

Evidence-based Sports Medicine

Second Edition

Edited by

Domhnall MacAuley

Visiting Professor
Faculty of Life and Health Science
University of Ulster
Belfast
United Kingdom
Specialist in Sport and Exercise Medicine

and

Thomas M. Best

Professor and Pomerene Chair in Family Medicine
Chief, Division of Sports Medicine
Ohio State University
Columbus
Ohio
USA

BMJ | Books

 **Blackwell
Publishing**

Evidence-based Sports Medicine

Second Edition

Evidence-based Sports Medicine

Second Edition

Edited by

Domhnall MacAuley

Visiting Professor
Faculty of Life and Health Science
University of Ulster
Belfast
United Kingdom
Specialist in Sport and Exercise Medicine

and

Thomas M. Best

Professor and Pomerene Chair in Family Medicine
Chief, Division of Sports Medicine
Ohio State University
Columbus
Ohio
USA

BMJ | Books

 **Blackwell**
Publishing

© 2002 BMJ Books

© 2007 by Blackwell Publishing

BMJ Books is an imprint of the BMJ Publishing Group Limited, used under licence

Blackwell Publishing, Inc., 350 Main Street, Malden, Massachusetts 02148-5020, USA

Blackwell Publishing Ltd, 9600 Garsington Road, Oxford OX4 2DQ, UK

Blackwell Publishing Asia Pty Ltd, 550 Swanston Street, Carlton, Victoria 3053, Australia

The right of the author to be identified as the author of this work has been asserted in accordance with the Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by the UK Copyright, Designs and Patents Act 1988, without the prior permission of the publisher.

First published 2002

Second edition 2007

1 2007

Library of Congress Cataloging-in-Publication Data

Evidence-based sports medicine / edited by Domhnall MacAuley and Thomas M. Best.—2nd ed.
p. ; cm.

Includes bibliographical references and index.

ISBN-13: 978-1-4051-3298-5 (hbk. : alk. paper)

I. Sports medicine. 2. Evidence-based medicine. I. MacAuley, Domhnall.

II. Best, Thomas M.

[DNLM: 1. Athletic Injuries—therapy. 2. Evidence-Based Medicine. QT 261 E93 2007]

RC1210.E925 2007

617.1'027—dc22

2006025870

ISBN: 978 1 4051 3298 5

A catalogue record for this title is available from the British Library

Set in 9.5/12pt Minion by Graphicraft Limited, Hong Kong

Printed and bound in Singapore by Fabulous Printers Pte Ltd

Commissioning Editor: Mary Banks

Editorial Assistant: Victoria Pittman

Development Editor: Lauren Brindley

Production Controller: Rachel Edwards

For further information on Blackwell Publishing, visit our web site:

<http://www.blackwellpublishing.com>

The publisher's policy is to use permanent paper from mills that operate a sustainable forestry policy, and which has been manufactured from pulp processed using acid-free and elementary chlorine-free practices. Furthermore, the publisher ensures that the text paper and cover board used have met acceptable environmental accreditation standards.

Blackwell Publishing makes no representation, express or implied, that the drug dosages in this book are correct. Readers must therefore always check that any product mentioned in this publication is used in accordance with the prescribing information prepared by the manufacturers. The author and the publishers do not accept responsibility or legal liability for any errors in the text or for the misuse or misapplication of material in this book.

Contents

Contributors, viii

Preface, xiv

Section 1: Prevention, 1

- 1 Is it possible to prevent sports and recreation injuries? A systematic review of randomized controlled trials, with recommendations for future work, 3
Jennifer M. Hootman
- 2 Evidence-based preparticipation physical examination, 18
Peter J. Carek
- 3 Does stretching help prevent injuries?, 36
Ian Shrier
- 4 What effect do core strength and stability have on injury prevention and recovery?, 59
Bryan Heiderscheit and Marc Sherry
- 5 Do foot orthoses prevent injury?, 73
Karl B. Landorf and Anne-Maree Keenan
- 6 Who should retire after repeated concussions?, 93
Paul McCrory
- 7 What recommendations should be made concerning exercising with a fever and/or acute infection?, 108
Christopher A. McGrew
- 8 Should you play sport with a congenital or acquired abnormality of a solid abdominal organ?, 120
Abel Wakai and John M. Ryan
- 9 What type of exercise reduces falls in older people?, 135
M. Clare Robertson and A. John Campbell
- 10 Is there a role for exercise in the prevention of osteoporotic fractures?, 167
Gladys Onambele-Pearson

Section 2: Acute injury, 187

- 11 What is the role of ice in soft-tissue injury management?, 189
Chris Bleakley and Domhnall MacAuley

- 12 Compression, 208
Andrew Currie and Matthew W. Cooke
- 13 NSAIDs and pain management in sports, 222
Weiya Zhang

Section 3: Chronic conditions, 241

- 14 Benefits of regular exercise in the treatment and management of bronchial asthma, 243
Felix S.F. Ram and Joanna Picot
- 15 What is the role of exercise in the prevention of back pain?, 257
Joanne Dear and Martin Underwood
- 16 How should you treat spondylolysis in the athlete?, 281
Christopher J. Standaert and Stanley A. Herring

Section 4: Injuries to the upper limb, 301

- 17 How evidence-based is our examination of the shoulder?, 303
Anastasia M. Fischer and William W. Dexter
- 18 How effective are diagnostic tests for the assessment of rotator cuff disease of the shoulder?, 327
Jeremy Lewis and Duncan Tennent
- 19 How should you treat an athlete with a first-time dislocation of the shoulder?, 361
Marc R. Safran, Fredrick J. Dorey, and Duncan Hodge
- 20 Are corticosteroid injections as effective as physiotherapy for the treatment of a painful shoulder?, 391
Daniëlle van der Windt and Bart Koes
- 21 How should you treat tennis elbow? An updated scientific evidence-based approach, 418
Alasdair J.A. Santini, Michael J. Hayton, and Simon P. Frostick

Section 5: Injuries to the groin and knee, 435

- 22 How reliable is the physical examination in the diagnosis of sports-related knee injuries?, 437
Anthony Festa, William R. Donaldson, and John C. Richmond
- 23 What is the optimal treatment of acute anterior cruciate ligament injury?, 453
Graham Bailie and Ian Corry
- 24 What is the most appropriate treatment for patellar tendinopathy?, 476
Jill L. Cook and Karim M. Khan

- 25 How do you treat chronic groin pain?, 491
Peter A. Fricker and Greg Lovell

Section 6: Injuries to the lower leg, 511

- 26 How evidence-based is our clinical examination of the ankle?, 513
C. Niek van Dijk
- 27 Can we prevent ankle sprains?, 519
Roald Bahr
- 28 How should you treat a stress fracture?, 538
Kim Bennell and Peter Brukner
- 29 What is the best treatment of subcutaneous rupture of the Achilles tendon?, 562
Deiary Kader, David J. Deehan, and Nicola Maffulli
- 30 How to manage plantar fasciitis, 586
Gerald Ryan
- Multiple-choice question answers, 602
- Index, 603

Updates website: www.evidbasedsportsmedicine.com

Contributors

Roald Bahr, MD, PhD

Oslo Sports Trauma Research Center, Norwegian School of Sport Sciences, PO Box 4014, Ullevål Stadion, 0806 Oslo, Norway

Graham Bailie, FRCS (Tr & Orth), MMedSci

Specialist Registrar in Orthopaedic Surgery, Royal Victoria Hospital, Grosvenor Road, Belfast BT12 6BA, UK

Kim Bennell, BAppSci(physio), PhD

Centre for Health, Exercise and Sports Medicine, Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne, Parkville, Victoria 3010, Australia

Thomas M. Best, MD, PhD, FACSM

Professor and Pomerene Chair in Family Medicine; Chief, Division of Sports Medicine; Director, Primary Care Sports Medicine Fellowship; Medical Director, The OSU Sports Medicine Center, The Ohio State University, 2050 Kenny Road, Pavilion, Suite 3100, Columbus, OH 43221, USA

Chris Bleakley, PhD, BSc, MCSP, SRP

Physiotherapist and Research Associate, University of Ulster, Shore Road, Jordanstown, Co. Antrim BT37 0QB, UK

Peter Brukner, MBBS, FRACSP

Centre for Health, Exercise and Sports Medicine, Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne, Parkville, Victoria 3010, Australia

A. John Campbell

Professor of Geriatric Medicine, Department of Medical and Surgical Sciences, University of Otago Medical School, PO Box 913, Dunedin, New Zealand

Peter J. Carek, MD, MS

Director, Trident/MUSC Family Medicine Residency Program, Professor Department of Family Medicine, Medical University of South Carolina, 9298 Medical Plaza Drive, Charleston, SC 29406, USA

Jill L. Cook, BApp Sci(Phy), PhD

Associate Professor, Musculoskeletal Research Centre, La Trobe University, Bundoora, Victoria 3086, Australia

Matthew W. Cooke, PhD, FRCS(Ed), FCEM, DipIMC

Professor of Emergency Medicine, Warwick Medical School, Medical School Building, Gibbet Hill Campus, Coventry CV4 7AL, and Heart of England NHS Foundation NHS Trust, UK

Ian Corry, MD, FRCS (Orth), Dip Sports Med

Consultant Orthopaedic Surgeon, Royal Victoria Hospital, Grosvenor Road, Belfast BT12 6BA, UK

Andrew Currie, BSc (Hons)

Graduate Medical Student, Warwick Medical School, Medical School Building, Gibbet Hill Campus, Coventry CV4 7AL, UK

Joanne Dear, BSc (Hons), MSc

Senior Research Fellow, Research Centre, The British School of Osteopathy, 275 Borough High Street, London SE1 1JE, UK

David J. Deehan

Department of Orthopaedics, Freeman Hospital, Freeman Road, High Heaton, Newcastle upon Tyne NE7 7DN, UK

William W. Dexter, MD, FACSM

Director, Sports Medicine Program, Maine Medical Center, 272 Congress Street, Portland, ME 04101, USA

William R. Donaldson, MD

Clinical Professor, Department of Orthopedics, Tufts–New England Medical Center, 750 Washington Street, Box 143, Boston, MA 02111, USA

Fredrick J. Dorey, PhD

Adjunct Professor, Department of Orthopedic Surgery, University of California, Los Angeles, CA 90095, USA

Anthony Festa, MD

Chief Resident, Department of Orthopaedic Surgery, Tufts–New England Medical Center, 750 Washington Street, Box 143, Boston MA, 02111, USA

Anastasia M. Fischer, MD

Sports Medicine Program, Maine Medical Center, 272 Congress Street, Portland, ME 04101, USA

Peter A. Fricker, OAM, MBBS, FACSP, FRACP (Hon)

Director of Medical Services, Australian Institute of Sport, Leverrier Crescent, Bruce, ACT 2617, Australia

Simon P. Frostick, MA, DM, FRCS

Professor of Orthopaedics, Department of Musculoskeletal Science, The Royal Liverpool University Hospitals, Liverpool L69 3GA, UK

Michael J. Hayton, BSc (Hons), MB.ChB, FRCS (Orth)

Consultant Orthopaedic Surgeon, Wrightington Hospital, Hall Lane, Appley Bridge, Wigan WN6 9EP, UK

Bryan Heiderscheit, PT, PhD

Assistant Professor, Department of Orthopedics and Rehabilitation, University of Wisconsin School of Medicine and Public Health, 1300 University Avenue, 4120 MSC, Madison, WI 53706-1532, USA

Stanley A. Herring, MD

Clinical Professor, Departments of Rehabilitation Medicine, Orthopaedics and Sports Medicine, and Neurological Surgery, Harborview Medical Center, University of Washington, 325 Ninth Avenue, Seattle, WA, USA

Duncan Hodge, MD

Department of Orthopedic Surgery, Northern California Permanente Medical Group, Walnut Creek Medical Center, 1425 S. Main Street, Medical Office Building, 1st Floor, Walnut Creek, CA 94596, USA

Jennifer M. Hootman, PhD, ATC, FACSM

Epidemiologist, Arthritis Program, Division of Adult and Community Health, Centers for Disease Control and Prevention, 4770 Buford Highway NE, Mailstop K-51, Atlanta, GA 30341, USA

Deiary Kader, MD, FRCS (Tr&Orth)

Consultant Orthopaedic Surgeon, Queen Elizabeth Hospital, Gateshead, Tyne and Wear, NE9 6SX, UK

Anne-Maree Keenan, BAppSc (Pod), MAppSc

Academic Unit of Musculoskeletal Medicine, University of Leeds, Chapel Allerton Hospital, Chapeltown Road, Leeds LS7 4SA, UK

Karim M. Khan, MD, PhD

Department of Family Practice, School of Human Kinetics, University of British Columbia, 211/2150 Western Parkway, Vancouver, BC V6T 1Z6, Canada

Bart Koes

Professor of General Practice, Department of General Practice, Erasmus University Medical Center, Rotterdam, PO Box 1738, 3000 DR Rotterdam, The Netherlands

Karl B. Landorf, DipAppSc (Pod), GradDipEd, PhD

Senior Lecturer and Research Coordinator, Department of Podiatry, Faculty of Health Sciences, La Trobe University, Bundoora, Victoria 3086, Australia

Jeremy Lewis, PhD, MCSP, MAPA, MMAPP, MMPA

Consultant Shoulder Physiotherapist, St. George's Hospital, London, UK Visiting Reader, St. George's University of London, Research Lead, Therapy Department, Chelsea and Westminster Hospital, London, UK

Greg Lovell, MBBS, Dip, DHM, FACSP, FASMF

Sports Physician, Department of Sports Medicine, Australian Institute of Sport, Leverrier Crescent, Bruce, ACT 2617, Australia

Domhnall MacAuley, MD, FRCGP, FFPHMI, FFSEM

Visiting Professor, Faculty of Life and Health Science, University of Ulster, and Specialist in Sport and Exercise Medicine, Hillhead Family Practice, 33 Stewartstown Road, Belfast BT11 9FZ, UK

Christopher A. McGrew, MD

Department of Orthopedics and Rehabilitation, and Department of Family and Community Medicine, University of New Mexico Health Sciences Center, 2211 Lomas Boulevard NE, Albuquerque, NM 87106, USA

Paul McCrory, MBBS, PhD, FRACP, FACSP, FACSM, FASMF, GradDipEpidStats

Neurologist and Sports Physician, Centre for Health, Exercise and Sports Medicine, University of Melbourne, Parkville, Victoria 3010, Australia

Nicola Maffulli, MD, MS, PhD, FRCS(Orth)

Professor of Trauma and Orthopaedic Surgery, Department of Trauma and Orthopaedic Surgery, Keele University School of Medicine, Thornburrow Drive, Hartshill, Stoke on Trent, Staffs ST4 7QB, UK

Gladys Onambele-Pearson, BSc, MSc, PhD

Research Fellow, Department of Exercise and Sports Science, Institute for Biophysical and Clinical Research into Human Movement, Manchester Metropolitan University, Hassall Road, Alsager, Stoke on Trent ST7 2HL, UK

Joanna Picot

Medical Researcher, Wessex Institute for Health Research and Development, Mailpoint 728, University of Southampton, Bolderwood SO16 7PX, UK

Felix S.F. Ram

Senior Lecturer in Respiratory Medicine and Clinical Pharmacology, School of Health Sciences, Massey University-Auckland, Private Bag 102 904, North Shore Mail Centre, Auckland, New Zealand

John C. Richmond, MD

Chairman, Department of Orthopaedic Surgery, New England Baptist Hospital, 125 Parker Hill Avenue, Boston MA 02120, USA

M. Clare Robertson

Research Associate Fellow, Department of Medical and Surgical Sciences, University of Otago Medical School, PO Box 913, Dunedin, New Zealand

Gerald Ryan, MD

Associate Professor, Department of Family Medicine, University of Wisconsin Medical School, 777 S Mills Street, Madison, WI 53715, USA

John M. Ryan, FRCSEd (A&E), FCEM, FFSEM, DCH, DipSportsMed

Consultant in Emergency Medicine, Emergency Department, St. Vincent's University Hospital, Elm Park, Dublin 4, Ireland

Raymond A. Sachs, MD

Department of Orthopedic Surgery, Southern California Permanente Medical Group, San Diego, and Assistant Clinical Professor of Orthopedic Surgery, University of California, 350 Dickinson Street, San Diego, CA 92103, USA

Marc R. Safran, MD

Associate Professor, Department of Orthopedic Surgery, University of California at San Francisco, 500 Parnassus Avenue, Box 0728, San Francisco, CA 94143, USA

Alasdair J.A. Santini, FRCS(Glasg,Eng), FRCS(Orth)

Consultant Orthopaedic Surgeon, The Royal Liverpool and Broadgreen University Hospitals, Liverpool L69 3GA, UK

Marc Sherry, PT, LAT, CSCS

Senior Physical Therapist and Athletic Trainer, University of Wisconsin Sports Medicine Clinic, Research Park Clinic, 621 Science Drive, Madison, WI 53711, USA

Ian Shrier MD, PhD, Dip Sport Med, FACSM

Past-president, Canadian Academy of Sport Medicine, and Associate Professor McGill University, Centre for Clinical Epidemiology and Community Studies, SMBD-Jewish General Hospital, 3755 Côte Ste-Catherine Road, Montreal, Quebec H3T 1E2, Canada

Christopher J. Standaert, MD

Clinical Assistant Professor, Departments of Rehabilitation Medicine, Orthopedics and Sports Medicine, and Neurological Surgery, Harborview Medical Center, University of Washington, 325 Ninth Avenue, Seattle, WA, USA

T. Duncan Tennent, FRCS (Orth)

Consultant Orthopaedic Surgeon, St. George's Hospital, Blackshaw Road, London SW17 0QT, and Honorary Senior Lecturer, St. George's Hospital Medical School, London, UK

Martin Underwood

Professor of General Practice, Institute of Community Health Sciences, Barts and the London Medical School, Queen Mary's School of Medicine and Dentistry, Queen Mary, University of London, Abernethy Building, Mile End, London E1 2AT, UK

Daniëlle van der Windt, PhD

Department of General Practice, EMGO Instituut, Vrije Universiteit Medical Centre, van der Boechorststraat 7, 1081 BT Amsterdam, The Netherlands and Primary Care Musculoskeletal Research Centre, Keele University, Keele, Staffordshire ST5 5BG, UK

C. Niek van Dijk

Department of Orthopedic Surgery, Academic Medical Center, Meibergdreef 9, PO Box 22660, 1100 DD, Amsterdam, The Netherlands

Abel Wakai, MD, FRCSI

Specialist Registrar in Emergency Medicine, Emergency Department, St. Vincent's University Hospital, Elm Park, Dublin 4, Ireland

Weiya Zhang, BSc, MSc, PhD

Associate Professor of Musculoskeletal Epidemiology, Academic Rheumatology, University of Nottingham, Clinical Sciences Building, City Hospital, Nottingham NG5 1PB, UK

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

References

- 1 Sackett DL, Rosenberg WM, Gray JA, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. *BMJ* 1996; 312:71–72.
- 2 Straus SE, Sackett DL. Using research findings in clinical practice. *BMJ* 1998; 317:339–342.

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 colleagues¹ 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?”

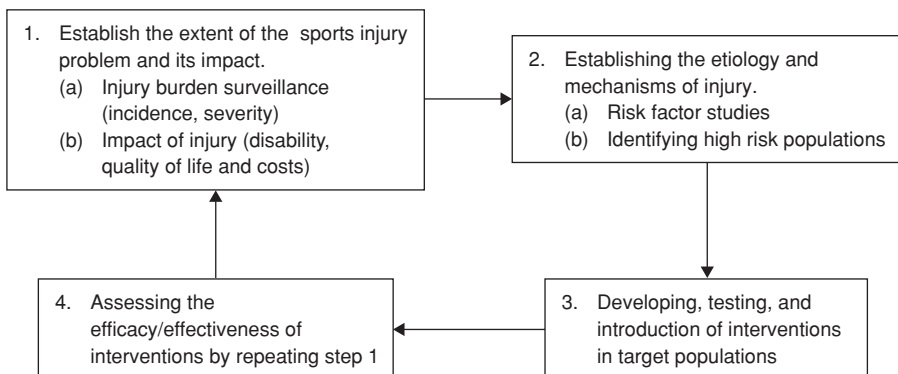


Figure 1.1 A modified version of the “sequence of prevention,” an injury prevention model proposed by van Mechelen and colleagues (adapted with permission from ref. 1).

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

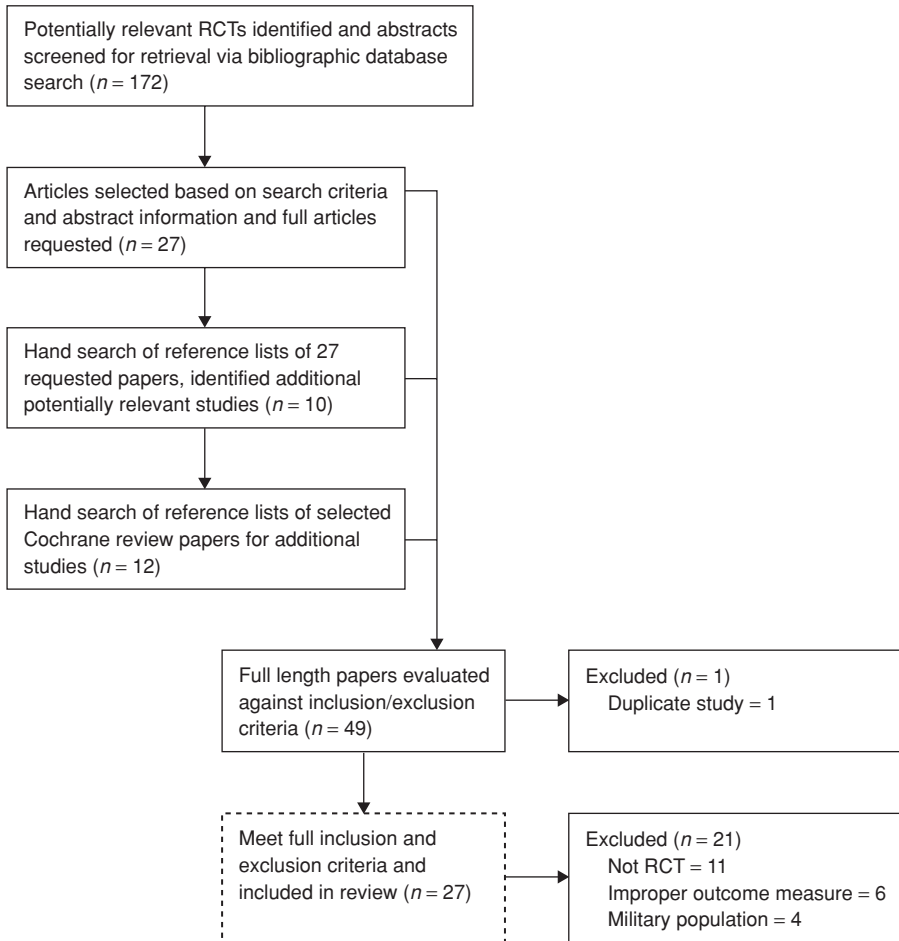


Figure 1.2 Flow chart of study selection for randomized controlled trials (RCTs) included in the review.

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, Stasinopoulos¹⁴ 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 baseball³⁵ 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 study³⁷ showed a 45-minute video on skiing injury prevention and proper equipment use during a bus

ride to a ski resort. The other study³⁸ used a 2-hour workshop format to present a video analysis of injury mechanisms in soccer, followed by a group discussion.

Other interventions. One study³⁹ 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 study⁷ 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 group³¹ 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		Components of interventions	Those favoring intervention[†] % (n)	Average quality score[‡]	Level of evidence[§]
Intervention type (n[†])					
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	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

- osteoarthritis
 - anterior cruciate ligament injury 461
 - hip joint 491
 - knee 237
 - NSAIDs in 224–5, 225, 226
- osteomyelitis 491, 539
 - bony pelvis 495
 - symphysis pubis 495
- osteoporosis 589
 - cross-sectional studies 170–1
 - definition of 167–8
 - exercise programs 171–80, 171
 - adverse effects 176–7
 - increasing bone density at spine and hip 172–4
 - whole-body microvibration 175–6
 - wrist strengthening 171–2
 - menopause 174–5
 - prophylaxis and treatment 168, 168
- Oswestry Disability Questionnaire 258
- Otago Exercise Program 136, 156, 158
- Oxford Centre for Evidence-based Medicine 7
- Oxford Shoulder Score 329, 352
- oxygen-ozone treatment 290

- Paget's disease 589
- painful arc test 305, 337
- pain-killing injection 198
- pain relief
 - adductor muscle strain 501
 - epicondylitis 425–6
 - osteitis pubis 499
 - patellar tendinopathy 480, 482, 483
 - shoulder pain 391–414
 - see also corticosteroids; NSAIDs
- pain relief score 223
- palpation 330–1, 331
- pamidronate 499
- paracetamol 237
- parachuters, ankle sprains in 529
- parathyroid hormone 541–2
- pars interarticularis 284, 293
 - stress fractures 553
 - see also spondylolysis
- passive elevation test 337
- passive external rotation 337
- patellar stress fractures 553
- patellar tendinopathy 476–89
 - conservative treatment 477–83, 485
 - exercise 477–80, 478–9
 - massage/frictions 480, 481
 - pharmacotherapy 480, 482, 483
 - diagnostic criteria 485–6
 - duration of symptoms 486
 - outcome measures 486
 - recommendations 487
 - surgical treatment 483, 484, 485
- patellar tendon
 - autograft 463, 464
 - palpation 330
- patellofemoral joint
 - injury 441–3, 443
 - pain 60, 65
 - NSAIDs in 225
 - orthoses 73
- patent ductus arteriosus 19
- peak bone mass 167, 171
- peak expiratory flow rate 245, 249, 251
- PEDro scores 76, 80
 - cryotherapy 190, 194–5
- pelvic disorders 491
- pelvic musculature 492
- Percy and Connochie scale 574
- Perthes disease 491, 497
 - management 501
- pes cavus 547, 588
- pes planus 547, 588
- phagocytes 109
- phonophoresis 480, 482, 483
- Physical Activity and Health: a Report from the Surgeon General* 13
- physical examination 22–7, 25
 - ankle 513–17
 - groin pain 493
 - knee injuries 437–50
 - anterior cruciate ligament 444–5
 - posterior cruciate ligament 445
 - plantar fasciitis 588–9
 - preparticipation 18–30, 25
 - athletic mortality and morbidity 19–20, 20
 - determination of clearance 27
 - disadvantages of 28
 - medical history 20–2, 21, 22
 - rates of clearance 20
- physiotherapy
 - epicondylitis 422–3
 - shoulder pain 391–414, 403, 404–5
 - effectiveness 410–11, 413
 - vs corticosteroids 403, 406–7, 408, 408
- Pilates, Joseph 59
- piroxicam
 - side effects 226, 227
 - see also NSAIDs
- placebo injection 198
- plantar fascia 586
- plantar fasciitis 73, 75, 586–99, 596
 - anatomy 586
 - diagnosis 587
 - differential diagnosis 589–90, 589
 - musculoskeletal 589–90
 - neuralgia 590
 - systemic disease 590
 - etiology 587
 - history 588
 - physical examination 588–9
 - treatment 590–5
 - casting 592–3
 - extracorporeal shock-wave therapy 593–4
 - heel cord stretching 591
 - heel pads and orthotics 591–2
 - night splints 592
 - radiofrequency therapy 594

- plantar fasciitis (*Cont'd*)
 rest 590–1
 steroid therapy 593–4
 surgery 594–5
 taping 592
 windlass effect 587
- plica syndrome 70
- pneumatic air braces 538
 stress fractures 549–50
see also bracing
- polidocanol 482
- polymer insoles for stress fracture 540
- pool running *see* deep water running
- postconcussion syndrome 94, 98–9
 symptoms 99
- posterior abdominal wall deficiency 500
- posterior cruciate ligament 445–7, 447
 examination 445
- posterior drawer test 320, 447
- posterior tibial nerve entrapment 590
- posterolateral capsule 448
- prednisolone 399
- preparticipation physical examination 18–30, 25
 athletic mortality and morbidity 19–20, 20
 determination of clearance 27
 disadvantages of 28
 medical history 20–2, 21, 22
 rates of clearance 20
- Preparticipation Physical Examination Task Force 18–19, 20
- Prevention of Falls Network Europe 155
- prevention of injury 3–15
 ankle sprains 519–35, 520, 523–5
 core strengthening 60–2, 66–9
 data abstraction 5–6
 educational programs 6–7
 effectiveness of programs 8–10
 exercise programs 6, 7, 8, 9
 low back pain 257–8
 orthoses 73–88
 protective/prophylactic equipment 6, 8, 9, 12
 recommendations 14
 retrieval of published studies 4
 sequence of prevention 3
 stretching 36–54, 40–51, 41, 42–5, 46–7, 50
 study quality 4–5
- primary abdominal musculofascial abnormality 494
- proprioceptive neuromuscular facilitatory stretching 39
- prostacyclin 229
- protective equipment 6, 8, 9, 12
- proton pump inhibitors 222, 231
- pubalgia 494
- pubic ramus
 fractures 491, 495, 501
 osteomyelitis 491
- pubic symphysis 493
- pulmonic stenosis 19
- punch-drunk syndrome 94, 100–1, 103
- Putti-Platt procedure 377, 380
- Q angle 441, 548
- quadriceps active test 447
- quality-adjusted life-years 223
 anterior cruciate injury 460
- radicular neuropathy 491
- radiofrequency therapy, plantar fasciitis 594
- radiography, in spondylolysis 285, 285, 286
- randomized trials
 corticosteroids 395, 396
 internal validity 393
 prevention of injury 5–6, 5
 range of movement 36–7, 38–9
- rectus femoris strain 491, 496–7
 management 501
- regression analysis 48
- rehabilitation, cryotherapy 200–1
- Reiter's syndrome 590
- renal transplantation 126
- rent test 330, 342
- return to sport
 concussion 96, 96, 97
 life-threatening brain injury 101–2, 102
 myocarditis 111–12
 stress fracture 541
- RICE 201, 208, 209
- risedronate 538, 540
- risk factors
 abdominal injuries 126–7
 cardiovascular 22
 groin pain 502
 stress fracture 545–9, 546
 stress fractures
 biochemical abnormalities 547–8
 dietary intake 549
 footwear and insoles 546–7
 menstrual status 548–9
 muscle flexibility and joint range of motion 548
 training 545–6
- rofecoxib 227, 228
 cost-effectiveness 230
- Roland Morris Questionnaire 258
- rotator cuff strength 309
 clinical tests 334–6
 injections 334–5
- rotator cuff tears 306–12, 308–11
 biopsy 328
 diagnostic tests 327–55
 for, search strategy 329
 observation 330
 palpation 330–1, 331
- infraspinatus atrophy 311
- pathology 328
- tests for 310
 belly-press test 307
 drop sign 309, 310
 empty can test 306, 309, 310, 324, 336
 external rotation lag sign 309, 310, 324
 full can test 307, 309, 310, 334, 336
 internal rotation lag sign 309, 310, 324
 Jobe's sign 306, 310

- lift-off test 307, 310, 324
- Neer sign 304, 305, 311
- supraspinatus test 306, 311
- rotator cuff tendinitis 327, 328, 391, 396
- rotator cuff tendinosis 327
- rotator cuff tendon palpation 330
- Rowe rating scale 362, 374, 376
- rowers, spondylolysis in 283
- rugby players
 - hip lesions 497
 - osteitis pubis 499
- runners *see* track and field
- sacroiliac joint
 - pain 60
 - slip 494
- sacroiliac ligament lesion 491, 497
 - management 502
- Sage test 441, 442
- scintigraphy 539
- scrotal injury 126, 131
- self-exercise 260, 261, 262, 263–4
- semi-rigid braces 12
- semi-rigid casts 211
- sesamoid, stress fractures 553
- Sever's disease 589, 597
- shin splints 73, 87
- shock-absorbing orthoses 77–80, 78–9
 - heel pads
 - plantar fasciitis 591–2
 - stress fracture 540
 - insoles 538, 540
 - randomized trials 80
- shoe types, and ankle sprains 527
- shoulder 303–25
 - biceps tendon pathology 319
 - clinical tests 335–6, 337–42
 - drop-arm sign 305, 341
 - drop sign 309, 310, 341
 - empty can test 306, 309, 310, 324, 336, 339
 - external rotation 340
 - external rotation lag sign 309, 310, 324, 341
 - full can test 307, 309, 310, 334, 336, 339
 - Hawkins test 304, 305, 324, 334, 336, 338
 - horizontal adduction cross body test 305, 339
 - internal rotation lag sign 309, 310, 324, 342
 - internal rotation resistance strength test 340
 - Neer sign 304, 305, 311, 324, 334, 336, 338
 - painful arc test 305, 337
 - passive elevation test 337
 - passive external rotation 337
 - speed 339–40
 - transdeltoid palpation (rent test) 342
 - Yergason test *see* Yergason test
 - imaging 343–50
 - magnetic resonance imaging 343, 345, 348–9, 350
 - ultrasound 344–5, 346–7
 - impingement syndrome 303–6, 505
 - injections 334–5
 - labral tears 312–19, 313, 315–17
 - range of movement 331, 332–3
 - rotator cuff tears *see* rotator cuff tears
 - strength measurement 334
 - subacromial bursitis 304
 - subscapularis rupture 208
 - tendon palpation 330–1, 331
- shoulder dislocation 361–87
 - cost-benefit ratio 380, 382, 383, 384, 386
 - ice hockey players 361, 366
 - incidence 361
 - natural history 364–71
 - athletes 366–7, 368
 - general population 364–5, 365
 - need for surgery 367, 369–71, 370
 - young population 365–6, 365
 - recurrence rates 365, 370
 - study quality 363, 364
 - treatment
 - immobilization 371
 - surgery 372–82, 373, 378, 379
 - young athletes 382–3
- shoulder instability 320–2, 322
 - apprehension-location test 320
 - apprehension test 320, 324
- shoulder laxity 319–20, 321
 - load and shift test 320
 - posterior drawer test 320
- shoulder pain
 - acupuncture 400
 - corticosteroids 391–414
 - adverse reactions 409
 - long-term outcomes 408–9
 - randomized trials 395, 396
 - vs NSAIDs 402, 403
 - vs physiotherapy 403, 406–7, 408, 408
 - vs placebo 396–402, 397–401, 402
 - NSAIDs 392–3
 - physiotherapy 391–414, 403
- Shoulder Pain and Disability Index 329
- shoulder weakness 334
- Single Assessment Numeric Evaluation (SANE) 374, 382
- single photon emission computed tomography, spondylolysis 285–6, 286, 289
- sinus bradycardia 23
- skiers, anterior cruciate ligament injury 467, 469
- slipped capital femoral epiphysis 491, 497
 - management 502
- Slocum test 445
- snapping hip syndrome 491, 496
- Snyder's joint compression test 318
- soccer players
 - ankle injuries 517
 - anterior cruciate ligament injury 469
 - asthma 254
 - compression 204
 - cryotherapy 204
 - groin pain 493
 - hip lesions 497
 - inguinal hernia 494
 - spondylolysis 283
 - sudden cardiac death 19

- soft-tissue injuries 189–204
see also knee injuries
- solitary kidney 120, 123
- solitary testicle 131
- South Manchester Back Pain Study 257
- Speed's test
 labral tears 316, 319
 rotator cuff tears 304, 305
- speed test 339–40
- spinal stabilization programs 262, 268, 272
- spine, increasing bone density 172–4
- splenic rupture 114, 115, 122
- splenic trauma 122–3
- spondylolisthesis 63, 283, 290
- spondylolysis 63, 281–96
 clinical implications 294
 clinical presentation 284
 current management 292
 diagnostic imaging 285–9, 285–8
 disk degeneration 283–4
 epidemiology 282–4, 282
 genetic tendency 284
 incidence 282
 isthmic 281, 284
 natural history 282–4, 282
 pathophysiology 284
 slip progression 283
 treatment 289–91, 291
- SportDiscus database 492
- sports hernia *see* inguinal hernia
- sport-specific exercise programs 262–3, 263–4
- squash players, hip lesions in 497
- standardized mean differences 394
- Staphylococcus aureus* 495
- stirrup orthoses 12
- strengthening exercises 263, 268–9, 272–3
- strength training 173
- stress fractures 76, 495
 diagnosis 539–41, 540
 femoral neck 491, 497, 553
 healing 550
 marathon runners 495
 medial malleolus 553
 metatarsals 553
 navicular 553
 pars interarticularis 553
 patella 553
 return to sport 541
 sesamoid 553
 talus 553
 tibia 87, 553, 556
 treatment 541–53, 554
 bracing 549–50
 electrical stimulation 542
 low-energy laser 542
 low-intensity pulsed ultrasound 542–3
 maintenance of fitness 543–4, 545
 modification of risk factors 545–9, 546
 muscle strengthening 543
 pain relief 541
 pharmaceutical therapies 541–2
 specific 553, 553
 surgery 552
- stress reactions 538
- stress tests 448
- stretch-induced hypertrophy 40
- stretching
 dynamic stretching 37
 improper technique 37
 and injury prevention 40–51, 41, 42–5, 46–7, 50
 conclusions 52–3
 equivocal studies 49
 negative studies 44–5, 48
 positive studies 41, 42–3, 48, 50, 51
 physiology 38–40
 immediate effects 38–9
 long-term effects 39–40
 proprioceptive neuromuscular facilitatory 39
 range of movement 36–7, 38–9
- stretch relaxation 38
- subacromial bursitis 304
- subacromial impingement 330
- subscapularis tendon
 palpation 331
 rupture 208
- substance P 329
- subtalar instability 515
- sudden cardiac death 19, 23, 29–30
- superior labrum anterior-posterior (SLAP) lesion 306, 312
- supraspinatus tendinitis 327
- supraspinatus tendon palpation 331
- supraspinatus test 306, 311
- sural nerve entrapment 567
- surgery
 anterior cruciate ligament injury 461–3
 arthroscopic knee surgery 196, 204
 patellar tendinopathy 483, 484, 485
 plantar fasciitis 594–5
 shoulder dislocation 372–82, 373, 378, 379
 complications 380–1
 need for 367, 369–71, 370
 outcomes assessment 381–2
 technique 377–80, 378, 379
 stress fracture 552
see also arthroscopy
- symphysis pubis 492
 magnetic resonance imaging 494
 osteomyelitis 495
- systemic lupus erythematosus 590
- systolic murmurs 23
- talofibular ligaments 208
- talus, stress fractures 553
- taping 209, 210, 213–17
 ankle injuries 516
 ankle sprains 521–2, 526–7
 plantar fasciitis 592
- Tegner's score 574
- tennis elbow *see* epicondylitis
- tennis players, knee injury 450
- tenotomy 427–8