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Title page

Title	**Physical activity as prevention of sports injuries – a systematic review and meta-analysis of randomized, controlled trials**
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Abstract

Background

Physical activity is important in both prevention and treatment of some of the most sizable conditions of our time, but sports injuries can pose serious problems besides impeding individuals in performing physical activity. As sports injuries are seldom easily managed, prevention of these is of great interest.

Objective

To determine whether preventive physical activity can reduce sports injuries in humans and perform stratified analyses of exposures and outcomes.

Design

Systematic review and meta-analysis.

Data sources

PubMed, Embase, Web of Science, and SPORTDiscus were searched to January 2013. Four blocks of keywords for prevention, diagnoses, sports, and randomized controlled trials were used with no publication date restrictions and yielded 3462 results.

Methods

Injury was defined according to the F-MARC consensus statement, broadened to physical activity and relevant randomized, controlled trials on sports injury prevention by different forms of physical activity were included. Article selection and quality assessments were conducted by two

independent authors and in case of insufficient reporting, efforts were made to contact the corresponding authors. Twelve studies that neglected to account for clustering effects were adjusted. The total estimate and *á priori*-specified subgroups were quantified in Stata12 and sensitivity-analyzed by intention-to-treat. Heterogeneity and small-study effects were formally tested.

Results

Twentyfive trials, including 26610 participants with 3464 injuries, were analyzed. The overall physical activity effect estimate was relative risk (RR) 0.632 (0.533-0.750). Stratified exposure analyses proved no beneficial effect for stretching (RR 0.963 (0.846-1.095)), whereas multiple exposure studies (RR 0.655 (0.520-0.826)), proprioception training (RR 0.550 (0.347-0.869)), and strength training (RR 0.315 (0.207-0.480)) showed increasing effect. When stratified by outcome, both acute injuries (RR 0.647 (0.502-0.836)) and overuse injuries (RR 0.527 (0.373-0.746)) could be reduced by physical activity prevention programs. Intention-to-treat sensitivity analyses consistently revealed even more robust effect estimates.

Conclusions

This study adds total, strength training, multiple exposure interventions, total acute and total overuse effect estimates to the field of sports injury prevention. Despite of a few outlying studies, consistently favorable estimates were obtained for all injury prevention measures except for stretching.

Introduction

Increasing evidence exists, for all age groups, that physical activity is important in both prevention and treatment of some of the most sizable conditions of our time[1-3], including cardiovascular disease, diabetes, cancer, hypertension, obesity, depression and osteoporosis. Although overall population levels of physical activity is a general concern, increasing levels of leisure time physical activity and sports participation have been reported in some population groups[4]. Although being virtually the sole drawback of exercise, injuries may be a common consequence of physical activity and have been shown to pose substantial problems[5-7]. Management of these injuries is difficult, time-consuming, and expensive, both socioeconomically and for the individual[8-10]. However, sports injury prevention by different kinds of strength training, proprioception exercises, stretching activities etc., including combinations of these, is accessible to virtually everyone and requires limited medical staff assistance. This adds several interesting aspects regarding the potential dispersion, applicability, and compliance to these programs.

Most studies on musculoskeletal injuries have focused on one particular intervention, injury type/location, sport or studied other relatively narrowly defined research questions. This applies to most reviews and meta-analyses as well[11-18]. However, Parkkari et al. (2001) described 16 controlled trials in a narrative review and central concepts of injury prevention such as extrinsic/intrinsic risk factors and the "sequence of prevention" model of van Mechelen[19] were summarized as well[20]. Aaltonen et al. (2007) presented an overview of all sports injury prevention measures, but as in the literature up until their search in Jan 2006, the focus of this review was primarily on protective devices and extrinsic risk factors[21 22]. More recently and with less restrictive exclusion criteria, Schiff et al. (2010) covered the same topic with additional studies[23]. However, as Aaltonen et al., Schiff et al. was unable to obtain full quantification of intervention effect estimates.

Steffen et al. (2010) presented a narrative review of acute injury prevention measures written by field experts for each location of injury[24], but a complete examination and quantification of specific training exposures and differentiated acute and overuse outcome effect estimates is still lacking.

This review and meta-analysis will broaden the scope of previous reviews and meta-analyses on the modifiable intrinsic risk factors and complement the existing extrinsic summative literature. Valuable, and perhaps even satisfactorily confirmed, summary literature exist for both neuromuscular proprioception[14 15] and stretching exercises[17 18]. However, aggregation and comparison with strength and multiple exposure study effect estimates could reveal new and interesting information, enabling proposals for future directions in the field of sports injury prevention.

Material and methods

Data sources and search strategy

A review protocol was composed, comprising of pre-specified analyses, inclusion/exclusion criteria, injury definition and search strategy. Injury was defined according to the F-MARC consensus statement for football, merely broadened to fit all forms of physical activity[25]. See appendix §1-2 for full injury definition and literature searches.

PubMed, Embase, Web of Science, and SPORTDiscus databases were searched to October 2012 with no publication date restrictions. The search was performed by four blocks of keywords related to prevention, diagnoses, sports, and randomized controlled trials. The searches were customized to accommodate the layout and search methods of each search engine and the application of additional free text words were based upon the coverage of subject terms. Reference lists of retrieved articles were hand searched for trials of potential interest and the search was updated to January 2013.

The literature search yielded 3462 results which were sorted by using the following *á priori*-specified inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
• Primary prevention	• Influencing pathology
• First time/free of injury (def)	• Surrogate measures
• In sports/physical activity	• Any use of devices (kinesiotaping, insoles etc.)
• Randomized controlled trials	• Any means of transportation (bicycles, motor driven, skies, equestrian etc.)
• Relevant intervention/control arms	• Occupational injury
• Conducted in humans	
• Articles in English	

- Peer reviewed publications
- Inadequate follow-up

Two reviewers (JBL and DMB) independently assessed the eligibility criteria with subsequent consensus by discussion. If unanimous consensus could not be reached, this was arbitrated by a third person (LBA).

In total, 25 studies were included[26-50]. See appendix §2-4 for detailed search entries and study selection flowchart and description.

Quality assessment

All included studies were assessed by the domain-based evaluation recommended by the Cochrane collaboration[51]. Two reviewers (JBL and DMB) independently collected the support for judgment and all final judgments required consensus from all authors of this paper. In case reporting was inadequate or unclear, efforts were made to contact the corresponding authors and ask by "open questions" in order to reduce the risk of overly positive answers. Weighting of studies by quality assessment was considered but not performed, as such appraisals would inevitably involve subjective decisions and no evidence in support of this approach exists[51].

Pre-specified analyses

Data extraction for total and exposure subgroup estimates covered the primary outcome defined by each study, which could be an all injuries, acute or overuse injury estimate or subsets of these. For the outcome subgroups we additionally extracted appropriate secondary data from studies with complete acute and overuse injuries estimates, in order to optimize the power of these analyses. Overlapping entities were omitted so no injury was analyzed more than once.

The stratification of studies into less heterogeneous exposure subgroups was, with the exception of Beijsterveldt et al., performed after completion of the literature search. Beijsterveldt et al. was added from the updated literature search and was unambiguously fitted into the multiple exposures group.

As compliance plays a pivotal role in the robustness of results, a sensitivity analysis without studies that neglected to analyze by intention-to-treat was conducted.

During the iterative process of hypothesis generation and preliminary searches the pre-specified eligibility criteria were elaborated but not changed. All *á priori* specified analyses were performed as planned and none were subsequently added.

Statistics

Whenever possible, only first-time injuries were taken into account as repeated outcomes are likely to be dependent of each other and therefore would introduce bias. Most studies have analyzed by calculation of RR, injury rate RR or Cox regression RR. When no appropriate estimates were reported or studies neglected to adjust for clustering effects, we adjusted for clustering effects and calculated a RR. Twelve included studies were not originally adjusted for cluster randomization. As individuals in clusters potentially lack independence of each other, a regulation of sample size calculations is usually required. The equation for cluster adjustment is

$$IF = 1 + (n - 1)\rho$$

where ρ is the intracluster correlation coefficient, n is the average cluster size, and IF is the inflation factor. Effective sample size is calculated by dividing sample size with IF[52].

The intracluster correlation coefficient is calculated by

$$\rho = s^2_c/(s^2_c + s^2_w)$$

where s^2_w is the within cluster variance of observations taken from individuals in the same cluster and s^2_c is the variance of true cluster means[53]. Studies that neglected this adjustment report the same effect estimate but underestimate the width of confidence intervals. In the nine cases where the corresponding authors did not provide us with sufficient data for ρ calculation, we achieved this by calculating an average intracluster correlation coefficient based on ρ-values reported in the articles which appropriately adjusted for clustering effects.

In order to address the subject of reporting bias formally, we sought to test all analyses by the Harbord test with a modified Galbraith plot[54]. This follows the recommendations by the Cochrane handbook for systematic reviews of interventions and is available in Stata 12[51 55]. The Harbord test avoids the mathematical association between the log relative risk and its standard error. Hence, false-positive test results are minimized while retaining power compared with alternative tests. Effective sample sizes for total intervention and total control group populations were used for the required binary data input to achieve cluster-adjusted RR for this test.

The heterogeneity for all analyses was assessed by the chi-squared (Q) p-value and I^2. I^2 is calculated from the Stata-given Q value and number of studies (n) by

$$I^2 = \frac{Q - (n - 1)}{Q}$$

A rough interpretation guide of I^2 has been proposed by Higgins et al.[51].

All analyses were computed in Stata12 by user-written commands described by Egger et al.[56]. The random effects model was used. Heterogeneous estimates were explored by a graphical display of the influence of each included study and reported in the appendix §9.

Results

Study characteristics

Table 1 summarizes the characteristics of 25 included studies (thorough characteristics is available in the appendix §5). In total 26610 individuals were included in the analysis and estimates were based on 3464 injuries. Four studies had relative risks ≥ 1 and eleven studies had statistically significant effect estimates.

Insert Table 1

We contacted nine authors and four supplied clarifying answers with subsequent change in their data or quality assessment. For detailed quality assessments see appendix §6 and §7 for summary table and figure.

Total estimate

The total effect estimate was 0.632 (95% CI 0.533-0.750, I^2=70% with a chi-squared p<0.001) (see appendix §9.1 for single study impact on estimate). Brushøj et al., Eils et al., Gilchrist et al., Holmich et al., and Soderman et al. did not report intention-to-treat data. When performing a sensitivity-analysis on the 20 studies with intention-to-treat data, an estimate of RR 0.608 (0.503-0.736, I^2=74%, chi-squared p<0.001) was found.

Insert Figure 1

Stratified exposure analyses

The strength training estimate including four studies was RR 0.315 (0.207-0.480, I^2=0%, chi-squared p=0.808). As all studies in the strength training group were analyzed by intention-to-treat a sensitivity analysis was superfluous (see appendix §8.1 for exposure Forrest plots).

The pooled effect estimate for six studies with proprioception training as the primary exposure showed a RR of 0.550 (0.347-0.869, I^2=66%, chi-squared p=0.012) (appendix §8.2 and §9.2 for single-study impact). Sensitivity analysis of intention-to-treat ruled out Eils and Söderman and revealed RR 0.480 (0.268-0.862, I^2=71%, chi-squared p=0.017).

Unlike the above two exposures the overall estimate for stretching did not prove significant with RR 0.963 (0.846-1.095, I^2=0%, chi-squared p=0.975) based on three studies. All studies in the stretching group analyzed by intention-to-treat (appendix §8.3).

The combined effect estimate for the twelve studies with multiple exposure interventions revealed a RR of 0.655 (0.520-0.826, I^2=69%, chi-squared p<0.001) (appendix §8.4 and §9.3). Sensitivity analysis of intention-to-treat excluded Brushoj, Gilchrist, and Holmich and revealed RR 0.625 (0.477-0.820, I^2=75%, chi-squared p<0.001).

Insert Figure 2

Stratified outcome analyses

Based on primary or secondary data from nine studies, the RR for all types of exposures against acute injury was 0.647 (0.502-0.836, I^2=73%, chi-squared p<0.001) (Figure 3a and appendix §9.4). One study had strength training as exposure, two studies did proprioception training, and the remaining six studies were from the group of multiple exposures. Sensitivity analysis of eight

intention-to-treat analyzed studies (Soderman was excluded) showed a RR 0.615 (0.470-0.803, I^2=75%, chi-squared p<0.001).

Six studies provided data on overuse injuries. RR from these six studies was 0.527 (0.373-0.746, I^2=19%, chi-squared p=0.287) (Figure 3b). All studies in this analysis, except one proprioception training study, were multiple exposure studies. All analyzed studies reported intention-to-treat data.

Insert Figure 3a-3b

Small-study effect

The Harbord test for the total estimate of all 25 studies showed a highly significant bias measure. Exposure and outcome subgroups revealed significant heterogeneity for only the multiple exposures group (Appendix §10.1 for modified Galbriath plot and §10.2 for Harbord tests).

Discussion

An overall estimate for physical activity prevention adjusted for clustering effects was 0.632 (0.532-0.750), and slightly lower when sensitivity-analyzed by intention-to-treat (RR 0.607 (0.501-0.735)). A preventive effect of this size should be considered convincing, but as the analysis was highly heterogeneous, it also suggests that some types of interventions may prove better than others.

Stretching did not show any protective effect (RR = 0.961 (0.836-1.106)), while strength training proved highly significant (RR 0.315 (0.207-0.480)). Proprioception training and multiple exposures prevention were also effective (RR = 0.480 (0.266-0.864) and 0.625 (0.477-0.820), respectively). The effect estimate of stretching and proprioception training analyses in this article corresponds to earlier reviews even though this analysis included recent studies[14 15 17 18]. Strength training showed a trend towards better preventive effect than proprioception training and proved significantly better than multiple exposure studies, even though all multiple exposure studies included a strength training component. Further research of strength training for a wider range of injuries is still needed, as our analyses suggest great sports injury prevention potential for these interventions. With a growing number of randomized controlled trials containing numerous exposures, it was of interest to assess interventions studies with multiple exposures separately, although still being a heterogeneous subgroup. Though it makes intuitive sense to design an array of exposures for prevention of all injuries, it is important to note that each component may get less attention and time allocation. Multiple exposure programs may reduce the proportion of proven beneficial exposures or decrease compliance if too extensive. Not all multiple intervention studies in this analysis showed an unambiguous effect on injuries although most were designed and carried out in a satisfactory way. This finding suggests that designs of multiple exposure interventions should

primarily be built from well-proven single exposures and that further research into single exposures remains important.

When analyses were stratified by outcome, both acute (RR 0.615 (0.470-0.803)) and overuse (RR 0.527 (0.373-0.746)) injuries were effectively reduced by preventive physical activity, although overuse injuries slightly better. Acute injuries have previously been argued to be more readily prevented than overuse injuries and have received greater attention[21 23 24]. Acute injury outcomes from Petersen et al. and Waldén et al. suggest that specific strength training may enable better accommodation of strains for the prevention trained structure. However, this form of intrinsic risk factor modulation probably demands specific, consistent and prolonged duration of training which may exceed the single-season follow-up period of most included studies before full onset of effects. Given the nature of acute injuries, these might also be harder to prevent by physical activity as a consequence of a greater influence of extrinsic risk factors. This suggests that acute injuries, to a higher degree than overuse injuries, may benefit from a wider array of interventions. As previously described by Parkkari et al. this can be aided by means of rules, devices and structural changes[20].

While acute injuries may be prevented in many ways, the risk of overuse injuries intuitively seem easier to control. Overuse injuries appear to benefit most from gradual increases in tissue stress, optimally prior to season initiation or other high risk sudden increases in physical activity. Alone the fact that almost all included studies provided some form of structured program and medical staff contact for advice, could be speculated to aid both inexperienced athletes and eager professionals in avoiding high risk behavior. Nonetheless, future studies should focus on acute and overuse outcomes separately or report separate measures for these in order to acquire further knowledge in this import area.

Strengths and limitations

Omission of intention-to-treat analysis and cluster adjustment are two sources of potentially serious bias. As compliance to intervention programs appear to be a variable and disputed phenomenon, the analysis by intention-to-treat plays a pivotal role in the robustness of results[57-61]. In the present meta-analysis we extracted data from intention-to-treat analyses whenever possible and performed sensitivity-analysis of five studies with no report of intention-to-treat analysis. Contrary to the expected more conservative effect estimate, the intention-to-treat sensitivity-analyses revealed even more beneficial effect estimates. As a result we can conclude that physical activity as primary prevention against sports injuries is effective, even if it has been argued that compliance issues could diminish the implementation and effect of these programs. We speculate the above to result from an association between using intention-to-treat analysis and study quality in general. For example, Brushoj et al. added concurrent training in the critical high risk period of military training initiation, which logically appears detrimental to overuse injuries. Soderman et al. as well exhibited several methodological issues and reported adverse effects of major injuries that have not been reproduced by other studies. None of them analyzed by intention-to-treat and excluding such studies consequently improve the estimate.

Cluster adjustment is similarly important in order not to overestimate the power of the study. A strength of this meta-analysis is the adjustment for clustering effects of studies that neglected to do so in their analyses. Corresponding authors of studies without cluster adjustment were contacted and three provided data for ρ-calculation. For the remaining nine studies we calculated an average ρ-value extracted from twelve values of ten studies that reported correct adjustment methods. This caused a, in some cases dramatic, down-regulation of effective sample size which affected the study-weight in the quantitative analyses.

A short discussion of the allocation concealment and participant blinding quality assessments is advocated. As true participant blinding is frequently argued to be impossible and allocation concealment makes less sense in non-pharmacological interventions, these quality assessments should be interpreted with caution. In spite of this, some of the included studies made qualified efforts to alleviate these, which, in this study, resulted in a lower risk of bias judgment. The domain-based tool was chosen as validation tool of this review as recommended by the Cochrane collaboration with the most convincing evidence in this area. Although imperfect, assessment of these parameters still holds relevance as these factors can greatly influence analyses[62 63].

A Harbord's small-study effect test and a modified Galbraith's plot were performed for this meta-analysis to assess publication bias. Smaller studies are often perceived to vary to a higher degree, be of lesser quality, and more susceptible to publication bias than larger ones[64]. A difference between small and large study effects may therefore indicate publication bias. The small-study effect test for the total estimate was highly significant, while the multiple exposures subgroup was the only subgroup showing a statistically significant test. According to Egger et al. significant small-study effects may arise from a number of reasons[65]. Four of those include true publication bias, heterogeneity, chance, and methodological differences between smaller and larger studies. As the p-value of the small-study effects increased when the total estimate test were divided into less heterogeneous subgroups, it is likely that a substantial part of the total estimate small-study effect originates in heterogeneity. Because of the relatively heavy burden of implementing physical activity interventions, it should be noted that smaller studies often would be able to pay greater attention to the intervention for each team/individual, thereby enabling them to obtain more thorough intervention quality. Hence, a methodological difference may exist as well.

Performing a meta-analysis inevitably leads to a discussion of heterogeneity as studies diverge in clinical and methodological characteristics. The difficulty lies in the decision of just how similar they need to be. One of the strengths of meta-analysis is that the consistency, and hence generalizability, of findings between studies can be assessed formally[66]. The I^2 measure reported describes the percentage of variability in point estimates that is found to be due to heterogeneity rather than sampling error[67]. However, as I^2 is merely a measure of statistical heterogeneity, it remains important to qualitatively address the magnitude of variation and how conclusions could be impacted[68]. The importance of the observed value of I^2 depends on both the magnitude and direction of effects and the strength of evidence for heterogeneity, in this analysis quantified by the chi-squared p-value[51]. As expected, the total estimate was quite heterogeneous. While the proprioception training group and multiple exposures group still exhibited heterogeneity, the strength training and stretching group showed that 0% of the variability could be explained by heterogeneity. A heterogeneous multiple exposures group was to be expected as well as it seems feasible that studies with many exposures would be heterogeneous by the design itself. Through this meta-analysis we consistently found a mild heterogeneity for overuse estimates while all acute outcomes, except for the stretch exposure, exhibited heterogeneity to a greater degree. This is in itself interesting and it could be hypothesized that acute injuries by their very nature are more heterogeneous than overuse injuries.

Conclusion

In general, physical activity was shown to effectively prevent sports injuries. Stretching proved no beneficial effect, whereas multiple exposures prevention, proprioception training, and strength training, in that order, showed increasing effect. Both acute and overuse injuries could be significantly reduced, overuse injuries by almost 50%. Apart from a few outlying studies,

consistently favorable estimates were obtained for all injury prevention measures except for stretching.

Already known

Effect estimates for stretching and proprioception exercises have been established and some randomized, controlled trials have differentiated between acute and overuse outcomes.

This study adds

This meta-analysis adds an overall estimate for sports injury prevention and thereby enables acute and overuse outcome estimates for the entire field. Strength training and multiple exposures effect estimates are likewise new and elaborate on the basis for future studies and directions.

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Conflicts of interest

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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Table

Table 1, Study characteristics summary

Study	Intervention	Population	Completion	Follow-up	Injuries	Primary out.
Askling et al. 2006[26]	Strength	Soccer, male, elite	Interv. 15 Con. 15	10 weeks + 1 season	Interv. 3 Con. 10	Hamstring inj.
Beijsterveldt et al. 2012[27]	Multi	Soccer, 18-40, male amateur	Interv. 223 Con. 233	9 months	Interv. 135 Con. 139	All injuries
Brushoj et al. 2008[28]	Multi	Conscripts, 19-26 years	Interv. 487 Con. 490	12 weeks	Interv. 50 Con. 48	Overuse knee inj.
Coppack et al. 2011[29]	Strength	Recruits, 17-30 years	Interv. 759 Con. 743	14 weeks	Interv. 10 Con. 36	Overuse ant. knee pain
Eils et al. 2010[30]	Proprio.	Basketball, 1^{st}-7^{th} league	Interv. 81 Con. 91	1 season	Interv. 7 Con. 21	Ankle inj.
Emery et al. 2005[31]	Proprio.	Students, 14-19 years	Interv. 60 Con. 54	6 weeks + 6 months	Interv. 2 Con. 10	All injuries
Emery et al. 2010[32]	Multi	Soccer, 13-18 years	Interv. 380 Con. 364	1 year	Interv. 50 Con. 79	All injuries
Emery et al. 2007[33]	Proprio.	Basketball, 12-18 years	Interv. 494 Con. 426	1 year	Interv. 130 Con. 141	All injuries
Gilchrist et al. 2008[34]	Multi	Soccer, collegiate	Interv. 583 Con. 852	12 weeks	Interv. 2 Con. 10	Noncontact ACL
Heidt et al. 2000[35]	Proprio	H. school, female, soccer	Interv. 42 Con. 258	1 year	Interv. 6 Con. 87	All injuries
Holmich et al. 2010[36]	Multi	Football, 2nd-5th level	Interv. 477 Con. 430	42 weeks	Interv. 23 Con. 30	Groin injuries
Jamtvedt et al. 2010[37]	Stretch	Internet, >18 years	Interv. 1079 Con. 1046	12 weeks	Interv. 339 Con. 348	Lower limb + trunk inj.

LaBella et al. 2011[38]	Multi	Athletes, female	Interv. 737 Con. 755	1 season	Interv. 50 Con. 96	Lower extremity inj.
Longo et al. 2012[39]	Multi	Basketball, male	Interv. 80 Con. 41	9 months	Interv. 14 Con. 17	All injuries
McGuine et al. 2006[40]	Proprio	Basketball, adolescent	Interv. 373 Con. 392	4 weeks + 1 season	Interv. 23 Con. 39	Ankle sprain
Olsen et al. 2005[41]	Multi	Handball, 15-17 years	Interv. 958 Con. 879	8 months	Interv. 48 Con. 81	Knee and ankle inj.
Pasanen et al. 2008[42]	Multi	Floorball, female, elite	Interv. 256 Con. 201	6 months	Interv. 20 Con. 52	Noncontact injuries
Petersen et al. 2011[43]	Strength	Soccer, male, elite	Interv. 461 Con. 481	12 months	Interv. 12 Con. 32	Hamstring injuries
Pope et al. 1998[44]	Stretch	Recruits, 17-35 years	Interv. 549 Con. 544	12 weeks	Interv. 23 Con. 25	4 specific LE injuries
Pope et al. 2000[45]	Stretch	Recruits, male	Interv. 666 Con. 702	12 weeks	Interv. 158 Con. 175	Lower limb injuries
Soderman et al. 2000[46]	Proprio.	Soccer, female, elite	Interv. 62 Con. 78	7 months	Interv. 28 Con. 31	Lower extremity inj.
Soligard et al. 2008[47]	Multi	Football, 13-17, female	Interv. 1055 Con. 837	8 months	Interv. 121 Con. 143	Lower extremity inj.
Steffen et al. 2008[48]	Multi	Soccer, female	Interv. 1073 Con. 947	8 weeks + 1 season	Interv. 242 Con. 241	All injuries
Waldén et al. 2012[49]	Strength	Soccer, 12-17, female	Interv. 2479 Con. 2085	7 months	Interv. 7 Con. 14	ACL injuries
Wedderkopp et al. 1999[50]	Proprio.	Handball, 16 - 18, female	Interv. 111 Con. 126	10 months	Interv. 11 Con. 45	All injuries

Figures and legends

Figure 1, Total estimate Forrest plot

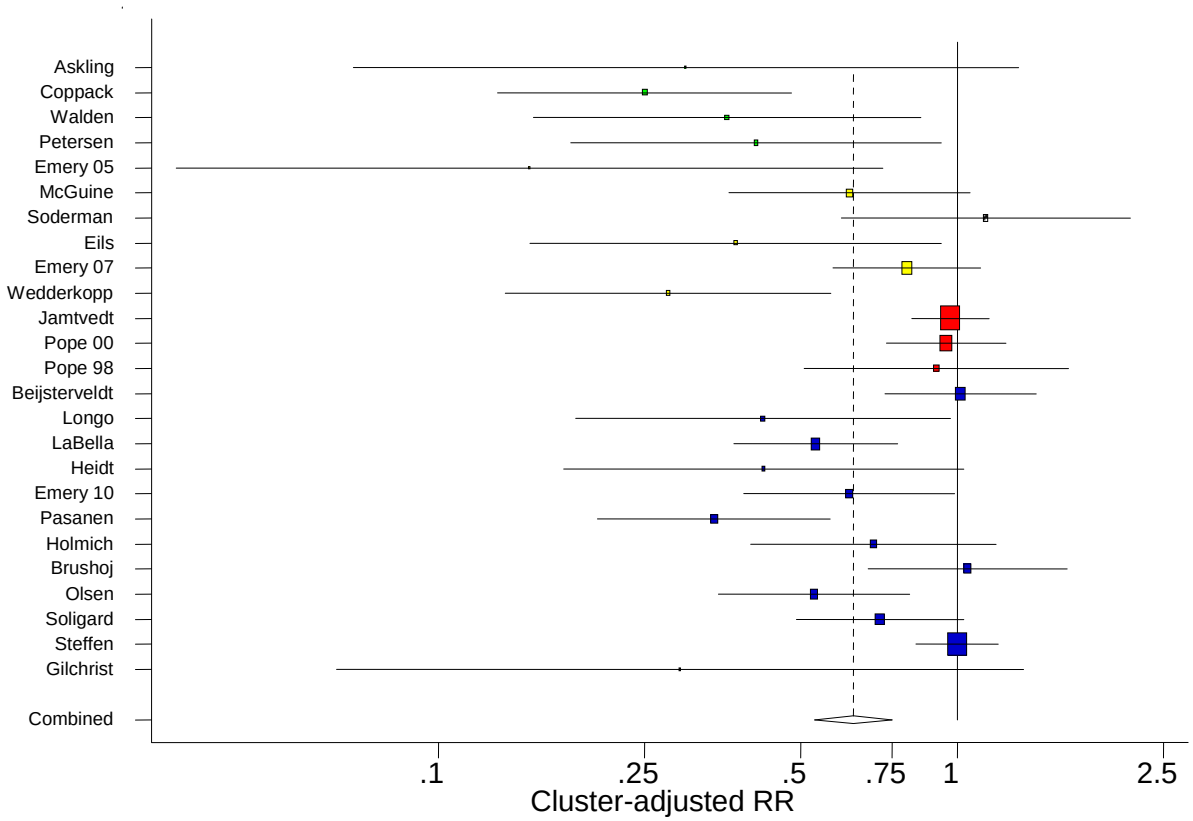


Figure 2, Exposure estimates Forrest plot

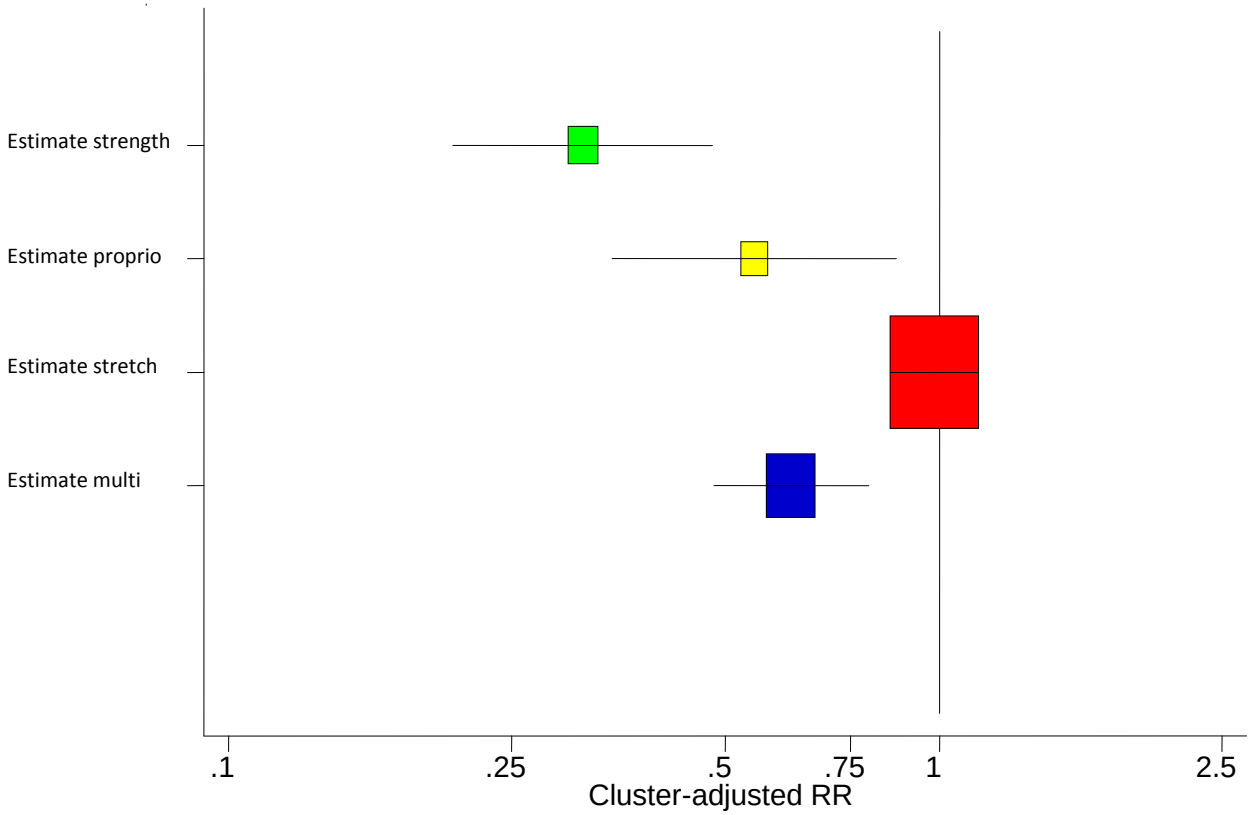


Figure 3a, Acute outcomes estimate Forrest plot

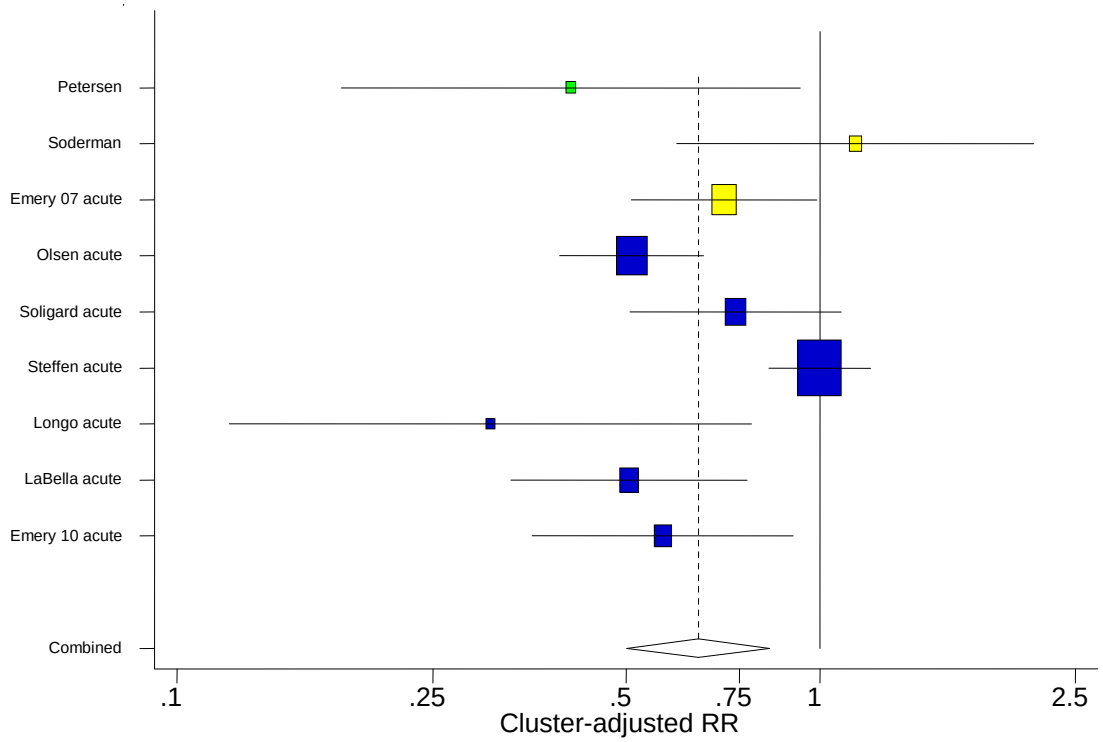
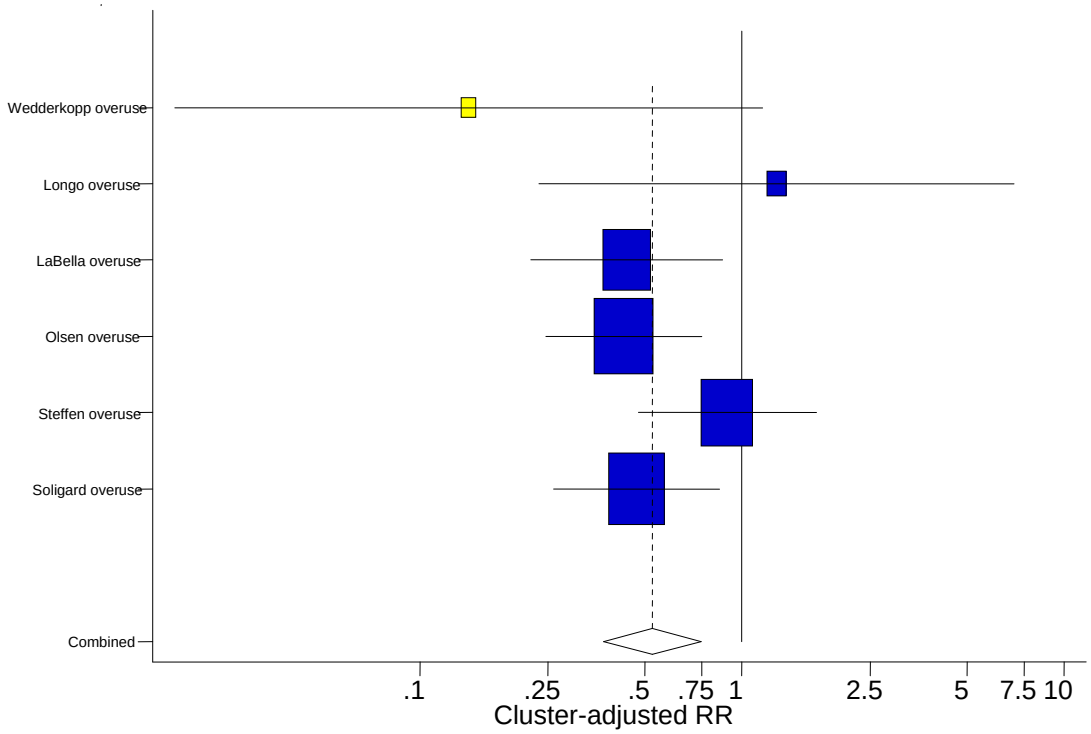


Figure 3b, Overuse outcomes estimate Forrest plot



Proposed appendix

§1, Definition of sports injury

This article will define an injury as;

“Any physical complaint sustained by an individual that result from sports-related physical activity, irrespective of the need for medical attention or time loss from sports-related physical activities. An injury that results in an individual receiving medical attention is referred to as a “medical attention” injury, and an injury that results in an individual being unable to take a full part in sports-related activities as a “time loss” injury.”

This definition originates in the F-MARC consensus group concerning soccer injuries and has merely been fitted to the scope of this analysis.

§2, Complete searches

PubMed (Mesh terms are exploded): 1023 results, performed 3/10-2012, updated 7/1-2013

("prevention"[All Fields] OR "preventive"[All Fields] OR "decrease"[All Fields] OR "reduce"[All Fields] OR "reduction"[All Fields] OR "prophylaxis"[All Fields] OR "risk"[All Fields] OR "incidence"[All Fields] OR "prevention program"[All fields] OR "prevention and control"[Subheading] OR "primary prevention"[Mesh] OR "accident prevention"[Mesh] OR "risk management"[Mesh] OR "risk assessment"[Mesh] OR "risk reduction behavior"[Mesh] OR "program evaluation"[Mesh] OR "exercise therapy"[Mesh])

AND

("injury"[All Fields] OR "injuries"[All Fields] OR "accident?"[All Fields] OR "trauma"[All Fields] OR "cumulative trauma disorders"[Mesh] OR "soft tissue injuries"[Mesh] OR "sprains and strains"[Mesh] OR "tendons/pathology"[Mesh] OR "tendon injuries"[Mesh] OR "fractures, bone"[Mesh] OR "fractures, cartilage"[Mesh] OR "musculoskeletal system/injuries"[Mesh] OR "musculoskeletal system/pathology"[Mesh] OR "musculoskeletal system/physiopathology"[Mesh] OR "arm injuries"[Mesh] OR "hand injuries"[Mesh] OR "neck injuries"[Mesh] OR "back injuries"[Mesh] OR "hip injuries"[Mesh] OR "leg injuries"[Mesh] OR "sports medicine"[Mesh] OR "athletic injuries"[Mesh])

AND

("sport?"[All Fields] OR "athletic?"[All Fields] OR "exercise"[All Fields] OR "physical activity"[All Fields] OR "game"[All Fields] OR "recreation"[All Fields] OR "train"[All Fields] OR "training"[All Fields] OR "workout"[All Fields] OR "competition"[All Fields] OR "contest"[All Fields] "handball"[All Fields] OR "baseball"[Mesh] OR "basketball"[Mesh] OR "football"[Mesh] OR "soccer"[Mesh] OR "golf"[Mesh] OR "gymnastics"[Mesh] OR "hockey"[Mesh] OR "racquet sports"[Mesh] OR "running"[Mesh] OR "swimming"[Mesh] OR "volleyball"[Mesh] OR "athletic performance"[Mesh] OR "physical fitness"[Mesh] OR "motor activity"[Mesh] OR "exercise"[Mesh] OR "Motion"[Mesh] OR "Movement"[Mesh] OR "Exercise Movement Techniques"[Mesh])

AND

("randomized controlled trial"[All fields] OR RCT OR "randomized controlled trial"[Publication Type])

EMBASE (advanced search, searches limited to human, English language, and randomized controlled trial + multicenter studies): 1314 results, performed 3/10-2012, updated 7/1-2013

Search 1 prevention or prevention/ or exp accident prevention/ or exp primary prevention/ or exp prevention study/ or decrease or reduce or reduction or risk or exp risk management/ or exp risk reduction/ or exp risk assessment/ or prophylaxis or exp prophylaxis/ or exp "primary prevention"/

Search 2 injury or injuries or exp injury/ or exp accidental injury/ or exp musculoskeletal injury/ or exp soft tissue injury/ or exp sport injury/ or accident? or trauma or exp "cumulative trauma disorder"/ or exp "sports medicine"/

Search 3 sport? or athletic? or exercise or "physical activity" or exp "physical activity"/ or train* or workout or competition or train or exp sport/ or handball or exp team sport/ or exp exercise tolerance/ or exp exercise/ or exp "physical performance"/ or exp training/ or "motor activity"/

Search 4 exp randomized controlled trial/ or RCT or "randomized controlled trial?"

Combine 1, 2, 3 and 4 with AND

Web of science (advanced search, English, articles, lemmatization on, combining sets with AND, and a sensitive scope of category refining): 728 results, performed 3/10-2012, updated 7/1-2013

Set 1 TS=(prevention OR preventive OR decrease OR reduce OR reduction OR incidence OR "primary prevention" OR "accident prevention" OR "prevention study" OR prophylaxis OR "risk reduction" OR "risk management" OR "program evaluation")

AND

Set 2 TS=(injury OR injuries OR accident OR trauma OR strain OR sprain OR tendinopathy OR tendinosis OR "tendon injury" OR "overuse injury" OR fracture OR "bone injury" OR "cartilage injury" OR "cumulative trauma" OR muscle injury OR muscular injury OR myopathy OR "musculoskeletal injury" OR "soft tissue injuries" OR "cartilage injury" OR "sports medicine" OR "athletic injuries")

AND

Set 3 TS=(sport? OR athletic? OR exercise OR "physical activity" OR "motor activity" OR movement OR game OR recreation OR train OR training OR workout OR contest OR competition OR handball OR baseball OR basketball OR football OR soccer OR rugby OR golf OR gymnastics OR hockey OR "racquet sports" OR running OR swimming OR volleyball)

AND

Set 4 TS=(randomized controlled trial OR RCT)

Search refined by

Language =(English)

Document Types =(Article)

Categories included =(SPORT SCIENCES (299), ORTHOPEDICS (201), MEDICINE GENERAL INTERNAL (147), GERIATRICS GERONTOLOGY (94), GERONTOLOGY (65), RHEUMATOLOGY (59), MEDICINE RESEARCH EXPERIMENTAL (33), HEALTH CARE SCIENCES SERVICES (24), PRIMARY HEALTH CARE (21), WOMEN'S STUDIES (4), BEHAVIORAL SCIENCES (2), HOSPITALITY LEISURE SPORT TOURISM (2), TRANSPORTATION (2))

"SPORTSDiscus" (including "SPORTDiscus", "SPORTDiscus with full text" and "academic search complete", advanced search, applying related words, subject terms (SU) exploded when possible, and English): 397 results, performed 3/10-2012, updated 7/1-2013

Search 1 preventive OR prevention OR decrease OR inhibit OR avoid OR prophylaxis OR risk OR SU ACCIDENT prevention OR SU MEDICINE, Preventive OR SU risk

AND

Search 2 injury OR injuries OR accident? OR trauma OR musculoskeletal OR SU MUSCULOSKELETAL system -- Wounds & injuries OR SU SOFT tissue injuries OR SU OVERUSE injuries OR SU OVEREXERTION injuries OR SU RUPTURE of organs, tissues, etc. OR SU FRACTURES OR SU SPORTS injuries OR SU SPORTS physical therapy OR SU SPORTS accidents

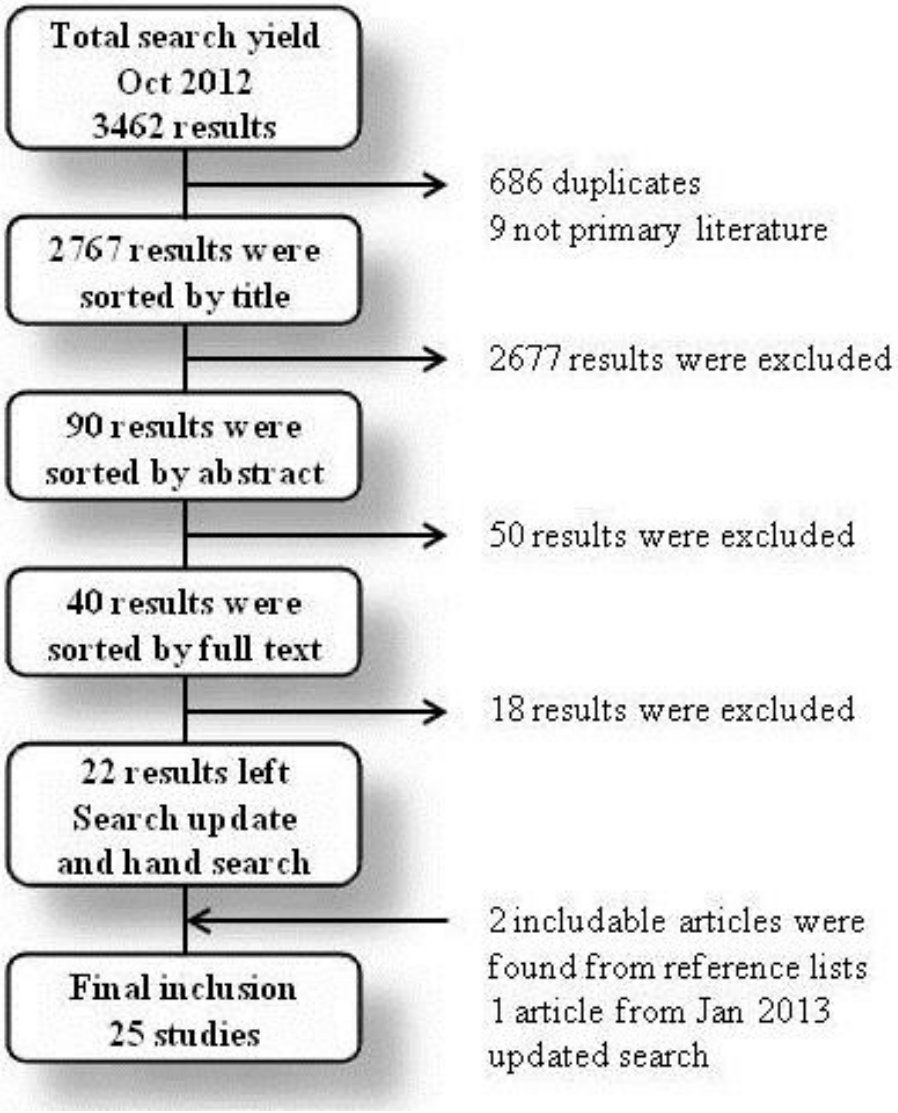
AND

Search 3 sport? OR athletic? OR exercise OR physical activity OR train OR SU TRAINING OR SU PHYSICAL activity OR SU PHYSICAL training & conditioning OR SU ATHLETES OR SU ATHLETICS OR SU RECREATIONAL sports OR SU SPORTS OR SU SPORT for All OR SU SPORTS tournaments

AND

Search 4 randomized controlled trial OR RCT OR SU RANDOMIZED controlled trials

§3, Study selection flowchart



§4, Detailed study selection description

The above searches revealed 3462 results

3462 sorted for duplicates (if identical title and first author) and reference type

- 686 referenceduplicates (2776 left)
- 2 book sections, 1 case, 5 newspaper articles, and 1 blank reference (2767 left)

2767 sorted by title

- 2677 excluded

90 sorted by abstract

- 43 studies sorted by screening for exclusion criteria
- 2 studies had inappropriate control group

  ("Buist, I., No effect of a graded training program on the number of running-related injuries in novice runners"/"Childs, J.D., Effects of Traditional Sit-up Training Versus Core Stabilization Exercises on Short-Term Musculoskeletal Injuries in US Army Soldiers: A Cluster Randomized Trial")

- 1 report duplicate

  ("Canham-Chervak, M., Does stretching before exercise prevent lower-limb injury?" same as *"Pope, R. P., A randomized trial of preexercise stretching for prevention of lower-limb injury")*

- 1 study had prevalence as outcome

  ("Cumps, E., Effect of a preventive intervention programme on the prevalence of anterior knee pain in volleyball players")

- 1 study included "healthy" participants regarded by the authors of this meta-analysis as having a "medical attention injury"

  ("Fredberg, U., Prophylactic training in asymptomatic soccer players with ultrasonographic abnormalities in Achilles and patellar tendons - The Danish super league study")

- 1 study had information/safety equipment as intervention

  ("Kendrick, D., Preventing injuries in children: cluster randomised controlled trial in primary care")

- 1 study was a review

  ("Oneill, T., Can we prevent fractures?")

40 sorted by full text

- 4 references were conference abstracts or course lectures

  ("Emery C., The efectivenes of a combined sport injury and obesity prevention program in junior high school"/"Richmond S., Examining a sport injury and obesity intervention program in junior high school"/"Sinaki M., Stronger back muscles reduce the incidence of vertebral fractures: A prospective 10 year follow-up of postmenopausal

women"/"Myklebust G., Prevention of noncontact anterior cruciate ligament injuries in elite and adolescent female team handball athletes")

- 3 references were study protocols

  ("van Beijsterveldt A., Effectiveness and cost-effectiveness of an injury prevention programme for adult male amateur soccer players: design of a cluster-randomised controlled trial"/"Finch C. The Preventing Australian Football Injuries with Exercise (PAFIX) Study: a group randomised controlled trial"/"Bredeweg S., The GRONORUN 2 study: effectiveness of a preconditioning program on preventing running related injuries in novice runners. The design of a randomized controlled trial")

- 3 studies weren't randomized

  ("Gatterer H., Effects of the performance level and the FIFA "11" injury prevention program on the injury rate in Italian male amateur soccer players"/"Kiani A., Prevention of Soccer-Related Knee Injuries in Teenaged Girls", "Caraffa A., Prevention of anterior cruciate ligament injuries in soccer. A prospective controlled study of proprioceptive training")

- 2 study had control group defined as physical activity by this study

  ("Bello M., Rhythmic stabilization versus conventional passive stretching to prevent injuries in indoor soccer athletes: A controlled clinical trial "/"Gabbe B., A pilot randomised controlled trial of eccentric exercise to prevent hamstring injuries in community-level Australian football")

- 2 studies with cluster randomization of 4 clusters and no adjustment for cluster effect were considered inadequate

  ("Parkkari J., Neuromuscular training with injury prevention counselling to decrease the risk of acute musculoskeletal injury in young men during military service: a population-based, randomised study"/"Verhagen E., Acute physical activity and sports injuries in children")

- 2 studies had physical activity intervention regarded insufficient for this analysis

  ("Collard D., Effectiveness of a school-based physical activity injury prevention program: a cluster randomized controlled trial"/"van Mechelen W., Prevention of running injuries by warm-up, cool-down, and stretching exercises")

- 2 report duplicates

2 articles included from article references were added to 22 articles

- *"Askling C., Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload"*
- *"Heidt R., Avoidance of soccer injuries with preseason conditioning"*

1 article included by the literature search update Jan 2013 was added to 24 articles

- *"van Beijsterveldt A., Effectiveness of an injury prevention programme for adult male amateur soccer players: a cluster-randomised controlled trial"*

25 articles for final inclusion

Interobserver kappa for sorting articles on basis of title was 0,582

Interobserver kappa for sorting articles on basis of abstracts was 0,602

§5, Characteristics of all included studies

Source/ location	Intervention	Popu-lation	Study completion	Follow-up	Outcome	Primary outcome	Remarks
Askling et al. Sweden 2003	- 10-week (16 sessions) preseason hamstring concentric/eccentric strength training. - Performed additional to standardized warm-up programme also performed by controls.	- 30 elite, male soccer players, except goalkeepers, in two teams from the Swedish premier-league division.	- 15 individuals in intervention group with a distribution of eight and seven subjects, from each team respectively. - 15 controls with seven individuals from one team and eight from the other. - No attrition	- Ten weeks preconditioning + one season of eight months.	- 3 injuries in intervention group. - 10 injuries in control group.	- Hamstring injury: Pain by use/palpation + time loss. - Evaluation by therapist and physician. - Injured players were excluded.	- True individual-randomized study, but potential contamination problems could exist - Intention-to-treat analysis. - All players reported having completed all sessions.
Beijsterveldt et al.	- 10-15min with ten exercises focusing on core stability, eccentric training of	- 487 male amateur players, aged 18-40	- 223 players in eleven intervention	- One season of nine months.	- 135 injuries in intervention group.	- All-injury: F-MARC consensus statement	- Intention-to-treat. - Sample

Netherlands 2013	the thighs, proprioception training, dynamic stabilization, and plyometrics with straight leg alignment. - 5 week pre-season familiarisation and full implementation by the start of the season. - Control group did the practice as usual.	years.	teams. - 233 players in twelve control teams. - Dropout of one team (21 players) plus 18 individuals in the intervention group and 13 from control group.		- 139 injuries in the control group.	definition - Team paramedic or sports trainer recorded injuries.	size calculation based on inflation factor estimate but no report of actual cluster adjustments in either study protocol or published report. - 73% compliance.
Brushoj et al. Denmark 2008	- 12-week program (three sessions, 15min each, per week) concurrent with start of basic military training. One session composed two strength exercises, three stabilization/	- 1020 conscripts, aged 19-26.	- 487 individuals in twelve intervention platoons – attrition of 20 - 490 in twelve control	- Twelve weeks.	- 50 primary outcome injuries in prevention group. - 48 outcome injuries in control group.	- Knee overuse injury: Pain + unrelated to trauma + specific criteria. - Medical officer and doctor.	- 75% training compliance. - True individualized randomization - No

	coordination exercises, and one stretching exercise. - Controls did placebo core/upper body exercises with stretch of the pectoral muscles.		teams - attrition 23			- Injuries within last month were excluded. - Repeated outcomes not taken into account. - Secondary: Total lower extremity injuries	intention-to-treat analysis. - True blinding have likely been achieved. - Concurrent training intervention in high risk period for overuse injuries may be detrimental
Coppack et al. United kingdom 2011	- 14 week program concurrent with military training. Seven training lessons/week with four strength exercises + four stretching exercises per training. - Control performed	- 44 male and female troops (clusters) with 1502 recruits. Aged 17-30y. - 100% of eligible	- 759 individuals in 21 intervention troops. - 743 in 23 control troops. - No	- 14 weeks	- 10 injuries in intervention group. - 36 injuries in control group. - Cox HR 0,25 (0,13-	- Overuse anterior knee pain injury: Pain criteria and other knee injuries excludable. - Military medical center and	- Study suspended early because of military operational commitments. - Within-cluster

	syllabus military warm-up and warm-down for parts of the body irrelevant for anterior knee pain.	recruits participated .	attrition.		0,48).	physiotherapist . - Recruits with signs or symptoms of pathologic conditions of the leg were excluded. - Secondary: Total, acute, and overuse injuries	correlation was accounted for. - Mean individual compliance rate for the 2 programs was 91%. - Intention-to-treat analysis.
Eils et al. Germany 2010	- Six proprioception exercises for 20min once per week concurrent with basketball training. - Controls continued normal workout routine.	- 198 basketball players in 35 teams from 7th highest to highest league.	- 81 individuals in intervention group. - 91 controls. - 35 teams.	- One season	-Seven injuries in intervention group. - 21 injuries in control group.	- Ankle injury: time loss. - Coach/ physiotherapist / player registration by questionnaire, followed by interview in case of injury. - Subjects were free of injuries at the	- No mention of compliance - No adjustments for clustering effects. - No mention of intention-to-treat.

						start of study.	
Emery et al. Canada 2005	- Proprioception, balance, and core training 20min/day for six weeks and weekly for six more months. - Students in the control group received only testing.	- 127 students from 10 high schools, aged 14-19. - 76% of eligible participants consented to participate.	- 60 students in 5 intervention schools. - 54 students in 5 control schools.	- Six weeks plus six months.	- 2 injuries in intervention group. - 10 injuries in control group. - RR 0,20 (0,05-0,88).	- All injuries: Medical attention and/or time loss. - Physiotherapist - Injuries within last 6 weeks prior to the study were excluded.	- Intention-to-treat analysis. - Adjusted for clustering effects. - Collected data on compliance was low (43,3%) but actual training compliance is unknown.
Emery et al. Canada 2010	- 5min warm-up + 10min strength, stretch, balance warm-up substitution + additional 15min wobble board. - Controls 15min standart warm-up.	- 885 soccer players in 60 clubs. Both boys and girls, aged 13-18. - 73% of eligible	- 380 players in 32 intervention teams. - 364 players in 28 control teams.	- One year follow-up, season was 20 weeks.	- 50 injuries in training group. - 79 injuries in control group. - RR 0,62 (0,39-0,99).	- All injuries: Medical attention and/or time loss. - Physiotherapist or athletic therapist.	- Intention to treat analysis used. - Adjusted for clustering. - Teams completing

		teams were enrolled.				- Injuries within 6 weeks were excluded. Secondary outcome: Total acute injuries.	exposure data performed all intervention warm-ups but reporting was poor (<15%).
Emery et al. Canada 2007	- 5min sport-specific balance training and 20min wobble board additional to control warm-up. - Control group performed "current standart practice" warm-up five times/week.	- 931 male and female high school basketball players, 12-18y in 89 teams.	- 494 players in 47 intervention teams. - 426 players in 41 control teams.	- One year follow-up. Season was 18 weeks.	- 130 injuries in intervention group - 141 injuries in control group - RR 0,8 (0,57-1,11).	- All injuries: Medical attention and/or time loss - Injury surveillance system from Canadian Intercollegiate Sports Injury Registry (CISIR) and therapist. - Injuries within 6 weeks were excluded.	- Self-recorded wobble-board compliance 60,3%. - Analysed by intention-to-treat. - Adjusted for cluster effect.
Gilchrist et	- Warm-up, stretch,	- Female	- 26	- One season	- 2 injuries in	- Noncontact	- As-treated

al. Switzerland 2008	strength, plyometric, and sport-specific agility three times per week consisting of 3-5 exercises for each discipline. - Controls normal warm-up.	collegiate soccer players in 75 teams.	intervention teams with 583 individuals. - Control 35 teams with 852 individuals.	of twelve weeks.	intervention group. - 10 injuries in control group.	ACL injury: time loss. - Athletic trainers, confirmed by either MR, arthroscopy, or visualization at the time of repair. - Previous injuries were included.	analysis. - No adjustments for clustering effects. - Average compliance with training regime was 26 times per team.
Heidt et al. USA 2000	- 20 individualized preseason conditioning sessions for seven weeks. Two sessions per week were sport-specific cardiovascular conditioning exercises with increasingly inclining treadmill to enforce forceful knee drive. One	- 300 female high school soccer players, 14-18y.	- 42 players in intervention group. - 258 controls.	- One year.	- 6 first-time injuries in 42 athletes of the intervention group. - 87 first-time injuries in 258 athletes in the control group.	- All-injury: time loss. - School athletic trainers. - No mention of previous injuries.	- The year included two separate seasons. - Intention-to-treat analysis as data from all 300 players were included. - True individual-

	plyometric session per week with progression of movements. - Sport cord drills, strength training, and flexibility training mentioned but not described as part of the 20 sessions - Control group activity not described.						allocation to groups. - No mention of player recruitment. - No mention of compliance rates.
Holmich et al. Denmark 2010	- Sit-ups, one-leg coordination, iliopsoas stretching, and three concentric, eccentric, and isometric adduction exercises for 13min as integrated part of warm-up. - Control group performed traditional warm-up	- Amateur football players, 2-5th level. - 46% of invited teams accepted participation.	- 477 players in 22 intervention clubs. - 430 players in 22 control clubs - 12 + 11 clubs withdrew	- 42 weeks.	- Corresponding author reported 23 injuries in intervention group and 30 injuries in control group. - Cox HR 0,69 (0,40-1,19).	- Groin injury: any physical complaint or medical attention. - Physiotherapist and coach. - Previous groin injuries included.	- 11 year report delay due to high number of competing tasks. - Adjusted for intracluster estimate. - 93% of players

			immediately after randomization and further 5 + 6 during the study.				presented with full data. - The intention-to-treat analysis were claimed not to show any differences but weren't reported.
Jamtvedt et al. Norway/ Australia 2010	- Seven muscle groups in the lower limb and trunk were stretched for at least 14min before and after vigorous activity. Instructions were accessible at website and subjects were asked to stretch for at least 30 sec and until felt strong but not painful stretch.	2377 participants worldwide, >18 years, English/ Norwegian speaking, vigorous activity ≥1 day(s) a week, and internet access.	- 1079 participants in intervention group. - 1046 controls.	- Twelve weeks.	- 339 injuries in intervention group and 348 in the control group. - Cox HR 0,97 (0,84-1,13).	- Lower limb and trunk injuries: internet-based self-reporting. - Current injuries were excluded.	- Entirely internet-based study design. - Intention to treat analysis. - According to self-reports 38,4% and 43,9% of the intervention group

	- Controls were asked not to stretch any lower limb or trunk muscle groups						complied fully or almost fully to target frequency and duration, respectively.
LaBella et al. USA 2011	- 20min full strength, plyometric, balance, and agility warm-up program before practice and dynamic motion warm-up before games. - Controls did usual warm-up.	- 95 coaches of 111 teams with 1558 female athletes in a mixed-ethnicity, pre-dominantly low-income, urban population.	- 45 intervention coaches (53 teams) with 737 athletes. - 45 control coaches (53 teams) coaches with 755 athletes.	- One season.	- 50 injuries in intervention group. - 96 injuries in the control group.	- Lower extremity injury: Time loss. - Physical therapy/ medicine/ advanced practice nursing students with diagnosis confirmation. - No specific exclusion criteria.	- Self-reported compliance to prescribed warm-up was 80% but most coaches did not use all the prescribed exercises. - No adjustments for clustering effects. - Intention-

							to-treat analysis.
Longo et al. Italy/England 2012	- 20min, three component warm-up program, 1: Slow running exercises with stretch/controlled partner contact, 2: strength/balance/jump exercises, 3: speed running with basketball-specific movements. Full warm-up before each training and running exercises before matches - Control usual warm-up	- 11 teams composed of 121 players from one club. Male players from U12, league to 3rd national league.	- Seven intervention teams with 80 players. - Four control teams with 41 players. - No attrition.	- Nine months.	- 14 injuries in intervention group. - 17 injuries in control group.	- All-injury: No mention of other criteria than diagnosis or not - Team medical staff and research center orthopaedic personnel. - No mention of inclusion/ exclusion of previous injuries.	- Analyzed by intention-to-treat. - Authors report 100% compliance. - No adjustments for clustering effects.
McGuine et al. USA 2006	- Four progressive phases with five sessions per week. Balance board preconditioning in four weeks followed by a maintenance phase during the	- 765 adolescent basketball and soccer players, 523 girls and 242 boys, high	- 27 intervention teams consisting of 373 participants. - 28 control	- Four weeks conditioning plus one season of follow-up.	- 23 injuries in intervention group. - 39 injuries in control group.	- Ankle sprain: disruption of ankle ligaments + time loss. - Athletic trainer	- Intention-to-treat analysis. - 9% missed four consecutive sessions

	season, three sessions per week - Controls did normal conditioning.	schools from twelve areas.	teams with 392 participants.		- Cox RR 0.56 (0.33-0.95).	assessed injuries. - Previous injuries (24% of participants) were included in the study.	and were defined as non-compliant. - No adjustments for clustering effects.
Olsen et al. Norway 2005	- 15 consecutive sessions of four exercises for a total of 15-20min every training session and then once a week for the remainder of the season. Comprised of warm-up, technique, balance and strength/power. - Controls trained as usual.	- 1886, 15-17 year-old, players in 123 handball clubs. - 85% of eligible were recruited.	- 61 intervention clubs of 958 players. - 59 control clubs of 879 players.	- One season of eigth months.	- 48 injuries in the intervention group. - 81 injuries in the control group. - Cox RR 0,53 (0.35-0.81).	- Knee and ankle injury: Time loss. - Physiotherapists. - No major injuries at inclusion.	- Intention-to-treat analysis. - Adjusted for clustering effect. - 87% compliance to programme.
Pasanen et al. Finland	- 20-30min of running techniques, balance/body control, plyometric,	- 28 teams with 475 female floorball	- 14 intervention teams of 256 players.	- One season of six months.	- 20 injuries in the intervention group.	- Non-contact injury: time loss. - Study doctor	- Intention-to-treat analysis. - A mean of

2008	and strength exercises. Players with lower back control difficulties or flexibility limitation were asked to stretch in addition. Two week introduction and thereafter the players were advised to carry out in own time. - Control usual warm-up	players of elite league, 1st, and 2nd division. - 86% of eligible players were recruited.	- 14 control teams of 201 players.		- 52 injuries in the control group. - RR 0,34 (0.20-0.57).	followed up on questionnaire reports. - Previous injuries were included and didn't differ between the two groups.	74% of sessions were completed. - Cluster adjusted by estimation of intracluster correlation coefficients. - On average 69% of players attended training.
Petersen et al. Denmark 2011	- Additional ten week progressive Nordic hamstring exercise and maintenance of three sets once a week. - Controls trained as usual.	- 54 men's soccer teams from the five best leagues in Denmark.	- 23 intervention teams with 461 players. - 27 control teams with 481 players. - No dropout.	- Twelve months.	- 12 injuries in intervention group. - 32 injuries in control group. - RR 0,41 (0,18-0,93).	- Acute hamstring injury: any physical complaint. - Medical staff or physiotherapist.	- 91% compliance to intended training. - Adjusted for intracluster coefficient. - Intention-

						- Previous injuries were included and didn't differ between the two groups.	to-treat analysis.
Pope et al. Australia 1998	- Two 20sec stretches for gastrocnemius and soleus before strenuous exercise, on average every second day. - Controls stretched wrist flexors and triceps.	- 1093 male recruits between 17-35 years.	- 549 subjects in 26 intervention platoons. - 544 subjects in 26 control platoons. - No attrition.	- Twelve weeks.	- 23 injuries in intervention group. - 25 injuries in control group. - Cox HR 0,92 (0,52-1,61).	- Injury definition: >3 days before taking up full duty without symptoms because of tendo-achilles lesion, ankle sprain, stress fracture, periostitis, or anterior tibial compartment pressure syndrome. - Reporting to medical assistants or nursing staff and diagnosis	- 96,7% of eligible recruits consented. - Analysed by survival analysis. - No mention of adjustment for clustering effects. - Intention-to-treat as there was no dropout.

						by medical officer or research physiotherapists. - Excluded if significant pre-existing injury.	
Pope et al. Australia 2000	- 40 sessions in twelve weeks with a 5min program with 20sec stretches interspersed with 4min warm-up. Six muscle groups of the leg were stretched. - Controls didn't stretch during warm-up.	- 1538 male army recruits in 39 platoons.	- 19 intervention platoons of 666 subjects. - 20 control platoons of 702 subjects.	- Twelve weeks.	- 158 injuries in intervention group. - 175 injuries in control group. - Cox HR 0,95 (0,77-1,18).	- Lower-limb injury: >3 days before taking up full duty without symptoms. - Reporting by medical assistants or nursing staff and diagnosis by medical officer. - Significant injuries were excluded.	- Intention-to-treat analysis. - No mention of adjustments for clustering effects. - No analysis of compliance other than reported training days.
Soderman et al.	- 10-15min additional balance board exercises	- 221 female soccer	- 62 players in seven intervention	- One season of seven months.	- 28 injuries in intervention	- Lower extremity injury: time	- No mention of cluster

Sweden 2000	consisting of five progressions of difficulty. Each exercise was carried out three times 15sec for each leg. Initially training each day for 30 days and after this three times per week the rest of the season. - No description of control group instructions.	players from 13 teams in the 2nd and 3rd Swedish division.	teams. - Control 78 players in six teams.		group. - 31 injuries in control group. - Cox RR 1,24 (0,74-2,06).	loss. Reported by players and coaches and diagnosed by authors. - Recurrent injuries analyzed.	adjustment. - Not analyzed by intention-to-treat. - Intervention group performed 77% of the planned sessions. 27 individuals who didn't complete more than 35 sessions were excluded. - Cox RR of major injuries 10.96 (2.10-57.3).
Soligard et	- 8min running	- 2540	- 52	- One season	- 121 injuries	- Lower	- Adjusted

al. Norway 2008	exercises, 10min of strength/balance/jump exercises, and 2min of football-specific movements before each training and the running exercises before each match. - Controls performed usual warm-up.	female football players in 125 clubs, aged 13-17 years. - 69% of eligible clubs participated.	intervention clubs with 1055 players. - 41 control clubs with 837 players.	of eigth months.	in intervention group. - 143 injuries in control group. - Cox RR 0,71 (0,49-1,03).	extremity injury: time loss. - Physical therapist and medical student. - Unknown whether previous injuries were included in analysis.	by intracluster coefficient. - Intention-to-treat analyses. - 77% compliance. - No injury occurred during the execution of the warm-up programme.
Steffen et al. Norway 2008	- 5min jogging followed by ten exercises focusing on core stability, balance, joint stabilization, and eccentric hamstring strength for about 15min. Performed for 15 consecutive sessions and after that, once a week for the rest of the	- About 2100 female soccer players in 113 teams from Norwegian U17 league. - 72% of eligible	- 1073 players in 58 intervention teams. - 947 players in 51 control teams.	- Two months pre-season + one season of eight months.	- 242 injuries in intervention group. - 241 injuries in control group. - RR 1,0 (0,8-1,2).	- All-injury: time loss. - Physical therapists. - Unknown whether previous injuries were included in analysis.	- Intention-to-treat analyses. - Adjusted for clustering effects. - The program was used at 52% of all trainings for

	season. - Controls trained and warmed-up as usual.	clubs participated.					the intervention group and the average attendance for these were 60% for each player.
Waldén et al. Sweden 2012	- 5min low intensity running warm-up and 15min for six neuromuscular exercises program. The six exercises were one legged knee squat, pelvic lift, two legged knee squat, the bench, the lunge, and jump/landing technique two times a week. - Controls trained as usual and teams already did injury prevention were excluded.	- 309 clubs with 4564 female soccer players, 12-17 years. - 75% of eligible clubs participated.	- 121 intervention clubs with 2479 players. - 109 control clubs with 2085 players.	- One season of seven months.	- Intervention group: 7 injuries. - Controls: 14 injuries. - Cox RR 0,36 (0,15-0,85).	- ACL injury: sudden onset time loss. - Study therapists and physicians with access to diagnostic imaging. - Unknown whether previous injuries were excluded.	- Intention-to-treat analysis. - Adjustment for clustering effects performed. - No report of compliance.

Wedderkop p et al. Denmark 1999	- 10-15min of ankle disc exercises and a minimum of two functional activities for all major upper and lower extremity muscle groups. - Controls were asked to practice as usual.	- 22 teams with 237 players, aged 16-18 years, in three tournament s.	- 11 intervention teams with 111 players. - 11 control teams with 126 players.	- One season of ten months	- 11 injuries in intervention group. - 45 injuries in intervention group. - OR 0.17 (0.089-0.324).	- All-injury: time loss. - Therapists and physicians. - Unknown whether previous injuries were excluded.	- Controlled for playing level. - Intention-to-treat analysis was performed. - No mention of adjustments for clustering effects.

§6, Quality assessments

Askling et al., Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload

Random sequence generation	Reported	*"were randomly assigned to either"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*N/A*
	Judgement	**Unclear** risk of bias
Blinding of participants/personnel	Reported	*"Before the start of the study, the players, coaches and medical personnel of the two*

		teams were informed about the purpose and the design of the study"
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"Before the start of the study, the players, coaches and medical personnel of the two teams were informed about the purpose and the design of the study"* *"medical personnel of each team were not part of the study, thus avoiding bias"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*Comment: No reported dropout or missing data*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Intention-to-treat analysis performed* *Comment: Possible contamination between study arms may underestimate intervention effect*
	Judgement	**Low** risk of bias

Beijsterveldt et al., effect Effectiveness of an injury prevention programme for adult male amateur soccer players: a cluster-randomised controlled trial

Random sequence generation	Reported	*Published study protocol reference:* *"Randomisation was done independently by drawing lots"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*N/A*
	Judgement	**Unclear** risk of bias
Blinding of participants/personnel	Reported	*Published study protocol reference: "The research team gave the clubs and their first team coaches information about the aims of the trial. The control group was asked to participate in a study on injury incidence and characteristics of practice sessions"*
	Judgement	**Low** risk of bias
Blinding of outcome assessment	Reported	*N/A*
	Judgement	**Unclear** risk of bias
Incomplete outcome data	Reported	*"Shortly after randomisation, the coach of one team from the intervention group refused to use The11 during the practice sessions"* *Comment: The above should count as dropout as the team were randomized at this point. This*

		means a dropout of 39 from the intervention group and 13 players from the control group according to the study flow chart
	Judgement	**High** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study was available but the published article don't report the pre-specified Cox regression or any satisfactory measures of first-time injury*
	Judgement	**High** risk of bias
Other bias	Reported	*Comment: Intention-to-treat analysis performed. Sample size calculations based in inflation factor estimate but no report of actual cluster adjustments in either study protocol or published report*
	Judgement	**High** risk of bias

Brushoj et al., Prevention of overuse injuries by a concurrent exercise program in subjects exposed to an increase in training load - A randomized controlled trial of 1020 army recruits

Random sequence generation	Reported	*"The conscripts were randomly divided (by personal registration number) into 8 companies each consisting of 3 platoons"* *Comment: True cluster-randomization was*

		achieved as personal registration numbers are randomly generated in Denmark
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"randomization was performed by the head nurse, who otherwise did not participate in the study"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*"the recruits did not know which of the training programs was being tested"* *"before their examination, the patients were informed by the head nurse not to reveal what exercise group they were allocated to"*
	Judgement	**Low** risk of bias
Blinding of outcome assessment	Reported	*"before their examination, the patients were informed by the head nurse not to reveal what exercise group they were allocated to"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*"Attrition reasons not related to the present study"* *Comment: Attrition of 20 and 23 in intervention and control group, respectively.*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: No clinical trials registry study*

		protocol available and no pooled estimate for pre-specified primary outcomes
	Judgement	**High** risk of bias
Other bias	Reported	*Comment: No intention-to-treat analysis or cluster adjustments* *Comment: Concurrent training in high risk period may be detrimental for overuse injuries and may lead to an increased injury risk in the intervention group.*
	Judgement	**High** risk of bias

Coppack et al., The Effects of Exercise for the Prevention of Overuse Anterior Knee Pain A Randomized Controlled Trial

Random sequence generation	Reported	*"A simple randomization procedure based on a computer-generated table of random numbers"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"An external administrator provided the group assignment"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*"An attempt was made to blind participants, but given the physical nature of the intervention, we refrain from calling this a double-blinded study"*

		Comment: participant blinding attempt through the application of dummy warm- up exercises for control group participants
	Judgement	**Low** risk of bias
Blinding of outcome assessment	Reported	*"Participants... were instructed not to reveal information about sessions to the AKP outcome assessor (physiotherapist)"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*"Because of the military setting, no individuals were lost to follow-up"* *"there was no evidence to suggest a difference in voluntary discharge rate between groups (P>0,05)"*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Adjustment for clustering effect and intention-to-treat performed*
	Judgement	**Low** risk of bias

Eils et al., Multistation proprioceptive exercise program prevents ankle injuries in basketball

Random sequence generation	Reported	*"198 subjects were randomly assigned to the control or the training group using a stratified randomization design, with the strata defined by performance (high, middle, or low) and sex"* *Comment: Performed by computer*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*Comment: No blinding*
	Judgement	**High** risk of bias
Blinding of participants/personnel	Reported	*Comment: Description of injury assessment and reporting indicate that blinding haven't been performed*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*Comment: Description of injury assessment and reporting indicate that blinding haven't been performed*
	Judgement	**High** risk of bias
Incomplete outcome data	Reported	*Comment: Figure 1 shows 15 and 11 lost to follow-up for training and control, respectively. Attrition is fairly balanced between the two groups with similar reasons for missing data reported.*
	Judgement	**Low** risk of bias

Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: No mention of intention-to-treat or adjustment for clustering effects*
	Judgement	**High** risk of bias

Emery et al. 2005, Effectiveness of a home-based balance-training program in reducing sports-related injuries among healthy adolescents: a cluster randomized controlled trial

Random sequence generation	Reported	*"Computer generated random numbers were used to recruit schools and students and to allocate the schools to the intervention or control group"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"Computer generated random numbers"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*"The study was blinded in that we randomly allocated schools to the intervention or control group following initial subject recruitment"* *Comment: This doesn't in itself ensure blinding*

		but given the nature of interventions in most of the included studies in this paper an effort is considered to at least minimize the risk of bias in comparison to studies that provide full info to all participants
	Judgement	**Low** risk of bias
Blinding of outcome assessment	Reported	*N/A*
	Judgement	**Unclear** risk of bias
Incomplete outcome data	Reported	*Comment: Participation flow chart states 6 and 7 exclusions from the intervention and control group, respectively. Exclusion reasons are stated and there are no indices that these shouldn't be balanced between groups or being of dissimilar reasons.*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Adjustment for clustering effects performed. Rate of collected data on compliance was low (43,3%) but as intention-*

		to-treat analysis was performed this would lead to an underestimation of the effect of the intervention effect and the conclusions of this study therefore seems robust
	Judgement	**Low** risk of bias

Emery et al. 2010, The effectiveness of a neuromuscular prevention strategy to reduce injuries in youth soccer: a cluster-randomised controlled trial

Random sequence generation	Reported	*"Teams were randomised by club"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"Randomisation was revealed following recruitment of teams to ensure allocation concealment"*
	Judgement	**High** risk of bias
Blinding of participants/personnel	Reported	*"Teams were blinded to the details of the other study-group programmes"* *Comment: Control group did a standard warm-up which made it possible to blind participants*
	Judgement	**Low** risk of bias
Blinding of outcome assessment	Reported	*"A study therapist (physiotherapist or athletic therapist) blinded to study group allocation was on site"*
	Judgement	**Low** risk of bias

Incomplete outcome data	Reported	*Comment: Participant flow chart shows an attrition of 89 individuals in the training group and 52 from the control group. Team dropout after randomization was considered uneven*
	Judgement	**High** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Adjusted for clustering effects.* *Comment: Rate of collected data on compliance was poor (<15%) but as intention-to-treat analysis was performed this would lead to an underestimation of the effect of the intervention effect and the conclusions of this study therefore seems robust* *Comment: Statistically significant difference in gender distribution at baseline*
	Judgement	**Low** risk of bias

Emery et al. 2007, A prevention strategy to reduce the incidence of injury in high school basketball: a cluster randomized controlled trial

Random sequence generation	Reported	*"Random selection of schools was done by computer generation of random numbers"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"following subject recruitment to ensure allocation concealment"*
	Judgement	**Unclear** risk of bias
Blinding of participants/personnel	Reported	*Comment: Subject blinding haven't been mentioned but design make true blinding possible*
	Judgement	**Unclear** risk of bias
Blinding of outcome assessment	Reported	*"The team therapist was blinded to training group allocation"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*Comment: Participation flow chart report a dropout of one team (n = 11 subjects) from intervention group.*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*

	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Adjusted for clustering effects and analysed by intention-to-treat*
	Judgement	**Low** risk of bias

Gilchrist et al., A Randomized Controlled Trial to Prevent Non contact Anterior Cruciate Ligament Injury in Female Collegiate Soccer Players

Random sequence generation	Reported	*"Intervention and control teams were paired by proximity"* *"Pairs were clustered geographically by region... and one pair from each region was selected randomly for observation"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"Participation and injury reports were submitted weekly by facsimile to study staff using codes for both teams and individual athletes for confidentiality"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*"Each team's ATC provided the athletes an overview of the study"*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"an ACL injury was counted only if the ATC reported confirmation by magnetic resonance*

		imaging, arthroscopy, or direct visualization at the time of repair“ *Comment: The above methods ensure a high level of objectiveness but, MR especially, can still contain a component of assessment.*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*"Eight intervention teams were excluded from the analysis because they did not use the program 12 or more times"* *Comment: Twelve teams dropped out after randomization from intervention group and two from control group*
	Judgement	**High** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: No intention-to-treat analysis or adjustment attempts for clustering effects*
	Judgement	**High** risk of bias

Heidt et al., Avoidance of soccer injuries with preseason conditioning

Random sequence generation	Reported	*"Before the start of the select season, 42 of these players were randomly selected to participate in the Frapier Acceleration Training Program"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*N/A*
	Judgement	**Unclear** risk of bias
Blinding of participants/personnel	Reported	*Comment: Customized athlete training makes blinding impossible*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"The athletic trainers were blinded as to which athletes participated in the preseason training program"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*Comment: All 300 participants was included in analysis*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias

Other bias	Reported	*Comment: Intention-to-treat analysis were performed and no serious sources of bias were found*
	Judgement	**Low** risk of bias

Holmich et al., Exercise program for prevention of groin pain in football players: a cluster-randomized trial

Random sequence generation	Reported	*"randomized to the prevention group (PG) or the CG by block randomization (block size two). The randomization was computer generated"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"The individual physiotherapists and coaches were informed about the allocation of their club by a letter in a sealed and opaque envelope mailed by a secretary not involved in the analysis of the data"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*"Because of the nature of the intervention, blinding of the participants and observers (physiotherapist and coach) was not possible"* *"The data manager, the statistician, and the authors were all blinded to the result of the*

		randomization"
	Judgement	**Low** risk of bias
Blinding of outcome assessment	Reported	*"Because of the nature of the intervention, blinding of the participants and observers (physiotherapist and coach) was not possible"*
	Judgement	**High** risk of bias
Incomplete outcome data	Reported	*"Because this ... was evenly distributed between the two allocations, we do not find this alarming from a trial quality point of view but very unfortunate from a sample size point of view."* *Comment: A dropout after randomization of 44% will inevitably lead to some extend of selection bias*
	Judgement	**High** risk of bias
Selective reporting	Reported	*Comment: No clinical trials registry study protocol available and results of the claimed intention-to-treat analysis wasn't reported*
	Judgement	**High** risk of bias
Other bias	Reported	*Comment: "11 year report delay due to high number of competing tasks* *Comment: Adjusted for intracluster correlation and intention-to-treat analysis was performed*

		but was not reported *Comment: With 907 injuries in 977 individuals repeated injuries must have been included.*
	Judgement	**High** risk of bias

Jamtvedt et al., A pragmatic randomised trial of stretching before and after physical activity to prevent injury and soreness

Random sequence generation	Reported	*"The randomisation schedule was unrestricted (no stratification or blocking) and was administered by computer"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"The allocation code was not broken until the analyses were compared and found to yield the same results"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*Comment: No attempts to blind participants were described. The recruitment methods make it unlikely that participants have been blinded*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"Participants who experienced an injury of the lower limb or back in the past week were asked to provide details about the injury, using an adaptation of the groupings and categories*

		recommended by Fuller et al." *Comment: No mention of injury-confirmation procedures* *Comment: Blinding will, in case of participant self-assessment, depend on participants blinding*
	Judgement	**High** risk of bias
Incomplete outcome data	Reported	*"Completeness of reporting was similar in the two groups"*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: In the stretching group only 38,4% and 7,7%, respectively, complied fully or almost fully with target frequency and target duration. This could lead to an underestimation of the effect and may originate in the limitations on participant motivation over the internet*
	Judgement	**High** risk of bias

LaBella et al., Effect of neuromuscular warm-up on injuries in female soccer and basketball athletes in urban public high schools: cluster randomized controlled trial

Random sequence generation	Reported	*"The statistician generated the randomization sequence using an online random number generator program"* *Comment: A minimization was conducted*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"The research coordinator (J.G.) informed coaches of their allocation"*
	Judgement	**High** risk of bias
Blinding of participants/personnel	Reported	*"The research coordinator (J.G.) informed coaches of their allocation"* *"The research assistants (RAs) were not blinded to group assignments"* *"We minimized this potential bias by objectively defining injury as one causing missed time from practice or game, and when a physician's diagnosis was unavailable, RA's consulted the principal investigator, who was blinded"*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"The principal investigator and coinvestigators*

		were blinded until data collection was complete"
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*"Drop-out rates were 6% for control coaches and 4% for intervention coaches"*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports lack a total estimate for primary outcome*
	Judgement	**High** risk of bias
Other bias	Reported	*Comment: Intention-to-treat analysis was performed but adjustments for clustering effects wasn't accounted for on primary outcome*
	Judgement	**High** risk of bias

Longe et al., The FIFA 11+ Program Is Effective in Preventing Injuries in Elite Male Basketball Players A Cluster Randomized Controlled Trial

Random sequence generation	Reported	*"Randomization was done independently by drawing lots"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"The statistician who conducted the randomization did not take part in the study"*

	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*"Another limitation of this study is that teams were not blinded to the exercise program"*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*Comment: Team medical staff reported to blinded orthopaedic personnel*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*Comment: Participants flow chart reveal 0 lost to final follow-up*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Analyzed by intention-to-treat but no adjustments for clustering effects*
	Judgement	**High** risk of bias

McGuine et al., The effect of a balance training program on the risk of ankle sprains in high school athletes

Random sequence generation	Reported	*"Randomization into intervention and controls*

		was performed using groups of two based on a schedule provided by the statistician"
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*N/A*
	Judgement	**Unclear** risk of bias
Blinding of participants/personnel	Reported	*"Subjects performing the intervention knew they were doing so to prevent ankle sprains"*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"the ATCs at the schools knew which teams were in the control and intervention groups"*
	Judgement	**High** risk of bias
Incomplete outcome data	Reported	*"(n = 11) of athletes dropped out of the study when they stopped participating on their interscholastic team and were included in the analysis through the last day of their team membership"*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Intention-to-treat analysis performed*

		but no adjustments for clustering effects
	Judgement	**High** risk of bias

Olsen et al., Exercises to prevent lower limb injuries in youth sports: cluster randomised controlled trial

Random sequence generation	Reported	*"block randomised these, with four clubs in each block to an intervention or control group"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"The statistician who conducted the randomisation was not involved in the intervention"* *"Data on injury and exposure were reported by the physiotherapist using a web based database in which all the data were coded anonymously"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*Comment: teams were informed of allocation*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"Ten research physiotherapists who were blinded to group allocation recorded injuries in both groups"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*"Data on players who dropped out during the study period were included for the entire period*

		of their participation" *Comment: Participants flow chart show 30 dropouts from intervention and 19 from control group and no difference in dropout rates*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*"We undertook all statistical analyses according to a pre-specified plan"* *Comment: A clinical trials registry study protocol wasn't available*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Well powered and design/analyses appears strong*
	Judgement	**Low** risk of bias

Pasanen et al., Neuromuscular training and the risk of leg injuries in female floorball players: cluster randomised controlled study

Random sequence generation	Reported	*"computer-generated randomisation"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"The statistician (MP) who carried out the computer-generated randomisation was not involved in the intervention"*
	Judgement	**Low** risk of bias

Blinding of participants/personnel	Reported	*"We informed the teams allocated to the intervention group about the upcoming training programme for preventing injuries"*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*Comment: study doctor was "not involved in the intervention"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*Comment: Participant flow chart showed 9 dropouts in each group, all were players with no contract*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: Clinical trials registry study protocol was available and inclusion criteria, intervention, and outcomes corresponded to the reported study*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Sufficiently powered and design/analyses appears strong with both intention-to-treat analysis and adjustments for clustering effects*
	Judgement	**Low** risk of bias

Petersen et al., Preventive effect of eccentric training on acute hamstring injuries in men's soccer: a cluster-randomized controlled trial

Random sequence generation	Reported	*"An independent research assistant did the randomization procedure by drawing a sealed, opaque envelope containing a team name followed by drawing another sealed, opaque envelope containing the allocation group"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"An independent research assistant did the randomization procedure by drawing a sealed, opaque envelope containing a team name followed by drawing another sealed, opaque envelope containing the allocation group"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*"the person responsible for the day-to- day running of the project, medical staff within the teams, and all players were aware of group allocation"*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"Reasons for dropping out were transfer or stop of active career"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*Comment: Dropout rates were 8% and 9% for intervention and control groups, respectively*

	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Adjusted for clustering effects but no intention-to-treat analysis*
	Judgement	**Low** risk of bias

Pope et al. 1998, Effects of ankle dorsiflexion range and pre-exercise calf muscle stretching on injury risk in Army recruits

Random sequence generation	Reported	*"Recruits with surnames commencing with the same letter were equally split between the two platoons"* *"Pairs of platoons were then randomly allocated to control and stretch groups for this study"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*N/A*
	Judgement	**Unclear** risk of bias
Blinding of participants/personnel	Reported	*"They were not told which muscle group and*

		injuries the researchers were investigating" *Comment: Control stretching of upper- limb muscles is likely the best possible way to achieve true blinding of subjects*
	Judgement	**Low** risk of bias
Blinding of outcome assessment	Reported	*N/A*
	Judgement	**Unclear** risk of bias
Incomplete outcome data	Reported	*Comment: 98 from the intervention group and 112 from the control group were either discharged, backsquadded or withdrawn from the study*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: No mention of either adjustment for clustering effects or intention-to-treat analysis*
	Judgement	**High** risk of bias

Pope et al. 2000, A randomized trial of preexercise stretching for prevention of lower-limb injury

Random sequence generation	Reported	*"were allocated to strecth or control groups using a blocked, stratified, random allocation procedure"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"All allocation procedures to this point were conducted by administrative staff at Kapooka, without regard for the research to be conducted"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*Comment: Participants/personnel haven't likely been effectively blinded*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"The RMO, who was masked to patient allocation, categorized all injuries by area and type"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*"170 (11%; 69 from stretch group, and 101 from the control group) were discharged or transferred to officer training before the end of the training program and without suffering a lower- limb injury"* *Comment: Survival analysis was conducted*

		with subject results weighted by number of days of participation
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Intention-to-treat analysis but no adjustments for clustering effects*
	Judgement	**High** risk of bias

Soderman et al., Balance board training: prevention of traumatic injuries of the lower extremities in female soccer players? A prospective randomized intervention study

Random sequence generation	Reported	*"Seven teams (n=121) were randomized to an intervention group and six teams (n=100) to a control group"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*N/A*
	Judgement	**Unclear** risk of bias
Blinding of participants/personnel	Reported	*N/A*
	Judgement	**Unclear** risk of bias

Blinding of outcome assessment	Reported	*N/A*
	Judgement	**Unclear** risk of bias
Incomplete outcome data	Reported	*"Drop-out in the intervention group (59/121) and control group (22/100)"*
	Judgement	**High** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available and the published reports do not report a total estimate for primary outcomes*
	Judgement	**High** risk of bias
Other bias	Reported	*Comment: Exclusion of 1/3 intervention group on the basis of compliance and not because of lack of data* *Comment: Analysis of recurrent injuries* *Comment: RR of 10.96 (2.10-57.3) regarding major injuries indicate that intervention may be detrimental*
	Judgement	**High** risk of bias

Soligard et al., Comprehensive warm-up programme to prevent injuries in young female footballers: cluster randomised controlled trial

Random sequence generation	Reported	*"We randomised"*

	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"The statistician (IH) who conducted the randomisation did not take part in the intervention"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*Comment: Both groups were informed of allocation*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"At the research centre one physical therapist and one medical student, who were blinded to group allocation, recorded injuries"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*"13 clubs in the intervention group did not start the warm-up programme nor did they deliver any data on injury or exposure"* *"Nineteen clubs in the control group did not provide any data"* *"The dropout rate was similar between the groups (23 (2,1%) vs. 24 (2,9%))"*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected*

		outcomes, including those that were pre-specified in the method section of this article
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Adjusted by intracluster coefficient and analyzed by intention-to-treat*
	Judgement	**Low** risk of bias

Steffen et al., Preventing injuries in female youth football – a cluster-randomized controlled trial

Random sequence generation	Reported	*Comment: Stratified block randomization was described*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"The statistician (IH) who conducted the randomisation did not take part in the intervention"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*Comment: Both groups were informed of allocation*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"The injury recorders were blinded to which group the teams and injured players belonged to"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*Comment: 18 and 54 players dropped out from*

		the intervention and control group, respectively. The reports on attrition is ambiguous
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*"The program was used at 52% of all trainings for the intervention group and the average attendance for these were 60% for each player"* *Comment: Both intention-to-treat analysis and clustering effect adjustments were performed*
	Judgement	**Low** risk of bias

Waldén et al., Prevention of acute knee injuries in adolescent female football players: cluster randomised controlled trial

Random sequence generation	Reported	*"We used a computer generated list of random numbers to randomise clubs stratified by district, whereby all teams from the same club were assigned to the same group"*

	Judgement	**Low** risk of bias
Allocation concealment	Reported	*"One author (IA) who was blinded to the identity of the clubs did the randomisation"*
	Judgement	**Low** risk of bias
Blinding of participants/personnel	Reported	*"The coaches, players, and study therapists were not blinded to group allocation"*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*"The coaches, players, and study therapists were not blinded to group allocation, but the study physicians who assessed the primary outcome were"*
	Judgement	**Low** risk of bias
Incomplete outcome data	Reported	*"the dropout frequency was 21% (intervention 16% (23/144 clubs), control 26% (38/147))"* *"no missing data for analysed clubs"*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: Clinical trials registry study protocol was available and inclusion criteria, intervention, and outcomes corresponded to the reported study of this article*
	Judgement	**Low** risk of bias
Other bias	Reported	*Comment: Both adjustment of clustering effects and intention-to-treat were performed.*

	Judgement	**Low** risk of bias

Wedderkopp et al., Prevention of injuries in young female players in European team handball. A prospective intervention study

Random sequence generation	Reported	*"Eleven teams with 11 players were randomised to the intervention group and 11 teams with 126 players to the control group"*
	Judgement	**Low** risk of bias
Allocation concealment	Reported	*Author correspondance: No blinding*
	Judgement	**High** risk of bias
Blinding of participants/personnel	Reported	*Author correspondance: No blinding*
	Judgement	**High** risk of bias
Blinding of outcome assessment	Reported	*Author correspondance: No blinding*
	Judgement	**High** risk of bias
Incomplete outcome data	Reported	*Comment: Analysis performed on same no. of players as reported were randomized*
	Judgement	**Low** risk of bias
Selective reporting	Reported	*Comment: A clinical trials registry study protocol wasn't available but the published reports appear to include all expected outcomes, including those that were pre-specified in the method section of this article*
	Judgement	**Low** risk of bias

Other bias	Reported	*Comment: Intention to treat but no mention of adjustment for cluster effects*
	Judgement	**High** risk of bias

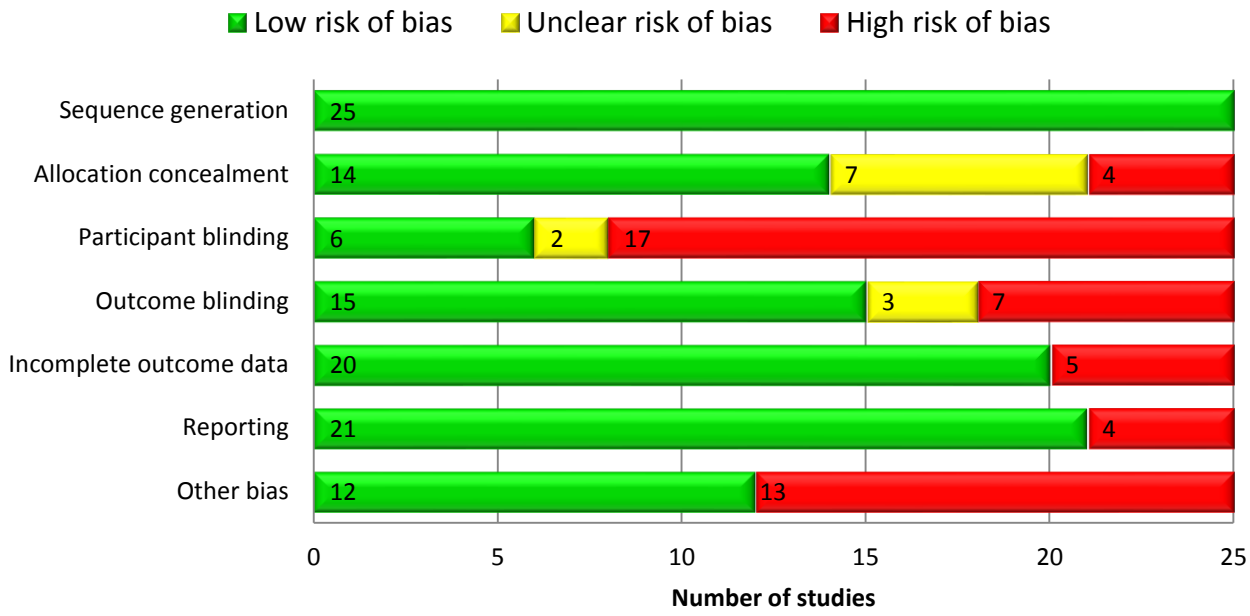
§7.1, Quality assessment summary

Total quality assessment 0-14 scale obtained by assigning studies 1 point for unclear and 2 for low

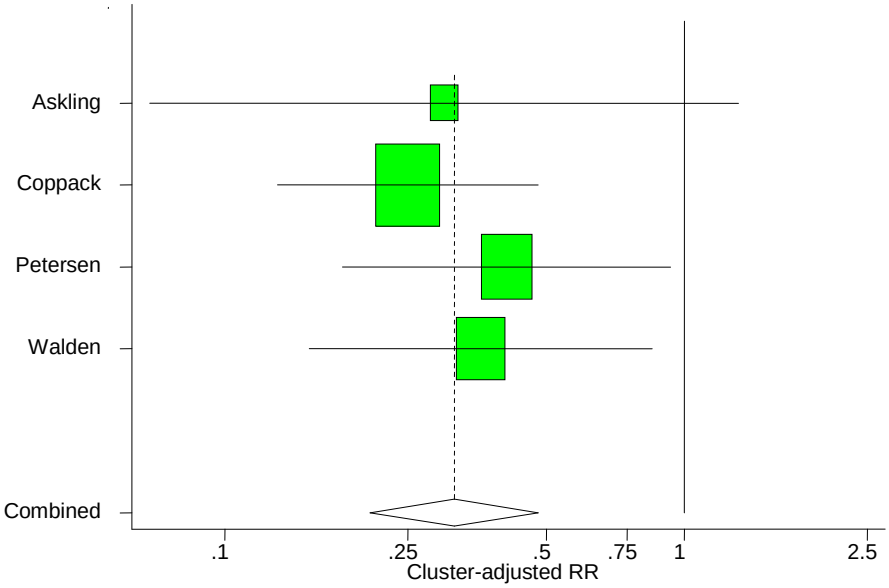
	Sequence genera-tion	Allocation conceal-ment	Participant blinding	Outcome blinding	Incomplete outcome data	Reporting	Other bias	Total quality assessment
Askling	Low	Unclear	High	Low	Low	Low	Low	11
Beijsterveldt	Low	Unclear	Low	High	High	High	High	5
Brushoj	Low	Low	Low	Low	Low	High	High	10
Coppack	Low	Low	Low	Low	Low	Low	Low	14
Eils	Low	High	High	High	Low	Low	High	6
Emery 05	Low	Low	Low	Unclear	Low	Low	Low	13
Emery 07	Low	Unclear	Unclear	Low	Low	Low	Low	12
Emery 10	Low	High	Low	Low	High	Low	Low	10
Gilchrist	Low	Low	High	Low	High	Low	High	8
Heidt	Low	Unclear	High	Low	Low	Low	Low	11
Holmich	Low	Low	Low	High	High	High	High	6
Jamtvedt	Low	Low	High	High	Low	Low	High	8
LaBella	Low	High	High	Low	Low	High	High	6
Longo	Low	Low	High	Low	Low	Low	High	10
McGuine	Low	Unclear	High	High	Low	Low	High	7
Olsen	Low	Low	High	Low	Low	Low	Low	12
Pasanen	Low	Low	High	Low	Low	Low	Low	12
Petersen	Low	Low	High	High	Low	Low	Low	10
Pope 00	Low	Low	High	Low	Low	Low	High	10
Pope 98	Low	Unclear	Low	Unclear	Low	Low	High	10
Soderman	Low	Unclear	Unclear	Unclear	High	Low	High	7
Soligard	Low	Low	High	Low	Low	Low	Low	12
Steffen	Low	Low	High	Low	Low	Low	Low	12

Walden	Low	Low	High	Low	Low	Low	Low	12
Wedderkopp	Low	High	High	High	Low	Low	High	6

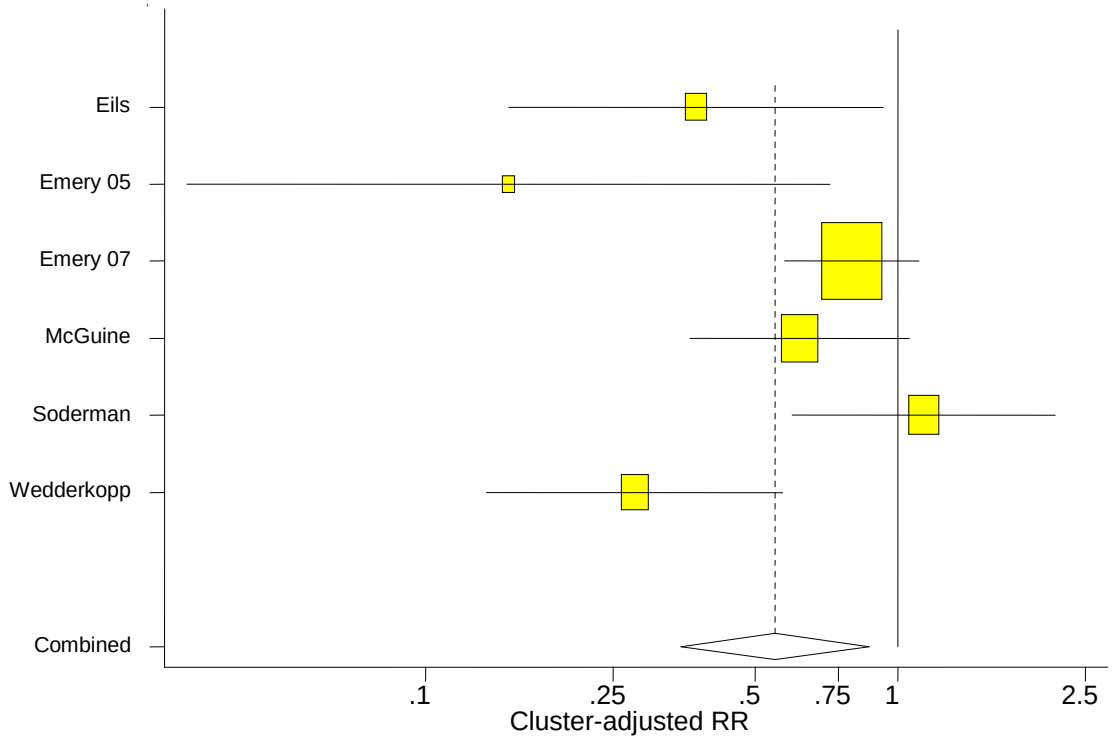
§7.2, Quality assessment summary figure



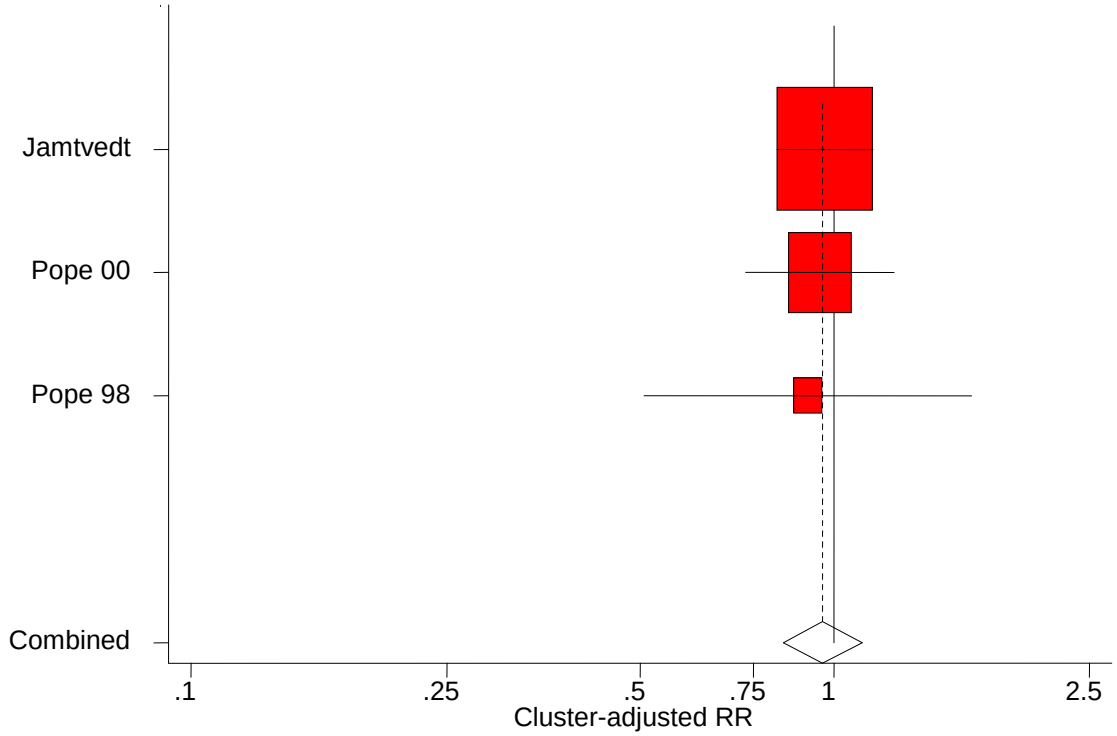
§8.1, Strength training estimate Forrest plot



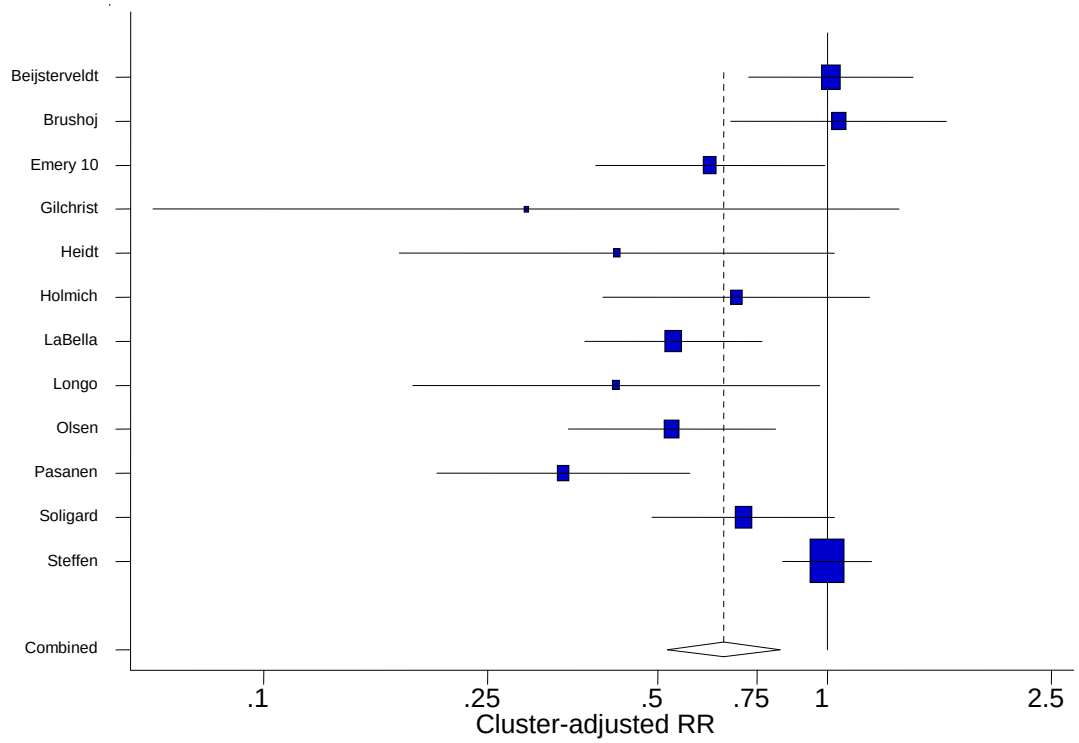
§8.2, Proprioception training estimate Forrest plot



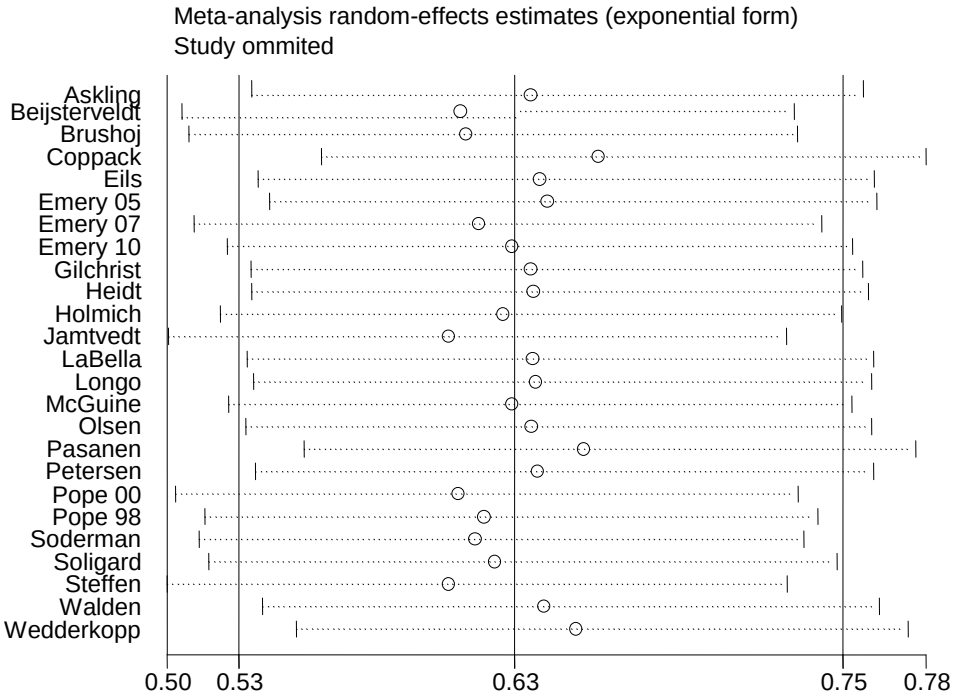
§8.3, Stretching estimate Forrest plot



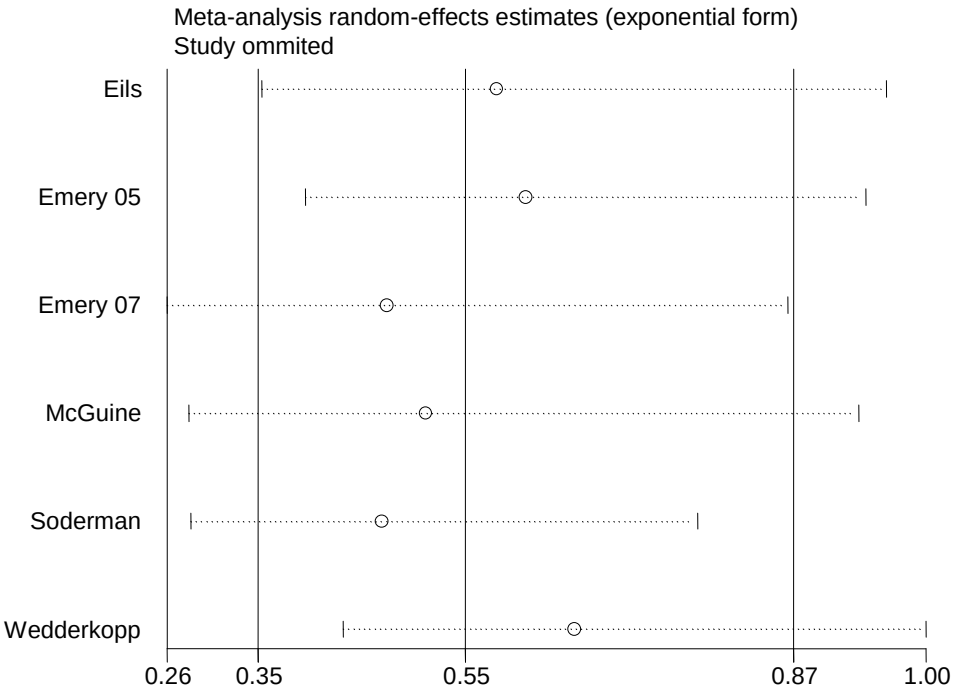
§8.4, Multiple exposure studies estimate Forrest plot



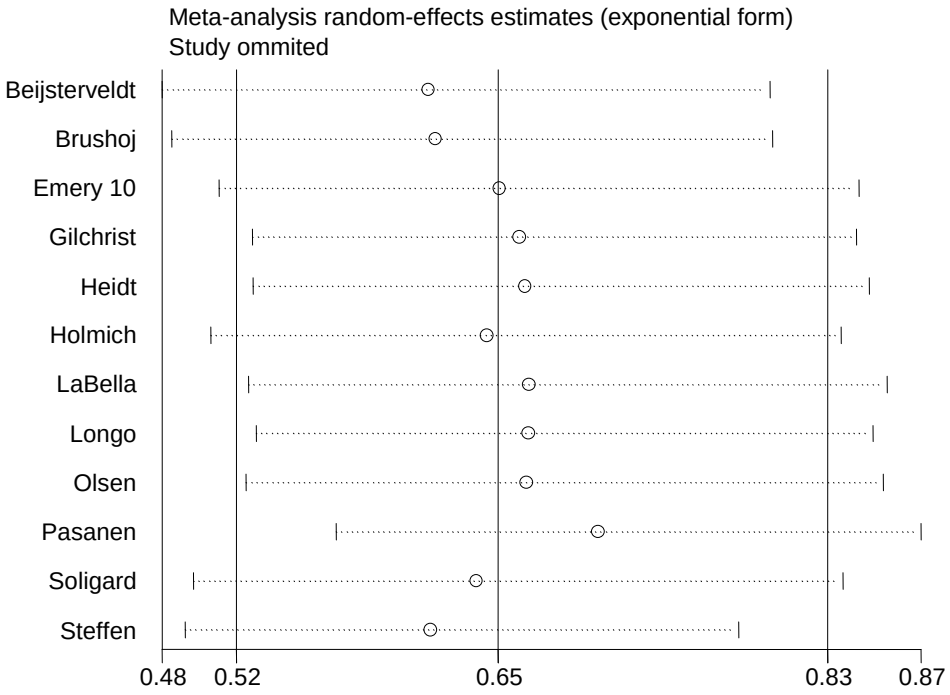
§9.1, Single-study effect on total effect estimate



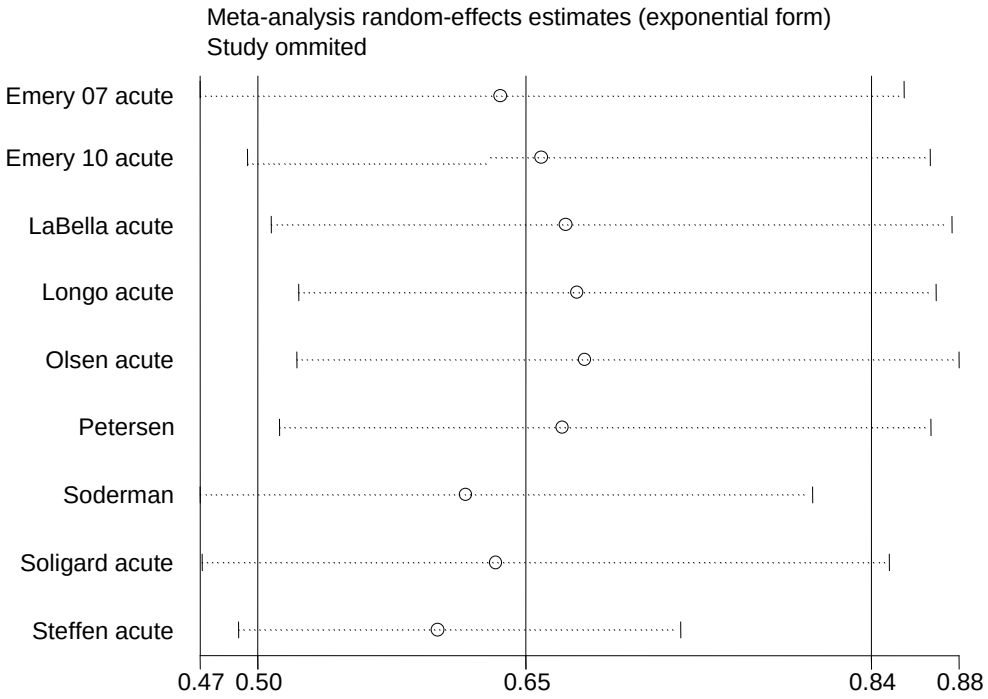
§9.2, Proprioception training single-study effect on group estimate



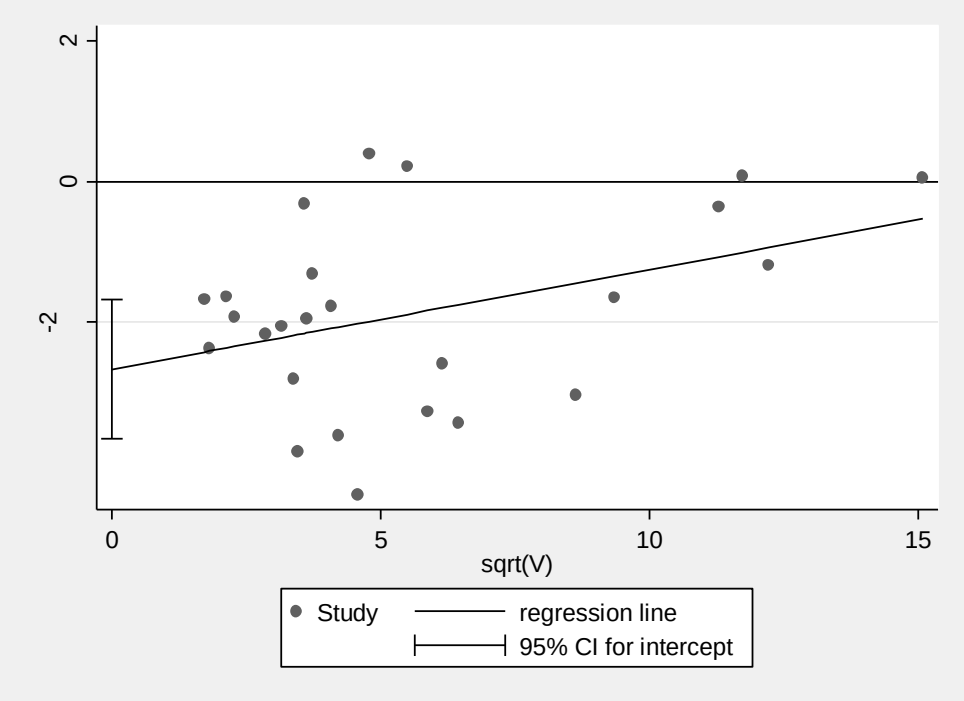
§9.3, Multiple exposure studies single-study effect on group estimate



§9.4, Acute outcome single-study effect on group estimate



§10.1, Modified Galbraith plot. Regress Z/sqrt(V) on sqrt(V) where Z is efficient score and V is score variance



§10.2. Harbord's tests for the total estimate and subgroups

Estimate	P-value for Harbord's test
Total estimate	< 0.001
Strength training	0.440
Proprioception training	0.128
Stretching	0.384
Multi interventions	0.012
Acute outcomes	0.129
Overuse outcomes	0.975