Warm up

Welcome to the future
An interesting study that should both reassure and inspire us was recently published in the journal *Circulation* (2001;104:1350–66). This study raises the issue of the role of sports and exercise medicine in the broader context of public health.

Many of us who see ourselves as “couch potatoes” or “mouse potatoes” to use the appropriate computer jargon, lament the passing of our former fitness. Well, hope is at hand. A study with a remarkable name, the Dallas Bed Rest and Training Study, has found in a 30 year follow up, that just six months of exercise can reverse the decline in cardiovascular capacity associated with aging. However, just three weeks of bed rest has a far more profound negative effect on cardiac fitness than aging alone.

The study findings showed that men who undertook a six month endurance training programme of walking, jogging, or stationary cycling were able to completely recover the aerobic fitness they had lost in the previous 30 years. None of the men had complications from the exercise and all managed to stick to their exercise regimen. Their training level increased weekly until at the end of six months they were exercising four hours per week over four to five sessions.

The study focused on five healthy men who at the age of 20 originally took part in the landmark Dallas study, and then participated in the 30 year follow up study. In the 1966 study, they did eight weeks of intensive exercise training after 20 days of bed rest. In the follow up, they were evaluated for the effects of age on cardiovascular response to exercise testing and cardiovascular adaptation to an exercise programme.

Researchers found that 20 days of bed rest at the age of 20 had a far more profoundly negative impact on cardiovascular fitness than did 30 years of aging. Over 30 years, the men’s body weight increased by 30% and their body fat doubled. Their $V_O_2_{\text{max}}$ decreased by 11% but unexpectedly the decrease was mainly due to an impaired efficiency in the peripheral oxygen extraction. There was no decline in maximal cardiac function despite the three decades of aging, with a decline in maximal heart rate balanced by an increased in maximal stroke volume.

The researchers concluded that physical activity accounted for as much as 40% of the age related decline in aerobic fitness. In the second phase of the study, the men’s loss of cardiovascular fitness in the previous 30 years was completely restored by the six month training programme. The *Circulation* study adds to the body of information on exercise and health but it also provides hope that one of the groups with the highest levels of cardiovascular problems—that is, middle-aged men—may be amenable to remarkably simple exercise prescription.

How then do we take this information into our clinical practice? This study is in line with previous studies demonstrating that in older patients relatively low intensity exercise can have a significant effect on health, injury prevention, and well being. Interestingly, another recent study (*Rheumatology* 2001;40:772–8) demonstrates the value of exercise in injury treatment. This study suggests that regular aerobics classes may be effective therapy for chronic low back pain. Although intuitively sensible, the far more interesting aspect of the study was that aerobics was equally as effective as either muscle reconditioning programmes and physiotherapy treatment.

Our duty then as sports physicians should be to consider the wider public health setting and to encourage exercise in all our patients. What a strangely simple idea in this new millennium!

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Raiders of the lost dream

The following amusing aside has been developed from an email circulating through the ether. I am assured by English cricket team medical staff that it originated in Australia. Even cursory inspection of the note reveals this not to be the case. Within Australia, the note is suspected to be an official communique designed to “sound out” the cricket public as to some proposed changes in a vain attempt to even up the current whitewash being repeatedly experienced by the English national team. Please note that individuals from non-cricket playing countries will not understand the concepts expressed herein. Please note that citizens of non-Commonwealth countries may not understand the concepts and terminology used in this article.

Memo
Following the crushing defeat of England in the last seven Ashes series, the International Cricket Council has imposed a new set of rules to make the contest more even: (1) England has been granted an automatic “wickie”, freeing up current wicket keeper, Alex Stewart, to defend the boundary. Under the rule, Australian batsmen will be deemed out “caught behind” if the ball nicks their bat and...
When to retire after concussion?

The decision to retire after repeated concussive injuries remains a complex and controversial area. For the most part, there are no evidence based recommendations to guide the practitioner. In the absence of scientifically valid guidelines, good clinical judgment and common sense remain the mainstay of management.

It is difficult for a team doctor when an athlete, professional or otherwise, has suffered a number of concussive injuries but has no residual neurological or cognitive symptoms. Concern expressed by the doctor, the patient, and other medical or coaching team members is often raised as the prelude to this decision making process. Far more difficult, and sadly far too common, is the trial “by media” in which anecdotal cases of athletes with poor outcomes following repeated “concussions” are described, often with little or no supporting medical evidence, as the basis for recommendations about the playing future of the player concerned.

Background
There is no scientific evidence that sustaining several concussions over a sporting career will necessarily result in permanent damage. Part of the neuromyology surrounding concussion is the concept of the “three strike rule”: if an athlete has three concussions then, he or she is ruled out of competition for a period of time. On occasions, this can result in permanent curtailment of sporting participation. This anecdotal approach was originally proposed by Quigley in 1945 and subsequently adopted by Thorndike, who suggested that if any athlete suffered “three concussions, which involved loss of consciousness for any period of time, the athlete should be removed from contact sports for the remainder of the season.” It is important to remember that this approach has no scientific validity, yet continues to be the rationale underpinning most of the current guidelines on return to play. It may also be worth noting that the definition of concussion used by both Quigley and Thorndike differs considerably from that in current use.

The unstated fear behind this approach is that an athlete suffering repeated concussions will suffer a gradual cognitive decline similar to the so called “punch drunk” syndrome or chronic traumatic encephalopathy seen in boxers. Based on published evidence, this fear is largely unfounded, and recent developments suggest that the risk of chronic traumatic encephalopathy in this setting may be largely genetically based rather than simply a manifestation of repeated concussive injury. Similarly the concept that repeated concussion may predispose an athlete to the

When to retire after concussion?
so called second impact syndrome has been largely discredited.4–6
This issue becomes further confused when stories of well known athletes suffering from recurrent head trauma appear in the media and lay press. In some cases, the brain injuries are more severe than the typical sport related concussive injuries, and long term symptoms are not wholly unexpected. In other cases, professional athletes suffer repeated concussions but are not banned from sport, in contrast with the advice given to recreational athletes. Understandably this leads to cynicism in the minds of the public about the differing standards of medical care applied to the elite and non-elite athlete. Far more commonly in my experience, many athletes suffer trauma triggered migraines that are misdiagnosed as episodes of concussion. It is these repeated headache episodes upon which management advice is often erroneously given.

Does repeat concussion result in cumulative damage?
Apart from boxing related head injuries, the most widely cited studies of the cumulative effects of concussion have been of patients with injuries sustained in motor vehicle accidents that were severe enough to warrant presentation to hospital. Generally, concussive injuries suffered in sports such as football involve lower acceleration-deceleration forces than are experienced in motor vehicle accidents.7–10 Patients with these sports related injuries typically recover quickly and usually do not require acute hospital admission.

It is widely acknowledged that boxing carries a high risk of neurological injury. Boxing, however, should not be considered as a model for cumulative head injury seen in other sports because it presents unique risks to the athlete in terms of the frequency of repetitive head trauma.11–12 Limitations of retrospective studies on concussion, such as the widely cited studies by Gronwall et al13–15 on injuries from motor vehicle accidents, include diagnostic uncertainty, relying on both self reported injury recall and medically invalidated injury diagnosis. For example, some head injuries in the cited studies were assessed up to eight years after their occurrence. Although methodological problems flaw this study, it supports the contention proposed by Symonds that cumulative deficits may follow repeated concussive injury, such as is evidenced by the "punch drunk" state of chronic traumatic encephalopathy seen in boxing.4–12 In other studies, specific genetic abnormality has been reported to be the major risk factor for the development of traumatic encephalopathy.5–7

In another series of retrospective studies involving retired Scandinavian soccer players, cognitive deficits were noted.15–18 However, considerable methodological problems flaw the results, including lack of data before the injury, selection bias, lack of observer blinding, and inadequate control subjects. About 40% of the control group were found to be cognitively impaired. The authors conclude that the deficits noted in the former soccer players could be explained by repetitive trauma such as heading the ball. However, the pattern of deficits is equally consistent with alcohol related brain impairment, a confounding variable that was not controlled for. To date, these findings have not been replicated by other independent groups.17–21

There have been surprisingly few prospective studies of sport related concussion.22–26 In a study of American gridiron football, it was found that, although information processing deficits were evident within 24 hours of injury, neuropsychological function had returned to normal when retested within 5–10 days of the injury.23 Similar findings were reported in studies of Australian Rules footballers.27 Concussive injuries in Australian Rules football tend to be mild, with neuropsychological performance returning to levels found before injury within a few days.28–30 Similarly, post-concussive symptoms such as headache, nausea, poor concentration, and fatigue also resolve within the first few days of injury. The classical "post-concussive syndrome" often seen after motor vehicle accidents and other forms of severe traumatic brain injury is exceedingly rare in sport.

In animal studies of experimental concussion, animals have been repeatedly concussed 20–35 times during the same day and within a two hour period. Despite these unusually high numbers of injuries, no residual or cumulative effect was found.29

Is there a genetic susceptibility to chronic brain injury in sports?
Recent research has suggested that chronic traumatic encephalopathy in boxers may be associated with a particular genetic predisposition. The apolipoprotein E ε-4 gene (ApoE), a susceptibility gene for late onset familial and sporadic Alzheimer's disease, may be associated with an increased risk of chronic traumatic encephalopathy in

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PTA, Post-traumatic amnesia; LOC, loss of consciousness; RTP, return to play.
In a non-boxing population, ApoE polymorphism was significantly associated with death and adverse outcomes following acute traumatic brain injury seen in a neurosurgical unit.11 In a recent prospective study, ApoE genotypes were tested to see if they could be used to predict days of unconsciousness and functional outcome after six months.12 There was a strong association between the ApoE allele and poor clinical outcome.

**Published guidelines for return to sport after concussion**

Guidelines recommending termination of all contact sport after three concussions during the course of an athletic season need to be considered carefully. In the absence of documented objective evidence of brain injury, there is no scientific support for this generalisation. Athletes excluded from competition on such a basis may consider a medicolegal appeal that would be impossible to defend in a court of law.

There are several anecdotal guidelines available in the literature.13–15 As mentioned above, these are not supported by published scientific evidence and should be considered management “options” at best (table 1).

It would seem that in the absence of a scientifically validated scale for return to sport, we are left to make a decision using either an arbitrary exclusion period or an individualised clinical and neuropsychological assessment of recovery. With new web based computerised neuropsychological test batteries available for screening athletes after injury, such measures are readily and cheaply available for all team doctors involved in the care of recreational as well as professional athletes.16 Before these new developments, access to neuropsychological assessment was a practical and logistical problem for the non-professional athlete, and the evolution of arbitrary exclusion periods was commonplace.

**Conclusion**

The issue of retirement because of repeated concussion remains controversial. At present, no scientifically validated guidelines exist upon which to base a medical decision. Inappropriate advice, at least at the professional level, may expose the doctor to medicolegal challenge. At present, best practice lies between arbitrary exclusion periods after injury or individualised clinical and neuropsychological assessment. The latter approach should be preferred, and the advent of web based neuropsychological assessment tools makes this a viable and practical option. Recent research suggests that long term chronic complaints resulting from concussion may often have a genetic basis rather than simply being a manifestation of repeated exposure.

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