OR = 1.46; 95% CI: 1.02-2.10; p = 0.039 (†)	Higher freq. ↑ risk
				Interval training (per 1.0d/wk ↑)	OR = 0.61; 95% CI: 0.43-0.88;	Higher freq. ↓ risk

					p = 0.008 (†)	
Malisoux et al (2013)	PC	75.0	General	Per 1.0kph ↑	HR = 0.95; p = 0.48	-
Hootman et al (2002)	RC	83.3	General	Prior 12.0mo (<9:20 (ref) >9:20min/km) (♂)	OR = 0.51; 95% CI: 0.35-0.74; p = <0.001 (†)	Lower pace ↓ risk
				Prior 12.0mo (<9:20 (ref) >9:20min/km) (♀)	-	-
Myburgh et al (1990)	CC	50.0	SFX	"Intensity" (values not reported)	-	-
Miller et al (2007)	CC	40.0	ITBFS	5km time (23.4 vs. 22.9min)	p = .84	-
Wen et al (1997)	CS 2 group	81.8	Shin	% time intervals (0 vs. 1-10 vs. >20)	OR = 55.91; p = 0.04 (†)	Inj. Performed more interval-based training
Lloyd et al (1986)	CS 2 group	72.7	General	5:12 vs. 4:48min/km	-	-
Marti et al (1988b)	CS 2 group	72.7	General	16km time (1:11:01 vs. 1:11:32)	p <0.05	Inj. had a higher pace

Jacobs & Berson (1986)	CS 2 group	63.6	General	<4:54min/km (~55% vs. ~45%) (histogram)	p <0.05	Higher % of inj. had a higher pace
				Interval sessions (values not reported)	-	-
				Sprint training (values not reported)	-	-
Duffey et al (2000)	CS 2 group	54.5	AKP	4:58 vs. 4:58min/km	-	-
Haglund-Åkerlind et al (1993)	CS 2 group	54.5	AT	Intervals (12.3 vs. 10.2km)	-	-
Messier et al (1991)	CS 2 group	54.5	PFPS	5:05 vs. 4:38min/km	-	-
Messier et al (1995)	CS 2 group	54.5	ITBFS	4:54 vs. 5:05min/km	p = 0.05	Inj. had a higher pace
McQuade (1986)	CS 2 group	27.2	General	4:48 vs. 4:48min/km	-	-
Messier & Pittala (1988)	CS 3 group	27.2	MTSS, ITBFS, PF	Control = 4:27; MTSS = 4:28; ITBFS = 4:06; PF = 4:21min/km	-	-

McCrory et al (1999)	CS 2 group	27.2	AT	4:38 vs. 4:52min/km	p <0.05	Inj. had a higher pace

AT, Achilles tendinopathy; CI, confidence interval; CC, case-control; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; ITBFS, iliotibial band friction syndrome; MTSS, medial tibial stress syndrome; OR, odds ratio; PC, prospective cohort; PF, plantar fasciitis; RC, retrospective cohort; RCT, randomised controlled trial; RR, relative risk; SFX, stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S8 Extracted information on running-related injury studies that had considered weight as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Kelsey et al (2007)	PC	91.6	SFX	Per 1.0kg ↓ (♀)	HR = 1.08; 95% CI: 0.99-1.16 (†)	-
Hirschmüller et al (2012)	PC	83.3	AT	73.2 vs. 70.9kg	-	-
Wen et al (1998)	PC	83.3	Foot	Inj./weeks accumulated (values not reported)	RIIR = 0.94; 95% CI: 0.89-0.99; p <0.05 (†)	Heavier ↓ risk
Thijs et al (2011)	PC	58.3	PFPS	70.1 vs. 68.3kg	p = 0.50	-
Van Ginckel et al (2009)	PC	50.0	General	69.8 vs. 69.9kg	p = 0.971	-
Ghani Zadah Hesar et al (2009)	PC	41.6	General	73.1 vs. 69.6kg	OR = 1.35; p = 0.15	-
Taunton et al (2002)	PC	41.6	Multiple varied injuries	60.0 (ref) <60.0kg (♂)	-	-

			PF	60.0 (ref) <60kg (♀)	OR = 0.38; 95% CI: 0.20-0.70 (†)	Lighter ↓ risk
			Multiple varied injuries	60.0 (ref) <60kg (♀)	-	-
Thijs et al (2008)	PC	33.3	PFPS	69.3 vs. 69.3kg	p = 0.98	-
Myburgh et al (1990)	CC	50.0	SFX	59.0 vs. 59.0kg	-	-
Wen et al (1997)	CS 2 group	81.8	Multiple varied injuries	-	-	-
Lloyd et al (1986)	CS 2 group	72.7	General	55.9 vs. 56.4kg	-	-
Marti (1988a)	CS 2 group	72.7	General	-	-	-
Gerlach et al (2005)	CS 2 group	63.6	Multiple varied injuries	-	-	-
Bennell et al (2004)	CS 2 group	54.5	TSFX	63.6 vs. 60.4kg (♀)	p = 0.25	-

Duffey et al (2000)	CS 2 group	54.5	AKP	69.5 vs. 70.2kg	p = 0.05	Inj. were lighter
Haglund-Åkerlind et al (1993)	CS 2 group	54.5	AT	69.7 vs. 68.0kg	-	-
Messier et al (1995)	CS 2 group	54.5	ITBFS	66.4 vs. 70.2kg	-	-
Niemuth et al (2005)	CS 2 group	54.5	Multiple varied injuries	-	-	-
Ribeiro et al (2011a)	CS 3 group	54.5	PF	Current = 78.0; history = 75.4kg; no = 71.9kg	p = 0.24	-
				Current = 57.8; history = 62.0; no = 55.8kg	p = 0.58	-
Ribeiro et al (2011b)	CS 3 group	54.5	PF	Current = 69.6; history = 72.3; no 66.8kg	p = 0.58	-
Valliant (1981)	CS 2 group	54.5	General	71.1 vs. 58.1kg	p <0.001	Inj. were heavier
Grimston et al	CS 2 group	36.3	SFX	55.5 vs. 53.1kg	-	-

(1991)						
McCrory et al (1999)	CS 2 group	27.2	AT	71.4 vs. 70.03kg	-	-

AKP, anterior knee pain; AT, Achilles tendinopathy; CC, case-control; CI, confidence interval; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; HR, hazard ratio; ITBFS, iliotibial band friction syndrome; OR, odds ratio; PC, prospective cohort; PF, planter fasciitis; PFPS, patellofemoral pain syndrome; RIIR, relative injury incidence rate; RR, relative risk; SFX, stress fracture; TSFX, tibial stress fracture; (-), not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S9 Extracted information on running-related injury studies that had considered body mass index as an exposure

Study	Design	Quality (%) (*)	Injury type	Descriptor (comparator (inj. group first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	Per 1.0kg/m^2 ↑	HR = 1.13; 95% CI: 1.03-1.23 (†)	Higher BMI ↑ risk
Macera et al (1989)	PC	91.6	General	26th-74th (ref) <26th percentile (♂)	OR = 1.2; 95% CI: 0.7-1.9 (†)	-
				26th-74th (ref) >74th percentile (♂)	OR = 0.7; 95% CI: 0.5-1.2 (†)	-
				26th-74th (ref) <26th percentile (♀)	OR = 2.0; 95% CI: 0.6-6.6 (†)	-
				26th-74th (ref) >74th percentile (♀)	OR = 3.0; 95% CI: 0.5-18.8 (†)	-
Kelsey et al (2007)	PC	91.6	SFX	Per 1.0kg/m^2 ↓ (♀)	HR = 1.20; 95% CI: 0.90-1.61 (†)	-
Nielsen et al (2013b)	PC	91.6	General	20.0-25.0 (ref) <20.0kg/m^2	cIRD at 500km; 14.1%; 95% CI: -31.6%-3.5%; p = 0.12	-

				20.0-25.0 (ref) 25.0-30.0kg/m^2	cIRD at 500km; 2.7%; 95% CI: -10.2%-15.7%; p = 0.68	-
				20.0-25.0 (ref) >30.0kg/m^2	cIRD at 500km; 10.3%; 95% CI: -3.7%-24.3%; p = 0.15	-
Nielsen et al (2014a)	PC	91.6	General	<30.0 (ref) >30.0kg/m^2 (≤3.0km 1st week)	-	-
				<30.0 (ref) >30.0kg/m^2 (3.0-6.0km 1st week)	cIRD = 14.3%; 95% CI: 3.3%-25.3%; p = 0.01	Higher BMI ↑ risk
				<30.0 (ref) >30.0kg/m^2 (>6.0km 1st week)	cIRD = 16.2%; 95% CI: 4.4%-28.0%; p <0.01	Higher BMI ↑ risk
Bredeweg et al (2013)	PC	83.3	General	24.4 vs. 24.7kg/m^2 (♂)	-	-
				24.3 vs. 23.3kg/m^2 (♀)	-	-
Buist et al (2010b)	PC	83.3	General	Per 1.0kg/m^2 ↑ (♂)	HR = 1.14; 95% CI: 1.05-1.25 (†)	Higher BMI ↑ risk
				Per 1.0kg/m^2 ↑ (♀)	-	-

Hirschmüller et al (2012)	PC	83.3	AT	23.6 vs. 22.9kg/m^2		-
Wen et al (1997)	PC	81.8	Heel	High vs. low (tertiles not reported)	OR = 1.24; p = 0.005 (†)	Higher BMI ↑ risk
Malisoux et al (2013)	PC	75.0	General	Per 1.0kg/m^2 ↑	HR = 1.03; p = 0.510 (†)	-
Kluitenberg et al (2015)	PC	75.0	General	Per 1.0kg/m^2 ↑	HR = 1.04; 95% CI: 1.00-1.07; p = 0.034 (†)	Higher BMI ↑ risk
Bennett et al (2012)	PC	66.6	In-season ERLP	18.5-24.9 (ref) <18.5kg/m^2	OR = 2.4; 95% CI: 0.5-11.1	-
			In-season medial ERLP	18.5-24.9 (ref) <18.5kg/m^2	OR = 1.6; 95% CI: 0.3-9.0	-
Buist et al (2010a)	PC	66.6	General	Per 1.0kg/m^2 ↑ (♂)	HR = 1.02; 95% CI: 0.94-1.11; p = 0.58 (†)	-
				Per 1.0kg/m^2 ↑ (♀)	HR = 1.06; 95% CI: 1.01-1.13; p = 0.028 (†)	Higher BMI ↑ risk

Taunton et al (2003)	PC	66.6	General	<21.0kg/m^2	-	-
				21.0-24.0kg/m^2	-	-
				24.0-26.0kg/m^2	-	-
				>26.0kg/m^2 (♂)	OR = 0.41; 95% CI: 0.21-0.79 (†)	Higher BMI ↓ risk
				<21.0kg/m^2	-	-
				21.0-24.0kg/m^2	-	-
				24.0-26.0kg/m^2	-	-
				>26.0kg/m^2 (♀)	-	-
Thijs et al (2011)	PC	58.3	PFPS	25.4 vs. 24.4kg/m^2	p = 0.20	-
Van Ginckel et al (2009)	PC	50.0	AT	24.9 vs. 24.7kg/m^2	p = 0.84	-

Thijs et al (2008)	PC	33.3	PFPS	24.9 vs. 25.1kg/m^2	p = 0.80	-
Hootman et al (2002)	RC	83.3	General	Prior 12.0mo (<25.0 (ref) >25.0kg/m^2)	-	-
Taunton et al (2002)	RC	50.0	Multiple varied injuries	21.0 (ref) <21.0kg/m^2 (♂)	-	-
			TSFX	21.0 (ref) <21.0kg/m^2 (♀)	OR = 2.43; 95% CI: 0.99-5.94 (†)	-
			Spinal	21.0 (ref) <21.0kg/m^2 (♀)	OR = 4.98; 95% CI: 1.36-18.27 (†)	Lower BMI ↑ risk
			Multiple varied injuries	21.0 (ref) <21.0kg/m^2 (♀)	-	-
Parker et al (2011)	CS 2 group	81.8	General training-related	≥25.0 (ref) <18.5kg/m^2 (♀)	OR = 1.71; 95% CI: 0.37-7.80; p = 0.49 (†)	-
				≥25.0 (ref) 18.5-24.9kg/m^2 (♀)	OR = 1.13; 95% CI: 0.61-2.07; p = 0.71 (†)	-
				≥25.0 (ref) <18.5kg/m^2 (♀)	OR = 2.30; 95% CI: 0.32-16.38; p =	-

					0.41 (†)	
				≥25.0 (ref) 18.5-24.9kg/m^2 (♀)	OR = 1.44; 95% CI: 0.59-3.52; p = 0.42 (†)	-
Rasmussen et al (2013)	CS 2 group	72.7	General	>25.0 vs. <25.0kg/m^2	RR = 0.88; 95% CI: 0.47-1.68; p = 0.70 (†)	-
Gerlach et al (2005)	CS 2 group	63.6	Multiple varied injuries	-	-	-
Bennell et al (2004)	CS 2 group	54.5	TSFX	22.2 vs. 22.1kg/m^2 (♀)	p = 0.91	-
Ribeiro et al (2011a)	CS 3 group	54.5	PF	Current = 25.5; history = 23.3; no = 23.5kg/m^2 (♂)	p = 0.24	-
				Current = 23.4; history = 22.3; no = 21.7kg/m^2 (♀)	p = 0.30	-
Ribeiro et al (2011b)	CS 3 group	54.5	PF	Current = 24.3; history = 23.0; no = 22.5kg/m^2	p = 0.30	-

AT, Achilles tendinopathy; BMI, body mass index; CI, confidence interval; cIRD, cumulative injury risk difference; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; ERLP, exercise-related leg pain; HR, hazard ratio; OR, odds ratio; PC, prospective cohort; PFPS, patellofemoral pain syndrome; RC, retrospective cohort; RCT, randomised controlled trial; RR, relative risk; SFX, stress fracture; TSFX, tibial stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S10 Extracted information on running-related injury studies that had considered diet and hormonal exposures

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Cobb et al (2007)	RCT	75.0	SFX	OC use (y vs. n) (♀)	HR = 0.57; 95% CI: 0.18-1.83 (†)	-
				OC use ≥1 month continued use (y vs. n) (♀)	HR = 0.23; 95% CI: 0.06-0.86 (‡) (†)	OC use ↓ risk
				OC use ≥3 months continued use (y vs. n) (♀)	HR = 0.42; 95% CI: 0.11-1.57 (‡) (†)	-
Kelsey et al (2007)	PC	91.6	SFX	Daily dietary calcium intake (per 100mg ↓) (♀)	HR = 1.11; 95% CI: 0.98-1.25 (†)	-
				Never used OCs (♀)	HR = 2.22; 95% CI: 0.65-7.69 (†)	-
				Total eating disorder inventory score (per	HR = 1.03; 95% CI: 0.86,	-

				5 units) (♀)	1.24 (†)	
				Menarche (per 1.0yr ↓) (♀)	HR = 1.92; 95% CI: 1.15-3.23 (†)	Younger age at menarche ↑ risk
				% body fat (per 5.0% ↓) (♀)	HR = 1.16; 95% CI: 0.71-1.89 (†)	-
				History of menstrual irregularity (<9p/yr) (♀)	HR = 1.90; 95% CI: 0.66-5.51 (†)	-
				Menstrual irregularity in past year (< 9p/yr) (♀)	HR = 1.05; 95% CI: 0.38-2.89 (†)	-
				History of menstrual irregularity (y vs. n)	HR = 3.41; 95% CI: 0.69-16.91 (†)	-
Satterthwaite et al (1999)	PC	58.3	Thigh	Social drinker (y vs. n)	OR = 1.38; 95% CI: 1.01-1.88; p <0.04 (†)	↑ risk if consumes alcohol socially
			Knee	Medication use (y vs. n)	OR = 1.56; 95% CI: 1.02-2.32 (†)	↑ risk if reported using medication

Myburgh et al (1990)	CC	50.0	SFX	OC use (y vs. n) (♀)	p <0.05	Higher % of inj. never used OCs
				Calcium (697 vs. 832mg)	p = 0.02	Higher calcium consumed by non-inj.
				Dairy product intake (9.7 vs. 12.9 portions p/w)	p <0.05	Higher # of dairy products consumed by non-inj.
				Energy intake (7.0 vs. 8.0mj/d)	-	-
				Protein (63 vs. 71gm/d)	-	-
				Fibre (22 vs. 20gm/d)	-	-
				Alcohol (15 vs. 14gm/d)	-	-
				Caffeine (326 vs. 297mg/d)	-	-
				Vitamin D (1.6 vs. 1.7mcg/d)	-	-
				Phosphorous (1166 vs. 1186mg/d)	-	-
				Current menstrual status (irregular vs. normal) (♀)	p <0.005	Higher % of inj. had irregular menstruation

				History of menstrual irregularity & familial osteoporotic fractures (y vs. n) (♀)	-	-
				Yrs of irregular menstruation (4.5 vs. 5.0yrs) (♀)	-	-
				Menarche (13.9 vs. 14.0yr) (♀)	-	-
Lloyd et al (1986)	CS 2 group	72.7	General	OC use (y vs. n) (♀)	p <0.001	Higher % of inj. never used OCs
				OC use (y vs. n) (♀)	p <0.0001 (†)	OC use ↓ risk
				Menstrual history (regular vs. irregular or absent) (♀)	p <0.025	Higher % of inj. had irregular menses
				Menstrual history (regular vs. irregular or absent) (♀)	p <0.029 (†)	Irregular or absent menstruation ↑ risk
				Menarche (12.90 vs. 12.86yr) (♀)	-	-
			SFX	OC use prior 24mo (never used inj. = 29% vs. used inj. = 12%) (♀)	p = 0.04	Higher % of inj. never used OCs

Gerlach et al (2005)	CS 2 group	63.6	General	% body fat (values not reported)	-	-
Henriksson et al (2000)	CS 3 group	63.6	General	Menstrual status (irregular = 34.1d interruption vs. regular = 9d interruption) (♀)	p <0.05	Higher # interrupted days of running in irregular group
Barrow & Saha (1988)	CS 3 group	54.5	SFX	Menses (regular = 29.0% vs. irregular = 39.0% vs. abnormal = 49.0%) (♀)	p <0.05	Higher % of irregular and abnormal menstruation in inj. group
Bennell et al (2004)	CS 2 group	54.5	TSFX	Menarche (13.8 vs. 14.3yr) (♀)	p = 0.35	-
				Number of menses prior 12mo (10.2 vs. 10.3) (♀)	p = 0.65	-
				Menstrual pattern (amen. = 1.1 vs. 0.3; oligo. = 1.1 vs. 1.1; eumen. = 13.4 vs. 14.9yr) (♀)	p = 0.47, p = 0.25, p = 0.58	-
				Menstrual index (mean annual menses since menarche; 8.7 vs. 9.7) (♀)	p = 0.23	-

	Previous OC use (11 vs. 17) (♀)	p = 0.46	-
	Duration of OC use (6.2 vs. 6.4yr) (♀)	p = 0.95	-

CI, confidence interval; CC, case-control; CS 2 group, cross-sectional two group comparison; HR, hazard ratio; OR, odds ratio; PC, prospective cohort; RCT, randomised controlled trial; RR, relative risk; SFX, stress fracture; TSFX, tibial stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S11 Extracted information on running-related injury studies that had considered footwear, insoles, and orthotics as exposures

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	Shoe system (hard sole (ref) soft sole)	HR = 0.92; 95% CI: 0.57-1.48; p = 0.731 (†)	-
Ryan et al (2014)	RCT	66.6	General	IIR per 1000hr (neutral = 3.56 (ref) part minimal = 15.83) (‡)	RR = 3.1%; 95% CI: 1.12% – 8.57%	Part minimal ↑ risk
				IIR per 1000hr (neutral = 3.56 (ref) full minimal = 7.17) (‡)	RR = 1.6%; 95% CI: 0.52%–4.96%	-
				Foot and ankle disability index (neutral vs. part/full minimal)	-	-
Ryan et al (2010)	RCT	50.0	General (VAS rest)	Neutral foot (motion control = 5.1 vs. stability = 1.5 vs. neutral = 0.8) (♀)	p <0.001	Higher pain in motion control
			General (VAS daily living)	Neutral foot (motion control = 10.7 vs. stability = 2.5 vs. neutral = 4.3) (♀)	p <0.001	Higher pain in motion control

			General (VAS run)	Neutral foot (motion control = 15.3 vs. stability = 7.3 vs. neutral = 12.5) (♀)	p <0.001	Higher pain in motion control
			General (VAS rest)	Pronated foot (motion control = 11.1 vs. stability = 2.9 vs. neutral = 4.1) (♀)	p <0.001	Higher pain in motion control
			General (VAS daily living)	Pronated foot (motion control = 12.6 vs. stability = 5.7 vs. neutral = 2.9) (♀)	p <0.001	Higher pain in motion control
			General (VAS run)	Pronated foot (motion control = 19.0 vs. stability = 11.4 vs. neutral = 5.6) (♀)	p <0.001	Higher pain in motion control
			General (VAS rest)	Highly pronated (motion control vs. stability vs. neutral) (♀)	-	-
			General (VAS daily living)	Highly pronated (motion control vs. stability vs. neutral) (♀)	-	-
			General (VAS run)	Highly pronated (motion control vs. stability vs. neutral) (♀)	-	-
Malisoux et al	PC	75.0	General	Footwear rotation (n (ref) y)	HR = 0.61; 95% CI: 0.39-	Shoe rotation ↓ risk

(2013)					0.97 (†)	
Kluitenberg et al (2015)	PC	75.0	General	Shoe condition (used (ref) new)	HR = 1.22; 95% CI: 0.79-1.89; p = 0.371 (†)	-
				Shoe condition (used (ref) other)	HR = 1.84; 95% CI: 0.96-3.52; p = 0.064 (†)	-
				Shoe age (<3 (ref) 3.0-12.0mo)	HR = 1.24; 95% CI: 0.80-1.90; p = 0.337 (†)	-
				Shoe age (<3.0 (ref) >12.0mo)	HR = 1.03; 95% CI: 0.64-1.67; p = 0.901 (†)	-
Taunton et al (2003)	PC	66.6	General overall (**)	Shoe age (1.0-3.0mo) (♂)	-	-
				Shoe age (4.0–6.0mo) (♂)	OR = 0.36; 95% CI: 0.15-0.83 (†)	↓ risk
				Shoe age (7.0-12.0mo) (♂)	-	-
				Shoe age (1.0-2.0yr) (♂)	-	-

				Shoe age (1.0-3.0mo) (♀)	-	-
				Shoe age (4.0–6.0mo) (♀)	OR = 1.74; 95% CI: 1.01-2.98 (†)	↓ risk
				Shoe age (7.0-12.0mo) (♀)	-	-
				Shoe age (1.0-2.0yr) (♀)	-	-
			General new (**)	Shoe age (1.0-3.0mo) (♀)	RR = 0.61; 95% CI: 0.38-0.99 (†)	
Myburgh et al (1990)	CC	50.0	SFX	Footwear age	-	-
Wen et al (1997)	CS 2 group	81.8	General	Footwear use/duration (tertiles not reported)	OR = 0.93; p = 0.042 (†)	Higher duration ↓ risk
				Insole use (y vs. n)	OR = 1.98; p = 0.048 (†)	Insole use ↑ risk
			Foot	Insole use (y vs. n)	OR = 6.85; p = 0.000 (†)	Insole use ↑ risk
			General	Footwear rotation (tertiles not reported)	-	-

McKean et al (2006)	CS 2 group	72.7	Multiple varied injuries	Orthotic use; <40yr (n (ref) y)	OR = 1.91; 95% CI: 1.47-2.49; p = 0.001 (†)	Orthotic use ↑ risk
				Orthotic use; >40yr (n (ref) y)	OR = 1.83; 95% CI: 1.33-2.53; p <0.001 (†)	Orthotic use ↑ risk
Marti (1988a)	CS 2 group	72.7	General	Footwear type (values not reported) (♀)	-	-
Marti et al (1988b)	CS 2 group	72.7	General	Orthotic use (13.8% vs. 7.1%)	p <0.001	Higher % inj. used orthotics
				Footwear brand choice	-	-
Chang et al (2012)	CS 2 group	63.6	Knee	Knee orthotics (y vs. n)	OR = 2.01; 95% CI: 1.31-3.11; p = 0.002 (†)	Orthotic use ↑ risk
				Soft insoles (y vs. n)	OR = 0.70; 95% CI: 0.47-0.92; p = 0.012 (†)	Soft insole use ↓ risk
			Hip	Medial arch support (y vs. n)	OR = 0.31; 95% CI: 0.11-0.86; p = 0.025 (†)	Medial arch support use ↓ risk

			Ankle	Ankle brace (y vs. n)	OR = 3.49; 95% CI: 1.41-8.63; p = 0.007 (†)	Ankle brace use ↑ risk
Duffey et al (2000)	CS 2 group	54.5	AKP	Footwear use (~860km vs. ~1,115km)	p = 0.003	Inj. accumulated a lower distance in running footwear
Messier et al (1991)	CS 2 group	54.5	PFPS	Footwear brand choice	-	-
Messier et al (1995)	CS 2 group	54.5	ITBFS	Footwear use (900.4km vs. 1176km)	-	-

AKP, anterior knee pain; CC, case-control; CI, confidence interval; CS 2 group, cross-sectional two group comparison; HR, hazard ratio; IIR, injury incidence rate; ITBFS, iliotibial band friction syndrome; OR, odds ratio; PC, prospective cohort; PFPS, patellofemoral pain syndrome; RCT, randomised controlled trial; RR, relative risk; SFX, stress fracture; VAS, visual analogue scale; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality); (‡) part minimal and full minimal represent progressively decreasing the thickness, heel height and stiffness of the midsole under the foot; (**) general overall and general new represent whether the participant was currently afflicted with injury or whether the injury was sustained during follow-up; part minimal footwear refers to a medium profile that situates between a barefoot style of running and a fully cushioned shoe

Electronic Supplementary Material Table S12 Extracted information on running-related injury studies that had considered terrain and surface as exposures

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	% of total sessions (hard surface)	HR = 1.00; p = 0.66	-
Kelsey et al (2007)	PC	91.6	SFX	% distance on pavement/concrete (per 5.0% ↓)	HR = 1.05; 95% CI: 0.94-1.18 (†)	-
Macera (1989)	PC	91.6	General	% time spent on concrete (1/3rd (ref) 2/3rd) (♀)	OR = 5.6; 95% CI: 1.1-29.3 (†)	Non-compliant surface ↑ risk
				% time spent on concrete (1/3rd (ref) 2/3rd) (♂)	OR = 1.4; 95% CI: 0.8-2.5 (†)	-
Walter et al (1989)	PC	91.6	General	Terrain and surface (values not reported)	-	-
Hespanhol Junior	PC	75.0	General	Surface; dirt, grass and gravel (ref not	OR = 0.89; 95% CI: 0.71-	-

et al (2013)	reported)	1.11; p = 0.287	
	Surface; asphalt and concrete (ref not reported)	OR = 1.06; 95% CI: 0.86-1.31; p = 0.588 (†)	-
	Surface; sand and synthetic (ref not reported)	OR = 0.25; 95% CI: 0.05-1.25; p = 0.092 (†)	-
	Surface; treadmill (ref not reported)	OR = 1.03; 95% CI: 0.87-1.21; p = 0.745	-
	Terrain; flat (ref not reported)	OR = 0.97; 95% CI: 0.81-1.17; p = 0.773	-
	Terrain; uphill (ref not reported)	OR = 0.53; 95% CI: 0.26-1.08; p = 0.081	-
	Terrain; uphill (ref not reported)	OR = 0.65; 95% CI: 0.38-1.13; p = 0.126 (†)	-
	Terrain; downhill (ref not reported)	OR = 0.09; 95% CI: 0.004-2.08; p = 0.133	-

				Terrain; downhill (ref not reported)	OR = 0.12; 95% CI: 0.01-1.75; p = 0.122 (†)	-
Malisoux et al (2013)	PC	75.0	General	% of total sessions (hard surface)	HR = 0.99; p = 0.48	-
Taunton et al (2003)	PC	66.6	General	% of time on road, trail, grass, treadmill (values not reported)	-	-
Myburgh et al (1990)	CC	50.0	SFX	Surface type (values not reported)	-	-
Wen et al (1997)	CS 2 group	81.8	Thigh	% time concrete (tertiles not reported)	OR = 0.05; p = 0.02 (†)	Lowest time on non-compliant surfaces ↓ risk
			Back	% time concrete (tertiles not reported)	OR = 0.19; p = 0.03 (†)	Lowest time on non-compliant surfaces ↓ risk
Marti (1988a)	CS 2 group	72.7	General	"Usual training terrain" (values not reported)	-	-
Jacobs & Berson	CS 2 group	63.6	General	Surface type (values not reported)	-	-

(1986)						
Duffey et al (2000)	CS 2 group	54.5	AKP	% time on different surfaces (values not reported)	-	-
Haglund-Åkerlind et al (1993)	CS 2 group	54.5	AT	Hills (0.8km vs. 0.7km)	-	-
Messier et al (1991)	CS 2 group	54.5	PFPS	% time on different surfaces (values not reported)	-	-
Messier et al (1995)	CS 2 group	54.5	ITBFS	% time synthetic track (5.4 vs. 1.4)	p = 0.007	Inj. had a higher % training time on track
				% time asphalt (75.9 vs. 74.5)	-	-
				% time dirt (7.2 vs. 9.8)	-	-
Knobloch et al (2008)	CS 2 group	27.2	AT	Asphalt (ref not reported)	OR = 0.47; 95% CI: 0.25-0.89; p = 0.019	Non-compliant surface ↓ risk
				Sand (ref not reported)	OR = 10; 95% CI: 1.12-92.8; p = 0.011	Compliant surface ↑ risk

McCrory et al (1999)	CS 2 group	27.2	AT	% time on different surfaces (values not reported)	-	-
Messier & Pittala (1988)	CS 3 group	27.2	MTSS, ITBFS, PF	Crowned roads, trails and/or hills (% reported in histogram)	-	-
Fonsenca et al (2015)	CS 2 group	18.1	General	Treadmill vs. no treadmill (values not reported)	p = 0.04	Treadmill ↓ inj. prevalence

AKP, anterior knee pain; AT, Achilles tendinopathy; CI, confidence interval; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; ERLP, HR, hazard ratio; ITBFS, iliotibial band friction syndrome; MTSS, medial tibial stress syndrome; OR, odds ratio; PC, prospective cohort; PFPS, patellofemoral pain syndrome; PF, plantar fasciitis; RCT, randomised controlled trial; RR, relative risk; SFX, stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S13 Extracted information on running-related injury studies that had considered stretching, warm-up, and cool-down as exposures

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Van Mechelen et al (1993)	RCT	41.6	General	Stretch, warm-up & cool-down program (ctrl vs. int.)	IIR = 4.9 vs. 5.5 per 1000h; 95% CI: 3.1-7.4 vs. 95% CI: 3.6-8.0	-
Walter et al (1989)	PC	91.6	General	Stretch (always (ref) usually) (♂)	-	-
				Stretch (always (ref) sometimes) (♂)	RR = 1.56; 95% CI: 1.10-2.21 (†)	↑ risk if reported stretching sometimes
				Stretch (always (ref) never) (♂)	-	-
				Stretch (always (ref) usually) (♀)	-	-
				Stretch (always (ref) sometimes) (♀)	-	-

				Stretch (always (ref) never) (♀)	-	-
				Warm up practices (values not reported)	-	-
Van Middelkoop et al (2008)	PC	83.3	General	Warm-up (always)	OR = 0.79; 95% CI: 0.55-1.12; p = 0.18 (†)	-
Van Middelkoop et al (2007)	PC	75.0	General	Cool-down (never (ref) always)	OR = 0.51; 95% CI: 0.21-1.26; p = 0.14 (†)	-
Hootman et al (2002)	RC	83.3	General	Stretch 2d/wk (y vs. n)	-	-
Jacobs & Berson (1986)	CS 2 group	63.6	General	Stretch prior to run (~89% vs. ~79%)	p <0.025	Higher % inj. stretched
Duffey et al (2000)	CS 2 group	54.5	AKP	Stretch (7.0 vs. 5.0min)	p = 0.042	On average, inj. stretched longer
Valliant (1981)	CS 2 group	54.5	General	Prior warm-up routine	-	-
McQuade (1986)	CS 2	27.2	General	Stretch (n (ref) y)	RR = 2.0: 95% CI: 1.07-3.8, p = 0.03	Inj. stretch longer (higher %

	group						of non-stretchers)

AKP, anterior knee pain; CS 2 group, cross-sectional two group comparison; IIR, injury incidence rate; OR, odds ratio; PC, prospective cohort; RC, retrospective cohort; RCT, randomised controlled trial; RR, relative risk; (-) = not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S14 Extracted information on running-related injury studies that had considered psychology as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Nielsen et al (2013b)	PC	91.6	General	TASRI (type B (ref) type A)	cIRD = -11.9%; 95% CI: -23.3%--0.5%; p = 0.04	Type A ↓ risk
Walter et al (1989)	PC	91.6	General	Competitive vs. fitness motive (♂)	RR = 1.73; 95% CI: 1.21-2.49 (†)	Competitive motive to race ↑ risk
				Competitive vs. fitness motive (♀)	-	-
Buist et al (2010b)	PC	83.3	General	JAS; type A vs. type B (♂)	HR = 1.02; 95% CI: 0.99-1.04 (†)	-
				JAS; type A vs. type B (♀)	-	-
Hespanhol Junior et al (2013)	PC	75.0	General	Motivation (y (ref) neutral/impartial)	OR = 1.22; 95% CI: 0.64-2.32; p = 0.554	-
				Motivation (y (ref) poor)	OR = 0.89; 95% CI: 0.35-2.25; p = 0.81	-

Buist et al (2010a)	PC	66.6	General	Motivation (competition (ref) health-oriented) (♂)	HR = 1.49; 95% CI: 0.84-2.66; p = 0.17	-
				Motivation (competition (ref) health-oriented) (♀)	HR = 1.08; 95% CI: 0.70-1.67; p = 0.73	-
Fields et al (1990)	PC	66.6	General	TASRI (>120 vs. <120au)	p <0.049	Higher % inj. type A
Parker et al (2011)	CS 2 group	81.8	General training-related	Self-reported; type A vs. type B (♀)	OR = 2.60; 95% CI: 1.14-5.91; p = 0.02 (†)	Type A ↑ risk
				Self-reported; type AB vs. type B (♀)	OR = 2.78; 95% CI: 1.29-5.98; p = 0.009 (†)	Type AB ↑ risk
			General marathon-related	Training satisfaction (not satisfied (ref) satisfied) (♀)	OR = 1.21; 95% CI: 0.29-5.00; p = 0.79 (†)	-
				Training satisfaction (not satisfied (ref) v. satisfied) (♀)	OR = 0.31; 95% CI: 0.08-1.28; p = 0.10 (†)	-

Marti et al (1988b)	CS 2 group	72.7	General	Competitive motive (32% vs. 24.0%)	p <0.001	Higher % inj. train to race
Valliant (1981)	CS 2 group	54.5	General	Toughminded (6.03 vs. 4.53au)	p <0.01	Inj. were less toughminded
				Forthright (5.2 vs. 3.8au)	p <0.05	Inj. were less forthright
Ekenman et al (2001)	CS 3 group	45.4	TSFX	JAS-S; hard-driving/speed-impatience (24.0 vs. 18.0au) (♀)	p <0.02	Higher sense of impatience ↑ risk
				HALTAM; time pressure (6.2 vs. 5.1) (♀)	p <0.05	Higher sense of time urgency ↑ risk
				CES; exercise dependency (23.0 vs. 11.3) (♀)	p <0.05	Higher conviction to exercise ↑ risk
				HALTAM; hostility	-	-
				HALTAM; anger	-	-
				HALTAM; dominance	-	-

				RIEC; locus of control	-	-
Marti & Rehmann (1987)	CS 2 group	36.3	General	Competitive motive (y vs. n)	SRC .036; p = 0.01 (†)	Competitive motive ↑ risk
				Health-concerned motive (values not reported)	SRC .036; p = 0.01 (†)	Health-related motive ↑ risk

Au, arbitrary unit, HALTAM, heart and lifestyle type A measure; CES, commitment to exercise scale; cIRD, cumulative injury rate difference; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; JAS-S, Jenkins activity survey Swedish modification; HR, hazard ratio; OR, odds ratio; RIEC, Rotter internal-external control scale; RR, relative risk; SRC, standardised regression coefficient; TARSI, type A self-reported inventory; TSFX, tibial stress fracture; (-) = not reported/statistically significant; (†) = adjusted measure of association; ↑ = increase; ↓ = decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S15 Extracted information on running-related injury studies that had considered other modifiable factors as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	Mean session intensity/pace (Borg RPE)	HR = 1.39; 95% CI: 1.04-1.87 (†)	Higher subjective intensities ↑ risk
Bredeweg et al (2012)	RCT	66.6	General	Preconditioning program (IIP = 15.2% [26/171] vs. 16.8% [32/191])	p = 0.69	-
				Preconditioning program (IIR = 31.0 vs. 30.0 per 1000h)	95% CI: 24-38 to 95% CI: 24-37	-
Jakobsen et al (1994)	RCT	41.6	General training-related	Individualised training plans (IIR = 7.4 vs. 6.9 per 1000h)	-	-
			General competition-related	Individualised training plans (IIR = 30.7 vs. 62.5 per 1000h)	p <0.005	Customised program ↓ risk
Van Middelkoop et al (2008)	PC	83.3	General	Daily smoking	OR = 0.25; 95% CI: 0.06-1.07; p = 0.06 (†)	-

Hespanhol Junior et al (2013)	PC	75.0	General	Race participation during follow-up (no (ref) yes)	OR = 0.79; 95% CI: 0.49-1.28; p = 0.33	-
Malisoux et al (2013)	PC	75.0	General	Mean session intensity/pace (Borg RPE)	-	-
Hootman et al (2002)	RC	83.3	General	Prior 12.0mo weight training 2d/wk (y vs. n) (♂)	-	-
				Prior 12.0mo weight training 2d/wk (y vs. n) (♀)	OR = 0.56; 95% CI: 0.32-0.98; p = 0.04 (†)	↓ risk
Parker et al (2011)	CS 2 group	81.8	General training-related	Type of training (other/solo (ref) GTP) (♀)	OR = 1.38; 95% CI: 0.86-2.23; p = 0.18 (†)	-
			General marathon-related	Type of training (other/solo (ref) GTP) (♀)	OR = 2.36; 95% CI: 1.15-4.83; p = 0.02 (†)	Group training ↑ risk
Chang et al (2012)	CS 2 group	63.6	Hip	Race group (10km vs. 42.2km)	OR = 3.02; 95% CI: 1.21-7.54; p = 0.02 (†)	10km ↑ risk
			Ankle	Race group (10km vs. 42.2km)	OR = 1.95; 95% CI: 1.21-3.13;	10km ↑ risk

					p = 0.006 (†)	
				Race group (21.1km vs. 42.2km)	OR = 0.38; 95% CI: 0.21-0.71; p = 0.002 (†)	21.1km ↑ risk
Jacobs & Berson (1986)	CS 2 group	63.6	General	Muscle strengthening exercises (values not reported)	-	-
Haglund-Åkerlind et al (1993)	CS 2 group	54.5	General	Strength training freq. (2.0 vs. 1.4d/wk)	-	-
Knobloch et al (2008)	CS 2 group	27.2	AT	Discipline (1500-3000m; ref not reported)	OR = 2.5; 95% CI: 1.09-5.84; p = 0.026	↑ risk
				Discipline (5km; ref not reported)	OR = 1.8; 95% CI: 1.04-3.18; p = 0.034	↑ risk
				Discipline (half marathon; ref not reported)	OR = 0.5; 95% CI: 0.28-0.92; p = 0.025	↑ risk
			PF	Discipline (marathon; ref not reported)	OR = 0.37; 95% CI: 0.18-0.77; p = 0.006	↓ risk

McQuade (1986)	CS 2 group	27.2	General	Strength training (54.0% vs. 65.0%)	-	-

AT, Achilles tendinopathy; CI, confidence interval; CS 2 group, cross-sectional two group comparison; GTP, group training program; HR, hazard ratio; IIR, injury incidence rate; OR, odds ratio; PC, prospective cohort; PF, plantar fasciitis; RCT, randomised controlled trial; RPE, rate of perceived exertion; RR, relative risk; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S16 Extracted information on running-related injury studies that had considered age as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	Per 1.0yr ↑	-	-
Kelsey et al (2007)	PC	91.6	SFX	Per 1.0yr ↓ (♀)	HR = 1.42; 95% CI: 1.05-1.92 (†)	Lower age ↑ risk
Nielsen et al (2013b)	PC	91.6	General	30.0-45.0 (ref) 18.0-30.0yr	cIRD at 500km; -1.6%; 95% CI: -12.3%-9.2%; p = 0.77	-
				30.0-45.0 (ref) 45.0-65.0yr	cIRD at 500km; 14.7%; 95% CI: -2.1%-31.5%; p = 0.08	-
Bredeweg et al (2013)	PC	83.3	General	42.6 vs. 39.1yr (♂)	-	-
				39.3yr vs. 35.2yr (♀)	-	-
Buist et al (2010b)	PC	83.3	General	Per 1.0yr ↑ (♂)	-	-
Hirschmüller et al (2012)	PC	83.3	AT	48.1 vs. 42.8yr	p = 0.013	-
Wen et al (1998)	PC	83.3	Multiple varied	-	-	-

			injuries			
Malisoux et al (2013)	PC	75.0	General	Per 1.0yr ↑	HR = 0.99; p = 0.428 (†)	-
Kluitenberg et al (2015)	PC	75.0	General	Per 1.0yr ↑	HR = 1.02; 95% CI: 1.00-1.04; p = 0.01 (†)	Higher age ↑ risk
Buist et al (2010a)	PC	66.6	General	Per 10.0yr ↑ (♂)	HR = 0.63; 95% CI: 0.48-0.82; p = 0.001 (†)	Higher age ↓ risk
				Per 10.0yr ↑ (♀)	HR = 0.82; 95% CI: 0.66-1.02; p = 0.07 (†)	-
Satterthwaite et al (1999)	PC	58.3	Front thigh	<25.0 (ref) 25.0-29.0yr	-	-
				<25.0 (ref) 30.0-34.0yr	OR = 1.83; 95% CI: 1.04-3.22 (†)	30.0-34.0yr ↑ risk
				<25.0 (ref) 35.0-39.0yr	-	-
				<25.0 (ref) ≥40.0yr	-	-
			Calf	<25.0 (ref) 25.0-29.0yr	-	-

				<25.0 (ref) 30.0-34.0yr	OR = 0.43; 95% CI: 0.23-0.78 (†)	30.0-34.0yr ↓ risk
				<25.0 (ref) 35.0-39.0yr	-	-
				<25.0 (ref) ≥40.0yr	OR = 0.40; 95% CI: 0.23-0.73 (†)	≥40yr ↓ risk
Taunton et al (2003)	PC	58.3	General overall (‡)	<31.0yr (♂)	-	-
				31.0-37.0yr (♂)	-	-
				38.0-43.0yr (♂)	-	-
				44.0-50.0yr (♂)	-	-
				>50.0yr (♂)	-	-
				>50.0yr (♀)	OR = 1.92; 95% CI: 1.11-3.33 (†)	>50yr ↑ risk
			General new (‡)	<31.0yr (♂)	-	-
				<31.0yr (♀)	RR = 0.58; 95% CI: 0.34-0.97 (†)	<31yr ↓ risk
				31.0-37.0yr	-	-
				38.0-43.0yr	-	-

				44.0-50.0yr	-	-
				>50.0yr	-	-
Thijs et al (2011)	PC	58.3	PFPS	41.6 vs. 37.5yr	p = 0.20	-
Van Ginckel et al (2009)	PC	50.0	AT	38.0 vs. 40.0yr	p = 0.88	-
Ghani Zadah Hesar et al (2009)	PC	41.6	General	40.6 vs. 38.7yr	OR = 1.20; p = 0.39	-
Thijs et al (2008)	PC	33.3	PFPS	39.4 vs. 37.6yr	p = 0.49	-
Hootman et al (2002)	RC	83.3	General	Per 10.0yr ↑ (♂)	OR = 0.83; 95% CI: 0.78-0.88; p = 0.0024 (†)	Higher age ↓ risk
				Per 10.0yr ↑ (♀)	-	-
Taunton et al (2002)	RC	50.0	PFPS	34.0 (ref) <34.0yr (♂)	OR = 1.90; 95% CI: 1.15-3.14 (†)	<34yr ↑ risk
			ITBFS	34.0 (ref) <34.0yr (♂)	OR = 2.77; 95% CI: 1.42-5.39 (†)	-
			PT	34.0 (ref) <34.0yr (♂)	OR = 4.21; 95% CI: 1.97-8.89 (†)	-

			MTSS	34.0 (ref) <34.0yr (♂)	OR = 4.58; 95% CI: 1.77-11.81 (†)	-
			PF	34.0 (ref) <34.0yr (♂)	OR = 0.39; 95% CI: 0.19-0.78 (†)	<34yr ↓ risk
			Meniscal	34.0 (ref) <34.0yr (♂)	OR = 0.22; 95% CI: 0.08-0.57 (†)	-
			AT	34.0 (ref) <34.0yr (♂)	OR = 0.36; 95% CI: 0.16-0.78 (†)	-
			Gluteus medius, SFX, spinal	34.0 (ref) <34.0yr (♂)	-	-
			PFPS	34.0 (ref) <34.0yr (♀)	OR = 2.16; 95% CI: 1.33-3.49 (†)	<34yr ↑ risk
			Meniscal	34.0 (ref) <34.0yr (♀)	OR = 0.44; 95% CI: 0.19-0.97 (†)	<34yr ↓ risk
			Multiple varied injuries	34.0 (ref) <34.0yr (♀)	-	-
Parker et al (2011)	CS 2 group	81.8	General training-related	<25.0 (ref) 25.0-39.0yr (♀)	OR = 1.37; 95% CI: 0.62-3.04; p = 0.44 (†)	-
				<25.0 (ref) 40.0-54.0yr (♀)	OR = 1.25; 95% CI: 0.52-3.02; p = 0.61 (†)	-

				<25.0 (ref) ≥55.0yr (♀)	OR = 0.62; 95% CI: 0.10-3.96; p = 0.61 (†)	-
			General marathon-related	<25.0 (ref) 25.0-39.0yr (♀)	OR = 1.44; 95% CI: 0.47-4.43; p = 0.52 (†)	-
				<25.0 (ref) 40.0-54.0yr (♀)	OR = 0.88; 95% CI: 0.25-3.12; p = 0.84 (†)	-
				<25.0 (ref) ≥55.0yr (♀)	OR = 2.17; 95% CI: 0.18-26.43; p = 0.54 (†)	-
Wen et al (1997)	CS 2 group	81.8	Multiple varied injuries	-	-	-
Lloyd et al (1986)	CS 2 group	72.7	General	33.7 vs. 31.6yr (♀)	-	-
Marti et al (1988b)	CS 2 group	72.7	General	34.8 vs. 35.0yr	-	-
Gerlach et al (2005)	CS 2 group	63.6	Multiple varied injuries	-	-	-
McKelvie & Valliant	CS 2 group	63.3	General	30.2 vs. 36.1yr	p = <0.01	Inj. group were

(1985)						younger
Bennell et al (2004)	CS 2 group	54.5	TSFX	29.4 vs. 30.6yr (♀)	p = 0.63	-
Haglund-Åkerlind et al (1993)	CS 2 group	54.5	AT	26.9 vs. 24.9yr	-	-
Messier et al (1995)	CS 2 group	54.5	ITBFS	33.9 vs. 35.0yr	-	-
Ribeiro et al (2011a)	CS 3 group	54.5	PF	Current = 46.0; history = 40.0; no = 36.0yr (♂)	p = 0.20	-
				Current = 44.0; history = 34.0; no = 38.0yr (♀)	p = 0.19	-
Ribeiro et al (2011b)	CS 3 group	54.5	PF	Current = 44.4; history = 38.3; no = 35.0yr	p = 0.19	-
Ekenman et al (2001)	CS 3 group	45.4	SFX	-	-	-
Grimston et al (1991)	CS 2 group	36.3	SFX	26.9 vs. 32.8yr (♀)	p <0.05	Inj. group were younger

Reinking & Hayes (2006)	CS 2 group	36.3	ERLP	19.3 vs. 19.5yr	-	-
			General	Per 1.0yr ↑ (♀)	HR = 0.84; 95% CI: 0.62-1.13 (†)	-
McCrory et al (1999)	CS 2 group	27.2	AT	38.4 vs. 34.5yr	-	-
McQuade (1986)	CS 2 group	27.2	General	26.7 vs. 25.9yr	-	-

AT, Achilles tendinopathy; CI, confidence interval; cIRD, cumulative injury risk difference; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; ERLP, exercise-related leg pain; HR, hazard ratio; ITBFS, iliotibial band friction syndrome; MTSS, medial tibial stress syndrome; OR, odds ratio; PC, prospective cohort; PFPS, patellofemoral pain syndrome; PF, plantar fasciitis; RC, retrospective cohort; RCT, randomised controlled trial; RR, relative risk; SFX, stress fracture; TSFX, tibial stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality); ‡ general overall and general new represent whether the participant was currently afflicted with injury or whether the injury was sustained during follow-up

Electronic Supplementary Material Table S17 Extracted information on running-related injury studies that had considered sex as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	♂ (ref) ♀	-	-
Nielsen et al (2013b)	PC	91.6	General	♀ (ref) ♂	cIRD at 500km; -4.4%; 95% CI: -15.2%-6.4%; p = 0.42	-
Hirschmüller et al (2012)	PC	83.3	AT	-	-	-
Kluitenberg et al (2015)	PC	75.0	General	♀ (ref) ♂	HR = 1.00; 95% CI: 0.66-1.53; p = 0.99 (†)	-
Malisoux et al (2013)	PC	75.0	General	♂ (ref) ♀	HR = 0.84; p = 0.51	-
Bennett et al (2012)	PC	66.6	In-season ERLP	♂ (ref) ♀	OR = 1.1; 95% CI: 0.3-4.3	-
			In-season medial ERLP	♂ (ref) ♀	OR = 3.6; 95% CI: 0.6-21.8	-

Buist et al (2010a)	PC	66.6	General	♀ (ref) ♂	HR = 1.42; 95% CI: 1.02-1.99; p = 0.04 (†)	♂ ↑ risk
Reinking et al (2007)	PC	58.3	ERLP	-	-	-
Van Ginckel et al (2009)	PC	50.0	AT		-	-
Ghani Zadah Hesar et al (2009)	PC	41.6	General	♂ (ref) ♀	OR = 1.35; p = 0.59	-
McKean et al (2006)	CS 2 group	72.7	Multiple varied injuries	♀ (ref) ♂ (<40yrs group)	OR = 1.28; 95% CI: 1.06-1.54; p = 0.012 (†)	♂ ↑ risk
				♀ (ref) ♂ (>40yrs group)	-	-
Rasmussen et al (2013)	CS 2 group	72.7	General	♀ vs. ♂	RR = 0.77; 95% CI: 0.46-1.31; p = 0.34	-
Jacobs & Berson (1986)	CS 2 group	63.6	General	-	-	-

Lopes et al (2011)	CS 2 group	54.5	General	♂ (ref) ♀	RR = 1.35; 95% CI: 1.05-1.72	♀ ↑ risk
Messier et al (1995)	CS 2 group	54.5	ITBFS	-	-	-
Satterthwaite et al (1999)	CS 2 group	54.5	Hamstring	♀ (ref) ♂	OR = 1.60; 95% CI: 1.04-2.47 (†)	♂ ↑ risk
			Hip	♂ (ref) ♀	OR = 1.88; 95% CI: 1.15-3.06 (†)	♀ ↑ risk
			Calf	♀ (ref) ♂	OR = 1.86; 95% CI: 1.29-2.68 (†)	♂ ↑ risk

AT, Achilles tendinopathy; CI, confidence interval; cIRD, cumulative injury risk difference; CS 2 group, cross-sectional two group comparison; ERLP, exercise-related leg pain; HR, hazard ratio; ITBFS, iliotibial band friction syndrome; OR, odds ratio; PC, prospective cohort; RC, retrospective cohort; RCT, randomised controlled trial; RR, relative risk; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S18 Extracted information on running-related injury studies that had considered height as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Kelsey et al (2007)	PC	91.6	SFX	Per 1.0cm ↓ (♀)	HR = 1.04; 95% CI: 0.96-1.12 (†)	-
Walter et al (1989)	PC	91.6	General	<170.0 (ref) 170.0-179.0cm (♂)	RR = 2.04; 95% CI: 1.15-3.46 (†)	'Average height' ↑ risk
				<170.0 (ref) ≥180.0cm (♂)	RR = 2.30; 95% CI: 1.29-3.90 (†)	'Tall' ↑ risk
				<160.0 (ref) 160.0-169.0cm (♀)	-	-
				<160.0 (ref) ≥180.0cm (♀)	-	-
Hirschmüller et al (2012)	PC	83.3	AT	175.9 vs. 175.5cm	-	-
Thijs et al (2011)	PC	58.3	PFPS	166.0 vs. 167.0cm	p = 0.5	-

Van Ginckel et al (2009)	PC	50.0	General	167.1 vs. 168.3cm	p = 0.65	-
Ghani Zadah Hesar et al (2009)	PC	41.6	General	168.6 vs. 168.4cm	OR = 1.03; p = 0.91	-
Thijs et al (2008)	PC	33.3	PFPS	164.5 vs. 167.4cm	p = 0.57	-
Taunton et al (2002)	RC	50.0	PF	157.0 (ref) <157.0cm (♂)	OR = 5.25; 95% CI: 2.02-13.67 (†)	<157cm ↑ risk
			Multiple varied injuries	157.0 (ref) <157.0cm (♂)	-	-
			PFPS	157.0 (ref) <157.0cm (♀)	OR = 1.61; 95% CI: 1.03-2.52 (†)	<157cm ↑ risk
			Multiple varied injuries	157.0 (ref) <157.0cm (♀)	-	-
Wen et al (1997)	CS 2 group	81.8	Multiple varied injuries	-	-	-

Lloyd et al (1986)	CS 2 group	72.7	General	163.7 vs. 164.2cm (♀)	-	-
Gerlach et al (2005)	CS 2 group	63.6	Multiple varied injuries	-	-	-
Bennell et al (2004)	CS 2 group	54.5	TSFX	169.1 vs. 165.1cm (♀)	p = 0.06	-
Duffey et al (2000)	CS 2 group	54.5	AKP	172.0 vs. 174.0cm	p = 0.03	Inj. group were shorter
Haglund-Åkerlind et al (1993)	CS 2 group	54.5	AT	183.0 vs. 183.0cm	-	-
Messier et al (1995)	CS 2 group	54.5	ITBFS	171.0 vs. 174cm	p <0.03	Inj. group were shorter
Ribeiro et al (2011a)	CS 3 group	54.5	PF	Current = 175.0; history = 166; no = 179.0cm (♂)	p = 0.10	-
				Current = 156.0; history = 176.0; no = 171.0cm (♀)	p = 0.24	-
Ribeiro et al (2011b)	CS 3 group	54.5	PF	Current = 168.0; history = 176.0; no = 171.0cm	p = 0.17	-

Valliant (1981)	CS 2 group	54.5	General	175.3 vs. 167.6cm	p <0.001	Inj. group were taller
Grimston et al (1991)	CS 2 group	36.3	SFX	166.3 vs. 161.1cm	-	-
McCrory et al (1999)	CS 2 group	27.2	AT	174.5 vs. 174.5cm	-	-

AKP, anterior knee pain; AT, Achilles tendinopathy; CI, confidence interval; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; OR, odds ratio; PC, prospective cohort; PF, plantar fasciitis; PFPS, patellofemoral pain syndrome; RC, retrospective cohort; RR, relative risk; SFX, stress fracture; TSFX, tibial stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S19 Extracted information on running-related injury studies that had considered experience as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	Per 1.0yr ↑	HR = 1.00; p = 0.69	-
				Regular runner prior 12mo (1.0 session p/w for 50% of the time)	HR = 0.42; 95% CI: 0.23-0.78 (†)	Regularity ↓ risk
				Competition/wk	HR = 0.85; p = 0.80	-
Kelsey et al (2007)	PC	91.6	SFX	Age started competing (per 1.0yr ↓) (♀)	HR = 1.01; 95% CI: 0.93-1.10 (†)	-
				Total # competitive seasons (per 1.0 unit ↓) (♀)	HR = 1.01; 95% CI: 0.93, 1.10 (†)	-
Macera et al (1989)	PC	91.6	General	3.0-9.0 (ref) 0.0-2.0yr (♂)	OR = 2.2; 95% CI: 1.5-3.3 (†)	Lower exp. ↑ risk
				3.0-9.0 (ref) ≥10.0yr (♂)	OR = 1.2; 95% CI: 0.8-1.9 (†)	-

				3.0-9.0 (ref) 0.0-2.0yr (♀)	OR = 1.4; 95% CI: 0.3-6.4 (†)	-
				3.0-9.0 (ref) ≥10.0yr (♀)	OR = 1.7; 95% CI: 0.5-6.1 (†)	-
Walter et al (1989)	PC	91.6	General	Run yr round (y vs. n) (♂)	RR = 1.64; 95% CI: 1.12-2.35 (†)	Regularity ↑ risk
				Run yr round (y vs. n) (♀)	RR = 2.00; 95% CI: 1.01-3.75 (†)	Regularity ↑ risk
Buist et al (2010b)	PC	83.3	General	Prev. active (axial loading (ref) non-axial load) (♂)	HR = 2.02; 95% CI: 1.00-4.05 (†)	Non-axial loading ↑ risk
				Prev. active (axial loading (ref) never) (♂)	HR = 1.23; 95% CI: 0.54-2.78 (†)	-
				Prev. active (axial loading (ref) non-axial load) (♀)	-	-
				Previously active; axial loading (ref) never (♀)	-	-
Hirschmüller et al	PC	83.3	AT	12.7 vs. 9.3yr	-	-

(2012)						
Wen et al (1998)	PC	83.3	General	High exp. (values not reported)	RIIR = 1.88; 95% CI: 1.16-3.05; p <0.05 (†)	Higher exp. ↑ risk
			Foot	High exp. (values not reported)	RIIR = 1.09; 95% CI: 1.03-1.15; p <0.05 (†)	Higher exp. ↑ risk
Hespanhol Junior et al (2013)	PC	75.0	General	Per 1.0yr ↑	OR = 0.99; 95% CI: 0.94-1.03; p = 0.601	-
Kluitenberg et al (2015)	PC	75.0	General	Exp. <12mo (y (ref) n)	HR = 2.38; 95% CI: 1.24-4.57; p = 0.009 (†)	Lower exp. ↑ risk
				Exp. <12mo (y (ref) >12mo)	HR = 1.41; 95% CI: 0.75-2.63; p = 0.28 (†)	-
				Prev. active (axial loading (ref) never)	HR = 1.18; 95% CI: 0.80-1.74; p = 0.42 (†)	-
				Prev. active (axial loading (ref) non-axial)	HR = 1.19; 95% CI: 0.77-1.86; p = 0.44 (†)	-

Malisoux et al (2013)	PC	75.0	General	Per 1.0yr ↑	HR = 0.99; p = 0.86	-
				Half-marathon participation prior 12mo (n (ref) y)	-	-
				Competitions (% of total volume)	-	-
Van Middelkoop et al (2007)	PC	75.0	General	3.0-10.0 (ref) 0.0-2.0yr	OR = 0.79; 95% CI: 0.31-2.01; p = 0.62 (†)	-
				3.0-10.0 (ref) ≥10.0yr	OR = 0.40; 95% CI: 0.12-1.30; p = .13 (†)	-
				# races (0.0-3.0 (ref) 4.0-7.0yr)	OR = 0.97; 95% CI: 0.23-4.05; p = 0.97 (†)	-
				# races (0.0-3.0 (ref) ≥8.0yr)	OR = 0.65; 95% CI: 0.15-2.91; p = 0.58 (†)	-
				# races prior 12mo (0.0-2.0 (ref) 3.0-6.0)	OR = 0.63; 95% CI: 0.13-3.10; p = 0.57 (†)	-

				# races prior 12mo (0-2 (ref) ≥7.0)	OR = 0.59; 95% CI: 0.13-2.59; p = 0.48 (†)	-
				Races of 0.0-5.0km (no (ref) yes)	OR = 2.61; 95% CI: 0.22-30.71; p = 0.45 (†)	-
Buist et al (2010a)	PC	66.6	General	Current participation (ref) restarted running (♂)	HR = 2.24; 95% CI: 1.13-4.45; p = 0.02 (†)	Resuming activities ↑ risk
				Current participation (ref) no exp. (♂)	HR = 2.61; 95% CI: 1.23-5.53; p = 0.012 (†)	No exp. ↑ risk
				Prev. active (axial loading (ref) prev. active non-axial loading) (♂)	HR = 0.88; 95% CI: 0.41-1.93; p = 0.76 (†)	-
				Prev. active (axial loading (ref) not previously active) (♂)	HR = 1.08; 95% CI: 0.57-2.04; p = 0.81 (†)	-
				Current participation (ref) restarted running (♀)	HR = 1.15; 95% CI: 0.65-2.02; p = 0.63 (†)	-
				Current participation (ref) no experience	HR = 2.14; 95% CI: 1.24-3.70;	No exp. ↑ risk

				(♀)	p = 0.007 (†)	
				Prev. active (axial loading (ref) prev. active non-axial loading) (♀)	HR = 1.85; 95% CI: 1.07-3.21; p = 0.029 (†)	Non-axial loading ↑ risk
				Prev. active (axial loading (ref) not prev. active) (♀)	HR = 1.53; 95% CI: 0.88-2.66; p = 0.130 (†)	-
Reinking et al (2007)	PC	58.3	ERLP	Yrs collegiate running (1^{st}-2^{nd} (ref) 3^{rd}-4^{th}) (quartiles of years running)	RR = 1.74; 95% CI: 0.81-3.73	-
Satterthwaite et al (1999)	PC	58.3	Hamstring	Debut marathon (y vs. n)	OR = 1.55; 95% CI: 1.08-2.22; p <0.02 (†)	Lower exp. ↑ risk
			Knee	Debut marathon (y vs. n)	OR = 1.66; 95% CI: 1.16-2.38; p <0.005 (†)	Lower exp. ↑ risk
Hootman et al (2002)	RC	83.3	General	# races prior 12.0mo (>3.0 vs. <3.0) (♂)	OR = 1.03; 95% CI: 1.00-1.06; p = 0.04 (†)	Higher # races ↑ risk
				# races prior 12.0mo (>3.0 vs. <3.0) (♀)	OR = 1.18; 95% CI: 1.07-1.31; p <0.001 (†)	Higher # races ↑ risk

Taunton et al (2002)	RC	50.0	MTSS	8.5 (ref) <8.5yr (♂)	OR = 3.53; 95% CI: 1.28-9.75 (†)	Lower exp. ↑ risk
			Multiple varied injuries	8.5 (ref) <8.5yr (♂)	-	-
			MTSS	8.5 (ref) <8.5yr (♀)	OR = 2.50; 95% CI: 1.07-5.82 (†)	Lower exp. ↑ risk
			Multiple varied injuries	8.5yr (ref) <8.5yr (♀)	-	-
Myburgh et al (1990)	CC	50.0	SFX	# competitions (values not reported)	-	-
				3.0 vs. 3.0yr	-	-
Miller et al (2007)	CC	40.0	ITBFS	Current mileage (6.0 vs. 6.3mo)	p = 0.87	-
Parker et al (2011)	CS 2 group	81.8	General training-related	Prev. marathon exp. (n (ref) y) (♀)	OR = 0.63; 95% CI: 0.38-1.04; p = 0.07 (†)	-
			General	Prev. marathon exp. (n (ref) y) (♀)	OR = 0.70; 95% CI: 0.35-1.40;	-

			marathon-related		p = 0.31 (†)	
Wen et al (1997)	CS 2 group	81.8	Hip	Least exp. (tertiles not reported)	OR = 0.17; p = 0.03 (†)	Lower exp. ↓ risk
				Most exp. (tertiles not reported)	OR = 0.24, P = 0.07 (†)	Higher exp. ↓ risk
Lloyd et al (1986)	CS 2 group	72.7	General	5.6 vs. 4.0yr (♀)	p <0.009	Inj. group had a higher exp.
				5.6 vs. 4.0yr (♀)	p <0.0013 (†)	Inj. group had a higher exp.
				Age started (27.8 vs. 27.6yr) (♀)	-	-
Marti et al (1988b)	CS 2 group	72.7	General	7.0 vs. 6.8yr	-	-
McKean et al (2006)	CS 2 group	72.7	Multiple varied injuries	-	-	-
Rasmussen et al	CS 2	72.7	General	Prev. marathon exp. (y vs. n)	RR = 0.60; 95% CI: 0.37-0.95;	Higher exp. ↓ risk

(2013)	group				p = 0.03 (†)	
Jacobs & Berson (1986)	CS 2 group	63.6	General	Overall exp. (values not reported)	-	-
				Prev. marathon participation (values not reported)	-	-
				>10 races prior 12mo (~35% vs. ~25%)	p <0.025	Higher % of the inj. group raced
Bennell et al (2004)	CS 2 group	54.5	TSFX	Yrs >20km p/w (8.2 vs. 6.7yr) (♀)	p = 0.13	-
Duffey et al (2000)	CS 2 group	54.5	AKP	9.6 vs. 9.6yr	-	-
Haglund-Åkerlind et al (1993)	CS 2 group	54.5	AT	8.9 vs. 5.2yr	p <0.01	Inj. group had a higher exp.
				Personal best (800m & 1500m)	-	-
Lopes et al (2011)	CS 2	54.5	General	45.0 vs. 36.0mo	P <0.001	Higher exp. ↑ risk

	group					
Messier et al (1995)	CS 2 group	54.5	ITBFS	7.8 vs. 10.6yr	p = 0.003	Inj. group had a lower exp.
Niemuth et al (2005)	CS 2 group	54.5	Multiple varied injuries	-	-	-
Grimston et al (1991)	CS 2 group	36.3	SFX	7.2 vs. 6.6yr (♀)	-	-
Messier et al (1991)	CS 2 group	36.3	PFPS	8.6 vs. 8.4yr	-	-
Reinking & Hayes (2006)	CS 2 group	36.3	ERLP	6.0 vs. 5.8yr	-	-
Knobloch et al (2008)	CS 2 group	27.2	Back	>10yr (ref not reported)	OR = 3.3; 95% CI: 1.16-4.57; p = 0.01	Higher exp. ↑ risk
			AT	>10yr (ref not reported)	OR = 1.6; 95% CI: 1.02-2.76; p = 0.04	Higher exp. ↑ risk

McCrory et al (1999)	CS 2 group	27.2	AT	11.9 vs. 9.6yr	p <0.05	Inj. group had a higher exp.
McQuade (1986)	CS 2 group	27.2	General	6.3 vs. 4.6yr	-	-
Messier & Pittala (1988)	CS 3 group	27.2	MTSS, ITBFS, PF	Control = 8yr; MTSS = 4yr; ITBFS = 5yr; PF = 7yr	-	-

AKP, anterior knee pain; AT, Achilles tendinopathy; CC, case-control; CI, confidence interval; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; ERLP, exercise-related leg pain; Exp, experience; HR, hazard ratio; ITBFS, iliotibial band friction syndrome; MTSS, medial tibial stress syndrome; OR, odds ratio; PC, prospective cohort; PFPS, patellofemoral pain syndrome; PF, plantar fasciitis; RC, retrospective cohort; RCT, randomised controlled trial; RR, relative risk; SFX, stress fracture; TSFX, tibial stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S20 Extracted information on running-related injury studies that had considered previous injury as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Theisen et al (2013)	RCT	91.6	General	Prior 12mo (n (ref) y)	HR = 1.74; 95% CI: 1.03-2.90 (†)	Previous injury ↑ risk
Kelsey et al (2007)	PC	91.6	SFX	History of ≥1.0 prior SFX (♀)	HR = 6.42; 95% CI: 1.80-22.87 (†)	Previous injury ↑ risk
Macera et al (1989)	PC	91.6	General	Prior 12.0mo (y vs. n) (♂)	OR = 2.7; 95% CI: 2.6-2.7 (†)	Previous injury ↑ risk
				Prior 12.0mo (y vs. n) (♀)	OR = 1.9; 95% CI: 0.7-4.9 (†)	-
Nielsen et al (2013b)	PC	91.6	General	Prev. inj. (n (ref) y)	cIRD at 500km; 5.2%; 95% CI: -8.9%-19.3%; p = 0.47	-
				Prev. non running-related inj. (n (ref) y)	cIRD at 500km; 11.1%; 95% CI: -0.2%-22.4%; p = 0.05	Previous injury ↑ risk
Walter et al (1989)	PC	91.6	General	Prior 12.0mo (y vs. n) (♂)	RR = 1.69; 95% CI: 1.27-2.25 (†)	Previous injury

						↑ risk
				Prior 12.0mo (y vs. n) (♀)	RR = 2.35; 95% CI: 1.33-4.07 (†)	-
Buist et al (2010b)	PC	83.3	General	never (ref) >3.0-≤12.0mo (♂)	HR = 2.64; 95% CI: 1.32-5.30 (†)	Previous injury ↑ risk
				never (ref) >12.0mo (♂)	HR = 2.14; 95% CI:1.05-4.35 (†)	Previous injury ↑ risk
				never (ref) >3.0-≤12mo (♀)	-	-
				never (ref) >12.0mo (♀)	-	-
Hirschmüller et al (2012)	PC	83.3	AT	Prev. Inj. Achilles (y vs. n)	OR = 3.8; 95% CI: 1.7-8.5; p = 0.001 (†)	Previous injury ↑ risk
Van Middelkoop et al (2008)	PC	83.3	General	Prior 12.0mo (y vs. n)	OR = 2.62; 95% CI: 1.82-3.78 (†)	Previous injury ↑ risk
Wen et al (1998)	PC	83.3	General	Prev. inj. (inj./weeks accumulated)	RIIR = 2.01; 95% CI: 1.27-3.21; p <0.05 (†)	Previous injury ↑ risk

			Shin	Prev. inj. (inj./weeks accumulated)	RIIR = 7.2; 95% CI: 2.40-21.82; p <0.05 (†)	Previous injury ↑ risk
Hespanhol Junior et al (2013)	PC	75.0	General	Total # (n (ref) y)	OR = 1.88; 95% CI: 1.01-3.51; p = 0.046 (†)	Previous injury ↑ risk
Kluitenberg et al (2015)	PC	75.0	General	Prev. musculoskeletal complaints (no (ref) yes, not attributable to sports)	HR = 1.78; 95% CI: 1.26-2.53; p = 0.001 (†)	Previous injury ↑ risk
				Prev. musculoskeletal complaints (no (ref) yes, attributable to sports)	HR = 1.19; 95% CI: 0.80-1.77; p = 0.400 (†)	-
				Prev. inj. (n (ref) y)	HR = 1.29; 95% CI: 0.75-2.22; p = 0.36 (†)	-
Malisoux et al (2013)	PC	75.0	General	Prior 12mo (n (ref) y)	HR = 1.72; 95% CI: 1.11-2.66 (†)	Previous injury ↑ risk
Van Middelkoop et al (2007)	PC	75.0	General	Prior 12.0mo (n (ref) y) (♂)	OR = 1.41; 95% CI: 0.48-4.09; p = 0.53 (†)	-
				Inj. at baseline (n (ref) y)	OR = 1.62; 95% CI: 0.61-4.33; p	-

					= 0.34 (†)	
Bennett et al (2012)	PC	66.6	In-season ERLP	ERLP prior 12.0mo	OR = 12.3; 95% CI: 3.1-48.9 (†)	Previous injury ↑ risk
			In-season medial ERLP	ERLP prior 1.0mo	OR = 10.3; 95% CI: 1.7-61.9 (†)	Previous injury ↑ risk
Buist et al (2010a)	PC	66.6	General	never (ref) <1.0yr (♂)	HR = 0.66; 95% CI: 0.34-1.31; p = 0.24	-
				never (ref) ≥1.0yr (♂)	HR = 0.98; 95% CI: 0.57-1.69; p = 0.94	-
				never (ref) <1.0yr (♀)	HR = 1.29; 95% CI: 0.81-2.05; p = 0.28	-
				never (ref) ≥1.0yr (♀)	HR = 0.86; 95% CI: 0.52-1.43; p = 0.57	-
Reinking et al (2007)	PC	58.3	ERLP	ERLP history (y (ref) n)	RR = 2.34; 95% CI: 1.01-5.42	Previous injury ↑ risk

Hootman et al (2002)	RC	83.3	General	Prior 12.0mo (y vs. n) (♂)	OR = 2.09; 95% CI: 1.63-2.68; p <0.001 (†)	Previous injury ↑ risk
				Prior 12.0mo (y vs. n) (♀)	OR = 2.81; 95% CI: 1.68-4.71; p <0.001 (†)	Previous injury ↑ risk
Taunton et al (2002)	RC	50.0	Multiple varied injuries	Prev. inj. same anatomical location	-	-
Parker et al (2011)	CS 2 group	81.8	General training-related	Prior 12.0mo (no (ref) mild) (♀)	OR = 3.54; 95% CI: 1.90-6.61; p <0.001 (†)	Previous injury ↑ risk
				Prior 12.0mo (no (ref) severe) (♀)	OR = 5.08; 95% CI: 2.95-8.73; p <0.001 (†)	Previous injury ↑ risk
			General marathon-related	Inj. during training (no (ref) mild) (♀)	OR = 3.79; 95% CI: 1.60-9.01; p = 0.003 (†)	Previous injury ↑ risk
				Inj. during training (no (ref) severe) (♀)	OR = 7.09; 95% CI: 3.30-15.25; p <0.001 (†)	Previous injury ↑ risk

Marti (1988a)	CS 2 group	72.7	General	-	p <0.05	Higher % inj. prev. inj.
Marti et al (1988b)	CS 2 group	72.7	General	20.8% vs. 12.7%	P <0.001	Higher % inj. prev. inj.
Rasmussen et al (2013)	CS 2 group	72.7	General	Prior 12mo (y vs. n)	RR = 2.23; 95% CI: 1.41-3.52; p <0.01 (†)	Previous injury ↑ risk

AT, Achilles tendinopathy; CI, confidence interval; cIRD, cumulative injury risk difference; CS 2 group, cross-sectional two group comparison; ERLP, exercise-related leg pain; HR, hazard ratio; OR, odds ratio; PC, prospective cohort; RCT, randomised controlled trial; RR, relative risk; RIIR, relative injury incidence rate; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S21 Extracted information on running-related injury studies that had considered biomedical factors as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Kelsey et al (2007)	PC	91.6	SFX	BMC whole body (per SD 293.2g ↓) (♀)	HR = 2.70; 95% CI: 1.26-5.88 (†)	Lower whole-body BMC ↑ risk
				BMC hip (per SD 5.78g ↓) (♀)	RR = 1.69; 95% CI: 0.95-2.94 (†)	-
				BMD hip (per SD 0.12g.cm^{-2} ↓) (♀)	RR = 1.45; 95% CI: 0.81-2.56 (†)	-
Hirschmüller et al (2012)	PC	83.3	AT	Neovascularisation	OR = 6.9; 95% CI: 2.6-18.8; p <0.001 (†)	Higher intratendinous micro-vessels ↑ risk
				Hyper/hypoechogenicity	p = 0.988	-
				Maximum tendon thickness	-	-
				Spindle-shaped thickening	-	-
Satterthwaite et al (1999)	PC	58.3	Calf	Illness prior to race (y vs. n)	OR = 1.42; 95% CI: 1.03-1.95; p <0.03 (†)	↑ risk

Myburgh et al (1990)	CC	50.0	SFX	BMD lumbar spine (1.01 vs. 1.11gm/cm^2)	p = 0.02	Inj. had lower BMD
				BMD proximal femur (0.93 vs. 0.13gm/cm^2)	p = 0.02	Inj. had lower BMD
				BMD femoral neck (0.83 vs. 0.89gm/cm^2)	p = 0.005	Inj. had lower BMD
				BMD trochanter (0.69 vs. 0.75gm/cm^2)	p = 0.01	Inj. had lower BMD
				BMD ward triangle (0.67 vs. 0.73gm/cm^2)	p = 0.01	Inj. had lower BMD
Bennell et al (2004)	CS 2 group	54.5	TSFX	BMD lumbar spine [L1-L4] (1.053 vs. 1.039gm/cm^2) (♀)	p = 0.54	-
				BMD total hip (1.144 vs. 1.098gm/cm^2) (♀)	p = 0.81	-
				BMD femoral neck (0.938 vs. 0.922gm/cm^2) (♀)	p = 0.77	-
				BMD trochanter (0.825 vs. 0.801gm/cm^2) (♀)	p = 0.65	-
				BMD tibia; region [R1] isolated marker (1.216 vs. 1.152gm/cm^2) (♀)	p = 0.57	-
				BMD tibia; region [R2] entire distal third (0.929 vs.	p = 0.57	-

				0.879gm/cm^2) (♀)		
				Anterior-posterior tibial width (2.32 vs. 2.32) (♀)	p = 0.91	-
				Medio-lateral tibial width (2.21 vs. 2.17) (♀)	p = 0.42	-
				Total cross-sectional tibial area (3.63 vs. 3.51cm^2) (♀)	p = 0.28	-
				Cortical area of tibia (3.07 vs. 2.94cm^2) (♀)	p = 0.19	-
Grimston et al (1991)	CS 2 group	36.3	SFX	BMD lumbar spine (0.92 vs. 0.85gm/cm^2) (♀)	p <0.05	Inj. had higher BMD
				BMD femoral neck (0.85 vs. 0.79gm/cm^2) (♀)	p <0.05	-
				BMD tibial diaphysis (18.67 vs. 17.02gm/cm^2) (♀)	-	-

AT, Achilles tendinopathy; BMC, bone mineral content; BMD, bone mineral density; CI, confidence interval; CS 2 group, cross-sectional two group comparison; CS 3 group, cross-sectional three group comparison; OR, odds ratio; PC, prospective cohort; RCT, randomised controlled trial; RR, relative risk; RRI, running-related injury; SFX, stress fracture; TSFX, tibial stress fracture; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)

Electronic Supplementary Material Table S22 Extracted information on running-related injury studies that had considered other non-modifiable factors as an exposure

Study	Design	Quality (%) (*)	Injury type	Exposure categories (inj. first)	Estimate, 95% CI, and p-value	Interpretation
Van Middelkoop et al (2008)	PC	83.3	General	High education	OR = 0.76; 95% CI: 0.55-1.07; p = 0.11 (†)	-
Lloyd et al (1986)	CS 2 group	72.7	General	# children (0.40 vs. 0.49)	-	-
Gerlach et al (2005)	CS 2 group	63.6	General	VO_{2max} (values not reported)	-	-
Jacobs & Berson (1986)	CS 2 group	63.6	General	Marital status, education, occupation, income (values not reported)	-	-
Marti & Rehmann (1987)	CS 2 group	36.3	General	Endurance capacity (values not reported)	SRC -.064; p = 0.002	Higher fitness ↓ risk
				Fitness level (low vs. medium vs. high)	-	-

CI, confidence interval; CS 2 group, cross-sectional two group comparison; HR, hazard ratio; OR, odds ratio; PC, prospective cohort; RR, relative risk; SRC, standardised regression coefficient; VO2max, maximal oxygen uptake per minute; (-) not reported/statistically significant; (†), adjusted measure of association; ↑, increase; ↓, decrease; (*), methodological quality score (higher numbers indicate superior quality)