Evidence-based Sports Medicine

Second Edition

Edited by

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Faculty of Life and Health Science
University of Ulster
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Specialist in Sport and Exercise Medicine

and

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Preface

It was perhaps only a decade ago that a formal definition of evidence-based medicine (EBM) was clearly articulated.[1] Sport and exercise medicine is now taking its place as an equal with other specialties in the era of EBM. As the quality of research improves and the knowledge base widens, it is now increasingly possible to base one's clinical decisions on higher-level evidence. Evidence-based sports medicine, once a new term, is no longer such a surprising expression, and we have become much more selective in our acceptance of original research and review articles. Anecdote has given way to evidence, opinion has given ground to research, and patients expect us to help guide their decisions on the basis of the latest findings in the literature. Best practice does not mean how you have learned to practice—it means learning from the best available evidence.

Sports-medicine practitioners have begun to look more closely at their own practice and question what they do. It may not have been doctors who were first to recognize the importance of evidence-based decision-making; our physiotherapy colleagues were perhaps the pioneers. But as we began to audit our practice, we began to realize the value of data and to see the potential for measuring our performance. The growth of university departments of sport and exercise medicine and the academic development of the discipline has led to a much better understanding of the importance of research. Journals now have a much sharper focus on the quality of the papers they publish. The methodological quality of published research has paralleled the interest in evidence-based medicine in our discipline. Prospective data collection, randomization, blinding, and appropriate control groups are continuing to find their way into a greater number of studies. And along with the increasing numbers of randomized controlled trials, there is now an opportunity to synthesize these findings and bring them together in systematic reviews of the literature. The process of systematic review assists the sports-medicine practitioner in interpreting study results and in understanding the relative validity of these results in the hierarchy of evidence. Whereas in the past we might have been satisfied with a narrative review, we now look for meta-analyses and systematic reviews.

The science of the systematic review has also evolved, and through efforts of the Cochrane Collaboration we now have well-established guidelines on how to undertake systematic reviews. Similarly, our colleagues in Australia have developed the PEDro database, a truly innovative concept in sport and exercise medicine. There are now well-accepted guidelines in systematic reviews. The *British Medical Journal* recommends reporting using the guidelines of the QUORUM group. There are recognized methods of selecting appropriate evidence, and we now grade the evidence.

It is our hope that the second edition of this book has captured the evolution and maturity of evidence-based sports medicine. In clinical practice, caring for patients generates many questions about diagnosis, prognosis, and treatment that should challenge all of us to keep abreast of the current literature. Conscientiously practicing EBM is one way to ensure that clinicians keep up to date with the exponential growth in the medical literature. This should be an ongoing exercise designed to improve our skills in asking questions, finding the best evidence, critically appraising it, integrating it with our clinical expertise and our patients' unique features, and applying the results to clinical practice. The best available clinical evidence is typically derived from clinical research that is patient-centered, that evaluates the accuracy and precision of diagnostic tests and prognostic markers, and takes into account the efficacy and safety of therapeutic, rehabilitative, and preventive regimens.

All of our authors were asked to provide the latest up-to-date and highest-quality research that answered a specific question. As can be seen, we still have level 4 or level 5 evidence for many of these questions. In other cases, a number of level 1 studies are now available that provide the basis for a structured systematic review. A new feature of this second edition is a greater emphasis on the reliability and validity of the clinical examination, perhaps somewhat of a lost art in today's practice of "high-technology" medicine. Many of the pearls we were taught in our younger days have never been properly evaluated and instead were accepted as dogma because an authoritative professor, through his or her name or stature alone, convinced us this was the right way to do things. For example, we now recognize that a clinician's use of tests relies heavily on pretest clinical assessment.[2] We have also tried to maintain consistency with the first edition by asking each author to provide key summary points and questions that address critical take-home messages.

In no way does this collection of 30 chapters do complete justice to the progress made in EBM and sports medicine. Topics were selected that we felt best illustrated the growth of our field and the potential for future research—we still have a long way to go! Our hope is that both undergraduate students and busy practitioners will read this book and become more engaged in the application of EBM to sports medicine. We appreciate the time and effort made by our authors, and we wish you success in the classroom and in your practice.

Domhnall MacAuley
Thomas M. Best

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SECTION 1
Prevention

CHAPTER 1

Is it possible to prevent sports and recreation injuries? A systematic review of randomized controlled trials, with recommendations for future work

Jennifer M. Hootman

Introduction

To determine whether the prevention of sports injuries merits the attention of the public health authorities and clinical institutions, we need to know whether sports and recreation injuries are a substantial problem, and if so, whether there are factors that can be changed in order to remedy the problem. Figure 1.1 illustrates a sports injury prevention model, the "sequence of prevention," first proposed by van Mechelen and colleagues[1] and used by others to illustrate the process and to promote the critical need for advances in sports injury prevention.[2–7] Some advances have already been seen, including the First World Congress on Sports Injury Prevention (convened in Oslo, Norway in June 2005), special journal supplements focusing on sports injury prevention, and multiple reviews on the topic.[2,5,6] In this chapter, I will review and update the scientific evidence on the topic of sports injury prevention, attempting to answer the question: "Is it possible to prevent sports injuries?"

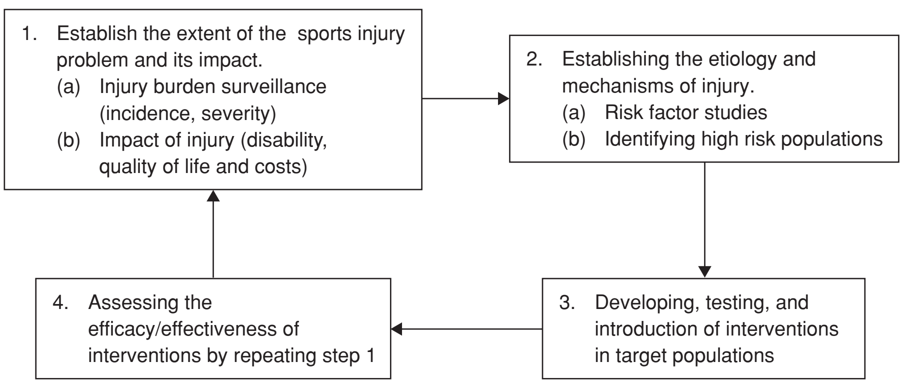

Figure 1.1 A modified version of the "sequence of prevention," an injury prevention model proposed by van Mechelen and colleagues (adapted with permission from ref. 1).

Methods

Inclusion/exclusion criteria

The following inclusion and exclusion criteria were developed and used for computerized bibliographic database searches and to define the final studies to be included in the review.

Inclusion criteria

- *Age range:* all.
- *Publications:* English-language, 1980–July 2005.
- *Interventions:* clinical or community-based, randomized controlled trials.
- *Outcomes:* injury frequency or rates, incidence of injury, hazard ratios; with or without exposure time data.
- *Sport:* sports and recreation activities, including school (interscholastic, intercollegiate, and intramural), community-based activities (Little League, soccer leagues, etc.), recreational individual sports (tennis, skiing, etc.), or team sports (volleyball, soccer, rugby, etc.).

Exclusion criteria

- Fall-related hip fractures.
- Military populations—specifically, recruits in basic or advanced training. Studies including students at U.S. military academies who participate in intramural or intercollegiate athletes were eligible.
- Bicycling (recreational and competitive) and other wheeled activities (skateboarding, scooters, rollerblading, etc.).

Retrieval of published studies

A comprehensive computer bibliographic database search was conducted using MEDLINE, EMBASE and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) for the dates 1980 through July 2005. The search terms used included: 1, "injury" OR "trauma" AND 2, "sports" OR "exercise" OR "athletic" OR "athlete," AND 3, "prevention," and were combined with the Cochrane highly sensitive search strategy for randomized controlled trials (RCTs).[8] The final search results were limited to English-language publications. Figure 1.2 illustrates the subsequent flow of the study selection process. All abstracts identified in the bibliographic search (n = 172) were read and evaluated according to the *a priori* inclusion/exclusion criteria. Any study not explicitly meeting the stated exclusion criteria at this stage was kept for further review. Complete copies of the 27 studies selected at this stage were requested through interlibrary loan. Hand searching of the reference lists of the 27 papers received, as well as the reference lists of select review papers[3,9–12] yielded another 22 potentially relevant papers. Of the 49 total papers identified, one was immediately excluded because it was a duplicate publication from the same study. The remaining 48 papers were evaluated a final time using a checklist of the inclusion/exclusion criteria stated above. This stage excluded 21 papers, leaving 27 RCTs for inclusion in this review.

Quality assessment

Each study meeting the inclusion criteria was evaluated using the methodological quality scoring scale developed by Jadad *et al.*,[13] with slight modifications. The three-item Jadad scale is an easy-to-use scale, with established psychometric properties, that assesses each study with regard to randomization, double-blinding, and reporting of withdrawals

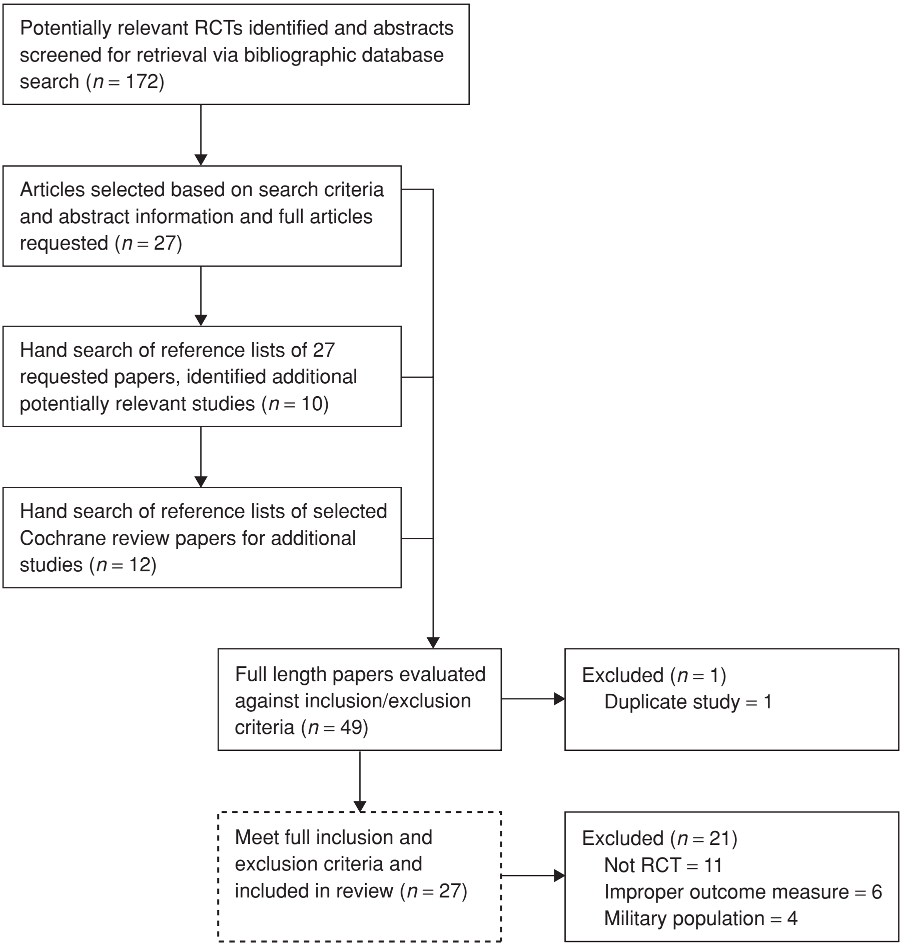

Figure 1.2 Flow chart of study selection for randomized controlled trials (RCTs) included in the review.

or participants lost to follow-up. The total score ranges from a minimum of 0 to a maximum of 5.

Since it is impossible to blind participants to select types of interventions used in sports medicine (e.g., exercise, braces, etc.), the second criterion regarding double-blinding was modified for this study. Studies received one point if the methods stated that the person or persons doing the assessments were blinded to the intervention assignment. An additional point was awarded if the process of blinding the assessors was described and appropriate. Since all studies had to be randomized controlled trials according to the inclusion criteria (assigned one point for the first criterion), the range of possible scores on the Jadad scale for this review was 1 to 5.

Data abstraction/statistical analysis

Information on the intervention type, publication year, subjects, country of origin, sport, primary and secondary outcome measures and quality scores were abstracted from each study and entered into a spreadsheet. Average quality scores were computed for each of the four intervention types.

RCTs were grouped according to the type of intervention: 1, neuromuscular, functional, or proprioceptive exercise programs (n = 12); 2, protective or prophylactic equipment (n = 10); 3, educational programs (n = 2); and 4, other programs (one warm-up/cool-down/stretching program and one multiple-component program). Several individual studies could be included in more than one category or had more than one comparison, since these reports included multiple interventions in the same study. For example, Stasinopoulos[14] compared three intervention groups: a technical sport-specific skill training group, an ankle disk proprioception exercise group, and an ankle orthosis group. Three separate outcome comparisons were presented for this study: technical skill versus orthosis, ankle disk exercise versus orthosis, and orthosis versus technical skill. For each of the four intervention types, a level of evidence rating was assigned using the Oxford Centre for Evidence-based Medicine criteria.[15]

For pooling of the 27 included studies, the data that were abstracted and entered into an analysis database included the author, year, quality score, effect (primary injury outcome), number injured (intervention and control), and number not injured (intervention and control) for each study. Mantel–Haenszel odds ratios (OR), 95% confidence intervals (CI) and Forrest plots were created, and summary effectiveness estimates were calculated using Comprehensive Meta-Analysis software (BioStat, Inc., Englewood, New Jersey, USA). Both fixed and random-effects models are presented, but since interventions were combined across sports, populations, and countries of origin (with possible heterogeneity), an *a priori* decision was taken to use the random-effects estimate and 95% confidence interval as the primary measure of effectiveness. The *Q*-statistic to test for homogeneity was also used to confirm heterogeneity.[16]

Results

Description of interventions

Neuromuscular, functional or proprioceptive exercise programs. The 12 studies classified in this category basically consisted of: 1, sport-specific or skill-specific functional exercise training (i.e., acceleration/deceleration activities, technical skills for landings and take-offs, plyometric and agility tasks, and power, strengthening and stabilization exercises, n = 5;[17–21] 2, balance or proprioception training programs, mostly using ankle disks/balance boards (n = 4);[22–25] and 3, a combination of both (n = 3).[14,26,27] The length of the interventions ranged from 7 weeks to the entire sport season. In general, details regarding the frequency per week, session duration, and length of the intervention were poorly reported.

Protective or prophylactic equipment. Of the 11 studies in this category, five investigated the effectiveness of ankle or knee braces/orthoses,[14,23,28–30] two studied custom mouth guards,[31,32] two studied wrist protectors,[33,34] and one each studied break-away bases in softball and baseball[35] and different shoe styles (high versus low top)[36] in basketball.

Educational programs. The two studies investigating educational approaches to injury prevention both used video formats to present information to subjects. One study[37] showed a 45-minute video on skiing injury prevention and proper equipment use during a bus ride to a ski resort. The other study[38] used a 2-hour workshop format to present a video analysis of injury mechanisms in soccer, followed by a group discussion.

Other interventions. One study[39] described a seven-component global soccer injury prevention program that included correction of training errors, provision of safety equipment, prophylactic ankle taping, controlled rehabilitation of injuries, exclusion of players with knee instability, education, and on-field medical supervision. The other study[7] consisted of a warm-up/cool-down and stretching program for runners.

Qualitative summary

Table 1.1 summarizes the studies by the four categories of intervention type and by individual studies. For neuromuscular, functional, or proprioception exercise programs, the majority (92%) of the studies reported significant reductions in injury outcomes and on average scored 2.4 in terms of methodological quality. Sixty-four percent of protective equipment interventions reported significant reductions in injury outcomes and had an average quality score of 2.7. Only half (50%) of the educational and other intervention types reported reduced injury outcomes and scored relatively low in terms of quality (educational = 1.5 and other = 1.0). Of the 27 studies, most (n = 16) originated from Scandinavian or European countries, six from the United States, and five from other countries.

Rating the evidence

On the basis of the Oxford Centre for Evidence-based Medicine levels of evidence, the studies included in both the neuromuscular, functional, or proprioception exercise and the protective or prophylactic equipment categories meet the 1A level of evidence, in which evidence is based on reports from large RCTs or systematic reviews. The educational program studies were graded A4 (evidence from at least one RCT) and the "Other" intervention group was graded A3 (evidence from at least one moderate-sized RCT or systematic review) (Table 1.1).

Quantitative summary

Pooled summary estimates are presented in Fig. 1.3 for the two intervention types that included more than two studies. Pooled estimates for the two educational program interventions were not significant (random-effects model OR 0.87; 95% CI, 0.34–2.21; $P = 0.77$) and are therefore not included in Fig. 1.3. Pooled estimates could not be calculated for the "Other" intervention types due to a lack of sufficient information in the printed manuscripts and the obvious heterogeneity between the two studies included in this category. All 12 of the neuromuscular, functional, or proprioception exercise studies reported data that could be pooled. However, one study in the protective equipment group[31] did not report sufficient raw data for summary estimates to be calculated, and therefore only nine studies were included in this analysis.

Neuromuscular, functional and proprioception exercise interventions. The Q-statistic to test for homogeneity indicated significant heterogeneity (Q-value 32.3, $P < 0.001$). Pooled effect estimates for the random-effects model suggest that neuromuscular, functional, or proprioception exercise interventions can reduce sports injuries by 65% (OR 0.35; 95% CI, 0.23–0.52; $P < 0.0001$).

Table 1.1 Summary of evidence for the effectiveness of interventions to prevent sports injuries, arranged by intervention type and individual studies

Evidence summary by intervention type

Intervention type (n*)	**Components of interventions**	**Those favoring intervention† % (n)**	**Average quality score‡**	**Level of evidence§**
Neuromuscular, functional, and/or proprioception exercise programs (n = 12)	Neuromuscular training programs, stability, power and strength exercises, balance and proprioception activities, sport- and skill-specific training	92% (11)	2.4	A1
Protective or prophylactic equipment interventions (n = 11)	Mouth guards, ankle braces and stirrup orthoses, lateral knee braces, break-away bases, wrist protectors, shoe styles	64%	2.7	A1
Educational programs (n = 2)	Video and video + group discussion	50% (1)	1.5	A4
Other (n = 2)	Warm-up/cool down and stretching program and multiple-component program	50% (1)	1.0	A3

Evidence summary for individual studies by intervention type

Neuromuscular, functional, and/or proprioception exercise programs

First author	**Year**	**Country**	**Sport or activity**	**Intervention**	**Primary findings +/–†**	**Quality score‡**
Tropp[23] (ankle disk vs. control)	1985	Sweden	Soccer	Ankle disk training	+	2
Wester[25]	1996	Denmark	Recreational athletes	Ankle disk training	+	2
Holme[19]	1999	Denmark	Recreational athletes	Strength and balance exercise	+	2
Wedderkopp[26]	1999	Denmark	Handball	Ankle disk + functional exercise training	+	1
Heidt[18]	2000	United States	Soccer	Frappier Acceleration Training Program	+	3