

Effects of Psychological Interventions on the Prevention of Sports Injuries

A Meta-analysis

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Background: Studies have shown that preventive psychological interventions can reduce the occurrence of sports injuries.

Purpose: To systematically evaluate the published literature on the effects of psychological interventions on rates of sports injuries and propose a set of psychological interventions to reduce such injuries.

Study Design: Systematic review; Level of evidence, 1.

Methods: A total of 11 randomized controlled trials and intervention control trials involving 1287 participants were included. A random-effects model was used to analyze the data. Pooled results were expressed as effect sizes and 95% CIs. Bias and heterogeneity among the studies were assessed, and sensitivity and subgroup analyses were performed.

Results: Meta-analysis suggested that preventive psychological interventions effectively prevented the occurrence of sports injuries (effect size = -0.55 ; $P < .001$), although the studies showed substantial heterogeneity ($I^2 = 94.2\%$; $P < .001$), which could not be attributed to specific variables. Nevertheless, sensitivity analysis suggested that overall results were reliable. No significant risk of publication bias was found.

Conclusion: Preventive psychological interventions moderately reduced the risk of sports injuries. Risk screening also significantly reduced the risk of sports injuries. These interventions should focus on cognitive behavior and be administered in 1 to 6 sessions over 7 to 12 weeks for 60 minutes per session.

Keywords: cognitive behavior; psychological intervention program; sports injuries

A sports injury refers to the loss of physical function or structure of the body because of sports activities during a clinical examination.³¹ A descriptive epidemiology study of severe injuries by the National Collegiate Athletic Association Injury Surveillance Program showed that 3183 severe

injuries occurred between 2009 and 2015, with an injury rate of 0.66 per 1000 athlete-exposures.¹⁷ Sports injuries can have major effects on athletes and their families; they can lead to dropping out of school, retirement from sports, chronic pain, disability, increased family burden, reduced social interactions, and increased medical expenses. Major causes of sports injuries include excessive stress,^{1,27} inability to concentrate, physical trauma, and overtraining.²⁸

Psychological research has associated sports injuries with emotional states,¹¹ coping resources,²⁸ social support,²² perceived vulnerability,⁸ varying personalities,⁸ and risk-taking behaviors.³⁰ The highly influential pressure-dependent damage model of Andersen and Williams³ holds that stress events affect an athlete's performance, which can increase the risk of sports injuries. To what extent an athlete experiences stress depends on his or her personality and coping resources. A pioneering study in sports injury prevention found that crisis interventions reduced the risk of sports injuries as well as increased self-confidence and self-control among alpine skiers at the 1988 Olympics.^{5,24} A small study of elite gymnasts found that stress management interventions significantly reduced injuries and stress levels.¹⁷

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TABLE 1
Inclusion and Exclusion Criteria

	Inclusion Criteria	Exclusion Criteria
Population	Athletes at risk for sports injuries (eg, professional athletes, college athletes)	Sports enthusiasts who do not train regularly
Intervention	Psychological intervention only (eg, stress management, cognitive behavioral therapy)	Psychological intervention combined with other techniques (eg, neuromuscular training)
Comparison	Nonpsychological interventions or no intervention at all in comparison group	Preventable psychological interventions in comparison group
Outcomes	Sufficient data provided to calculate effect size (mean \pm SD, Cohen d and 95% CI, or Cohen d and SE)	Other endpoints
Study design	Randomized controlled trials and intervention control trials in English published in journals or conference proceedings for which full text was available	Pre/post design (also quasi), theses, reviews, interviews, letters, posters, and book chapters

In fact, wider literature has supported the efficacy of at least certain sports injury prevention measures. A systematic review and meta-analysis of randomized controlled trials and quasi-experiments involving 7 types of measures found that showing skiers videos on injury prevention lowered their rate of injuries. Another meta-analysis found that psychological interventions, mainly cognitive behavioral therapy based on the pressure-dependent damage model, significantly decreased the rate of injuries in 6 of 7 sports (overall Hedges $g = 0.82$).¹⁵ A third meta-analysis similarly concluded that preventive psychological interventions can significantly reduce injury rates, leading the authors to recommend psychosocial-based interventions.²⁹ Other meta-analyses have suggested that psychological interventions can reduce the rate of injuries and loss of exercise time.¹⁰ As a result, some experts have suggested that sports injury prevention plans should be based on psychological interventions, including mindfulness, imagery, self-talk, stress management, relaxation, and goal setting.¹⁵

While the overall benefit of preventive interventions seems clear from the literature, less clear is how the characteristics of the interventions, such as their content and delivery, may affect their efficacy. Therefore, the present meta-analysis aimed to determine the effect of additional variables on the risk of sports injuries. These variables included risk screening as well as the content, duration, length, and number of preventive psychological interventions. We began with 3 hypotheses: preventive psychological interventions reduce the risk of sports injuries; risk screening can improve the efficacy of preventive psychological interventions; and the efficacy of interventions depends on their content, duration, length, and number. Our findings led us to make recommendations to strengthen psychological intervention programs for sports injuries.

METHODS

Eligibility Criteria

This meta-analysis was carried out following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.²⁰ The inclusion and exclusion

criteria were therefore designed based on the PICOS (Population, Intervention, Comparison, Outcomes, Study design) model (Table 1).

Literature Search

The Web of Science, PubMed (MEDLINE), ScienceDirect, EBSCO, Engineering Village, SpringerLink, and Google Scholar were searched from between inception and May 31, 2019. The topics searched were (“Athletic injury” OR “Sport injury”) AND (“Psychological Intervention” OR “Psychological Prevention”). References in each included article were also reviewed. Articles that were recommended by each database were additionally reviewed.

Study Selection and Data Extraction

A total of 2 investigators (S.L., Q.W.) independently reviewed the literature and extracted data based on the inclusion and exclusion criteria listed in Table 1. Disagreements between investigators or inconsistent information were resolved by a discussion with a third investigator (Z.C.). The following data were extracted from each study: name of the first author; year of publication; country; sport; risk screening; outcomes; content, duration, and length of the intervention; sample size; effect size with its standard error and 95% CI; and mean and standard deviation of variables in the control and intervention groups.

Bias Assessment

The risk of bias was assessed using Cochrane Review Manager 5.3. “+” was scored for a low bias risk, “?” for an unclear bias risk, and “-” for a high bias risk in the following 7 areas: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. Studies that received 6 to 7 “+” were classified as showing a low risk of bias, 4 to 5 “+” as showing a moderate risk of bias, and <4 “+” as showing a high risk of bias.

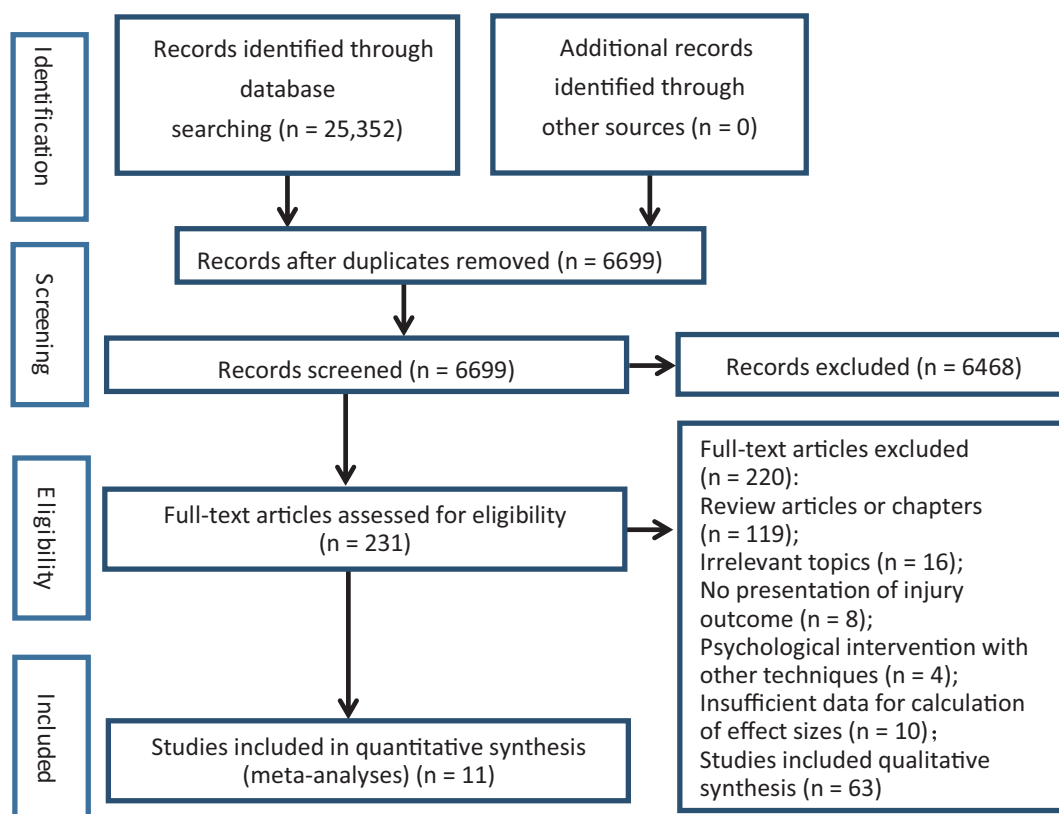


Figure 1. Description of the selection process for included studies using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

Data Calculation and Statistical Analysis

Meta-analysis was performed using STATA 13.0 (Stata-Corp) and a random-effects model. Differences between the control and intervention groups were expressed as the standard mean difference. The effect size and its standard error were calculated using 3 methods. First, effect sizes and their 95% CIs that could be directly extracted from studies were expressed using the following formula:

$$SE = (CIU - CIL) / 2 T,$$

where CIU is the upper limit of the 95% CI, CIL is the lower limit of the 95% CI, and T is $T_{inv}(1 - 95\%, df)$ for degrees of freedom. Alternatively, effect sizes and their 95% CIs were calculated as the mean and standard deviation, and then the standard error was calculated using the above formula. Effect sizes and standard errors were simply extracted directly from the study if reported. Effect sizes were classified as small (<0.2), medium (0.2-0.8), or large (>0.8).¹² Heterogeneity (I^2) was considered negligible (0%-25%), moderate (>25%-50%), high (>50%-75%), or substantial (>75%-100%).⁶

RESULTS

The study selection is presented in Figure 1. A total of 6699 related articles were retrieved. Titles and abstracts were

screened, leaving 231 potentially relevant articles that were read in full. Removing 168 studies with incomplete data sets and 52 studies that were entirely qualitative left 11 studies[‡] (randomized controlled trials and intervention control trials) for meta-analysis (Figure 1).

Study Characteristics

The 11 articles involved 1287 participants from Canada, the United States, New Zealand, Iceland, Sweden, and Spain. The patients participated in gymnastics, boating, soccer, rugby, and cricket. Interventions were focused on stress management, cognitive behavioral stress management, cognitive behavioral therapy, and combination training. Intervention programs among these studies varied widely. Each intervention session lasted 30 to 120 minutes and continued for 1 to 16 sessions distributed over 0 to 36 weeks. Endpoints were different outcomes related to sports injuries, such as the number of injuries, time loss due to injuries, and injury frequency (Table 2).

Risk of Bias Within Studies

The assessment of the risk of bias is shown in Figure 2. One study¹⁵ was ranked as having a low risk of bias, while the

[‡]References 4, 9, 14, 16, 18, 19, 23, 25, 26, 32, 33.

TABLE 2
Overview of All Studies Included in This Meta-analysis^a

First Author (Year)	No. of Patients	Country	Sport	Risk Screening	Outcomes	Intervention Content	Intervention Duration, wk	Length of Intervention Session, min	No. of Intervention Sessions
Kerr ¹⁸ (1996)	C: 12 (8 M, 4 F); I: 12 (8 M, 4 F)	Canada	Gymnastics	No	Time loss due to injuries	Stress management	32	60	16
Perna ²⁶ (2003)	C: 16 (7 M, 9 F); I: 18 (7 M, 11 F)	USA	Boating	Yes	Time loss due to injuries	Combination training	3	45-90	7
Kolt ¹⁹ (2004)	C: 10; I: 10	New Zealand	Gymnastics	No	Time loss due to injuries	Stress management	36	60	12
Arnason ⁴ (2005)	C: 144 (144 M); I: 127 (127 M)	Iceland	Soccer	No	No. of injuries	Cognitive behavioral therapy	<1	120	1
Johnson ¹⁶ (2005)	C: 16 (8 M, 8 F); I: 16 (7 M, 9 F)	Sweden	Soccer	Yes	No. of injuries	Combination training	20	30-60	8 (2 telephone calls)
Maddison ²³ (2005)	C: 24; I: 24	New Zealand	Rugby	Yes	Time loss due to injuries	Combination training	4	90-120	6
Edvardsson ⁹ (2012)	C: 14 (13 M, 1 F); I: 13 (8 M, 5 F)	Sweden	Soccer	Yes	No. of injuries	Cognitive behavioral therapy	9	30-60	7
Ivarsson ¹⁴ (2015)	C: 20; I: 21	Sweden	Soccer	No	Injury frequency	Combination training	7	45	7
Tranaeus ³² (2015)	C: 208 (109 M, 99 F); I: 193 (94 M, 99 F)	Sweden	Cricket	Yes	Injury frequency	Cognitive behavioral therapy	12	60	6
Tranaeus ³³ (2015)	C: 171 (87 M, 84 F); I: 175 (87 M, 88 F)	Sweden	Cricket	No	Injury frequency	Cognitive behavioral therapy	12	60	6
Olmedilla-Zafra ²⁵ (2017)	C: 20 (20 M); I: 21 (21 M)	Spain	Soccer	No	Injury frequency	Stress management	24	60	12

^aC, control group; F, female; I, intervention group; M, male.

remaining 10[§] showed a moderate risk of bias. The percentages of studies at each bias ranking for the different types of bias are shown in Figure 3.¹³

Impact of Preventive Psychological Interventions on Risk of Sports Injuries

Overall, psychological interventions contributed to sports injury prevention (ie, reduced the frequency of sports injuries and time loss) (effect size = -0.55; $P < .001$) (Figure 4). Subgroup analysis showed that psychological interventions to prevent injuries in boating, soccer, cricket, gymnastics, and rugby demonstrated effect sizes of -0.80 to 0.99 (Figure 4).

Heterogeneity testing showed that the I^2 value across all studies was 94.2% ($P < .001$), indicating substantial heterogeneity. Therefore, meta-analysis was performed using a random-effects model (Figure 4).

[§]References 4, 9, 16, 18, 19, 23, 25, 26, 32, 33.

Risk of Publication Bias

No significant publication bias was indicated by the Egger's test ($P = .35$).

Sensitivity Analysis

The meta-analysis results did not change significantly when each of the studies was removed one by one (Figure 5). This suggests that the results are reliable despite the heterogeneity.

Subgroup Analysis

First, we compared the effects of psychological interventions on sports injuries between athletes who underwent risk screening and those who did not. Data in both groups showed substantial heterogeneity (no screening: $I^2 = 92.7%$, $P < .001$; screening: $I^2 = 82.3%$, $P < .001$). Interventions reduced sports injuries to a greater extent in the

Study	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Armason A 2005	+	-	-	-	+	+	+
Edvardsson A 2012	-	+	+	?	-	+	+
Ivarsson A 2015	+	+	+	+	-	+	+
Johnson U 2005	+	-	+	+	-	-	+
Kerr 1996	+	-	+	+	-	+	+
Kolt GS 2004	-	+	-	+	+	+	+
Maddison R 2005	+	?	+	+	-	+	+
Olmedilla-Zafra A 2017	+	+	?	-	+	+	+
Perna FM 2003	+	+	+	+	-	?	+
Tranaeus U1 2015	-	-	+	+	+	+	+
Tranaeus U2 2015	-	-	+	+	+	+	+

Figure 2. Assessment of the risk of bias for included studies. +, low bias risk; -, high bias risk; ?, unclear bias risk.

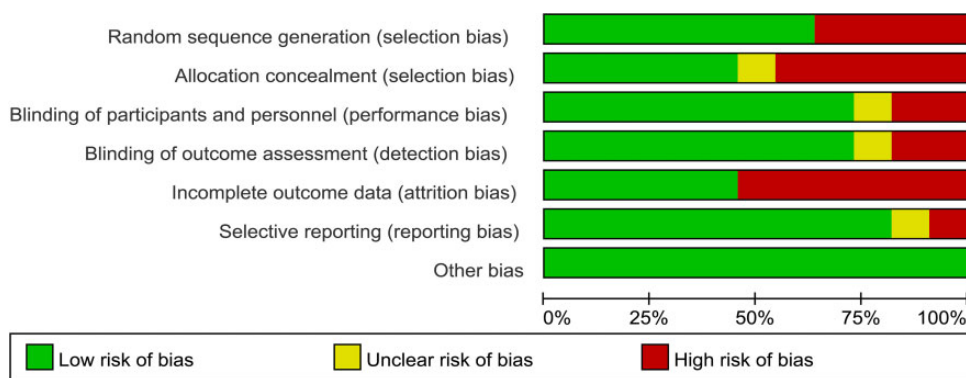


Figure 3. Distribution of studies across the bias ranking for each type of bias.

unscreened group (effect size = -1.16; $P < .001$). This result suggests that risk screening may not be beneficial in sports injury prevention, and it may also mean the opposite: the screening process itself may “prime” athletes to alter their psychology and their training to reduce the risk of injuries.

High heterogeneity was observed in the subset of athletes who received stress management ($I^2 = 70.1\%$; $P = .018$) or combination training ($I^2 = 88.1\%$; $P < .001$). Substantial heterogeneity was observed in the subset of patients who received cognitive behavioral therapy ($I^2 = 98.0\%$; $P < .001$), and this group showed a large reduction in sports injuries (effect size = -0.71; $P < .001$). These results justify further work into the potential efficacy of cognitive behavior interventions for athletes.

Among subgroups stratified by the duration of intervention, high heterogeneity was observed among those receiving interventions for 0 to 6 weeks ($I^2 = 75.5\%$; $P = .007$) or >12 weeks ($I^2 = 82.0\%$; $P < .001$), while substantial heterogeneity was observed among those receiving interventions for 7 to 12 weeks ($I^2 = 98.0\%$; $P < .001$). Nevertheless,

the largest reduction in sports injuries was observed among those who received an intervention for 7 to 12 weeks (effect size = -0.69; $P < .001$). These results justify further work into the potential efficacy of interventions for 7 to 12 weeks for athletes.

Among subgroups stratified by the length of each intervention session, heterogeneity was substantial among those whose sessions lasted ≤ 60 minutes ($I^2 = 95.6\%$; $P < .001$), while no heterogeneity was found among those whose sessions lasted >60 minutes. Because the group whose sessions lasted ≤ 60 minutes showed a larger reduction in sports injuries (effect size = -0.57; $P < .001$), this session length may be more effective than longer sessions for preventing sports injuries.

Among subgroups stratified by the total number of intervention sessions, heterogeneity was substantial among those who had 1 to 6 sessions ($I^2 = 97.1\%$; $P < .001$) or 7 to 12 sessions ($I^2 = 92.4\%$; $P < .001$), and it was high among those who had >12 sessions ($I^2 = 70.1\%$; $P = .018$). Because those who had 1 to 6 sessions showed the

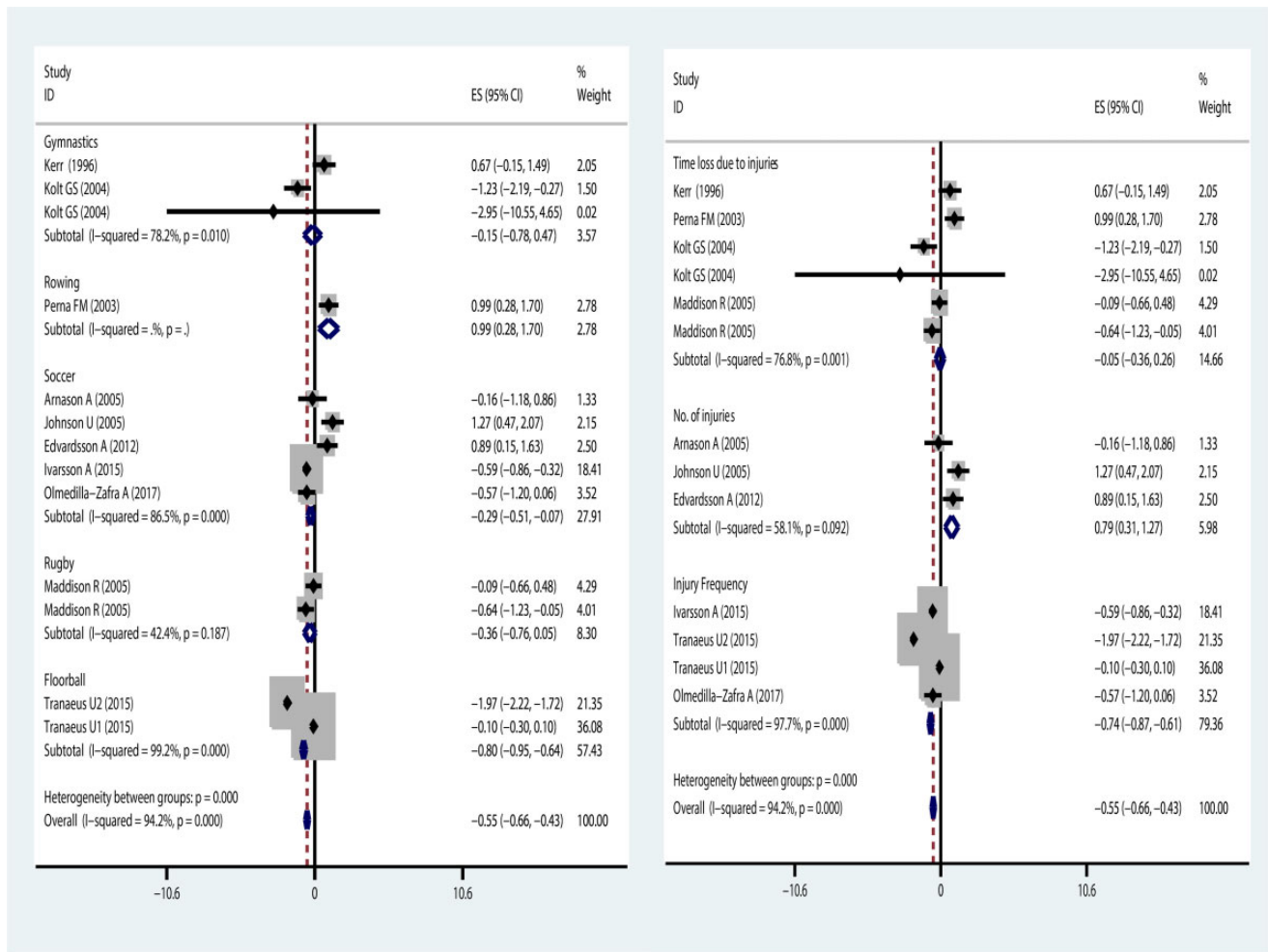


Figure 4. Meta-analysis of the effect of psychological interventions on sports and different outcomes. Kolt¹⁹ and Maddison²³ counted the results of 2 different intervention cycles in the same study. ES, effect size; ID, identification.

largest reduction in sports injuries (effect size = -0.73 ; $P < .001$), interventions involving 1 to 6 sessions may be more effective at preventing sports injuries (Table 3).

Metaregression

Metaregression showed that pooled results did not depend significantly on geographic region; risk screening; outcome indicators; and the content, duration, length, or number of interventions. Therefore, these variables were not the source of heterogeneity in our meta-analysis (Table 4).

DISCUSSION

This meta-analysis of 11 studies (randomized controlled trials and intervention control trials) suggests that preventive psychological interventions can moderately reduce the frequency of sports injuries. Our results are likely to be reliable because the risk of bias was assessed to be low, and sensitivity analysis showed the results to be robust to the

removal of individual studies. Similar to our results, a previous meta-analysis showed that preventive psychological interventions reduced the number of sports injuries.^{32,33} That previous study observed a greater injury reduction than we did, but our results may be more representative because we included a larger study population. Our meta-analysis further suggests that preventive psychological interventions should focus on cognitive behavior and should take place in 1 to 6 sessions, each lasting no more than 60 minutes, for 7 to 12 weeks.

All the studies included in this meta-analysis reported that preventive psychological interventions reduced the incidence of sports injuries. In particular, these psychological interventions shortened time loss due to injuries and athletes' number of injuries. Almost all interventions focused on stress-induced cognitive impairment and stress management techniques, reflecting their basis in the pressure-dependent damage model. Stress levels are associated with the activation of neurons in the amygdala and with the secretion of cortisol and oxytocin.⁷ Stress management techniques therefore aim at reducing the release of

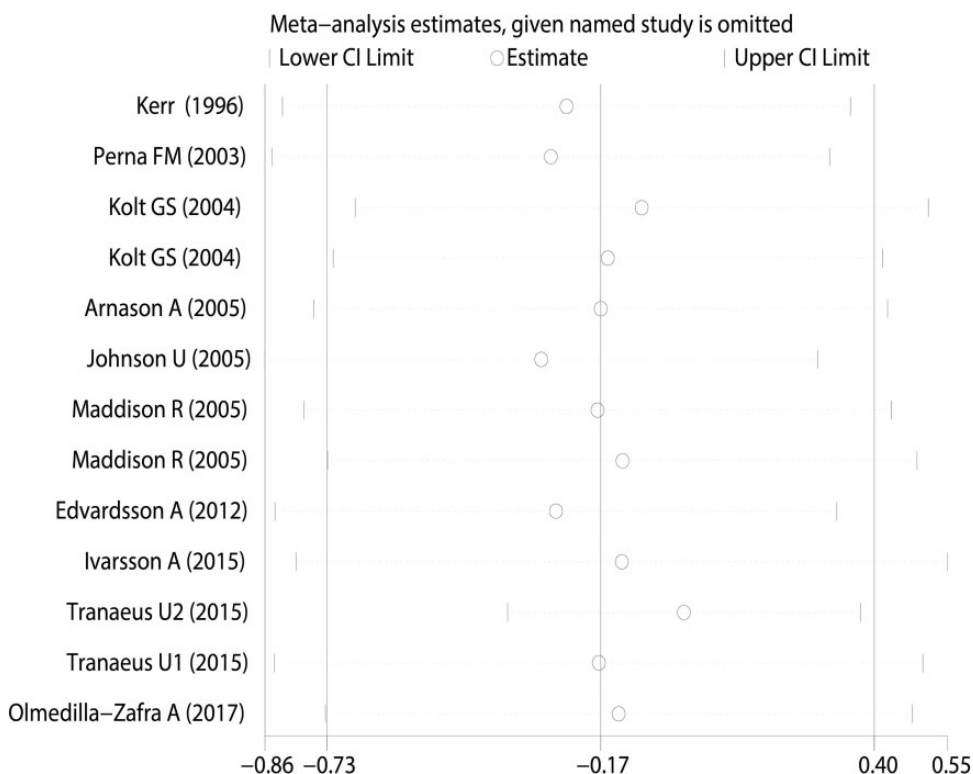


Figure 5. Sensitivity analysis. Kolt¹⁹ and Maddison²³ counted the results of 2 different intervention cycles in the same study.

TABLE 3
Subgroup Analysis of Effects of Preventive Psychological Interventions on Sports Injuries

Subgroup	Heterogeneity Test			Effect Size (95% CI)	2-Tailed Test	
	χ^2 Value	P Value	I ² Value, %		Value	P Value
Risk screening						
No	81.71	<.001	92.7	-1.16 (-1.33 to -0.99)	13.36	<.001
Yes	28.22	<.001	82.3	0.02 (-0.14 to 0.19)	0.27	.791
Intervention content						
Stress management	10.04	.018	70.1	-0.36 (-0.80 to 0.08)	1.60	.110
Combination training	33.49	<.001	88.1	-0.26 (-0.47 to -0.05)	2.47	.014
Cognitive behavioral therapy	150.00	<.001	98.0	-0.71 (-0.86 to -0.56)	9.29	<.001
Intervention duration, wk						
0-6	12.27	.007	75.5	-0.03 (-0.37 to 0.30)	0.19	.847
7-12	149.55	<.001	98.0	-0.69 (-0.83 to -0.56)	10.21	<.001
>12	22.18	<.001	82.0	0.02 (-0.37 to 0.41)	0.09	.926
Length of intervention session, min						
≤60	202.67	<.001	95.6	-0.57 (-0.69 to -0.45)	9.00	<.001
>60	1.86	.395	0.0	-0.33 (-0.71 to 0.05)	1.70	.090
No. of intervention sessions						
1-6	136.83	<.001	97.1	-0.73 (-0.87 to -0.58)	9.93	<.001
7-12	39.34	<.001	92.4	-0.12 (-0.35 to 0.11)	1.03	.301
>12	10.04	.018	70.1	-0.36 (-0.80 to 0.08)	1.60	.110

these stress hormones. Our meta-analysis supports the efficacy of this approach in reducing the risk of sports injuries, at least to a moderate degree. Further studies should explore the potential efficacy of other approaches as well.

The types of psychological preventive intervention programs varied greatly among studies included in this meta-analysis, including stress management, cognitive behavioral therapy, muscle relaxation, and attention

TABLE 4
Metaregression Analysis of Variables^a

	Coefficient	SE	<i>t</i> Value	<i>P</i> Value	95% CI
Europe	0.43	0.64	0.67	.52	-1.00 to 1.87
North America	1.50	0.87	1.73	.11	-0.43 to 3.43
No risk screening	-1.06	0.48	-2.19	.05	-2.12 to 0.01
Injury frequency	-1.52	0.64	-2.37	.40	-2.95 to -0.09
No. of injuries	1.12	0.60	1.87	.09	-0.20 to 2.45
Combination training	0.58	0.75	0.77	.46	-1.10 to 2.25
Stress management	-0.34	0.68	-0.50	.63	-1.83 to 1.15
Intervention duration of 7-12 wk	-0.50	0.72	-0.70	.50	-2.10 to 1.09
Intervention duration of >12 wk	-0.03	0.73	-0.04	.97	-1.67 to 1.61
Length of intervention session of >60 min	-0.18	0.68	-0.27	.80	-1.68 to 1.32
No. of intervention sessions of 1-6	-1.21	0.59	-2.05	.07	-2.52 to 0.10
No. of intervention sessions of >12	-0.99	0.69	-1.44	.18	-2.52 to 0.54
Constant	0.58	0.44	1.32	.22	-0.40 to 1.57

^aControl variables in metaregression: Oceania, with risk screening (yes), time loss due to injuries, cognitive behavioral therapy, intervention duration of 0-6 weeks, length of intervention session of ≤ 60 minutes, and No. of intervention sessions of 7-12.

training. Despite this, all studies had the same results and conclusion. We speculate that all psychological interventions somewhat reduced stress-related brain activities, leading to improved attention, decision, or response time.

The bias in studies included in this meta-analysis was generally low to moderate. Inadequate group blinding, incompleteness of data reporting, and selective data reporting contributed to the overall moderate risk of bias in these studies. While the sample size of most studies was relatively small, they evaluated clinical effects using the effect size, which is independent of sample size.²¹ More quantitative studies are needed on the effect of psychological interventions on sports injuries as well as more standardization in important endpoints. For example, 4 of the studies in our meta-analysis examined injury frequency,^{14,25,32,33} 4 examined time loss due to injuries,^{18,19,23,26} and 3 measured number of injuries.^{4,9,16} This heterogeneity makes it difficult to compare studies.

Our subgroup analysis by type of sport found that psychological interventions to prevent injuries in boating, football, cricket, gymnastics, and rugby demonstrated effect sizes of -0.80 to 0.99. The purpose of preventive psychological interventions is to reduce the potential psychological risk factors of an injury and improve understanding of sports injuries. Such interventions may not be effective in sports in which the risk of injuries is intrinsically high, such as because they involve dangerous equipment and elaborate physical routines (gymnastics) or physical collisions (rugby).

We also found that psychological interventions were more effective without risk screening for reducing sports injuries. This may be because during risk screening, information in the questionnaire may increase athletes' awareness of sports injuries, leading to increased thoughtfulness and preventive training regimens.⁶ Therefore, less effective interventions may actually reflect a lower baseline frequency of injuries. This phenomenon also agrees with our finding that cognitive behavioral therapy was the most effective in preventing sports injuries. The core of cognitive

behavioral therapy is to recognize current states (eg, anxiety, nervousness, stress) so that behaviors can be changed accordingly.² These interventions should not last too long because longer sessions and total duration were not more effective than shorter interventions.

There are many risk factors for sports injuries.¹⁰ Future research should continue to validate and extend the understanding of psychological interventions for preventing sports injuries. Sports psychology professionals are therefore encouraged to conduct cross-disciplinary studies in the future. Studies should systematically evaluate the entire process of a sports injury, including predicting injuries, preventing injuries, details of the injury itself, recovery, and return. This meta-analysis did not separately evaluate different types of sports injuries or the relationship between injuries and stress. Future studies should consider the role of behavioral change strategies in reducing sports injuries.

Despite our findings in this study, the pooled data may demonstrate substantial heterogeneity, which was not explained by variations in geographic region, risk screening, outcome indicators, or intervention type and delivery. Therefore, we suspect that the heterogeneity has other causes. Clinical heterogeneity may be caused by different sex ratios and types of sports, which we tried to control to some extent by performing subgroup analysis based on sport. We could not perform subgroup analysis based on sex because most studies did not report those data. Methodological heterogeneity may be caused by differences in interventions that were not clearly described. Finally, statistical heterogeneity may be caused by different outcome units and different probabilities of injuries occurring during training and competitions.

Aside from heterogeneity, our meta-analysis has a few limitations. First, the sample size was relatively small. Therefore, this meta-analysis should be repeated when more original clinical studies become available. Second, we did not evaluate sports injuries caused by factors other than psychological ones, such as sports environment,

venue, or equipment. Researchers are therefore encouraged to study these factors to reduce sports injuries.

Despite these limitations, our meta-analysis provides evidence that psychological interventions can reduce the frequency of sports injuries, reduce the number of sports injuries, and reduce time loss due to injuries. Interventions comprising 6 sessions of ≤ 60 minutes in length over a period of 7 to 12 weeks may be particularly effective.

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