

Concussion in children

Can we manage sport related concussion in children the same as in adults?

P McCrory, A Collie, V Anderson, G Davis

Evidence based guidelines are required for the management of concussive injury in children

Consensus guidelines for managing sport related concussion in adults have been increasingly widely implemented.¹ So far, there are no guidelines that enable clinicians to manage similar sporting concussive injuries in children. Furthermore, there are a number of important anatomical, physiological, and behavioural differences between adults and children that suggest that adult guidelines will need to be either modified or rewritten to manage injuries in this age group.

EPIDEMIOLOGY OF CONCUSSION IN CHILDREN

The annual incidence of traumatic brain injury (TBI) in adults is remarkably constant worldwide and has been estimated at between 180 and 300 cases per 100 000 population.²⁻⁵ This is believed to be an underestimate of the true incidence as an equivalent number of mild injuries are treated by general practitioners and do not result in hospital admission.⁶ Direct sport participation accounts for approximately 15–20% of all such TBI⁷ and in children a further smaller percentage of TBI is associated with play activities.⁸

In children aged 15 years and under, the estimated incidence rate of TBI is 180 per 100 000 children per year of which approximately 85% are categorised as mild injuries.⁷ In the US, it has been estimated that more than 1 million children sustain a TBI annually and that TBI accounts for more than 250 000 paediatric hospital admissions as well as more than 10% of all visits to emergency service settings.⁹

In child and adolescent populations, few well controlled studies exist to identify the age specific frequency and outcome of sport related concussive injuries.

INTRINSIC DIFFERENCES BETWEEN CHILD AND ADULT CONCUSSION

The most common cognitive sequelae of concussive injuries in children are the same as for adults, namely reduced

speed of information processing, poor attention, and impaired executive function.¹⁰⁻¹⁴ Concussion may also have a significant negative secondary impact upon educational and social attainment, as these processes are critical for performing common day to day activities in childhood and adolescence, such as acquiring new knowledge and attending to school work. The nature, magnitude, and duration of these post-concussion cognitive impairments are yet to be determined, and the academic and social consequence for the child remains unknown at this time. In addition, it has been reported that children may suffer from a variety of post-concussion behavioural sequelae despite normal neuropsychological testing.¹⁵

It is also known that brain tolerance to biomechanical forces differs between adults and children.¹⁶ In broad terms, a two to three fold greater impact force is required to produce clinical symptoms in children compared to adults. This is due to a combination of factors, including an age dependent physiological response to mechanical stress, the differing geometry of the skull and brain, and the constitutive structural properties of the head. This means that if a child exhibits clinical symptoms after head injury, then it is reasonable to assume that they have sustained a far greater impact force compared to an adult with the same post-concussive symptoms.

There are rare but well recognised post-traumatic clinical sequelae that occur predominantly in children and teenagers, such as diffuse cerebral swelling.¹⁷⁻²⁰ The concussive impact, however trivial, sets in train the rapid development of cerebral swelling that usually results in brainstem herniation and death. Its cause is unknown but is thought to involve disordered cerebral vascular autoregulation. Although repeated concussive injuries have been proposed as the basis for this syndrome (the so called second impact syndrome), the evidence for repeated concussion as a specific risk factor is not compelling.²¹ It is more likely that a single impact of any severity may result in this rare

complication; however, participation in sport simply draws attention to incidental concussive injuries in this setting. There is also limited published evidence that a specific genetic abnormality predisposes to brain swelling following mild head injury in children.²²

NEUROPSYCHOLOGICAL DIFFERENCES BETWEEN CHILDREN AND ADULTS

Over and above any cognitive effects of concussion, there is an additional issue that makes assessment difficult, namely the fact that the brain is cognitively maturing during this period. This has two major implications. Firstly, the child's brain potentially may be more vulnerable to the impact of head injury than the more mature adult brain due to the disturbances of neuronal maturation caused by brain trauma.¹⁴ Secondly, unlike adults where cognitive function is relatively stable over time, children's cognition continues to develop. Thus any assessment of baseline or post-injury cognitive function needs to factor in the normal maturation in cognition that is occurring over this period. Pilot unpublished cross sectional data collected in 180 healthy children using a computerised cognitive test paradigm (CogSport) indicates substantial improvement in performance between the ages of 9 and 18 years on tests of simple and choice reaction time, working memory, and new learning. The largest improvements in test performance occur between the ages of 9 and 15, with minimal changes after this age paralleling adult performance (fig 1).

These developmental changes are of comparable magnitude to post-concussive impairments observed on computerised cognitive post-injury assessment in adults.^{23, 24} This has the potential for confusion in assessment given that maturational improvements occurring between baseline and post-concussion testing may offset any injury related cognitive impairment in concussed children and adolescents.

RISK FACTORS FOR SEQUELAE AND POOR RECOVERY AFTER CONCUSSION IN CHILDREN

It has been argued that individuals are not at equal risk for symptoms and cognitive dysfunction following concussion, and also that some individuals may be at higher risk of sustaining concussion than others. There is circumstantial evidence that a prior history of brain injury is a risk factor for subsequent concussive injury in children.^{15, 25}

Other potential risk factors that may predict more severe neurobehavioral

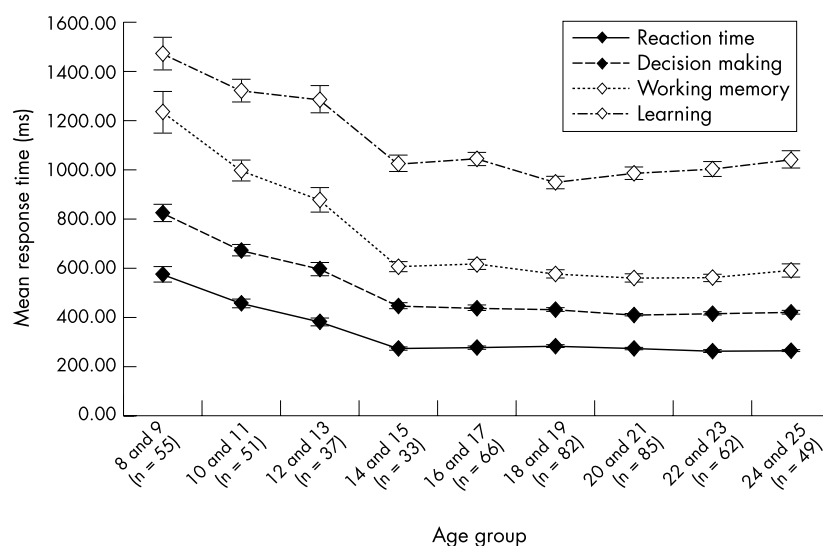


Figure 1 Mean (and standard error) response speed on four cognitive tasks in nine different age bands, from 8 to 25 years of age.

sequelae following injury, especially in younger children where the brain is less mature, include the presence of pre-morbid cognitive, attention, and behavioural impairments.¹⁵⁻²⁶

It has also become a widely held belief that having sustained a sport related concussive injury, an athlete is then more prone to future concussive injury. The evidence for this in sport is limited with most studies being methodologically flawed.²⁷⁻²⁹ It has been suggested that individuals with more aggressive playing styles may be at the greatest risk of concussion.

Although helmet use may be effective in preventing superficial head injury in children, its role in preventing concussion and other forms of traumatic brain injury remains unproven. Furthermore, recent studies have shown a differential behavioural response of children to protective equipment with some adopting increased risk taking behaviour and hence paradoxically increasing their risk of sustaining a concussive injury by wearing a "protective" helmet.³⁰⁻³¹

There is also evidence that an individual's genetic make up may predict outcome from head injury. In particular, an association has been identified between the apolipoprotein E $\epsilon 4$ allele and poor clinical outcome in adult patients with mild head injury.³² Although only in the early stages of understanding, the interaction between genetic and environmental factors may be critical in the development of post-concussive phenomena. These data suggest that it may be possible to identify individuals who are at greater risk for poor outcomes from concussion and in the future management practices may need to be tailored to incorporate such information.

CAN WE USE ADULT CONCUSSION RETURN TO PLAY STRATEGIES IN CHILDREN?

There have been numerous attempts in the past to formulate evidence based concussion management guidelines,³³ with that developed at the recent Vienna Consensus Conference¹ being most widely accepted today. In broad terms, this approach recommends baseline cognitive testing to enable accurate individual assessment of recovery, in order to guide return to play following concussion.

There are no current guidelines for diagnosis and management of concussion in children beyond generic recommendations for observation and neuroimaging following childhood mild head injury.³⁴ This is also reflected in the variable specialist clinical management that may be offered in this situation. In a recent pilot study of paediatric neurosurgical management of sport related concussive injury in children, there was no consensus between the surgeons being studied as to the significance of specific clinical symptoms or on recommendations regarding hospitalisation, time off school and sport, or the use of protective equipment following injury.³⁵

The "comparison to own baseline" model of assessment remains a powerful method of assessing change in cognitive function after concussion, and in the absence of conflicting evidence, should be adopted as a conservative approach to identifying post-concussion cognitive deficits in children as it is in adults. The central issue is how often baseline testing should be conducted. During the period of rapid cognitive maturation (8–15 years of age), baseline testing would have to be

performed at least 6 monthly to enable accurate comparison for serial testing. Apart from elite junior athletes, such regular testing would be beyond the resources of most sports and individuals. For any child or adolescent athlete participating in collision sport or where there is a significant risk of concussion, annual cognitive testing should be considered. Any statistical decision about whether cognition has changed from baseline following concussion must also include an adjustment for developmental changes in cognition. This in turn requires knowledge of how performance changes on specific tests over time. Figure 1 demonstrates the cognitive maturation process that is maximal between 8 and 15 years of age and gives an estimate of the degree of this change. Beyond 15 years of age an annual baseline test would be suitable, as for adult athletes, and be applied in the same fashion as for adults and without any developmental increment.

THE CLINICAL MANAGEMENT OF CONCUSSION IN CHILDREN

Current adult management of concussion involves an initial diagnosis using a validated assessment tool such as the Maddocks questions³⁶ or the Standardized Assessment of Concussion³⁷. Neither tool has been specifically tested or validated in children with concussion.

One preliminary study suggests that high school aged children (14–18 years) may also have prolonged cognitive recovery when compared with young adults (18–25 years), but that symptom recovery is equivalent between these groups.³⁸ This finding raises the possibility that symptom ratings and cognitive testing may be differentially sensitive to concussion in minors and adults; however, there is no such information available for younger children. This in turn raises concern as to how sport related concussion assessment may be performed in these age groups and the validity of existing assessment tools.

Return to play concussion guidelines recommend baseline cognitive evaluation of all individuals participating in contact and collision sport.¹ The heterogeneity of concussion ensures that individual comparison to baseline allows more sensitive identification of post-concussion symptom elevation and cognitive dysfunction than arbitrary classification according to a retrospective grading scale.³⁹⁻⁴⁰

Statistical models used to determine the significance of any observed post-concussion cognitive change require knowledge of how cognitive test performance and symptom ratings change in

healthy, uninjured individuals.⁴¹ In adult populations (and potentially children aged 16 years and over) available data suggest that cognitive performance remains relatively stable over time on tests commonly used in concussion management.⁴²

These findings support the need for prospective serial investigation of cognitive and behavioural function in healthy and concussed children and adolescents, including specific assessment of how cognitive processes (including response variability) change within individuals. Such data will be invaluable in informing the development of concussion management guidelines in this population, and the interpretation of post-concussion cognitive test data.

The issue of neuroimaging is often raised for children following mild head injury. With young patients, this issue is often problematic given that they may require a general anaesthetic in order to obtain adequate images, although new generation spiral CT scanners are able to perform extremely rapid imaging sequences. If imaging is desired by the health practitioner in this setting or by the subsequent development of symptoms of intracranial pathology, then CT scanning is the imaging modality of choice in the emergency setting. The American Academy of Paediatrics guidelines state that there is no indication for routine use of skull x ray in paediatric concussion and "no data are available that demonstrate that children who undergo CT scanning early after minor closed head injury with loss of consciousness have different outcomes compared with children who receive observation alone after injury".³⁴

In broad terms, a previously neurologically healthy child with a concussive injury who has normal mental status, no abnormal or focal abnormalities on neurological exam, and no physical evidence of skull fracture simply requires observation by a competent caregiver. The risk of clinically significant intracranial pathology in this setting is less than 0.02%^{34, 43} although earlier studies had suggested higher figures.^{44, 45} It is likely that many of these early studies suffered from selection bias and over estimated this risk in this situation.³⁴

SUMMARY

At the present time, there are no evidence based guidelines using which sport related concussive injury in childhood and adolescence can be scientifically managed. There are significant differences between adults and children in this regard and a child who is symptomatic following head injury is likely

to have sustained a far greater impact force as compared to an adult with the same post-concussive symptoms.

The extent and duration of the cognitive effect on children with acute concussive injuries is variable and there may be persistent effects on scholastic performance and behaviour long after the clinical concussive symptoms and measurable neuropsychological impairment have resolved. Even subtle and transient impairments in attention and information processing skills can have a dramatic effect on the young person's capacity to cope with school demands, with these issues being particularly critical for those at later secondary school levels.

Based on pilot data, cognitive maturation is greatest in those under 15 years of age and beyond this time plateaus to an adult level of performance. Although comparison to baseline cognitive performance remains a powerful method of assessing function following a concussion injury, its application in children under 15 years of age is problematic given the rapid cognitive maturation that is occurring in this period. With regular baseline testing, an "adult" management strategy could be adopted in this age group, whereas in its absence only an estimate of normal age related cognitive function can be made. Beyond 15 years of age, it would be reasonable to follow the adult concussion management consensus guidelines utilising a "return to baseline" approach.

It is suggested that concussive symptoms take longer to resolve than in adults although this may be a surrogate marker of the biomechanical differences between child and adult concussion as outlined above. It is critical therefore that concussed children and adolescents not resume sport, school, or training until all the physical symptoms fully resolve. This is important also because of the risk of diffuse cerebral swelling that may occur in children after a single head injury no matter how trivial the impact may be. The adoption of a conservative adult management strategy with a thorough assessment of symptom resolution followed by "return to baseline" cognitive function remains the most appropriate management strategy in this age group.

Further research is required to characterise the duration and nature of the subclinical cognitive impairment that may exist during this recovery period in children. Increased awareness of these issues by those involved in the management of a child with concussion may assist in avoiding problems caused by this putative impairment.

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REFERENCES

- 1 **Aubry M**, Cantu R, Dvorak J, *et al*. Summary and agreement statement of the first International Conference on Concussion in Sport, Vienna 2001. *Br J Sports Med* 2002;**36**:6–10.
- 2 **Annegers J**, Hauser W, Coan S, *et al*. A population based study of seizures after traumatic brain injuries. *N Engl J Med* 1998;**338**:20–4.
- 3 **Jennett B**. Epidemiology of head injury. *J Neurol Neurosurg Psychiatr* 1996;**60**:362–9.
- 4 **Tate R**, McDonald S, Lulham J. Incidence of hospital-treated traumatic brain injury in an Australian community. *Aust N Z J Public Health* 1998;**22**(4):419–23.
- 5 **Alexander M**. Mild traumatic brain injury. *Neurology* 1995;**45**:1253–60.
- 6 **Wrightson P**, Gronwall D. Mild head injury in New Zealand: incidence of injury and persisting symptoms. *N Z Med J* 1998;**111**:99–101.
- 7 **Kraus JF**. Epidemiological features of brain injury in children: occurrence, children at risk, causes and manner of injury, severity and outcomes. In: Broman S, Michel M, eds. *Traumatic head injury in children*. New York: Oxford University Press, 1995:22–39.
- 8 **Clapperton A**, Cassell E, Wallace A. Injury to children aged 5–15 years at school. In: MUARC, ed. *Hazard. Victorian Injury Surveillance and Applied Research System*. Melbourne, Australia: Monash University Accident Research Centre, 2003:1–16.
- 9 **Yeates K**, Luria J, Bartkowski H, *et al*. Postconcussive symptoms in children with mild closed head injuries. *J Head Trauma Rehabil* 1999;**14**:337–50.
- 10 **Collie A**, Darby D, Maruff P. Computerised cognitive assessment of athletes with sports-related head injury. *Br J Sports Med* 2001;**35**(5):297–302.
- 11 **Echemendia R**, Julian L. Mild traumatic brain injury in sports: neuropsychology's contribution to a developing field. *Neuropsychol Rev* 2001;**11**(2):69–99.
- 12 **Macciocchi SN**, Barth JT, Alves W, *et al*. Neuropsychological functioning and recovery after mild head injury in collegiate athletes. *Neurosurgery* 1996;**39**(3):510–4.
- 13 **Maddocks D**, Dicker G. An objective measure of recovery from concussion in Australian rules footballers. *Sport Health* 1989;**7**(suppl):6–7.
- 14 **Anderson V**. Outcome from mild head injury in young children: a prospective study. *J Clin Exp Neuropsychol* 2001;**23**(6):705–17.
- 15 **Ponsford J**, Willmott C, Rothwell A, *et al*. Cognitive and behavioral outcome following mild traumatic head injury in children. *J Head Trauma Rehabil* 1999;**14**(4):360–72.
- 16 **Ommaya AK**, Goldsmith W, Thibault L. Biomechanics and neuropathology of adult and paediatric head injury. *Br J Neurosurg* 2002;**16**(3):220–42.

- 17 **Bruce DA**, Alavi A, Bilaniuk L, *et al*. Diffuse cerebral swelling following head injuries in children: the syndrome of 'malignant brain oedema'. *J Neurosurg* 1981;**54**(2):170–8.
- 18 **Bruce DA**. Delayed deterioration of consciousness after trivial head injury in childhood. *Br Med J* 1984;**289**:715–6.
- 19 **Pickles W**. Acute general edema of the brain in children with head injuries. *N Engl J Med* 1950;**242**:607–11.
- 20 **Snoek JW**, Minderhoud JM, Wilmink JT. Delayed deterioration following mild head injury in children. *Brain* 1984;**107**:15–36.
- 21 **McCrary P**, Berkovic SF. Second impact syndrome. *Neurology* 1998;**50**(3):677–84.
- 22 **Kors E**, Terwindt G, Vermeulen F, *et al*. Delayed cerebral edema and fatal coma after minor head trauma: role of the CACNA1A calcium channel subunit gene and relationship with familial hemiplegic migraine. *Ann Neurol* 2001;**49**:753–60.
- 23 **Bleiberg J**. Consistency of within-day and across-day performance after mild brain injury. *Neuropsychiatry Neuropsychol Behav Neurol* 1997;**10**(4):247–53.
- 24 **Makdissi M**, Collie A, Maruff P, *et al*. Computerised cognitive assessment of concussed Australian rules footballers. *Br J Sports Med* 2001;**35**(5):3543–60.
- 25 **Rutter M**, Chadwick O, Shafiqer D. Head injury. In: Rutter M, eds. *Developmental neuropsychiatry*. New York: Guilford Press, 1983:77–83.
- 26 **Lovell M**, Iverson G, Collins M, *et al*. Does loss of consciousness predict neuropsychological decrements after concussion? *Clin J Sport Med* 1999;**9**:193–9.
- 27 **Gerberich SG**, Priest JD, Boen JR, *et al*. Concussion incidences and severity in secondary school varsity football players. *Am J Public Health* 1983;**73**(12):1370–5.
- 28 **Albright J**. Head and neck injuries in college football. An eight year analysis. *Am J Sports Med* 1985;**13**:147–52.
- 29 **Guskiewicz KM**, McCrea M, Marshall SW, *et al*. Cumulative effects associated with recurrent concussion in collegiate football players. *JAMA* 2003;**290**(19):2549–55.
- 30 **Finch C**, McIntosh A, McCrary P. What do under 15 year old schoolboy rugby union players think about protective headgear? *Br J Sports Med* 2001;**35**:89–95.
- 31 **Finch C**, McIntosh AS, McCrary P, *et al*. A pilot study of the attitudes of Australian Rules footballers towards protective headgear. *J Sci Med Sport* 2003;**6**(4):505–11.
- 32 **Liberman J**, Stewart W, Wesnes K, *et al*. Apolipoprotein E e4 and short term recovery from predominantly mild brain injury. *Neurology* 2002;**58**:1038–44.
- 33 **McCrary P**, Johnston K, Meeuwisse W, *et al*. Evidence based review of sport related concussion: basic science. *Clin J Sport Med* 2001;**11**:160–6.
- 34 **American Academy of Pediatrics**. The management of minor closed head injury in children. *Pediatrics* 1999;**104**(6):1407–15.
- 35 **Davis G**, McCrary P. The paediatric sport-related concussion pilot study. *Br J Sports Med* 2004 (in press).
- 36 **Maddocks DL**, Dicker GD, Saling MM. The assessment of orientation following concussion in athletes. *Clin J Sport Med* 1995;**5**(1):32–5.
- 37 **McCrea M**, Kelly J, Randolph C, *et al*. Standardised assessment of concussion (SAC): on site mental status evaluation of the athlete. *J Head Trauma Rehabil* 1998;**13**:27–36.
- 38 **Field M**. Does age play a role in recovery from sports-related concussion? A comparison of high school and collegiate athletes. *J Pediatr* 2003;**142**(5):546–53.
- 39 **Collie A**, Maruff P, McCrary P, *et al*. Statistical procedures for determining the extent of cognitive change following concussion. *Br J Sports Med* 2004;**38**(3):273–8.
- 40 **Johnston K**, McCrary P, Mohtadi N, *et al*. Evidence based review of sport-related concussion – clinical science. *Clin J Sport Med* 2001;**11**:150–60.
- 41 **Collie A**, Maruff P, McStephen M, *et al*. The effects of practice on the cognitive test performance of neurologically normal individuals assessed at brief test-retest intervals. *J Int Neuropsychol Soc* 2003;**9**(3):419–28.
- 42 **Collie A**, Maruff P, Makdissi M, *et al*. CogSport: reliability and correlation with conventional cognitive tests used in post concussion medical evaluations. *Clin J Sport Med* 2003;**13**(1):28–33.
- 43 **Teasdale G**, Murray G, Anderson E. Risks of acute traumatic intracranial complications in hematoma in children and adults: implications for head injuries. *Br Med J* 1990;**300**:363–7.
- 44 **Dacey RG Jr**, Alves WM, Rimel RW, *et al*. Neurosurgical complications after apparently minor head injury. Assessment of risk in a series of 610 patients. *J Neurosurg* 1986;**65**(2):203–10.
- 45 **Hahn Y**, McLone D. Risk factors in the outcome of children with minor head injury. *Pediatr Neurosurg* 1993;**19**:135–42.

Sport psychology and concussion

Sport psychology and concussion: new impacts to explore

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In recent years, there has been great interest in examining the psychological effects of athletic injuries. This has also extended to interventions in which coping strategies have been suggested to enhance recovery. Concussive injuries, which are common to many sports, hold particular problems in this regard. For example, a concussed athlete may be prone to experience isolation, pain, anxiety, and disruption of daily life as a result of the injury. This may be a problem for individual sport athletes—for example, professional skiers—who do not have the support of team mates to help them through their rehabilitation and recovery, as well as team sport athletes whose team mates may inadvertently pressure them to return to play.

Besides the physical loss resulting from an injury, there may also be psychological distress. Commonly reported emotion responses resulting

from athletic injury have included anger, denial, depression, distress, bargaining, shock, and guilt.^{1–5} These are particularly seen in career ending injuries. Such emotional distress can negatively affect the athletes' recovery process.

“...concussed athletes in team sports seem to have fewer long term problems”

Injured athletes have also reported feelings of isolation and loneliness. Researchers found that athletes prevented from participating in their activity have lost contact with their team, coach, and friends.^{6,7} For example, Gould *et al*⁶ examined the emotional reactions of US national team skiers to season ending injuries and found that 66.6% cited lack of attention and isolation as a source of stress during their injury. In another study of injured

athletes, Brewer *et al*² surveyed 43 sports medicine practitioners to discover side effects of psychological distress. These side effects included exercise addiction, weight control problems, family adjustment, and substance abuse. These problems have been reported individually as well as being associated with depression and anxiety and have been shown to cause severe health complications.⁷

Injured athletes have reported different levels of satisfaction with the social support they have received after injury. In particular, team mates have been shown to have a greater affect on the emotional state of injured athletes than coaches or medical professionals.⁸ This leads one to speculate that individual sport athletes may experience different adjustment difficulties while recovering from a concussion. This may also suggest why concussed athletes in team sports seem to have fewer long term problems, such as persistent post-concussive symptoms. In an environment in which team mates are likely to have experienced similar injuries, there is a greater corporate memory of such injuries and hence more reassurance as to the likely recovery time frame and validation of subjective symptoms experienced by the injured athlete.

UNIQUENESS OF CONCUSSION INJURIES

A number of unique characteristics of concussion injuries exist. Firstly, a concussion is an “invisible injury”. This

means there are no crutches, swelling, stitches, or other visual signs of the injury. This makes it very difficult for a casual observer to identify the athlete as injured. A second unique characteristic of concussion injuries is the overlap of post-concussive symptoms with psychological responses to injury. A third problem may be a loss of fitness (through loss of both aerobic and resistance training activity), particularly if the post-concussive symptoms persist. A fourth problem, unique to professional sport, is the relentless media commentary that typically occurs after injury. This increases pressure on injured athletes to regain their sporting place.

“...it is often not considered acceptable to spend prolonged time rehabilitating a concussion injury”

Another issue surrounding concussion injuries is the lack of acceptance or understanding of long term rehabilitation. Whereas it is often considered necessary to rehabilitate an orthopaedic injury for a number of months, it is often not considered acceptable to spend prolonged time rehabilitating a concussion injury. This may result in more anxiety and frustration for the athlete and coach. Finally, concussion injuries are unique because there is at present no standard intervention technique. For most other injuries, rehabilitative treatments are available—for example, physiotherapy, medication, exercise, surgery, etc. However, this is not the case for concussion injuries; the athlete may leave the doctor with either no specific management or at best a minimally structured treatment plan.

SOCIAL SUPPORT GROUPS

It is not uncommon for people who have experienced life events such as addiction, illness of a family member, injury, or a significant loss to have difficulty dealing with the stress and anxiety of their situation. As a result of the distress encountered, different methods of coping and psychological support have been developed. Throughout the last 20 years, the role of social support in dealing with disease has increased significantly.⁹ Support groups have been developed to educate, prevent isolation, and help in coping.¹⁰ Positive outcomes from support groups have been proven effective for sufferers of AIDS,¹¹ cancer,¹³ obsessive compulsive disorder,¹⁴ and pregnancy loss,¹⁵ and families of critically ill patients.¹⁶ It has also been shown that general social support is beneficial for athletes suffering from injuries.¹⁷ A support group for injured athletes may

also provide the same benefits as it has for non-athletic populations.

Intervention strategies and psychological rehabilitation techniques have included imagery, relaxation, modelling, goal setting, positive self talk, social support and support groups, pain management, simulation training, education, stress management, and cognitive reconstruction.⁵ Social support and communication have been two most commonly suggested rehabilitation strategies. Lynch²² stressed the importance of the sport psychologist in encouraging athletes to discuss their experiences with others. These interactions were designed to help reduce the injured athlete's feelings of isolation and loneliness.

SOCIAL SUPPORT IN ATHLETIC INJURY REHABILITATION

Two distinct types of social support have been used during injury rehabilitation in an athletic setting: support groups and peer modelling.⁴ Support groups for injured athletes have allowed injured athletes to come together to voice their concerns, share ideas about coping, learn vital performance enhancement strategies, and realise that they are not alone.⁴ The goal is that athletes will support one another both mentally and physically by helping deal with the demands of rehabilitation and not participating in their sport.²⁰

Numerous studies on non-athletic populations have been published showing the benefits of support groups in reducing anxiety, depression, and isolation and enhancing coping strategies.¹¹⁻¹⁴ To date there have been very few academic sources that have addressed the use of support groups for athletic injury and only one for concussion.²⁰⁻²⁵ Granito *et al*²⁰ offered anecdotal support for an injured athlete support group programme, and Horton *et al*²⁵ attempted to determine if participation in social support groups could reduce negative psychological side effects in concussion. It was shown that participants in the experimental concussed group improved their mood state, reducing effects such as anger, confusion, frustration, anxiety, depression, and isolation.

Social support has also been proven to have a significant effect on rehabilitation adherence. Udry¹⁸ reported that the most discriminating factor for rehabilitation adherence was level of social support. Athletes who perceived social support for their rehabilitation had better rehabilitation adherence, higher levels of motivation, and adopted a goal mastery orientation towards their rehabilitation.¹⁸

SUMMARY

The use of sport psychology techniques in the management of concussion may assist in solving some of the real and very practical problems facing clinicians, namely certain aspects of the post-concussive syndrome and the influence of anxiety and other adverse psychological states, which in turn may impact on injury outcome. Techniques derived from other areas of psychology such as peer modelling may be successfully used in this setting.

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REFERENCES

- Brewer BW, Linder DE, Phelps CM. Situational correlates of emotional adjustment to athletic injury. *Clin J Sport Med* 1995;**5**:241-5.
- Brewer BW, Van Raalte JL, Linder DE. Role of the sport psychologist in treating injured athletes: a survey of sports medicine providers. *J Appl Sport Psychol* 1991;**3**:183-90.
- Quinn AM, Fallon BJ. The changes in psychological characteristics and reactions of elite athletes from injury onset until full recovery. *J Appl Sport Psychol* 1999;**11**:210-29.
- Weiss MR, Troxel RK. Psychology of the injured athlete. *Athletic Training* 1996;**21**:104-10.
- Wiess DM, Weiss MR. Psychological rehabilitation and the physical injury: implications for the sports medicine team. *Sport Psychol* 1987;**1**:318-30.
- Gould D, Udry E, Bridges D, *et al*. Stress encountered when rehabilitating from season ending ski injuries. *Sport Psychol* 1997;**11**:361-78.
- Petipas A, Danish SJ. Caring for injured athletes. In Murphy SM, ed. *Sport psychology interventions*. Champaign, IL: Human Kinetics, 1995:225-81.
- Udry E, Gould D, Bridges D, *et al*. People helping people? Examining the social ties of athletes coping with burnout and injury stress. *Journal of Sport and Exercise Psychology* 1997;**19**:368-95.
- Cohen S, Wills TS. Stress, social support, and the buffering hypothesis. *Psychol Bull* 1985;**98**:310-57.
- Kates N. Support groups in psychiatry: an untapped resource. *Can J Psychiatry* 1995;**40**:367-8.
- DiPasquale JA. The psychological effects of support groups on individuals infected by the AIDS virus. *Cancer Nurs* 1990;**13**:278-85.
- Ribble D. Psychological support groups for people with HIV infection and AIDS. *Holist Nurs Pract* 1989;**3**:52-62.
- Deans G, Bennett-Emslie GB, Weir J, *et al*. Cancer support groups: who joins and why? *Br J Cancer* 1988;**58**:670-4.
- Broatch JW. Obsessive-compulsive disorders: adding value to treatment through patient support groups. *Int Clin Psychopharmacol* 1996;**11**:89-94.
- Bonno C. Peer support network. In: Woods J, Esposito J, eds. *Pregnancy loss: medical*

- therapeutics and practical considerations*. Los Angeles: Williams & Wilkins, 1987:225–47.
- 16 **Acorn S**. Head-injured survivors: caregivers and support groups. *J Adv Nurs* 1993;18:39–45.
 - 17 **Green SL**, Weinberg RS. Relationships among athletic identity, coping skills, social support, and the psychological impact of injury in recreational participants. *J Appl Sport Psychol* 2001;13:40–59.
 - 18 **Udry E**. Social support: exploring its role in the context of athletic injury. *Journal of Sport Rehabilitation* 1996;5:151–63.
 - 19 **Gilbourne D**, Taylor AH. From theory to practice: the integration of goal perspective theory and life development approaches within an injury-specific goal-setting program. *Journal of Applied Sport Psychology* 1998;10:124–39.
 - 20 **Granito VJ**, Hogan JB, Varnum LK. The performance enhancement group: integrating sport psychology and rehabilitation. *J Athl Train* 1995;30:328–31.
 - 21 **levleva L**, Orlick T. Mental links to enhanced healing: an exploratory study. *Sport Psychology* 1991;5:25–40.
 - 22 **Lynch GP**. Athletic injuries and the practicing sport psychologist: practical guidelines for assisting athletes. *Sport Psychology* 1988;2:161–7.
 - 23 **Smith AM**. Psychological impact of injuries in athletes. *Sports Med* 1996;6:391–405.
 - 24 **Taylor J**, Taylor S. *Psychological approaches to sports injury rehabilitation*. Gaithersburg, MD: Aspen Publications, 1997.
 - 25 **Horton AS**, Bloom GA, Johnston KM. The impact of support groups on the psychological state of athletes experiencing concussions. *Med Sci Sports Exerc* 2002;34:99.

Manual therapy

To treat or not to treat: new evidence for the effectiveness of manual therapy

M M Sran

Manual therapy has been shown to be effective for certain conditions but more research is needed to identify other suitable patients

Recent randomised clinical trials found manual therapy to be more effective than other methods of conservative management for low back and neck pain.^{1–5} On the other hand, some randomised clinical trials,^{6–13} systematic reviews,¹⁴ and meta-analyses¹⁵ concluded that there was no evidence that spinal manipulative therapy is superior to other standard treatments for patients with low back or neck pain. This provides the clinician with a Shakespearean quandary—to treat or not to treat using manual therapies? Therefore this leader addresses the question: what explains these apparently inconsistent data?

DEFINITIONS AND SEARCH STRATEGY

The term manual therapy has many connotations, but for this leader it includes manually performed assessment and treatment methods (which can include joint, neural tissue, and/or muscle techniques). The term manipulation is typically used to describe small amplitude thrust techniques performed with speed.¹⁶

I searched Medline, Cinahl, and Embase databases for randomised clinical trials comparing spinal manual joint techniques (mobilisation with or without manipulation) or manipulation only with other conservative treatments for back or neck pain. Only studies published as full papers, in English, between 1 January 1998 and 31 December 2003 were included. Pilot studies were not included. Table 1 out-

lines search strategies for each database. Thirteen studies met the criteria (table 2). One study of bone setting by Finnish folk healers who lacked formal education¹⁷ was excluded as all other studies involved formally educated professionals.

Examining the trials for homogeneity revealed that the mean age of participants was similar among the studies and most participants were white (except for two studies^{6, 11}). Thus factors related to the population studied did not appear to explain the conflicting results. There were, however, at least four factors that differed among the interventions that constituted manual therapy, and I focus on these differences to see whether they explain the conflicting outcomes.

DIFFERENCES IN MANUAL THERAPY THAT MAY EXPLAIN STUDY FINDINGS

Whether or not the study used manual therapy or manipulation only

Four of the 13 studies reported better results in the manual therapy group than the other group(s).^{1–4} Five of the remaining nine studies used manipulation only, and all but one³ reported no significant difference or a poorer response than the other group(s).^{7, 8, 10, 11}

Use of a variety of manual therapy techniques, rather than joint manipulation alone, appears to yield better results. For example, Jull *et al*³ studied the effectiveness of manual therapy delivered by physical therapists, specific exercise therapy delivered by physical therapists, combined manual and specific exercise therapy, and a control group, for treatment of cervicogenic headache. At the 12 month follow up, both manual therapy and specific exercise groups had significantly reduced headache frequency and intensity, neck pain, and disability. In this study,³ manual therapy included both low velocity cervical joint mobilisation techniques and high velocity manipulation techniques. These results are relevant to physical therapists with postgraduate certification in manual therapy, as they are well trained in both of these techniques. Similarly, Hoving *et al*²

Table 1 Search strategy

Database	MeSH headings	Limits
Medline	Manipulation, orthopaedic Manipulation, chiropractic Manipulation, osteopathic Physical therapy techniques Musculoskeletal manipulations Comparative study (Back or neck) and pain	Human English 1998–2003
Cinahl	Manual therapy Chiropractic Chiropractic manipulation Manipulation, orthopaedic Osteopathy (Back or neck) and pain	English Clinical trial 1998–2003
Embase	Manipulative medicine (Back or neck) and pain	Human English 1998–2003

Table 2 Studies reviewed

Reference	Population characteristics (n)	MT limited to manipulation only	MT delivered by:	Clinically relevant guideline based MT	Interventions, groups	Control group	Dose (MT or manipulation)	Results	Effect size for positive studies
Aure <i>et al</i> ¹	20–60 years; chronic LBP > 8 weeks, less than 6 months (49)	No	Physical therapists	Yes	1. MT plus ET. 2. ET alone	No	45 min (15 min MT); 2 sessions/week, 8 weeks	Significantly larger improvements in MT group (maintained at 1 year follow up)	0.78
Hoving <i>et al</i> ²	18–70 years; pain or stiffness in the neck for at least 2 weeks (183)	No	Physical therapists	Yes	1. MT plus specific exercise training. 2. Active exercise focused physical therapy. 3. Continued care by GP	No	45 min; 1 session/week for up to 6 weeks	Physical therapy, including MT more effective than physical therapy without MT or continued care by a GP	Not given
Jull <i>et al</i> ³	18–60 years; cervicogenic headache at least 1 ×/week for 2 months–10 years (200)	No	Physical therapists	Yes	1. MT. 2. ET (low load endurance training). 3. Combined MT and ET. 4. Control	Yes	30 min, 8–12 sessions, 6 weeks	MT as effective as ET and both significantly better than control	0.80
Moseley ⁴	Chronic LBP > 2 months (57)	No	Physical therapists	Yes with respect to clinical relevance (individualised and variety of techniques allowed but no references cited for MT techniques)	1. MT, specific exercise training, and neurophysiology education. 2. Medical management by GP	No	2 ×/week, 4 weeks	Combined physiotherapy treatment including MT, specific exercise training, and neurophysiology education resulted in improved function and pain at 1 and 12 months.	Not given
Giles & Muller ⁵	17 years or older; mechanical back or neck pain for a minimum of 13 weeks (115)	Yes	Chiropractors	Yes for LBP. No for neck pain	1. Spinal manipulation. 2. Sports physician follow up (limited) and medication. 3. Acupuncture (needle).	No	20 min, 2 ×/week, maximum 9 weeks	Greater short term benefit for with manipulation, but not for neck pain. Acupuncture more effective for neck pain.	Not given
Andersson <i>et al</i> ⁶	20–59 years; LBP lasting at least 3 weeks but less than 6 months (178)	No	Osteopaths	Yes	1. Osteopathic treatment 2. "Standard care" by physicians	No	1 ×/week for 4 weeks then 1 ×/2 weeks for 8 weeks	No significant difference between groups. Both groups improved	
Bronfort G <i>et al</i> ⁷	20–65 years; mechanical neck pain for at least 12 weeks (191)	Yes (but this group also received 45 min of sham microcurrent therapy)	Chiropractors	No. A reference for the use of spinal manipulation for LBP is cited, but only cervical and thoracic spine techniques were used.	1. Spinal manipulation plus upper body and neck strengthening exercise. 2. Aerobic exercise plus MedX cervical extension and rotation machine. 3. Spinal manipulation	No	20 × 1 hour sessions over 11 weeks	No significant difference between groups with respect to pain, neck disability, medication use	
Cherkin <i>et al</i> ⁸	20–64 years; LBP minimum 7 days after seeing physician (321)	Yes	Chiropractors	No, side lying only	1. Chiropractic manipulation. 2. Education booklet. 3. McKenzie exercises	No	Up to 9 × over 1 month	No significant difference between groups	
Curtis <i>et al</i> ⁹	21–65 years; acute LBP of less than 2 months (295)	No (manipulation plus muscle energy techniques)	Physicians with limited training (18 h) in manual therapy	No	1. Manipulation and muscle energy techniques plus enhanced care 2. Enhanced care alone	No	Initial plus 4 follow ups; 2 ×/wk for 2 weeks	Only 43% of patients in the MT group actually received the planned treatment; no significant difference between groups	

Table 2 Continued

Reference	Population characteristics (n)	MT limited to manipulation only	MT delivered by:	Clinically relevant, guideline based MT	Interventions, groups	Control group	Dose (MT or manipulation)	Results	Effect size for positive studies
Hsieh <i>et al</i> ⁰	18 years or older; LBP > 3 weeks and less than 6 months (200)	Yes	Chiropractors	No, limited techniques	1. Back school. 2. Myofascial therapy. 3. Joint manipulation. 4. Combined joint manipulation & myofascial therapy	No	3 × week for 3 weeks	All groups improved; no significant between-group differences at 3 or 6 months	
Hurwitz <i>et al</i> ¹¹	18 years or older; LBP (681)	Yes	Chiropractors	Yes	1. Medical care only. 2. Chiropractic care only. 3. Medical care with limited physical therapy. 4. Chiropractic care with modalities.	No	Treatment dose not prescribed	Chiropractic no better than other groups; physical therapy plus medical care group had less pain at 6 weeks and 6 months than medical care only	
Jordan <i>et al</i> ²	20–60 years; chronic neck pain at least 3 months (167)	No	Mobilisation by physical therapists; manipulation by chiropractors	Yes with respect to clinical relevance (individualised) but no references cited for mobilisation or manipulation techniques.	1. Manipulation. 2. Physiotherapy without manipulation. 3. Strength training (with a focus on neck muscle training).	No	Physiotherapy: 30 min, 2 ×/week, 6 weeks. Chiropractic: 15–20 min, 2 ×/week, 6 weeks	No significant difference between groups.	
David <i>et al</i> ³	18–75 years; neck pain > 6 weeks duration (70)	No	Physical therapists	Not clear	1. Physiotherapy. 2. Acupuncture.	No	1 ×/week, 6 weeks (maximum)	No significant difference between acupuncture and physiotherapy groups. Both groups improved.	

MT, Manual therapy; EI, exercise therapy; LBP, low back pain.

compared physical therapy including manual therapy with physical therapy without manual therapy for patients with chronic neck pain. Of note, they allowed the use of low velocity joint mobilisations but no high velocity low amplitude thrust techniques (synonymous with “manipulation”).

Was the choice of intervention based on clinically relevant treatment guidelines (“best practice”) of the discipline?

Assessment and treatment protocols used in randomised controlled trials (RCTs) are not always similar to clinical practice guidelines, which are typically textbooks or guidelines written by experts in the field/discipline and based on current available evidence. Treatment protocols that do not mirror clinical practice have been examined in some studies. For example, Andersson *et al*⁶ compared osteopathic treatment (including manual therapy) with “standard care” by doctors. However, the reported standard care included medication, active physical therapy, ultrasonography, diathermy, hot or cold packs (or both), use of a corset, or transcutaneous electrical nerve stimulation (TENS). Clearly health maintenance organisation doctors do not have the time (45 minutes), equipment, or skills—that is, active physical therapy—to provide this treatment. Further, two of the groups studying manipulation by chiropractors included participants with back or neck pain, yet they only cited references for low back pain management.^{5–7} Three studies used very restricted manual assessment and/or treatment techniques^{8–10} which do not reflect best practice. Three of the five studies with positive results used manual treatment (by physical therapists) based on published guidelines or clinical texts written by experts in the field.^{1–3}

The dose of manual therapy or manipulation (minutes, sessions, weeks)

The optimal dose is also a consideration. Time per session, number of sessions, and number of weeks are all important factors for therapists, patients, and payors.

Knowing the optimal treatment duration has obvious implications on cost effectiveness, but probably also has an impact on the effectiveness of manual therapy. Despite the importance of these variables, there is great variability between the protocols used in these 13 studies. One study compared chiropractic care only, medical care only, medical care with limited physical therapy, and chiropractic care with modalities but did not prescribe a treatment dose.¹¹

However, they did monitor use of the various treatment modes and time per session and found that one third of patients randomly assigned to medical care with physical therapy had no physical therapy visits, and 20% of patients in the chiropractic groups received concurrent medical care, whereas only 7% of patients in the medical care groups received concurrent chiropractic care. They also report that chiropractors and medical providers in their study spent an average of 15 minutes with patients at each visit, and physical therapists averaged 31 minutes per patient visit.

Only six studies reported the time per session. Time varied from 20 to 60 minutes per treatment. Of interest, three of the five studies with positive results allowed between 30 and 45 minutes per treatment. One (of the studies with positive results) did not report treatment time,⁴ and the other had mixed results (positive for back pain but not for neck pain) and allowed 20 minutes per treatment.⁵

The total number of sessions varied from 5 to 20, with a frequency of between once a week and three times a week. Some studies did not prescribe a maximum or minimum number of sessions a week (table 2).

The number of weeks of treatment varied from 3 to 12. Of note, the five studies with positive results used between four and nine weeks of treatment.¹⁻⁵

Combination therapies

A number of studies have investigated a combination of therapies such as two healthcare professionals or a combination of manual therapy or manipulation with another mode of treatment.

Of note, four of the five studies with positive results used manual therapy in combination with another aspect of physical therapy (exercise therapy,^{1,2} specific exercise training,^{3,4} and neurophysiology education⁴). Similar positive results were not seen in chiropractic studies of spinal manipulation combined with exercise^{7,10} or modalities.¹¹

METHODOLOGICAL FACTORS

This critical appraisal also examined two key methodological factors that can influence randomised RCT findings. Firstly, the presence or absence of a control group is an important factor, yet only one³ study had a control (table 2). Secondly, an important issue when examining discordant outcomes of RCTs is power,¹⁸ as underpowered studies can lead to type II error. Fewer than one third of the studies reviewed reported prospective power calculations,^{1,3,8,9} and one study reported what appears to be retrospective power.¹⁰

Retrospective power has limitations as described in detail elsewhere,¹⁹ thus all RCTs should calculate power a priori.

SUMMARY AND CONCLUSIONS

In summary, I return to the question that was the genesis of this leader, what explains the apparently inconsistent data in the field of manual therapy outcomes? Critical appraisal suggests that more precise interventions are successful in treating low back pain, chronic neck pain, and cervicogenic headache. There are clinically relevant differences between studies reporting positive results of manual therapy and those reporting no significant difference over other conservative treatments. Specifically, the treatment protocol needs to reflect what therapists are actually doing in clinical practice—that is, using more than one manual therapy technique or combining manual therapy with other modes of treatment such as specific exercise training. Interventions based on best practice guidelines/texts appear to be more successful, and physical therapy including manual therapy at a dose of 30–45 minutes per session, for four to eight weeks has been shown to be effective.¹⁻⁴

Further research is needed to identify populations who are most likely to improve with manual therapy. For example, Flynn *et al*²⁰ identified five variables to form a clinical prediction rule for patients with low back pain who are likely to respond favourably to a specific manipulative technique. In that study decisions on the side to be manipulated were not based on clinical best practice guidelines and only one manipulation technique was used (thus not representative of clinical practice), yet this approach to refine clinically relevant procedures may prove very useful.

Finally, manual therapy is not only used in the treatment of low back and neck pain. Further investigations of the effectiveness of manual therapy in special populations are needed. Pilot studies have been conducted in patients with thoracic pain,²¹ cervicobrachial pain syndrome,²² and we have conducted studies on the safety of manual therapy in the osteoporotic spine.²³ The next step is for researchers to conduct well designed RCTs to determine the effectiveness of manual therapy for pain and disability in these populations.

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REFERENCES

- 1 Aure OF, Nilsen JH, Vasseljen O. Manual therapy and exercise therapy in patients with chronic low back pain: a randomized, controlled trial with 1-year follow-up. *Spine* 2003;**28**:525–31.
- 2 Hoving JL, Koes BW, de Vet HC, *et al*. Manual therapy, physical therapy, or continued care by a general practitioner for patients with neck pain. A randomized, controlled trial. *Ann Intern Med* 2002;**136**:713–22.
- 3 Jull G, Trott P, Potter H, *et al*. A randomized controlled trial of exercise and manipulative therapy for cervicogenic headache. *Spine* 2002;**27**:1835–43.
- 4 Moseley L. Combined physiotherapy and education is efficacious for chronic low back pain. *Aust J Physiother* 2002;**48**:297–302.
- 5 Giles LG, Muller R. Chronic spinal pain: a randomized clinical trial comparing medication, acupuncture, and spinal manipulation. *Spine* 2003;**28**:1490–502.
- 6 Andersson GB, Lucente T, Davis AM, *et al*. A comparison of osteopathic spinal manipulation with standard care for patients with low back pain. *N Engl J Med* 1999;**341**:1426–31.
- 7 Bronfort G, Evans R, Nelson B, *et al*. A randomized clinical trial of exercise and spinal manipulation for patients with chronic neck pain. *Spine* 2001;**26**:788–97.
- 8 Cherkin DC, Deyo RA, Battie M, *et al*. A comparison of physical therapy, chiropractic manipulation, and provision of an educational booklet for the treatment of patients with low back pain. *N Engl J Med* 1998;**339**:1021–9.
- 9 Curtis P, Carey TS, Evans P, *et al*. Training primary care physicians to give limited manual therapy for low back pain: patient outcomes. *Spine* 2000;**25**:2954–60.
- 10 Hsieh CY, Adams AH, Tobis J, *et al*. Effectiveness of four conservative treatments for subacute low back pain: a randomized clinical trial. *Spine* 2002;**27**:1142–8.
- 11 Hurwitz EL, Morgenstern H, Harber P, *et al*. A randomized trial of medical care with and without physical therapy and chiropractic care with and without physical modalities for patients with low back pain: 6-month follow-up outcomes from the UCLA low back pain study. *Spine* 2002;**27**:2193–204.
- 12 Jordan A, Bendix T, Nielsen H, *et al*. Intensive training, physiotherapy, or manipulation for patients with chronic neck pain. A prospective, single-blinded, randomized clinical trial. *Spine* 1998;**23**:311–18.
- 13 David J, Modi S, Aluko AA, *et al*. Chronic neck pain: a comparison of acupuncture treatment and physiotherapy. *Br J Rheumatol* 1998;**37**:1118–22.
- 14 Gross AR, Kay T, Hondras M, *et al*. Manual therapy for mechanical neck disorders: a systematic review. *Man Ther* 2002;**7**:131–49.
- 15 Assendelft WJ, Morton SC, Yu EI, *et al*. Spinal manipulative therapy for low back pain. A meta-analysis of effectiveness relative to other therapies. *Ann Intern Med* 2003;**138**:871–81.
- 16 Maitland GD, Banks K, English K, *et al*. *Maitland's vertebral manipulation*, 6th ed. Boston: Butterworth Heinemann, 2001.
- 17 Hemmila HM, Keinanen-Kiukaanniemi SM, Levoska S, *et al*. Long-term effectiveness of bone-setting, light exercise therapy, and physiotherapy for prolonged back pain: a randomized controlled trial. *J Manipulative Physiol Ther* 2002;**25**:99–104.

- 18 **Glantz SA.** *Primer of biostatistics*, 5th ed. New York: McGraw-Hill, 2001.
- 19 **Zumbo B**, Hubley A. A note on misconceptions concerning prospective and retrospective power. *The Statistician* 1998;**47**: 385–8.
- 20 **Flynn T**, Fritz J, Whitman J, *et al.* A clinical prediction rule for classifying patients with low back pain who demonstrate short-term improvement with spinal manipulation. *Spine* 2002;**27**:2835–43.
- 21 **Schiller L.** Effectiveness of spinal manipulative therapy in the treatment of mechanical thoracic spine pain: a pilot randomized clinical trial. *J Manipulative Physiol Ther* 2001;**24**:394–401.
- 22 **Allison GT**, Nagy BM, Hall T. A randomized clinical trial of manual therapy for cervicobrachial pain syndrome: a pilot study. *Man Ther* 2002;**7**:95–102.
- 23 **Sran MM**, Khan KM, Zhu Q, *et al.* Failure characteristics of the thoracic spine with a posteroanterior load: investigating the safety of spinal mobilization. *Spine* 2004;**24**:in press.

ELECTRONIC PAGES

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Aseptic bone necrosis in an amateur scuba diver

G D M Laden, P Grout

A case is reported that provides further evidence of an old occupational hazard, dysbaric osteonecrosis, presenting in a new population (sports scuba divers) who also appear to be at risk. It highlights the need for an accurate diagnosis of diving related illness.

(*Br J Sports Med* 2004;**38**:e19) <http://bjsm.bmjournals.com/cgi/content/full/38/5/e19>

Abdominal coarctation in a hypertensive female collegiate basketball player

B Sloan, S Simons, A Stromwall

The purpose of the preparticipation examination is to identify health conditions that might adversely affect an athlete while participating in sport. Hypertension is the most common. This case report details a female basketball player found to be hypertensive, and complaining of fatigue, at her preparticipation physical examination. Presentation, diagnostics, treatment, and final outcome of coarctation involving the abdominal aorta are summarised.

(*Br J Sports Med* 2004;**38**:e20) <http://bjsm.bmjournals.com/cgi/content/full/38/5/e20>

Clinical and magnetic resonance imaging features of cricket bowler's side strain

D Humphries, M Jamison

The clinical features of 10 cases of lateral trunk muscle injury in first class cricket pace bowlers are described. Typically the injury occurs during a single delivery, is associated with considerable pain, and prevents the bowler from continuing.

The clinical picture is typical of a muscular or musculo-tendinous injury. The most consistent clinical tests were focal tenderness on palpation and pain with resisted side flexion towards the painful side. The magnetic resonance image in.

70% of cases was consistent with an injury to the internal oblique, the external oblique, or the transversalis muscles at or near their attachments to one or more of the lowest four ribs. The injury occurs on the non-bowling arm side. Recovery can be prolonged. The injury was a recurrence in six of the 10 cases. The biomechanics of the injury are not yet understood.

(*Br J Sports Med* 2004;**38**:e21) <http://bjsm.bmjournals.com/cgi/content/full/38/5/e21>