Finally, it seems that training in people with spinal cord injuries improves their general wellbeing, temperature regulation, and sleeping patterns and reduces pressure sores, all important effects in addition to those mentioned above. It is therefore vital to encourage physical activity, including the use of electrical stimulation devices, in this group of patients in order to prevent diseases associated with physical inactivity. Such diseases not only occur in this group of people, but also reflect the general pattern in our modern inactive society. Results obtained in research on people with spinal cord injuries may therefore help to provide a basis for recommendations on exercise in the general population also.

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Magnetic resonance technology in training and sports

When muscles are used to perform physical activity they must metabolise available fuel to generate energy for contraction. The harder a muscle must work, the more fuel is required. The relation between how hard muscles must work and their need for fuel is an area of intense interest in the study of human performance. In the past, intramuscular energy metabolism has been measured directly by muscle biopsies,[1] which are invasive. During the last two decades, the sophistication of magnetic resonance (MR) technology has steadily improved. Using magnetic resonance spectroscopy (MRS), it is now possible to detect non-invasively changes in a number of important intramuscular fuel sources, such as muscle glycogen,[2–5] during exercise and recovery. Magnetic resonance imaging (MRI) has been used for some time to examine anatomical effects of sport and training.[6] Recently it has become possible to measure exercise induced physiological changes with MRI and use information from these measurements to determine muscle activity patterns.[7–9] These more recent advances open up a new range of possibilities to use MR technology not only as a diagnostic tool, as in the past, but in a proactive manner to assess human performance.

Although MRS cannot completely replace the direct biochemical measurements obtained from muscle biopsy samples, it offers distinct advantages that are not available with biopsies. It provides a non-invasive direct measurement of muscle energy metabolite concentrations (glycogen, creatine phosphate, glucose 6-phosphate, inorganic phosphate, and lactate) with better time resolution, repeatability, and somewhat better precision.[2–5] The drawbacks of MRS (the availability of expensive equipment and an inability to distinguish between muscle fibre types) are offset by the muscle biopsy technique.[3] When MRS and muscle biopsy samples are obtained concurrently, the small amount of tissue obtained in the biopsy sample (50–80 mg muscle) does not need to be used to determine muscle glycogen concentration and can be used to assess other important metabolic indicators such as enzymatic activities. This complementary nature of MRS and muscle biopsy means that, when used in combination, they become a powerful tool for optimising athletic training programmes. In such a programme, MRS samples obtained from individual athletes may be used to (*a*) monitor the effectiveness of different carbohydrate loading protocols, (*b*) optimise the efficiency of training schedules and avoid overtraining, (*c*) assess metabolic recovery from training sessions, and (*d*) measure the athlete's state of readiness to participate in an event. Ultimately MRS and biopsy measurements are indicators of an athlete's physical condition at a specific point in time (pre-season, mid-season, end of the season), and therefore are of great benefit in optimising an athlete's performance and minimising the risk of injury.

MRI is another non-invasive method that has the potential to be a powerful training tool, and it is much more universally available than MRS. Muscles that have actively participated in the performance of an exercise appear hyperintense on MR images.[7] It is thought that this increase in MRI signal results from movement of fluid into the exercised muscle, brought about by increased metabolic activity in the muscle.[8 9] Electromyography (EMG) measures neural activation as differences in electrical activity across the muscle membrane and has been used traditionally to measure muscle activity. It has the advantage that it is sensitive to small changes in electrical activity and it can detect the onset of neural fatigue.[10] However, it cannot be used non-invasively to study deep muscles, and it can only study the muscles that it is set up to study.[10] MRI can be used to study both surface muscles and deep muscles non-invasively, and may be a better indicator of how hard a muscle has worked.[10] As with MRS and muscle biopsy, there is a great potential to use MRI and EMG in combination to optimise a training programme. Traditional MRI methods can be used to study an athlete's anatomy, making measurements such as heart chamber volumes (particularly left ventricle) and arterial development (measured as the arterial diameter of major arteries). Both of these variables are augmented by training and therefore are a measure of the degree of training of an athlete.[11] Functional MRI methods can be used to assess the muscle activation patterns that contribute to the complex biomechanical movements involved in sports.[10] This technology can be used to (*a*) identify muscles that are activated and (*b*) assess the extent of activation of each muscle relative to that muscle's maximum capacity to perform work.[9 10] Information obtained from functional MRI measurements can be used to compile individual databases of each athlete's muscle activation patterns when he or she is at peak performance. This information can be valuable if the athlete is injured or if there is a pronounced decline in peak performance. Functional MRI measurements of identical exercise obtained under such conditions, when compared with information from the athlete's database, could provide insight into injury induced changes in muscle activation patterns. Functional MRI may also be used to monitor an athlete's recovery from an injury. As with MRS, MRI provides a measure of an athlete's physical conditioning at a specific point in time.

In summary, it is possible that, by combining MRI and MRS with more traditional methods, we may create an organised training and evaluation tool capable of elevating human performance to a new level. At this level we would be able to (*a*) minimise instances of overtraining and therefore reduce overtraining injuries, (*b*) optimise event readiness thereby reducing injuries that are associated with fatigue during an event, and (*c*) optimise injury recovery programmes so as to reduce the incidence of reinjury. These reductions could make a significant impact on sports related injuries in elite and professional athletes.

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Stretching before exercise: an evidence based approach

Clinicians are under increasing pressure to base their treatment of patients on research findings—that is, to practice evidence based medicine.[1] Although some authors argue that only research from human randomised clinical trials (RCTs) should be used to determine clinical management,[2] an alternative is to consider the study design (RCT, cohort, basic science, etc) as one of many variables, and that no evidence should be discarded a priori. In other words, the careful interpretation of all evidence is, and has always been, the real art of medicine.[3] This editorial explores these concepts using the sport medicine example of promoting stretching before exercise to prevent injury. In summary, a previous critical review of both clinical and basic science literature suggested that such stretching would not prevent injury.[4] This conclusion was subsequently supported by a large RCT published five months later.[5] Had the review relied only on previous RCT data, or even RCT and cohort data, the conclusions would likely have been the opposite, and incorrect.

Was there ever any evidence to suggest that stretching before exercise prevents injury? In 1983 Ekstrand *et al*[6] found that a group of elite soccer teams randomised to an intervention of warming up and stretching before exercise, leg guards, special shoes, taping ankles, controlled rehabilitation, education, and close supervision had 75% fewer injuries than the control group. There was one other RCT and a quasi-experimental study that also supported this conclusion,[7 8] both using at least warm up as a co-intervention.

Clinical evidence suggesting that stretching before exercise does not prevent injuries has also been reported. van Mechelen[9] published an RCT showing that the intervention had no effect, but many subjects were non-compliant. If we look at "less strong evidence", both Walter *et al*[10] and Macera *et al*[11] published cohort studies that suggested that stretching before exercise was not beneficial, and there have been several cross sectional studies as well.[12 13] Of course, there were significant limitations to all of these studies.

In summary, the RCTs could easily be interpreted to suggest a probable effect using strict evidence based medicine guidelines. The use of cohort studies may weaken the conclusion, but would be unlikely to reverse it. Understanding the basic scientific research allows one to put this clinical evidence into perspective and explain results that may appear contradictory.

Firstly, some people believe that a compliant muscle is less likely to be injured. From the basic science research, we find that an increase in tissue compliance due to temperature,[14] immobilisation,[15] or fatigue[16 17] is associated with a decreased ability to absorb energy. Although this is not the equivalent of stretching, no basic science research shows that an increase in compliance is associated with a greater ability to absorb energy. Secondly, most injuries are believed to occur during eccentric contractions,[18] which can cause damage within the normal range of motion because of heterogeneity of sarcomere lengths.[19–22] If injuries usually occur within the normal range of motion, why would an increased range of motion prevent injuries? Thirdly, even mild stretching can cause damage at the cytoskeletal level.[23] Fourthly, stretching somehow increases tolerance to pain—that is, it has an analgesic effect.[24–26] It does not seem prudent to decrease one's tolerance to pain, possibly create some damage at the cytoskeletal level, and then exercise this damaged anaesthetised muscle. Of note, there is no basic science evidence to suggest that stretching would decrease injuries. Fifthly, there are some basic science data to suggest that a warm up may help to prevent