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SYSTEMATIC REVIEW

IS THERE EVIDENCE FOR AN ASSOCIATION BETWEEN CHANGES IN TRAINING LOAD AND RUNNING-RELATED INJURIES? A SYSTEMATIC REVIEW

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ABSTRACT

Background: Sudden changes (increases and decreases) in training load have been suggested to play a key role in the development of running-related injuries. However, the compiled evidence for an association between change in training load and running-related injury does not exist.

Purpose: The purpose of the present systematic review was to compile the evidence from original articles examining the association between changes in training load and running-related injuries.

Study Design: Systematic review.

Methods: Four databases (Pubmed/Medline, SPORTDiscus, Embase, and Scopus) were systematically searched. Two reviewers screened titles, abstracts, and full-text articles independently. Articles were included if i) the study design was a randomized trial, a prospective cohort study, a cross-sectional study or a case-control study, ii) participants were runners between 18-65 years, and iii) specific information on changes in training load was provided. Methodological quality of included articles was assessed using the Newcastle Ottawa Scale and the PEDro rating scale.

Results: Four articles fulfilled the eligibility criteria of which three found an association between increases in training load and an increased risk of running-related injuries: This association was shown by an increased injury risk amongst runners: i) if they recently had performed one or more changes in either velocity and/or distance and/or frequency compared with the non-injured runners (p = 0.037), ii) increasing their average weekly running distance by more than 30% compared to an increase less than 10% (Hazard Ratio = 1.59 (95% Confidence Interval: 0.96; 2.66)), iii) increasing their total running distance significantly more the week before the injury origin compared with other weeks (mean difference: 86%; 95% Confidence Interval: 12%; 159%, p = 0.026). However, no difference was found between a 10% and a 24% average increase in weekly volume (HR = 0.8, 95% CI: 0.6; 1.3).

Conclusion: Very limited evidence exists supporting that a sudden change in training load is associated with increased risk of running-related injury.

Level of evidence: 2

Keywords: Etiology, running-related injuries, training load.

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Conflicts of interest
None of the authors have any conflicts of interest, including relevant financial interests, activities, relationships, and affiliations.

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INTRODUCTION

Unravelling the etiology of running-related injury (RRI) has received extensive scientific attention throughout the past decades. A vast number of different risk factors for injury have been proposed, such as foot strike patterns, age, gender, body mass index (BMI), anthropometrics, footwear properties and anatomical factors, with absence of clear support for many of them.[1] A history of previous injury is consistently reported in the literature as a strong risk factor for injury development; however, owing to its non-modifiable nature, the relevance of including it as a factor in an effective injury prevention intervention strategy is minor. Conversely, focusing on readily modifiable and causal plausible factors, such as scheduling of training load, has been suggested to have greater impact on RRI development.

Therefore, investigation of the role of training load as the main exposure of interest is essential to succeed with developing effective injury prevention strategies. Within sports injury research, the phenomenon "training too much, too soon", or a sudden increase in training load, has been acknowledged to play a key role on injury development.[2-8] This phenomenon also seems to resonate within RRI research,[9,10] and furthermore, is being highlighted by runners and coaches as especially important in relation to injury development.[11] From a theoretical viewpoint, injury occurs when the cumulative training load, over one or several running sessions exceeds the body's load capacity for adaptive tissue repair;[2,9] training load comprises several variables (e.g. running distance, number of steps or strides, running pace or speed, and time spent running). Consequently, running data should be analyzed using changes in training load between each running session (or short period of time), as training load continuously changes over time and therefore should be considered as a time-dependent variable.[12] This approach seems more appropriate to illuminate RRI etiology compared with examining running data as fixed, absolute, weekly mean values, or with investigating non-training-related risk factors for injury that simply identify sub-populations at higher or lower risk of injury.

In a previous systematic review[13] aiming to investigate the association between training characteristic (i.e. volume, duration, intensity, and frequency of running) and RRI, training error in a specific training characteristic could not be identified. However, considerations about sudden changes in the training load were not considered as a potential injury mechanism.[2-7,14] With the current high focus on sudden changes in training load, as well as the use of more complex statistical approaches in sports medicine,[12] new evidence might be available. Therefore, the purpose of the present systematic review was to compile the evidence from original articles examining the association between changes in training load and running-related injuries.

METHODS

Literature Search

The first and the second author (CD and SG) performed an electronic literature search in four databases (Pubmed/Medline, SPORTDiscus, Embase, Scopus) from their inception to April 31st 2017. Database limits were set to published articles or articles in press written in English. A certified research librarian at Aarhus University Library, Denmark supervised the building of the search string through using the PICOS approach.[15] The complete search strategy for all four databases are provided in Appendix 1.

Study selection

All articles were systematically and independently screened for eligibility by three reviewers (CD, SG and LM). All titles and abstracts were screened by CD and SG, and eligible articles retrieved in full text were carefully read by CD and LM. To be eligible for inclusion, the articles had to fulfill the following criteria:

Inclusion criteria:

1) The research of interest was specifically focused on changes in training load in relation to RRI;
2) the study design was a randomized trial, a prospective cohort study, a cross-sectional study or a case-control study;
3) the study participants were between the age of 18 and 65 years;
4) participants were runners (novice runners, recreational runners, elite runners, distance

runners, long-distance runners, road runners, trail runners, marathoners, ultra-marathon runners, extreme runners, track athletes, cross-country runners or orienteers);

Exclusion criteria:

1) running was not the participants' primary sport activity, e.g. football players, soccer players;

2) the RRI was not a musculoskeletal injury (i.e. blisters, skin abrasions, delayed onset muscle soreness or superficial bruises;

3) study subjects were military or army recruits;

In cases of disagreements between the reviewers regarding inclusion or exclusion of an article, a consensus meeting was held and if no consensus was reached, a fourth reviewer (RON) made the final decision.

Quality Assessment

The methodological quality assessment of the included full text articles was performed by three authors (CD, SG and LM) in an independent and blinded manner. The Newcastle Ottawa Scale (NOS) was chosen for assessing the quality of the included non-randomized studies due to its previous use within RRI.[16,17] Furthermore, the NOS is reported as one of two most useful tools by the Cochrane Handbook for Systematic Reviews of Interventions and allows customization to the review question of interest.[18] The original NOS contains 11 criteria designed to assess the risk of bias, and uses a star rating system to indicate the quality of a study. The 11 criteria are as follows: 1) description of runners or type of runners; 2) definition of the running-related injury; 3) representativeness of the exposed cohort; 4) selection of the non-exposed cohort; 5) ascertainment of exposure; 6) demonstration that outcome of interest was not present at the start of the study; 7) comparability of cohorts on the basis of the design or analysis; 8) assessment of outcome; 9) was follow-up long enough for outcomes to occur; 10) adequacy of follow-up of cohorts; and 11) statistic measurement of risk association.

The highest possible quality score in the original version is 12 stars (it is possible to award Criterion 7 with two stars). However, the tool was modified for the present review by excluding two of the 11 criteria; Criterion 4 was excluded because an exposed versus non-exposed cohort was irrelevant as long as the total study population was exposed to running, and Criterion 7 was excluded because it was linked to Criterion 4 comparing the exposed with the non-exposed cohort. These modifications decreased the highest possible quality score to 9 stars.

The methodological quality of the included, randomized trial was rated using the PEDro rating scale, which is based on the Delphi list developed by Verhagen and colleagues.[19] The PEDro scale also contains 11 criteria to assess the risk of bias, which are as follows: 1) eligibility criteria were specified; 2) participants were randomly allocated to groups; 3) allocation was concealed; 4) groups were similar at baseline; 5) blinding of all participants; 6) blinding of all therapists who administered the intervention; 7) blinding of all assessors who measured at least one key outcome; 8) measures of at least one key outcome were obtained for more than 85% of participants initially allocated to groups; 9) data for at least one key outcome was analyzed by "intention-to-treat"; 10) results of between-group statistical comparisons reported for at least one key outcome; 11) study provided both point measures and measures of variability for at least one key outcome. In a recently published study by Yamato et al. 2017,[20] the use of the PEDro scale demonstrated both high validity and inter-rater reliability when compared to the Cochrane back and neck risk of bias tool.[21]

The total methodological quality of each included article was expressed in percent by calculating the number of criteria being fulfilled divided by the total number of possible ratings. All disagreements between the researchers in relation to the methodological quality assessment were resolved by a consensus meeting between the assessors (CD, SG, LM).

Data Extraction

Two authors (CD and LM) independently extracted the following information and data from the included studies; 1) first author and date, 2) injury type, 3) definition of exposure, 4) specification of exposure and 5) results. In case of any doubts about the extracted data, a meeting was held between the three authors (RON, CD, LM) to clarify the accuracy of the data. The interpretation of results included the proportion of injured and non-injured runners, the mean difference between them, measures of associations, and the corresponding level of statistical significance.

RESULTS

Literature Search

A total of 8,242 articles were identified through searching the four databases. Of those, 2,399 were duplicates, leaving 5,843 articles for screening of the title and abstract.

Primary screening resulted in exclusion of 5,779 articles, leaving 64 articles eligible for full assessment one of which was not available in full text. While assessing the remaining 63 full texts in accordance with the eligibility criteria, the reference list within each article were screened to identify potential new articles that were not found in the primary literature search. By this process, two additional articles were identified as eligible, and thus included in the assessment of full text articles. Out of the total 65 articles assessed in full text, 61 were excluded primarily due to no available information about changes in training load. The remaining four articles were included in the quality assessment. The selection process of the literature is presented in the PRISMA diagram (Figure 1).

Description of the included articles

In Table 1, the included studies are described according to: 1) year of publication; 2) country of origin; 3) study design; 4) study population; 5) sample size of participants; 6) baseline characteristics including injury history; 7) the collection method for the running data; 8) the collection method for the injury status; 9) injury definition. In three studies, all participants were injury free prior to baseline,[10,22,23] whereas in one study, a group of injured runners was compared to a group of non-injured runners.[24] In the study by Cantidio et al.[24] the proportion of runners who reported recent variations in one or more of the running variables among the two groups (the injured and the non-injured runners) was presented, whereas no result for statistical comparison was provided. Therefore, as all data were available to run a Chi-square test this was performed by the present authors in order to compare the two proportions.

Risk of Bias Assessment

Information on potential risk of bias for the included studies is shown in Table 2. Among the non-randomized studies, [23,24] the most frequent reasons for decreased quality scores were: low external validity, a follow-up period shorter than 12 weeks, and lack of reporting a measure of association, while the risk of bias was more related to the absence of blinding procedures in the included randomized trial.[22]

Changes in Training Load and RRI

An overview of the existing evidence for the association between a change in training load and RRI is presented in Table 3. Overall, a tendency toward an increased injury risk following a sudden increase in training load was identified in three out of the four studies included[10,23,24]. Cantidio et al.[24] (22% methodological quality assessment score) showed that a significantly higher proportion of the injured runners had recently changed one or more of the running variables (velocity, distance, volume or frequency) compared with the non-injured runners ($p = 0.037$). In Nielsen et al.[23] (67% methodological quality assessment score), two different analyses related to an increase in running distance were reported. First, the runners who developed an injury during follow-up had increased their average weekly running distance with $31.6 \pm 3.1\%$, while the average for the runners that stayed injury free was $22.1 \pm 2.1\%$ ($p = 0.07$). Second, the mean difference between the increase in the running distance the week before the onset of an injury and the average weekly increase during other weeks was found to be 86% (95% confidence interval (95% CI): 12.9; 159.9, $p = 0.026$). In the other study by Nielsen et al.[10] (100% methodological quality assessment score), an increased Hazard Ratio (HR) = 1.59 (95% CI: 0.96; 2.66) for distance-related injuries (i.e. patellofemoral pain, iliotibial band syndrome, medial tibial stress syndrome, gluteus medius injury, greater trochanteric bursitis, injury to the tensor fascia latae and patellar tendinopathy) was found when increasing the weekly running distance by more than 30% compared to a less than 10% change (increase or decrease)

In contrast with the three studies above, the randomized trial by Buist et al.[22] (73% methodological

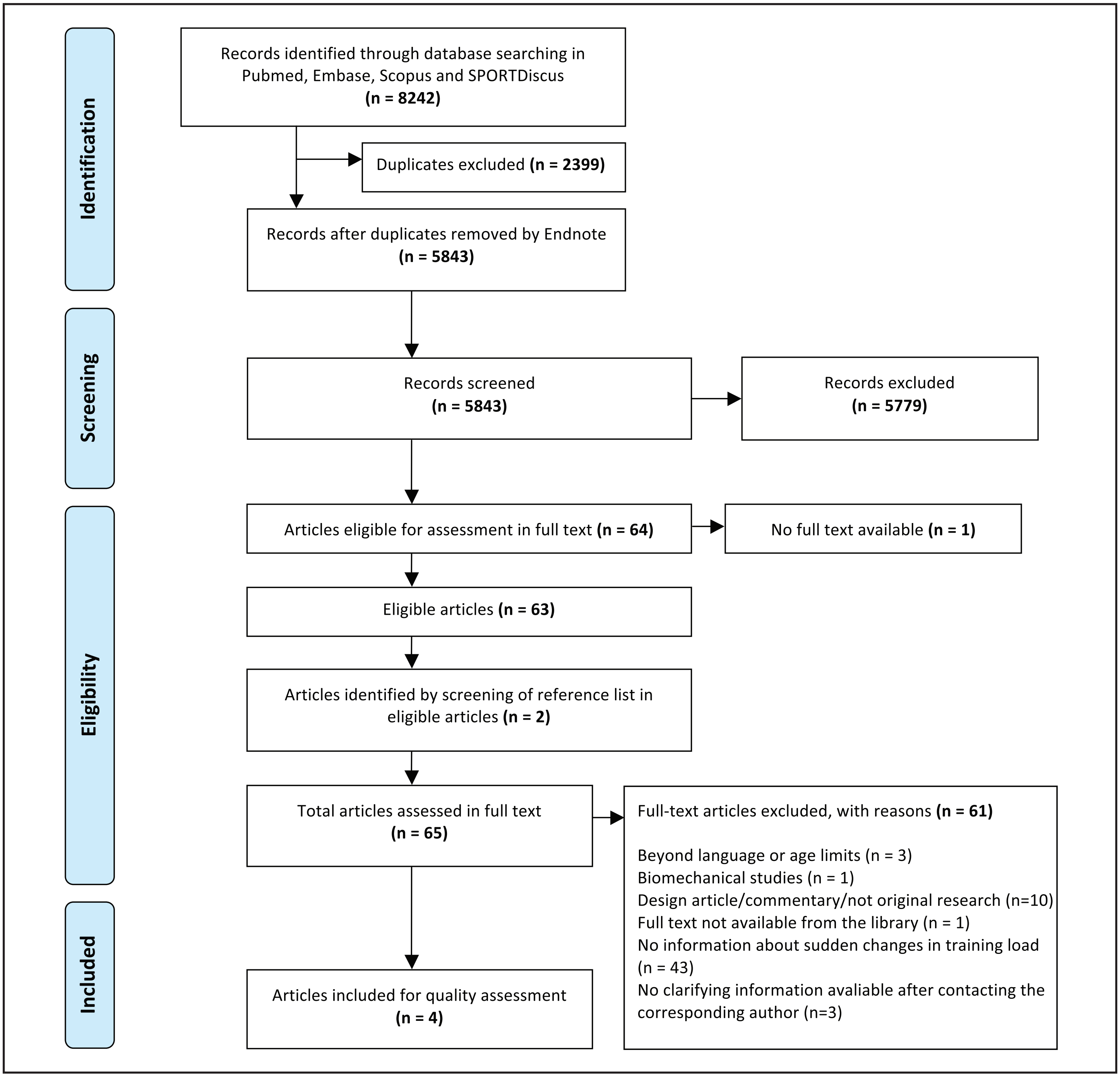

Figure 1. *The PRISMA diagram visualizing the selection process of articles for the present systematic review.*

quality assessment score) found that the novice runners who followed the graded training program characterized by a 10% average increase in weekly volume were not at a lower injury risk (HR= 0.8, 95% CI: 0.6; 1.3) when compared to the novice runners who followed the standard training program (24% average increase in weekly volume).

DISCUSSION

Main Findings

The aim of the present systematic review was to search the literature for articles examining the association between changes (progressions and regressions) in training load and RRI. Four articles were included and of these, three studies found an

Table 1.

References, Country of origin	Study design (follow-up)	Study population	Baseline characteristics	Data collection method	Musculoskeletal injury definition
Buist et al. 2008[22], The Netherlands	Randomized Controlled Trial (8 and 13 weeks for the standard and the graded training group, respectively)	532 novice runners (306 females). No running history the previous 12 months	Age range 18–65 years. No injury of the lower extremity within the preceding 3 months	Internet-based running log for both main exposure and outcome	Any self-reported running-related musculoskeletal pain of the lower extremity or back causing a restriction of running for at least 1 week (three scheduled trainings)
Cantidio Ferreira et al. 2012 [24], Brazil	Cross-sectional study	100 leisure-time runners (27 females). Running history: minimum 3 months. Weekly frequency: 3-4 times. Mean distance per session: 5-7 kilometers	Age range 18-60 years with no history of previous trauma in lower limbs	Information about recently training variations and injury status was covered using a questionnaire	Injury, pain or aggravation which had limited or prohibited participation of the athletes in training and/or competitions for one or more days in the prior 6 months
Nielsen et al. 2013[23], Denmark	Prospective study (10 weeks)	58 novice runners (28 females). Running history: below 10 kilometers in total in all training sessions in the previous 12 months	Healthy novice runners age range 18–65 years with no injury in the lower extremities or back 3 months preceding baseline investigation	GPS watch data uploaded on an internet-based training diary and examination of injured runners by a physiotherapist	Any musculoskeletal complaint of the lower extremity or back causing a restriction of running for at least 1 week
Nielsen et al. 2014[10], Denmark	Prospective study (1 year)	873 novice runners (432 females). Running history: below 10 kilometers in total in all training sessions in the previous 12 months	Healthy novice runners age range 18–65 years with no injury in the lower extremities or back 3 months preceding baseline investigation	GPS watch data uploaded on an internet-based training diary and examination of injured runners by a physiotherapist	Any musculoskeletal complaint of the lower extremity or back causing a restriction of running for at least 1 week

Table 2.

Newcastle Ottawa Scale (Adapted)

References	*Study design*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Total*	*%*
Cantidio Ferreira et al., 2012[24]	CS	*	*	0	0	0	0	0	0	0	2/9	22%
Nielsen et al., 2013[23]	PC	*	*	0	*	*	*	0	*	0	6/9	67%
Nielsen et al., 2014[10]	PC	*	*	*	*	*	*	*	*	*	9/9	100%

Pedro Scale

References	*Study design*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*Total*	*%*
Buist et al, 2008[22]	RCT	*	*	*	*	0	0	0	*	*	*	*	8/11	73%

increased risk of injury development following either a sudden increase in running distance between two weeks [10,23], or a non-specific recent change in one or more of the training variables velocity, distance, volume or frequency during the past weeks (no available data on the timing of this sudden change)[24]. In contrast, in the fourth included study, Buist et al.[22], found no difference was found in injury risk when comparing two intervention groups (a graded training program with 10% average increase in weekly volume vs. a standard training program with 24% average increase in weekly volume). Thus, very limited evidence exists supporting that sudden changes are associated with increased injury risk among runners. As it may be plausible to assume that excessive progression in training load is associated with

Table 3. *Results.*

Reference	Study population	Injury	Definition of exposure	Specification of exposure	Outcome
Buist 2008[22]	532 novice runners (306 females). No running history the previous 12 months	Overall RRI	Increase in weekly volume on average (%)	GTG: 10% increase in volume STG : 24% increase in volume	Incidence of RRI: GTG: 20.8% STG: 20.3% (p-value: 0.9) HR: 0.8 [0.6; 1.3][a]
Cantidio Ferreira 2012[24]	100 leisure-time runners (27 females). Running history: minimum 3 months. Weekly frequency: 3-4 times. Mean distance per session: 5-7 kilometers	Overall RRI	Recent training variation	Variation in velocity, distance, volume or frequency during the past couples of weeks	Recent training variation: Injured group: 52.5% Non-injured group: 31.7% p-value: 0.037[b]
Nielsen 2013[23]	58 novice runners (28 females). Running history: below 10 kilometers in total in all training sessions in the previous 12 months	Overall RRI	Increase in running distance (%)	Average weekly progression in running distance (%)	Injured: 31.6±3.1% Injury free: 22.1±2.1% p-value: 0.07[c]
				Progression the week before the onset of the injury *versus* weekly progression in the other weeks	Mean difference: 86% [12.9; 159.9%] p-value: 0.026[d]
Nielsen 2014[10]	873 novice runners (432 females). Running history: below 10 kilometers in total in all training sessions in the previous 12 months	Overall RRI	Weekly progression in running distance (%)	<10% (ref) 10% - 30% >30%	1 (Ref) HR: 0.99 [0.55; 1.82] [a] p-value: 0.99 HR: 1.17 [0.84; 1.63] [a] p-value: 0.36
		Distance-related injuries		<10% (ref) 10% - 30% >30%	1 (Ref) HR: 1.03 [0.37; 2.90] [a] p-value: 0.96 HR: 1.59 [0.96; 2.66] [a] p-value: 0.07
		Pace-related injuries		<10% (ref) 10% - 30% >30%	1 (Ref) HR: 0.91 [0.32; 2.63] [a] p-value: 0.86 HR: 0.83 [0.44; 1.57] [a] p-value: 0.56

RRI: Running-related injuries as defined in table 1; GTG: Graded Training Group; STG: Standard Training Group; HR: Hazard Ratio [and its 95% confidence interval]; Ref: Reference group; a Cox regression analysis; bChi-square test; ct-test; dpaired t-test.

increased injury risk, it is emphasized that future studies are highly needed to better define the role of sudden changes on RRI occurrence in a causal perspective.[25]

Study Quality Aassessment

The overall methodological quality of the studies included in the present systematic review is varied. The study populations and RRI were accurately defined in all four studies, but failure to report measures of association, short follow-up periods, and lack of generalizability were observed in two of the prospective cohort studies.[23,24] Also, the randomized trial did not include any blinding procedure.[22]

Definition of Change

In the articles in the current systematic review a change was defined as the change in running distance or running volume from one week to another, or more specifically, as "a recent change in one or more training variables". Several other definitions have been used within the body of sports injury research such as the "acute:chronic workload ratio"[26] or a rolling average seven days prior to the injury.[27] Other ways of understanding, defining and analyzing the role of changes in training load have been proposed including non-linear relationships in terms of U-shaped patterns,[13] exponentially weighted moving averages[28] or the role of sudden sharp spikes of training load in the training regime.[5,26]

Independent of the way changes have been defined and the statistical approaches used, the main scientific aim is to shed light upon: What defines a change? Which magnitude of sudden changes has clinical relevance in relation to injury risk? Despite the substantial attention that these questions have paid, no clear consensus has been reached yet.[29]

This demonstrates the need for identifying which definition of change(s) appears to have the strongest association with injury development in order to explore if one definition turns out to be more relevant compared to others, bearing in mind that one definition might be clinically relevant for a specific sports discipline or population while less valuable in another contexts.

Defining an Upper Limit for Sudden Increases

When examined from a practical and clinical perspective, the results from the present systematic review reveal that no evidence exists for the use of the so-called "10% rule", which is commonly used by runners, coaches and clinicians as a guideline for a maximum increase in training load per week.[30] Buist et al. 2008[22] compared injury risk based on an average increase in weekly volume of 10% and 24%, but did not find any difference between the two groups. An average weekly increase in training load of 24% may not be sufficiently large to reflect the mechanism of running too much, too soon in novice runners. This interpretation is in accordance with the findings by Nielsen et al.[10] who found that the injurious mechanism of sudden increase happened for the novice runners increasing their average weekly distance more than 30% compared with the reference group increasing less than 10% while no difference was found for the group increasing by 10%-29% compared with the reference group. However, it should be noted that in the study by Buist et al.,[22] an average increase in weekly volume was used (13 weeks and eight weeks for the study group increasing 10% and 24%, respectively). In the study by Nielsen et al.,[10] the examination of the association between training characteristics and RRI focused on the comparison between one week and the next, but multiple changes over time were not accounted for. In the study by Cantidio et al.[24] a higher proportion of runners with recent training changes were found among the injured group compared to the non-injured group. However, it was neither specified to which extend nor direction the training load changed, and thus, it is not possible to quantify the size of a potentially injurious sudden change in training load based on the results. Therefore, based on the four included studies, no evidence was found to support a well-defined threshold for hazardous sudden changes in training load above which the risk of injury development is significantly increased. Such a threshold might be specific to the definition and the method used to assess sudden changes, and above all, to the population of runners investigated. Given that the absolute training load was low in the populations investigated so far (e.g. total distance over a full year period less than 10 kilometers), a small increase in training load might result in a large relative sudden increase (e.g. increasing from 2 to 3 km per week represents an absolute difference of 1 km but a relative sudden increase of 50%). These runners' profiles cannot be compared to other populations of runners with larger training load (e.g. a competitive runner running 100 km per week would only observe a 3% sudden increase in training load with an absolute increase of 3 km from one week to the next, and he would have to increase training load by 50 km per week to observe a 50% sudden change).

Limitations

The main limitations of the present study include: 1) the number of relevant databases that were searched: 2) the screening of articles for eligibility and 3) the limited generalizability of the findings. Regarding the databases the four largest (Pubmed/

Medline, SPORTDiscus, Embase, Scopus) and most relevant for the specific research question in the present systematic review were searched. However, other databases such as PEDro and Web of Science could also have been relevant. In relation to the screening of articles for provision of information about changes in training load, this was performed on an abstract level in order to screen out articles just reporting the difference in injury risk between different subgroups of runners having performed a different weekly average. However, it is unknown if some articles deemed ineligible at this stage may have contained information about training load and injury that would have been evident if evaluated in full-text. Considering the generalizability of the findings, this is an important issue to address as all the studies included in the present systematic review only involved "novice" and "amateur" runners, which limits the applicability of the findings to other populations of runners. Finally, due to the heterogeneity observed in the study designs, the runners' profiles, as well as the methods used for data collection and analysis of changes in training load, comparison of the results of the four included studies in the present systematic review must be performed with caution.

CONCLUSIONS

Very limited evidence exists supporting that changes (increases and decreases) in training load are associated with injury development. Specifically, no evidence was found to support the use of the so-called "10% rule", which is commonly used by runners, coaches and clinicians as a guideline for a maximum increases in training load per week. Actually, a well-defined threshold for hazardous or sudden changes in training load above which the risk of injury development is significantly increased is still unknown. Future studies in runners of varied abilities are needed to better define the role of changes on RRI occurrence in a causal perspective using methodological approaches that take into account the time-varying nature of changes in training load.

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APPENDIX 1

SEARCH TERMS FOR PUBMED

(running[Majr] OR running)

AND

(exercise OR exposure OR "Exercise Therapy"[MeSH] OR "physical education and training/methods"[MeSH] OR "Healthy People Programs"[MeSH] OR (training method) OR regime OR program OR programme OR marathon OR training OR (training characteristics) OR (running patterns) OR volume OR intensity OR frequency OR speed OR pace OR distance OR mileage OR (number of strides) OR (number of steps) OR duration OR (number of running sessions) OR (cumulated stress) OR cadence OR (time spent running) OR progression* OR change OR alterations OR transition*)

AND

("Athletic Injuries"[MeSH] OR "running/injuries"[MeSH] OR injury OR (running injur*) OR (running-related injur*) OR injur* OR (overuse injur*)) OR "patellofemoral pain syndrome"[MeSH] OR "compartment syndromes"[MeSH] OR "iliotibial band syndrome"[MeSH] OR inflammation OR (cartilage injuries) OR tendin* OR fractur* OR fasciitis OR bursitis OR splint* OR tear* OR sprain* OR strain* OR entrapment* OR rupture* OR split* OR tenosynovitis)

NOT

("addresses"[Publication Type] OR "bibliography"[Publication Type] OR "biography"[Publication Type] OR "case reports"[Publication Type] OR "clinical conference"[Publication Type] OR "comment"[Publication Type] OR "congresses"[Publication Type] OR "dictionary"[Publication Type] OR "directory"[Publication Type] OR "editorial"[Publication Type] OR "festschrift"[Publication Type] OR "government publications"[Publication Type] OR "interview"[Publication Type] OR "lectures"[Publication Type] OR "legal cases"[Publication Type] OR "legislation"[Publication Type] OR "letter"[Publication Type] OR "news"[Publication Type] OR "newspaper article"[Publication Type] OR "retracted publication"[Publication Type] OR "retraction of publication"[Publication Type] OR "review"[Publication Type] OR "scientific integrity review"[Publication Type] OR "technical report"[Publication Type] OR "twin study"[Publication Type] OR "validation studies"[Publication Type] OR football OR basketball OR triathlon OR pregnancy OR rugby OR soccer OR rheumatoid* OR baseball OR military OR army OR combat OR animal* OR mice OR (case series) OR hockey OR rats)

SEARCH TERMS FOR SPORTDISCUS

(DE ‘RUNNING’ OR running)

AND

(exercise OR exposure OR DE “Exercise Therapy” OR DE “physical education” OR DE “PHYSICAL training & conditioning” OR DE “PHYSICAL activity” OR (training method) OR regim* OR program OR programme OR marathon OR training OR (training characteristics) OR (running patterns) OR volume OR intensity OR frequency OR pace OR distance OR mileage OR (number of strides) OR (number of steps) OR duration OR (number of running sessions) OR (cumulated stress) OR cadence OR (time spent running) OR progression* OR change OR alterations OR transition*)

AND

(DE ‘SPORTS injuries’ OR DE “RUNNING injuries” OR DE “OVERUSE injuries” OR OR DE “PLICA syndrome” OR DE “COMPARTMENT syndrome” OR DE “ILIOTIBIAL band syndrome” OR injury OR (running injur*) OR (running-related injur*) OR injur* OR inflammation OR (cartilage injuries) OR tendin* OR fractur* OR fasciitis OR bursitis OR splint* OR tear* OR sprain* OR strain* OR entrapment* OR rupture* OR split* OR tenosynovitis)

APPENDIX 1 (continued)

NOT

(football OR basketball OR triathlon OR 'pregnancy' OR rugby OR soccer OR rheumatoid* OR baseball OR military OR animal* OR mice OR (case reports) OR (case series) OR hockey OR rats)

SEARCH TERMS FOR EMBASE

('running'/exp OR running)

AND

(exercise OR exposure OR 'kinesiotherapy'/exp OR 'training'/exp OR 'health promotion'/exp OR (training method) OR regim* OR program OR programme OR marathon OR training OR (training characteristics) OR (running patterns) OR volume OR intensity OR frequency OR pace OR distance OR mileage OR (number of strides) OR (number of steps) OR duration OR (number of running sessions) OR (cumulated stress) OR cadence OR (time spent running) OR progression* OR change OR alterations OR transition*)

AND

('sport injury'/exp OR 'patellofemoral pain syndrome'/exp OR 'iliotibial band friction syndrome'/exp OR 'compartment syndrome'/exp OR injury OR (running injur*) OR (running-related injur*) OR injur* OR inflammation OR (cartilage injuries) OR tendin* OR fractur* OR fasciitis OR bursitis OR splint* OR tear* OR sprain* OR strain* OR entrapment* OR rupture* OR split* OR tenosynovitis)

NOT

(football OR basketball OR triathlon OR pregnancy OR rugby OR soccer OR rheumatoid* OR baseball OR military OR army OR combat OR animal* OR mice OR (case series) OR (case report) OR (cross sectional) OR hockey OR rats)

SEARCH TERMS FOR SCOPUS

running

AND

exercise OR training method OR program

AND

injury OR sports injuries