

Clinical review

Recent advances

Sports medicine

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Sports medicine conjures up television images of sideline treatment of professional athletes. The field has widened, however, to encompass the many specialties where sport, exercise, and medicine meet. Sports medicine now comprises two main areas: the health benefits of regular physical activity and the health problems associated with sport and physical activity. The first area has become increasingly important now that inactivity and obesity are common. The health problems associated with sport have also assumed increasing importance because of increased participation and professionalism in sport.

Methods

I used information from articles found through the Medline database on topics I selected after reviewing major sports medicine journals. I selected topics relating to advances where primary care doctors have a key role in promoting physical activity and preventing and treating medical problems in active patients.

Health benefits of regular physical activity

One of the most important advances in medicine is the documentation that regular physical activity reduces the risk of premature mortality, coronary heart disease, hypertension, colon cancer, obesity, and diabetes mellitus.¹ Recent studies have shown that inactivity and low cardiorespiratory fitness are as important predictors of mortality and morbidity as overweight, obesity, smoking, and raised cholesterol levels and blood pressure.¹⁻⁶ Physical activity also protects against breast cancer, and possibly prostate, lung, and endometrial cancer.¹

Substantial health benefits can be obtained by undertaking a moderate amount of physical activity on most, if not all, days of the week.¹ Most recommendations suggest moderately intense exercise with large muscle groups—such as brisk walking—for 30 minutes. Recent evidence suggests that exercise sessions may be split into shorter bouts of 5-10 minutes' duration, or even shorter bouts if exercise intensity is high enough.

Most people are capable of this level of physical activity, and expensive training studios, fashionable tights, and even running shoes are not necessary to achieve better health. A recent study in previously sed-

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Daily, moderately intense exercise such as walking for 30 minutes yields substantial health benefits

Regular physical activity attenuates the health risks associated with overweight and obesity

Strength training in elderly people prevents bone loss with age and improves balance, thus reducing the risk of falls and osteoporotic fractures

Balance training and bracing and taping of the ankle prevent recurrent ankle sprain

Knee injuries may be prevented by balance training and strength and agility training

Balance training may also prevent injuries to the anterior cruciate ligament, which are common among female athletes

entary healthy adults showed that a programme incorporating physical activity into the participants' lifestyle was as effective after two years of follow up as a structured programme to improve physical activity, cardiorespiratory fitness, and blood pressure.⁷ Doctors working in primary care are in a key position to promote this level of physical activity; practical tools, such as physician based assessment and counselling for exercise (PACE),⁸ may help them to advise patients effectively.

Obesity, physical activity, and health

Body weight has been increasing at an alarming rate worldwide, mainly as a result of decreasing daily energy demands owing to increased mechanisation at home and work and during leisure time.⁹ Several recent prospective observational studies show that regular physical activity lowers many of the health risks associated with overweight and obesity.^{10 11} Furthermore, obese people who are active have lower mortality and morbidity than people whose weight is normal but who are sedentary.¹⁰ This means that for the

overweight or obese patient, starting and maintaining a regular exercise programme yields important health benefits, even in the absence of substantial weight loss.^{10 11} This is encouraging, as maintaining regular physical activity of moderate intensity may be perceived as more attainable than reducing body weight.

Strength training in elderly people

As low functional capacity and a high incidence of chronic disease are common among elderly people, exercise training should be particularly encouraged in this population.¹² Advancing age brings progressive loss of muscle strength, muscle mass, and muscle quality, resulting in a condition known as sarcopenia.¹³ Studies in recent years have shown that strength training can reverse the loss of muscle function and the deterioration of muscle structure associated with advanced age.^{14 15} Strength training improves functional ability and health, not only by increasing muscle mass, strength, and power, but also by improving bone mineral density.¹⁵⁻¹⁷

Strength training also improves balance.¹⁷ Sarcopenia, osteoporosis, and reduced balance are the main risk factors for falls and osteoporotic fractures.^{13 17} Strength training may therefore prevent osteoporotic fractures, one of the main sources of physical disability and obstacles to independent living among elderly people.^{12 16} Although exercise has not yet been proved to prevent falls and fractures in elderly people, epidemiological studies (case-control and prospective cohort follow up studies) consistently show that both past and current physical activity do protect against hip fracture, reducing the risk by up to 50%.¹⁸

Most of the studies on strength training have used high intensity, progressive, resistance training protocols similar to those used by athletes, focusing on large muscle groups (hip and knee extensors). Trial subjects have trained with a resistance of 80% of the maximal load the subject can fully lift once only, and resistance has been increased as strength improves. For maximal effect, strength training should be done three days a week for at least three months. Each muscle group should be exercised in three sets of eight repetitions each session. High intensity strength training can be done at home or in a group but requires skilled instruction at the start.

Regular physical activity, especially if started in childhood and adolescence, is a cheap, safe, readily available, and largely acceptable way of improving bone strength and reducing the propensity to fall.¹⁸ Physical activity, including specific strength training for target groups, should therefore become an essential part of strategies aimed at controlling the alarming increase in osteoporotic fractures.

Prevention of ankle injury

Participation in sport entails a risk of injury. Ankle injuries are the most common, with an incidence of 1 per 100 000 people a day, accounting for about 20% of all sports injuries. Most ankle injuries are moderate ligament sprains. With proper functional treatment the patient can return to work or sport within a few weeks or even days, and most injuries heal without sequelae.

Some ankle sprains, however, cause prolonged disability in the form of persisting pain or instability.

The protective effects of taping and bracing have been shown persuasively in soccer and basketball, but only for players with previous ankle injury.¹⁹⁻²¹ Taping or bracing reduces the incidence of sprains and results in less severe sprains, whereas the efficacy of "high top" basketball shoes is unclear. Braces seem to be more effective than tape in preventing ankle sprains.^{22 23} Bracing is also more comfortable and more cost effective if used long term.^{22 23} Different types of braces are widely available commercially (fig 1). Taping can be performed by the doctor, physiotherapist, or even the patient with a little instruction.

How tape and braces work is uncertain; they may simply improve neuromuscular control of the ankle joint. This view is corroborated by the fact that their effect is limited to players with previous injury¹⁹⁻²¹—when neuromuscular function is reduced—and the fact that braces do not seem to restrict inversion enough to substantiate their prophylactic effect.²² If the protective effect were mechanical, an effect in healthy ankles would also be expected.

Neuromuscular control can be restored after previous injury with a training programme using a "balance board," which reduces the risk of reinjury to the same level as in healthy ankles (fig 2). Athletes with a sprained ankle should therefore complete supervised rehabilitation, including a 6-10 week programme of balance training. An appropriate brace should be worn at least until completion of rehabilitation. Ideally, the doctor should fit a brace on the first visit to the clinic after injury or at least refer the patient to a physiotherapist for a brace and instructions on proper balance training.

Prevention of knee injury

Serious knee injuries, particularly those to the anterior cruciate ligament, are causing increasing concern. The highest incidence is seen in 15-25 year old athletes in "pivoting" sports such as football, basketball, and hand-



Fig 1 An ankle brace (right ankle) or tape (left ankle) should be worn during sporting and other high risk activities at least until completion of a supervised rehabilitation programme, including 6-10 weeks of balance training



Fig 2 Balance board training is performed with the player standing on one leg on a balance board. The objective is to control balance using an “ankle strategy”—that is, without using hands, hips, or knees to adjust body position, but to correct balance using only the ankle as much as possible. Thus, arms are held across the chest, and the opposite leg is held still in 90° knee flexion

ball, and the incidence is three to five times higher among women than among men.²⁴ The introduction of stiffer ski boots and “carving” skis (skis designed to aid turning) has also been associated with an increase in injuries to the anterior cruciate ligament.²⁵ These injuries cause lengthy absence from work and sport and greatly increase the risk of long term sequelae—such as abnormal joint dynamics and early onset of degenerative joint disease.²⁵ Although better treatments are being researched, there is no good evidence that reconstructive surgery of either menisci or cruciate ligaments decreases the rate of post-traumatic osteoarthritis. Nor has repair of isolated cartilage lesions been proved to prevent or retard the development of osteoarthritis.

Although the development of improved treatments for knee injuries is important, it is arguably even more important to identify risk factors and try to prevent them.

The anterior cruciate ligament may be injured during activities that most athletes consider routine to their sport, usually without any direct contact to the knee,²⁶ implying that there may be important intrinsic factors that lead to rupture of the anterior cruciate ligament. Nevertheless, recent data suggest that improving knee control may reduce the rate of such injuries.

Caraffa and colleagues studied the preventive effect of a gradually increasing balance training programme in Italian semiprofessional or amateur footballers during three seasons.²⁷ They observed an 87% reduction in the incidence of injuries to the anterior cruciate ligament. Other studies have observed a reduced incidence of injuries in young female footballers using a pre-season conditioning programme,²⁸ in young female European handball players using a training programme (including balance training) throughout the season,²⁹ and in a mixed group of US high school female athletes using mainly jump training exercises emphasising knee control.³⁰ Although these latter studies were too small to evaluate statistically the effect on injuries to the anterior cruciate ligament in particular, it seems reasonable to conclude that the risk of serious knee injuries may be reduced through structured training programmes with a focus on neuromuscular knee control.

The clinical importance of these studies and of the similar studies on ankle sprains is that medical staff need to participate in encouraging coaches and players to focus on general conditioning exercises to prevent serious knee injuries. In addition, balance training represents a new form of training not usually used by coaches. As balance exercises reduce the risk of injury to the anterior cruciate ligament, doctors have to assume responsibility in teaching coaches and athletes how to train effectively. Unfortunately, teaching aids are not readily available yet, except through postgraduate sports medicine courses for doctors and physiotherapists.

Doping in sport

Doping represents a formidable threat to the future of sport, and the recent advances in this area have been political rather than scientific.

The political events providing momentum to the antidoping movement started in 1998 when the Tour de France cycle race was hit by the worst drug scandal in its history. In the same year, authorities investigated the Italian Olympic Committee’s testing laboratory. These and other high profile stories, together with much negative media exposure, prompted the International Olympic Committee to reconsider its approach to combating doping and led to renewed discussions about the list of banned substances and methods to detect their use.

Current regulations call for a minimum two year suspension and heavy fines for athletes found guilty of taking steroids and other performance enhancing substances, and the scientific and technical standards and procedures for analyses and equipment have been standardised. In November 1999 the World Anti-Doping Agency was established to coordinate testing done outside competitions. However, the World Anti-Doping Agency is faced with many challenges, including the development of effective testing methods.

Taking erythropoietin boosts the body’s red blood cell count, improving the blood’s ability to transport oxygen to the muscles, and thereby enhancing endurance performance. The potential improvement in performance from using erythropoietin is formidable—maximal oxygen uptake may be increased by more than 10%. Some international sports federations have

Additional educational resources

- Blair SN, Brodney S. Effects of physical inactivity and obesity on morbidity and mortality: current evidence and research issues. *Med Sci Sports Exerc* 1999;31:S646-62
- Fletcher GF et al. Statement on exercise: benefits and recommendations for physical activity programs for all Americans. A statement for health professionals by the Committee on Exercise and Cardiac Rehabilitation of the Council on Clinical Cardiology, American Heart Association. *Circulation* 1996;94:857-862
- Verhagen E et al. The effect of preventive measures on the incidence of ankle sprains. *Clin J Sport Med* 2000;10:291-6

URLs

- Physical activity and health: a report of the US surgeon general (www.cdc.gov/nccdphp/sgr/sgr.htm)
- SportSmart: New Zealand for injury prevention (www.sportsmart.org.nz/)
- Sport and Recreation Victoria: preventing sports injuries (www.sport.vic.gov.au/web/srv/srvsite.nsf/pages/research_injury)

BMJ archive

- Hackney RG. ABC of sports medicine: nature, prevention, and management of injury in sport. *BMJ* 1994;308:1356-9
- Kannus P. Preventing osteoporosis, falls, and fractures among elderly people. *BMJ* 1999;318:205-6
- Andrews GR. Promoting health and function in an ageing population. *BMJ* 2001;322:728-9
- MacAuley D. Drugs in sport. *BMJ* 1996;313:211-5

excluded athletes with packed cell volume or haemoglobin levels above certain limits from participation in competition. However, a substantial improvement in maximal oxygen uptake may be achieved even with normal haemoglobin levels. Although the World Anti-Doping Agency has funded considerable research with promising results, it has still not established efficient testing methods to combat misuse of erythropoietin. The development of more effective methods to detect the misuse of erythropoietin and other hormones is one of the biggest challenges for sports scientists.

The future

Sport and physical activity should be part of a healthy lifestyle. Preventing and treating medical problems in active patients is as important as promoting exercise. To do both effectively, primary care doctors need to be educated, and sports medicine must be included in the curriculum at all levels of medical training.

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- 1 Centers for Disease Control and Prevention. Surgeon general's report on physical activity and health. *JAMA* 1996;276:522.
- 2 Farrell SW, Kampert JB, Kohl HW, Barlow CE, Macera CA, Paffenbarger RS Jr, et al. Influences of cardiorespiratory fitness levels and other predictors on cardiovascular disease mortality in men. *Med Sci Sports Exerc* 1998;30:899-905.
- 3 Wei M, Kampert JB, Barlow CE, Nichaman MZ, Gibbons LW, Paffenbarger RS Jr, et al. Relationship between low cardiorespiratory fitness and mortality in normal-weight, overweight, and obese men. *JAMA* 1999;282:1547-53.

- 4 Blair SN, Kampert JB, Kohl HW, Barlow CE, Macera CA, Paffenbarger RS Jr, et al. Influences of cardiorespiratory fitness and other precursors on cardiovascular disease and all-cause mortality in men and women. *JAMA* 1996;276:205-10.
- 5 Haapanen N, Milunpalo S, Vuori I, Oja P, Pasanen M. Association of leisure time physical activity with the risk of coronary heart disease, hypertension and diabetes in middle-aged men and women. *Int J Epidemiol* 1997;26:739-47.
- 6 Rosengren A, Wilhelmsen L. Physical activity protects against coronary death and deaths from all causes in middle-aged men. Evidence from a 20-year follow-up of the primary prevention study in Goteborg. *Ann Epidemiol* 1997;7:69-75.
- 7 Dunn AL, Marcus BH, Kampert JB, Garcia ME, Kohl HW, Blair SN. Comparison of lifestyle and structured interventions to increase physical activity and cardiorespiratory fitness: a randomized trial. *JAMA* 1999;281:327-34.
- 8 Patrick K, Sallis JF, Long B, Calfas K, Wooten W, Heath G, et al. A new tool for encouraging activity. *Physician Sportsmed* 1994;22:45-55.
- 9 Weinsier RL, Hunter GR, Heini AF, Goran MI, Sell SM. The etiology of obesity: relative contribution of metabolic factors, diet, and physical activity. *Am J Med* 1998;105:145-50.
- 10 Blair SN, Brodney S. Effects of physical inactivity and obesity on morbidity and mortality: current evidence and research issues. *Med Sci Sports Exerc* 1999;31:S646-62.
- 11 Pescatello LS, VanHeest JL. Physical activity mediates a healthier body weight in the presence of obesity. *Br J Sports Med* 2000;34:86-93.
- 12 Evans WJ. Exercise training guidelines for the elderly. *Med Sci Sports Exerc* 1999;31:12-7.
- 13 Hurley BF, Roth SM. Strength training in the elderly: effects on risk factors for age-related diseases. *Sports Med* 2000;30:249-68.
- 14 Fiatarone MA, O'Neill EF, Ryan ND, Clements KM, Solares GR, Nelson ME, et al. Exercise training and nutritional supplementation for physical frailty in very elderly people. *N Engl J Med* 1994;330:1769-75.
- 15 Hartard M, Haber P, Ilieva D, Preisinger E, Seidl G, Huber J. Systematic strength training as a model of therapeutic intervention. A controlled trial in postmenopausal women with osteopenia. *Am J Phys Med Rehabil* 1996;75:21-8.
- 16 Heinonen A, Kannus P, Sievanen H, Oja P, Pasanen M, Rinne M, et al. Randomised controlled trial of effect of high-impact exercise on selected risk factors for osteoporotic fractures. *Lancet* 1996;348:1343-7.
- 17 Nelson ME, Fiatarone MA, Morganti CM, Trice I, Greenberg RA, Evans WJ. Effects of high-intensity strength training on multiple risk factors for osteoporotic fractures. A randomized controlled trial. *JAMA* 1994;272:1909-14.
- 18 Kannus P. Preventing osteoporosis, falls, and fractures among elderly people. *BMJ* 1999;318:205-6.
- 19 Surve I, Schwellnus MP, Noakes T, Lombard C. A fivefold reduction in the incidence of recurrent ankle sprains in soccer players using the Sport-Stirrup orthosis. *Am J Sports Med* 1994;22:601-6.
- 20 Tropp H, Asklund C, Gillquist J. Prevention of ankle sprains. *Am J Sports Med* 1985;13:259-62.
- 21 Sittler M, Ryan J, Wheeler B, McBride J, Arciero R, Anderson J, et al. The efficacy of a semirigid ankle stabilizer to reduce acute ankle injuries in basketball. A randomized clinical study at West Point. *Am J Sports Med* 1994;22:454-61.
- 22 Verhagen EA, van Mechelen W, de Vente W. The effect of preventive measures on the incidence of ankle sprains. *Clin J Sport Med* 2000;10:291-6.
- 23 Thacker SB, Stroup DF, Branche CM, Gilchrist J, Goodman RA, Weitman EA. The prevention of ankle sprains in sports. A systematic review of the literature. *Am J Sports Med* 1999;27:753-60.
- 24 Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer. NCAA data and review of literature. *Am J Sports Med* 1995;23:694-701.
- 25 Natri A, Beynon BD, Ettlinger CF, Johnson RJ, Shealy JE. Alpine ski bindings and injuries. Current findings. *Sports Med* 1999;28:35-48.
- 26 Boden BP, Griffin LY, Garrett WE Jr. Etiology and prevention of noncontact ACL injury. *Physician Sportsmed* 2000;28:53-60.
- 27 Caraffa A, Cerulli G, Proietti M, Aisa G, Rizzo A. Prevention of anterior cruciate ligament injuries in soccer. A prospective controlled study of proprioceptive training. *Knee Surg Sports Traumatol Arthrosc* 1996;4:19-21.
- 28 Heidt RS Jr, Sweeterman LM, Carlonas RL, Traub LA, Tejkulve FX. Avoidance of soccer injuries with preseason conditioning. *Am J Sports Med* 2000;28:659-62.
- 29 Wedderkopp N, Kalltoft M, Lundgaard B, Rosendahl M, Froberg K. Prevention of injuries in young female players in European team handball. A prospective intervention study. *Scand J Med Sci Sports* 1999;9:41-7.
- 30 Hewett TE, Lindenfeld TN, Riccobene JV, Noyes FR. The effect of neuromuscular training on the incidence of knee injury in female elite athletes. A prospective study. *Am J Sports Med* 1999;27:699-709.

**Endpiece
Magisterial**

Physicians are like kings—they brook no contradiction.

John Webster, English playwright (c1580-c1625)

Submitted by Donald Scott, retired consultant,
London