SPORTS MEDICINE NEW ZEALAND INC

NEW ZEALAND
Journal of Sports Medicine

Vol 42 • No 1 • 2015

Official Journal of Sports Medicine New Zealand Inc.

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ISSN 0110-6384 (Print)
ISSN 1175-6063 (On-Line)

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Talking about a Revolution

BRUCE HAMILTON

It is an unfortunate reality of the world in which we live, that many of the day to day elements of working in the field of sports medicine remain off the mainstream teaching syllabus. As any cursory discussion with coaches and athletes will highlight, one of the key abilities that those working with elite athletes require is clairvoyance; specifically, one requires the ability to see into the future and answer the question "…when will he/she be able to play Doc (insert "physio" as appropriate)". Despite expertise in clairvoyance being a preferred skill in sports medicine and physiotherapy practitioners (as determined by our key clients), it remains a technique not routinely taught at an undergraduate level. Where then, do we learn this ability to see into the proverbial crystal ball and predict the future, or is it just a gift that some lucky practitioners have?

The need for clairvoyance in life is not a new phenomenon, nor is it in any way restricted to practitioners of the noble art of Sports Medicine. The ability to speculate on future events has a long history in medicine and science with an unsurprising variability in the level of scientific scrutiny they withstand. At one end of the BS (that's Believable Science) scale for predicting the future, is perhaps the most famous medical fortune teller, Michel de Nostredame (Nostradamus 1503 – 1566). It is an under-recognised fact that Nostradamus completed studies in both pharmacy and medicine, during the period when the plague (aka "The Black Death" - Yersinia Pestis – transmitted by fleas, carried by rats) was rampant in Europe. Nostradamus himself lost several children to the plague, but by the age of forty-five he was making a solid living publishing predictions of the future for the rich and famous; predictions allegedly based on "scientific" studies of astrological signs. Unfortunately, while Nostradamus made thousands of predictions in his life-time, it remains debated as to whether any of these predictions have ever been confirmed as having occurred.

In the same historical period, Nicolaus Copernicus (1473 – 1543) was also studying medicine (along, it should be noted, with most other fields of academia). For more than 1400 years before Copernicus appeared on the academic scene, the firmly held belief was that the earth was the centre of the universe, with planets and stars rotating around us (the so-called Ptolemaic system). After vacillating on his proposal for many years, Copernicus ultimately published his thesis in the same year as his death, turning the Ptolemaic system on its head by suggesting that it was actually the sun that was the centre of the universe. In contrast to his colleague Nostradamus, Copernicus based his beliefs on sound observation and mathematical workings, and perhaps as a result of this approach had difficulty convincing the rich and famous at the time of the validity of his claims. It was over 150 years before the predictions of Copernicus were substantiated, resulting in a seismic shift in our understanding of our place in space.

It is perhaps a preposterous leap to suggest that trying to estimate (or "guess") the recovery time for muscle injuries in athletes, is in any way the 21st century equivalent to either of these historical examples of prediction by medical practitioners. However, as was discussed at last year's SMNZ conference, muscle injuries remain one of the most common soft tissue injuries in sport, and the hamstring is the grand-daddy of all. Unfortunately, despite their frequency and high rate of recurrence, our understanding of why they first occur, and why they subsequently recur remains limited at best.[1] In recent years there have been a range of manuscripts (all excellent in their own right), supposing to be "better" at predicting the time at which athletes will be able to return to sport (RTS). While methodological constraints and study sample sizes certainly contribute to the limitations in our knowledge, it may be that an innate variability in individual injury regeneration (reflecting factors we don't yet understand) contributes to the wide range of RTS durations reported for seemingly "similar" injuries. Where then, does our ability to predict RTS after a muscle injury sit on the BS scale, and is it time to re-think the whole way we are considering the issue? The work of scientist / philosopher Thomas Kuhn (1922 –1996) may help us with this question.[2]

In 1962 Kuhn published one of the most influential science texts of all time – "The Structure of Scientific Revolutions". In this dissertation, Kuhn outlines many key features of scientific endeavour, including defining the term "paradigm". Specifically, he characterises a scientific paradigm as a "sufficiently unprecedented [theory/process, as] to attract an enduring group of adherents…" while at the same time leaving the issues "sufficiently open-ended to leave all sorts of problems…".[(p10)] Applying his concept of a paradigm to the field of muscle injuries, it seems reasonable to conclude that the ground-breaking framework for muscle injury grading, first proposed by the sports medicine pioneers of the 1960's, constitutes a scientific paradigm (the muscle injury grading systems of the 1960's have after all, dictated our clinical and research framework and left many challenges for us!).[3-5,11] This historical paradigm, in which we continue to work, asserts that at a single point in time, through a clear history and examination (and more recently imaging), an RTS duration can accurately be predicted.

Kuhn didn't stop there. He also articulated the concept of "normal" science, as the "activity which most scientists inevitably spend almost all their time" and which is based on the assumption that the "scientific community knows what the world is like". Kuhn suggests that by its conservative nature, "normal" science limits novelty and thinking outside of the box.[(p5)] While in no way intending to diminish the work of authors in the field of muscle injuries, it would seem that the majority of muscle "grading" papers published in the recent past are content with applying a "normal" science approach to a paradigm first articulated in the 1960's. Thus, in studying the history, examination and more recently imaging at a (random) point in time of injured athletes, researchers have persisted with attempts to predict RTS durations – with only limited success.[6-11]

Finally (at least for the purposes of this discussion), Kuhn considers the nature of a "Paradigm Shift". He argues that while paradigm change may occur through the gradual accumulation of new data via "normal science", cataclysmic paradigm shifts (such as that of Copernicus) will occur if there is a prolonged period of recognised and sustained anomalies in observed data, culminating in an academic "crisis".[(p69)] Applying this concept to predicting return to play after muscle injury, is it time that Sports Medicine recognised that the available data on the prediction of RTS is weak and anomalous?[11] Only when we acknowledge this can we begin to appropriately question the merits of the current paradigm (which contends that we can accurately predict what is ultimately an incredibly complex 4-6 week muscle regeneration process from a single point in time).

Remarkably, the "paradigm shift" required may be as simple as increasing our data time points, thereby increasing the information available to make a valid RTS prediction. I am obviously not the first to propose that a "revolutionary" approach to predicting a RTS from muscle injury may be that we observe an individual's improvement over time – indeed this is routine clinical practice. By having more than a single time point of observation (eg. one week apart), clinically we suspect (and indeed anticipate) that we increase the accuracy of our RTS prediction. Despite this less than dramatic proposal for a change in paradigm, this is not an approach being taken by those practicing "normal science" within this field.

Kuhn's 1962 text provides a framework for us to critically evaluate our scientific approach. When the evidence to support predictions of RTS duration following muscle injury is so lacking in validity, it is time for us to challenge and provide alternatives to the paradigm we inherited from Sports Medicine pioneers. In the interests of providing athletes with the best care available, let's hope that in another 50 years, we will be thought of as scientists like Copernicus, rather than fortune tellers like Nostradamus.

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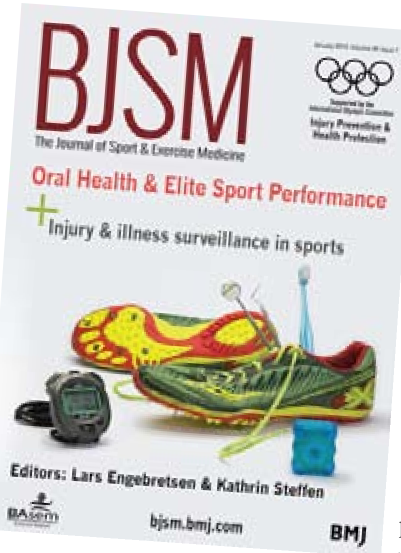
CHRIS MILNE

The January issue could be called the oral health issue. It contains several articles describing the oral health of athletes and its relationship to elite sport performance. The first of these was a consensus statement entitled 'Oral health in elite sport performance' written by Prof Ian Needleman of the Eastman Dental Institute in London. The authors comment that despite a limited research base, there are consistent reports of poor oral health in athletes since the first reporting at the 1968 Olympic Games. Not surprisingly, the causes are multi-factorial, but in recent times the consumption of energy drinks high in carbohydrate has been thought to be a significant contributor to erosion of tooth enamel and subsequent dental caries. In addition, the pro-inflammatory effects of a high carbohydrate intake might also increase the risk of periodontal disease. Athletes tend to focus on their training needs and energy intake, often at the expense of general health issues such as dental health issues. The authors recommend that oral health be embedded within other aspects of health promotion and that athletes have regular assessments of their oral health by a dental professional.



This position statement was complemented by a systematic review of the oral health of elite athletes and its association with performance. This article was also from the Eastman Dental Institute. They found 16 studies reporting the oral health of athletes, with a high prevalence of oral disease. For example, dental caries varied between 15 75%; periodontal disease 15% and dental erosions 36-85%. In four of these studies between 5-8% of athletes reported a negative effect of oral health or trauma on their performance. However, the authors comment that the methodological quality of the included studies was generally low. Not surprisingly, they recommend further representative studies of athletes and a comparison with performance using objective measures.

Rock climbing is an activity that is experiencing increasing participation rates. A Canadian study from Calgary found an injury incidence of 4.44 injuries per 1000 climbing hours. Not surprisingly, strains and sprains were the predominant injury types. My personal perspective on this issue is that the loading through the finger tendons in rock climbers is very high and damage to pulleys that restrain the flexor tendons is relatively common. Ultrasound in skilled hands can be very useful in evaluating this specific pathology.

Later in the same issue, a group from Vancouver Canada, studied the effect of inhaled salbutamol on athletic performance in cyclists with and without asthma. They studied 49 male athletes with a randomised controlled cross over design trial, which should have had sufficient statistical power to pick up a difference if one was evident. Whilst there was a significant increase in resting lung function both in athletes with a positive response to eucapnic voluntary hyperventilation and also a negative response, this improvement in lung function did not translate to improved exercise performance.

The second issue of the year looked at predictors for susceptibility to acute mountain sickness. The most cited risk factors are the rate of ascent, the altitude attained (the sleeping altitude) and past history of acute mountain sickness in that individual. MacInnes and co-authors performed a meta analysis of 17 studies including 7921 participants. They found that a past history of acute mountain sickness had only a 50% sensitivity and 75% specificity for development of the condition at a later date. A negative history was found to be more informative.

With the increasing complexity of medicine, more people are exercising following receipt of a solid organ transplant. The most high profile New Zealander is Jonah Lomu, former All Black. A study by Don McKenzie (well-known to New Zealanders) and colleagues from Vancouver Canada, considered the various issues relevant to transplant recipients. They commented on limitations to performance in the transplant patient which may be partly due to use of immunosuppressive agents, but also comment on a lack of training response in these people. They are relatively negative about participation in contact sports, but emphasise weighing the risks and benefits of any activity. Participation in prolonged strenuous activities such as endurance running or triathlons should only be considered by transplanted athletes with a knowledgeable support team.

Anterior cruciate ligament injuries are relatively common and any programme that can potentially prevent them is worth considering. Jeffrey Taylor and colleagues completed a systematic review of 13 studies of preventive training programmes for ACL injuries and found a significant reduction in these injuries. The reduction for all ACL injuries was 39% and for non-contact ACL injuries 65%.

Somewhat counterintuitively, they found that emphasis on balance training may actually increase injury risk, whereas static stretching may decrease injury risk. These issues clearly need further study, but the positive effect of ACL prevention programmes is beyond question. Dr Mark Fulcher has taken a lead role in promoting these programmes with the relevant authorities.

Sitting is known to be hazardous, but the data in older people are relative sparse. Toby Pavey and colleagues from the University of Queensland followed 6656 participants in the Australian Longitudinal Study on Women's Health for up to nine years. Compared to participants who sat for less than 4 hours a day, those who sat for 8-11 hours a day had a 1.45 times greater risk of death, and those who sat for over 11 hours per day had a 1.65 times higher risk of death. These data provide further support for remaining active into old age.

Issue 3 could be called the ultrasound issue. It contains several articles on the use of musculoskeletal and other ultrasound in sports medicine plus a position statement from the American Medical Society for Sports Medicine. Jonathan Finnoff and colleagues updated the 2010 curriculum for the American Medical Society for Sports Medicine. This document outlines the core competencies of sports ultrasound. The Americans came rather late to ultrasound; I recall a senior Australian sports physician telling me that they had to import an Australian to run the ultrasound service at the Atlanta Olympics in 1996. Now the enthusiasm is in full flower, but I get the impression that ultrasound guidance is being recommended for all injections. As a senior clinician who has been performing landmark guided injections to a variety of sites for over 20 years, I remain to be convinced that it is necessary in the subacromial space or knee, for example.

Still on the topic of ultrasound, it is being increasingly used to pick up fractures. There was a detailed article by Douglas Hoffman and colleagues with useful images of such varied pathology as acute midshaft fracture of the ulna, 4th metacarpal fracture and 4th metatarsal stress reaction. Whilst the portable ultrasound in particular has great appeal, in that it can be used at venues at major games and, indeed, was at the London Olympics, I would caution against undue reliance on ultrasound alone. In discussions with other New Zealand sports physicians, we all too frequently see patients who have had an ultrasound scan but no plain x-ray, and this would be regarded as an inadequate evaluation of virtually all body parts apart from perhaps the midsection of the Achilles tendon. The importance of plain x-rays is one of the many great teaching points imparted to us by the late Jock Anderson.

Later in the same issue was an article by Evan Peck on ultrasound evaluation of focal neuropathies in athletes. This article also includes some excellent reproductions of images of various neuropathies including suprascapular; ulnar nerve at the elbow, wrist and hand; radial neuropathy at the supinator; and tibial neuropathy at the tarsal tunnel.

The final article in this issue described ECG findings in competitive rowers. Written by Meagan Wasfy and colleagues, it describes a study of 330 competitive rowers who underwent a standard 12-lead ECG; 94% of the rowers had one or more training related ECG patterns including sinus bradycardia and sinus arrhythmia in about half of cases. Application of the Seattle Criteria resulted in only 4% of ECGs being classified as abnormal. This data is consistent with that of David Prior and his Australian colleagues that was published in BJSM in 2014. With an increasing number of international federations requiring a 12-lead resting ECG in elite athletes competing at World Championships, we will progressively accumulate a large database on this topic. Dr Dan Exeter, sports physician, has taken a particular interest in this area and leads the way in this country.

The fourth issue included an article on physical impairments and activity limitations in people with femoroacetabular impingement. Written by Laura Diamond and colleagues from Australia, they performed a systematic review of 16 studies published between 2011 and 2013. They comment that arthroscopic surgery may improve some but not all impairments in range of motion and that physiotherapy may be needed to normalise hip range of motion after arthroscopy. It is early days and further study is recommended as this is an area of great topical interest.

Can exercise help dementia? Possibly it can. A Dutch and Canadian group studied 86 women aged 70-80 years with mild cognitive impairment and assigned these randomly to a six month/twice weekly programme of either aerobic training, resistance training, or balance and tone training. After six months they found the aerobic training group had significantly increased hippocampal volume. The significance of this is difficult to ascertain. The authors comment that exercise appears to be an effective intervention strategy to combat cognitive decline in those with mild cognitive impairment.

Sitting behaviour and screen time is frequently in the news these days. Bethany Howard and colleagues looked at sitting time and TV viewing and found a positive association with plasma fibrinogen and CRP in men and women, with a positive association between TV viewing time and fibrinogen in women only. These data are consistent with previous studies and provide further evidence for limiting our TV viewing time, or at least getting up frequently for refreshments.

Surgeries performed in professional Australian male cricketers

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ABSTRACT

Aim/Study Design/Setting/Participants

A descriptive epidemiology study, which aims to describe the distribution and rate of surgical operations performed in professional Australian male cricketers.

Methods/Outcome Measures

Australian cricket has maintained an injury database since season 1998-99 with surgical details for players inconsistently recorded as part of injury records. This existing database was updated with surgical records from file review of all male players contracted to Australia, Victoria and New South Wales between seasons 1998-99 and 2013-14. The procedures performed on players in these states were used to determine the rate of surgeries per 100 player seasons. The definition of surgery was a cricket-related procedure which required hospital admission (i.e. excluding procedures performed at a cricket ground or clinic like suturing of wounds and excluding hospital admission for a medical illness only).

Results

There were 1295 player years studied which included 254 surgeries, a rate of 19.6 surgeries per 100 player years. There were 46 revision surgeries (18%). The most common procedures were: knee arthroscopy (47), ankle posterior impingement procedures (22), shoulder arthroscopy (24), ankle arthroscopy (19) and fixation of wrist & hand fractures (15). Fast bowlers had a higher rate of surgery (25.0 per 100 player seasons) and batsmen had a lower rate of surgery (13.9 per 100 player seasons) than other positions.

Discussion/Conclusions

Published surgical audits in professional sport have usually looked at a single operation or body part series, with relatively few publications detailing the entire profile of surgery in athletes. From the limited previous audits of the football codes in Australia, it is apparent that the annual rate of surgery in fast bowlers approaches that of footballers, but the rate of surgery in batsmen, spin bowlers and wicketkeepers is clearly lower. There are differences in the distribution of surgeries compared to other sports with fast bowlers requiring more ankle posterior impingement procedures, for example, and finger fracture fixation being common in cricketers.

INTRODUCTION

Professional athletes require surgery more frequently than amateur athletes and non-athletes.[1-7] The surgical literature regarding elite and professional athletes is mainly made up of case series and case reports. There are limited publications regarding incidence rates of surgery in professional cricketers (or other athletes).

This study is a descriptive epidemiology study, to record the distribution and rate of surgical operations in professional Australian male cricketers. The aim is to present the rates of various procedures in terms of incidence of surgery over time. Results are discussed from a perspective of comparing the rates of surgeries between the various positions and considering how these rates may differ from other professional sports (eg, Australian football, rugby league, soccer).

METHODS

Australian cricket has maintained an injury database since season 1998-99, but with surgical details for players only inconsistently recorded as part of injury records. The original definition of injury from Australian injury surveillance included "any injury that required surgery" as constituting a definable injury.[8] This component of the injury definition was removed in 2005 when international definitions were agreed upon.[9-12] This existing database (surgeries from 1998 to 2005) was updated with surgical records from file review of all male players contracted to Australia, Victoria (Vic) and New South Wales (NSW) between seasons 2004-05 and 2013-14. Victoria and New South Wales (2 of the 6 domestic cricket-playing states) were chosen because of continuity of the authors giving rise to confidence that the vast majority of surgical files could be recovered. The procedures performed on players in the national squad and in these two states were used to determine the rate of surgeries. Duplicate player seasons (ie, Australian and NSW/Vic player contracted in the same season) were only considered a single player season. That is, the Australian player cohort could be considered those players contracted to Australia in any given year from the other 4 states (Western Australia, Tasmania, South Australia and Queensland) as the NSW and Vic players were already part of a state cohort.

The definition of a cricket-related surgery was a procedure which required hospital admission (ie, excluding procedures performed at a cricket ground or clinic, like suturing of wounds). The procedure had to be related to cricket, meaning either that it was performed for an injury or illness that manifested itself during a cricket match or training session, or it was performed for a condition (eg, musculoskeletal) which required surgery to enable ongoing cricket participation.

Guided injections of cortisone, even if performed in a hospital facility, were not included in our study. Appendicectomy, tonsillectomy and removal of wisdom teeth were likewise not included as these operations were not considered to be related to cricket. Bilateral procedures were considered to be two surgeries.

The only outcome measure considered is whether revision surgery was required. Other objective and subjective outcomes were not assessed.

For the purposes of this study, a revision procedure was a second procedure to the same body part as part of this cohort. There was no timeframe determinant in our definition of revision surgery.

A comparison was made between the incidence rates in this study (surgeries per 100 player seasons) and a previous study of professional rugby league players in Sydney.[3] Odds ratios and 95% confidence intervals for undergoing a given procedure in a season were calculated using Taylor Series expansions.[13] A significant difference between the surgery rates of cricketers and rugby league players was considered when the 95% CI rates did not include 1.0.

RESULTS

Our study cohort consisted of 288 players (designated as 101 batsmen, 26 wicketkeepers, 117 pace bowlers and 44 spin bowlers). A total of 1295 player seasons were studied with 254 operations performed, representing a rate of surgery of 19.6 operations per player per 100 seasons. Of these 254 operations, 46 (18%) were revisions.

Table 1 – Operations performed in cricketers over 1295 player seasons

Surgery Category	Procedures	Revisions	Rate(Operations/ Player/100 Seasons)
Knee arthroscopy	47	12	3.6
Fracture fixation	37	2	2.9
- Wrist/hand (15)			
- Other upper limb (5)			
- Facial (4)			
- Fifth metatarsal (7)			
- Other lower limb (5)			
Shoulder arthroscopy	24	6	1.9
Ankle posterior impingement surgery	22	6	1.7
Ankle arthroscopy	19	4	1.5
Shoulder reconstruction	11	4	0.9
Adductor tenotomy	10	0	0.8
Tendon repair/tenolysis	9	0	0.7
Finger/wrist reconstruction	8	0	0.6
Hip arthroscopy	8	3	0.6
Knee ACL reconstruction	6	1	0.5
Elbow arthroscopy	6	1	0.5
Groin hernia / conjoint tendon repair	6	0	0.5
Foot surgery other	5	1	0.4
Cardiac operation	4	1	0.3
Other neurolysis procedures	4	0	0.3
Spine operation	3	2	0.2
Compartment release	3	0	0.2
Elbow reconstruction	3	0	0.2
Piriformis/hamstring release	3	1	0.2
Wrist arthroscopy	3	0	0.2
Acromioclavicular (A/C) joint operation	2	0	0.2
Nasal reduction under anaesthetic	2	0	0.2
Removal of metal procedures	2	2	0.2
Patellofemoral reconstruction	2	0	0.2
Other miscellaneous operations	5	0	0.4
ALL PROCEDURES	254	46	19.6

Knee surgery

The most commonly required procedure was the knee arthroscopy (approximately 20% of all operations).

There were 35 primary knee arthroscopies and 12 revisions (47 surgeries), meaning that 25% of all knee arthroscopy surgeries were revision procedures. The majority (but not all) knee arthroscopies had pathological findings listed. The primary pathology noted was 5 primarily medial meniscal tears, 12 primarily lateral meniscal tears, 3 meniscal tears (side not specified), 3 removal of loose bodies and 17 chondroplasties without menisectomy. Pace bowlers were slightly over-represented in knee arthroscopies with 24 of the 47 arthroscopies performed in these bowlers (and pace bowlers representing 40% of the player cohort).

There were 6 knee Anterior Cruciate Ligament (ACL) reconstructions, 5 of which were primary ACL reconstructions performed using hamstring tendon grafts. One player developed an infection in the immediate post-operative period and this primary ACL reconstruction was revised using an allograft. There were 2 patellofemoral reconstruction procedures performed.

Figure 1: Os trigonum seen on X-ray which may cause posterior impingement

Figure 2: Third metacarpal fracture fixation surgery seen on X-ray

Shoulder surgery

There were 35 glenohumeral surgeries, subdivided into 24 shoulder arthroscopies and 11 shoulder reconstructions (anterior or posterior labral repairs), although since the majority of reconstructions were done arthroscopically there is some overlap between the two categories. Although complete details were not available for all procedures there was documentation of 7 SLAP repair procedures, 3 rotator cuff repairs, 1 biceps tenodesis and 2 subacromial decompressions.

In addition 4 of the tendon repairs were to shoulder region (2 pectoralis major, 1 latissimus dorsi, 1 proximal biceps) and there were two A/C (acromioclavicular) joint procedures. One of the neurolysis procedures was for the axillary nerve.

Groin and hip surgery

There were 10 adductor release tenotomies (4 single side and 3 bilateral), 8 hip arthroscopies and 6 inguinal region surgeries (4 single side and 1 bilateral although 2 adductor release procedures were done in conjunction with the inguinal surgeries on the same side and not counted separately). Three of the hip arthroscopies were revision procedures.

Ankle arthroscopy and impingement surgery

There were 16 unilateral and 3 bilateral posterior impingement ankle procedures performed, 6 of which were revision procedures.

There were 19 ankle arthroscopy procedures that did not involve an open posterior impingement procedure. Although full details of all reports were not available, anterior impingement spur resection was the most common procedure performed. No ankle reconstructions were performed.

Hand surgery

There were 16 fracture fixation surgeries done in the hand and wrist region with 14 of these performed on phalanges, 1 metacarpal and 1 scaphoid. Two of the procedures were revisions for non-unions in the same player.

There were 3 wrist arthroscopies performed and 8 wrist/hand region reconstructive procedures. One of these was a scapholunate ligament reconstruction, 1 was a repair of subluxing tendon and the other 6 were metacarpophalangeal (MCP) or interphalangeal (IP) joint reconstruction procedures (including one IP fusion).

Two of the miscellaneous procedures were drainage of finger infections, two of them were in-theatre hand laceration repairs and one of the compartment release procedures was performed in a fingertip. One of the neurolysis procedures was a carpal tunnel release.

Comparative rates in different positions

Table 2: Injury comparison rates between positions

	Player Years Studied	Surgeries	Rates / 100 Player Years
Batsmen	503	70	13.9
Pace Bowlers	520	130	25.0
Spin Bowlers	169	36	21.3
Wicket Keepers	103	18	17.5
Total	1295	254	19.6

The rates of surgery between the various player positions are detailed in Table 2. The highest rate of surgery was seen in pace bowlers and this was significantly higher than the other positions (OR 1.56, 95% CI 1.19-2.05). The lowest rate of surgery was seen in batsmen and this was significantly lower than the other positions (OR 0.60, 95% CI 0.45-0.81).

Comparative rates between cricket and rugby league

Some of the rates of surgery between cricketers and rugby league players could be directly compared, although there was some variation in the categories used for this and the previous study.[3] The overall rate of surgery (in surgeries/season) in cricketers was significantly lower than rugby league players (OR 0.55, 95% CI 0.45-0.67). There was no single operative category that was significantly more common in cricketers than rugby league players. However the overall rate of ankle operation in cricketers was similar to rugby league players. The breakdown in the rugby league study was not available. However in cricket the majority of ankle procedures were posterior impingement procedures, whereas this pathology was not prominent in rugby league players and hence this surgery was probably less likely. By contrast, ankle surgeries other than posterior impingement procedures were probably more common in rugby league players.

Whilst the overall rates of wrist and hand fracture fixation procedures were not greatly different between cricketers and rugby league players, the distribution of these fractures seems more sport-specific. Cricketers almost certainly undergo more finger fracture fixations whereas rugby league players require more surgeries in the way of wrist and hand fracture fixation.

Individual surgical categories that are clearly more common in rugby league players than cricketers include shoulder reconstruction (OR 0.28, 95% CI 0.13-0.58), knee reconstruction (OR 0.15, 95% CI 0.06-0.36) and A/C joint procedures (OR 0.12, 95% CI 0.03-0.55) and these injuries in turn clearly reflect the contact nature of the sport of rugby league.

DISCUSSION

Published surgical audits in professional sport have usually focused on a single operation or body part series, with relatively few publications detailing the entire profile of surgery in an athletic cohort.[1] From the limited previous audit of the football codes in Australia, it is apparent that the annual rate of surgery in fast bowlers approaches that of footballers, but the rate of surgery in batsmen, spin bowlers and wicketkeepers is lower. There are differences in the distribution of surgeries compared to other sports with fast bowlers requiring more ankle posterior impingement procedures, for example. This can be readily explained by the kinematics of pace bowling with significant forces through a plantarflexed front foot at the point of front foot contact and delivery.[14] Finger fractures are common in cricketers, almost invariably from ball contact whilst batting or in the field.[6] Reconstructions for instability (eg, ACL reconstruction, shoulder reconstruction) are relatively uncommon in all cricketers compared to contact team sports like rugby league.

By further comparison, a squad of 25 cricketers could expect to generate 5 surgical procedures per year on average, whereas a squad of 40 rugby league players would generate 14 surgical procedures per year on average. The overall rate of surgery in AFL players is very similar to NRL players although the profile is slightly different.[3]

This study does have some weaknesses and limitations. The methods of recording surgeries, whilst likely to be quite reliable, varied throughout the study and from state to state. For the early years of the study a prospective database was used. For NSW and Australia the surgeries were prospectively recorded as they occurred, whereas for Victoria a retrospective review of all players' files/charts was performed. Both methods have the capacity to "miss" the occasional case although the capture appears to be fairly accurate.

The definition of a revision was made for ease of assessing cases (ie, recurrence within this series) but it was possible that the revision rate was even higher (i.e. some of the primary cases in this series may have been revisions of surgical cases performed before the player joined this cohort). Our definition of revision did not include a timeframe for repeat surgery and hence a revision surgery performed 10 years after a primary operation would not have been considered a surgical failure. The revision rate should therefore be seen as representing just this rather than being considered a surgical success or failure descriptive. It is a limitation of this study that surgical outcomes (particularly player-centred outcomes of having resolved the presenting complaint) were not specifically assessed.

It can be presumed that certain surgeries are very likely to be successful – for example fracture fixations. A displaced fracture requiring surgery which in turn restores anatomical alignment demonstrates success of the procedure very easily. There are other surgeries where success is less easily demonstrated. The most common procedure from this series, knee arthroscopy, is in this category. In recent years the success of knee arthroscopy in middle aged patients has been called into question by a series of poor results in Randomised Controlled Trials (RCTs).[15,16] To the best of our awareness, there have not been similar RCTs carried out for knee arthroscopy in the young athletic population and extrapolation of results from the middle aged cohort into our cricketing cohort would not necessarily reflect the pathologies dealt with and probable significant disparity in levels of activity, let alone age difference. However the presumption should not be made that because knee arthroscopy is available that it is therefore the best management. The very fact that one quarter of the knee arthroscopies were revisions calls into question somewhat that the surgery is routinely successful, whilst at the same time also reflecting the high physical demands in the elite cricketing population.

In conclusion, this study has shown a moderately high rate of surgeries in cricketers, particularly fast bowlers, in Australia over the past 15 years. Knee arthroscopy is the most commonly performed procedure, whilst ankle posterior impingement procedures appear to be particularly common in fast bowlers.[7] Finger fracture fixation procedures are also common.[6]

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Change to injury profile of elite male cricketers in the T20 era

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ABSTRACT

Background/Aim

Since the introduction of T20 cricket, there has been a 35% increase in the number of overall matches played by Australian men's state and national cricket teams. This increase has been almost entirely T20 matches. This report analyses injuries occurring prospectively in Australian cricket at the men's state and national levels. In particular, comparisons are made between the last 9 years (2005-06 to 2013-14 inclusive, the "T20 era") and the preceding 9 years (1996-97 to 2004-05 inclusive, the "pre-T20 era") to analyse long-term trends of injury.

Study Design

Prospective longitudinal cohort study, observational.

Participants/Subjects

Elite Australian male cricketers.

Outcome Measures

Injury incidence, match injury incidence; match bowling injuries; seasonal injury incidence; injury prevalence.

Results

For match injury incidence overall, there was a significantly higher chance of injury in the T20 era compared to the pre-T20 era (RR 1.18, 95% CI 1.03-1.35). Domestic one day matches was the one match format with a significantly increased risk of injuries (RR 1.61, 95% CI 1.20-2.17). For match bowling injuries overall, there was a significantly increased risk in the T20 era (RR 1.28, 95% CI 1.05-1.54). However, the only individual categories of injuries that significantly increased in the T20 era were thigh and hamstring strains (RR 1.44, 95% CI 1.18-1.76) and other shoulder (not tendon) injuries (RR 1.66 95% CI 1.02-2.68). Overall injury prevalence increased in the T20 era as did the injury prevalence for all positions.

Conclusion

The T20 era was generally associated with increased risk of injury. In addition, injured players missed more games in the T20 era, primarily because the games were scheduled more closely to fit the T20 games into the calendar.

INTRODUCTION

The first major series of published studies on cricket injuries appeared in the late 1980s and early 1990s, with the earliest attempts at recording larger series of injuries[1-4] and exploring risk factors for lumbar injuries in fast bowlers.[5-11] Cricket researchers published the first ever consensus international injury definitions for a sport in 2005, co-published in four major sports medicine journals,[12-15] a process that arose partially out of Australia's ongoing injury surveillance system.[16] Other team sports such as football (soccer; 2006)[17] and rugby union (2007)[18] also published consensus definitions. The international definitions have been a qualified success in that since their publication there have been injury surveillance publications of from the West Indies,[19] Australia,[20, 21] and New Zealand.[22] Since these publications, there have been significant changes to the cricket calendar with a potential to have an effect on injury surveillance. These are:

1 The explosion of T20 cricket as a major format of the game. T20 cricket had been played in England at domestic level prior to 2005, but subsequent to this time it has quickly become a very prominent form of the game in terms of number of matches, crowds and television ratings; and

2 The increased number of teams that an average player represents. Prior to 2005, an Australian male player might represent his state and country with a minority of players occasionally playing county cricket in the off-season in England. In the T20 era many Australian players will play for four teams – state, country, Big Bash team and Indian Premier League (IPL) or English county/domestic T20 team. There are some players who are T20 specialists who can represent 5 or 6 teams in a single year. The implications are that it is more common for an injury sustained playing for one team to affect availability for another team.

METHODS

Methods for the Cricket Australia injury survey have been described previously[12,14,16,20] and are summarised below.

a Injury definitions

The definition of a cricket injury (or 'relevant' injury for surveillance purposes) is any injury or other medical condition that either:

(1) prevents a player from being fully available for selection in a major match; or

(2) during a major match, causes a player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain.

The major injury rates presented are injury incidence and injury prevalence:

- Injury incidence analyses the number of injuries occurring over a given time period.
- Injury match incidence considers only those injuries occurring during major matches. The preferred unit in this report is injuries per 1000 days of play, which was not the recommended unit in the 2005 definitions but is more suitable to compare the various formats in the era of T20 cricket, as detailed in a recent publication.[21]
- Injury seasonal incidence considers the number of defined injuries occurring per squad per season. This can take into account gradual onset injuries, training injuries and match injuries in the one measurement. A 'squad' is defined as 25 players and a 'season' is defined as 60 days of scheduled match play.
- Injury prevalence considers the average number of squad members not available for selection through injury for each match divided by the total number of squad members. Injury prevalence is expressed as a percentage, representing the percentage of players missing through injury on average for that team for the season in question. It is calculated using the numerator of 'missed player games', with a denominator of number of games multiplied by squad members. Player movement monitoring essentially requires that all players are defined in each match as either: (1) playing cricket (2) not playing cricket due to injury or illness (3) not playing cricket for another reason (eg, non-selection with no lower grade game available).

For consistency, the starting date for the Australian cricket year has been designated as the start of whichever series was being played after 1 May for every season under consideration.

Table 1 - Schedule and overs comparison of eras.

Average Annual		Team Matches		Team Days Played		Overs Bowled	
	Format	Pre Era	T20 Era	Pre Era	T20 Era	Pre Era	T20 Era
Domestic	Champions League T20		9.4		9.4		89
	Domestic T20		42.4		42.0		782
	Domestic One Day	52.4	56.9	52.0	56.4	2510	2533
	Domestic First Class	62.0	62.0	231.8	233.1	9821	9707
International	International T20	0.1	8.6	0.1	8.4	3	151
	One Day International	27.0	27.4	26.7	27.1	1204	1154
	Test match	12.0	11.3	51.3	50.9	1945	1917
Totals		153.6	213.9	361.9	423.2	15483	16334

Table 2 - Incidence comparison of eras.

Average Annual		Match Incidence (inj /1000 days of play)		Bowling Incidence (inj / 1000 overs)	
	Format	Pre Era	T20 Era	Pre Era	T20 Era
Domestic	Champions League T20		127.7		2.5
	Domestic T20		166.7		2.0
	Domestic One Day	177.4	285.4	1.9	2.8
	Domestic First Class	106.4	120.6	1.2	1.6
International	International T20		189.2		3.7
	One Day International	270.8	245.9	1.6	2.2
	Test match	123.4	102.6	1.8	1.1
Totals		131.1	154.5	1.4	1.8

b Statistical calculations and comparison of eras.

Data presented in this report are categorised into pre-T20 era 9 year averages (1996-7 to 2004-05 inclusive) and T20-era 9 year averages (2005-06 to 2013-14 inclusive). The two eras are statistically compared to give relative risks (RR) of injuries between eras. The 95% confidence intervals were calculated using Taylor Series expansions.[23]

c Ethics

The methods used for Cricket Australia injury surveillance conform to the Code of Ethics of the World Medical Association (Declaration of Helsinki) and the latest National Health and Medical Research Council (NHMRC) guidelines for research.[24] They have been approved by the Cricket Australia Sports Science Sports Medicine Advisory Group as the relevant institutional review board. As injury surveillance is non-interventional and the methods preserve confidentiality of the players, it is characterised as 'low or negligible risk'.

RESULTS

Bowling workload (number of overs bowled) has stayed fairly steady in First Class/List A matches over the past 18 years, as shown in Table 1. Because of the shortened duration of matches, additional T20 matches add relatively little to the overall (total) burden of overs bowled. However the number of total matches and days played did increase substantially in the T20 era and as a result the variation in the number overs bowled per match also increased.

a Injury incidence

Injury incidence results are presented in Table 2. For overall match incidence and for the various games formats, there were few significant differences (at 95% CI level) between the pre-T20 and T20 eras, although there were trends towards more injuries in the T20 era. For matches injuries overall, there was a significant increase in the T20 era (RR 1.18, 95% CI 1.03-1.35). Domestic one day matches was the one match format with a significantly increased risk of injuries (RR 1.61, 95% CI 1.20-2.17). For domestic first class matches (RR 1.13, 95% CI 0.94-1.37) there was a non-significant trend towards more bowling injuries in the T20 era. Of course, T20 matches themselves could not be compared between eras (there was only a single International T20 game played in 2004-05 which was included in the era defined as "Pre T20").

For overall bowling match incidence and for the various game formats, there were some significant differences (at 95% CI level) between the pre-T20 and T20 eras. For match bowling injuries overall, there was a significant increase in the T20 era (RR 1.28, 95% CI 1.05-1.54). For domestic one day matches (RR 1.46 , 95% CI 0.94-2.17) and domestic first class matches (RR 1.35, 95% CI 1.03-1.74) there were non-significant and significant trends respectively towards more bowling injuries in the T20 era. However, for Test cricket there was a non-significant trend towards fewer bowling match injuries in the T20 era (RR 0.60, 95% CI 0.37-1.06).

Table 2 analyses match injury incidence by the unit of injuries per 1000 days of play. These units were not recommended by the international definitions, but enable a more direct comparison between T20 cricket and the other forms. From Table 2, it can be seen that Domestic T20 matches had somewhat comparable overall match injury incidences to other forms of domestic cricket. Bowling injury incidence was also comparable in terms of injuries per 1000 overs bowled. The international and Champions League T20 figures follow similar trends although are subject to quite small sample size due to relatively few games each season.

Seasonal incidence (Table 3) shows generally similar injury incidence for most injury categories in T20 era compared to pre-T20 era. Of the individual injury categories, only thigh and hamstring strains (RR 1.44, 95% CI 1.18-1.76) and other shoulder (not tendon) injuries (RR 1.66 95% CI 1.02-2.68) have increased significantly in incidence in the T20 era.

Table 3 - Injury seasonal incidence by body area and injury type.

Region	Injury type	Pre era	T20 era	Significant Change
Head & neck	Fractured facial bones	0.1	0.2	
	Other head and facial injuries	0.2	0.1	
	Neck injuries	0.1	0.1	
Shoulder	Shoulder tendon injuries	0.6	0.5	
	Other shoulder injuries	0.4	0.7	1.66 95% CI 1.02-2.68
Arm/elbow	Arm/forearm fractures	0.1	0.0	
	Other elbow/arm injuries	0.3	0.4	
Wrist/hand	Wrist and hand fractures	1.1	1.2	
	Other wrist/hand injuries	0.6	0.8	
Trunk	Side and abdominal strains	1.3	1.6	
	Other trunk injuries	0.2	0.4	
Lumbar spine	Lumbar stress fractures	0.6	0.9	
	Other lumbar injuries	1.3	1.3	
Groin/hip/thigh	Groin and hip injuries	1.2	1.3	
	Thigh and hamstring strains	2.6	3.7	1.44, 95% CI 1.18-1.76
	Buttock and other thigh injuries	0.2	0.4	
Knee	Knee cartilage injuries	0.9	0.9	
	Other knee injuries	0.7	0.5	
Shin/foot/ankle	Shin and foot stress fractures	0.4	0.6	
	Ankle and foot sprains	1.0	0.8	
	Other shin, foot and ankle injuries	1.4	1.6	
Medical	Heat-related illness	0.1	0.0	
	Medical illness	1.0	0.8	

b Injury prevalence

Injury prevalence rates (Tables 4 and 5) have generally increased over the T20 era of cricket. The injury prevalence overall significantly increased for the T20 era (RR 1.41 95% CI 1.37-1.45).

The injury prevalence for every position increased significantly in the T20 era. In absolute terms it increased most for fast bowlers from 15.2% to 19.9% (a 4.7% increase). However in relative terms the increase for fast bowlers was the least of all positions. Batsmen, spin bowlers and wicketkeepers all had absolute increases of injury prevalence of approximately 3% in the T20 era but coming off a low base in the T20 era their relative injury prevalence compared to pre-T20 era was much higher. For example, spin bowlers increased from 4.1% to 7.2% average injury prevalence in the T20 era.

Table 4 - Injury prevalence by player position between eras.

	Pre Era %	T20 Era %	Relative Risk T20:preT20	95% CIs
Batsman	4.4	7.2	1.64	1.53-1.75
Keeper	2.0	5.1	2.57	2.10-3.14
Pace Bowler	15.2	19.9	1.31	1.27-1.36
Spinner	4.1	7.2	1.77	1.60-1.97

The notable injury categories which led to more missed playing time in the T20 era (Table 5) were: Other (non-tendon) shoulder injuries RR 1.55 95% CI (1.35-1.78), Wrist and hand fractures RR 1.35 95% CI (1.21-1.52), Side and abdominal strains RR 1.48 95% CI (1.33-1.65), Lumbar stress fractures RR 1.69 95% CI (1.56-1.84), Thigh and hamstring strains RR 2.08 95% CI (1.90-2.27) and Shin and foot stress fractures RR 1.75 95% CI (1.52-2.00).

The notable injury categories which led to less missed playing time in the T20 era were: Medical illness RR 0.55 95% CI (0.47-0.66) and Arm/forearm fractures RR 0.38 95% CI (0.24-0.62).

DISCUSSION

The number of Test, first class, one day international (ODI) and List A matches was essentially unchanged from the pre-T20 era to the T20 era, but there was a 35% increase in the number of overall matches played, with the increase entirely being T20 matches. There was only a minimal effect on overall

Table 5 - Injury prevalence categories significant changes between eras.

Region	Body region	Pre era %	T20 era %	Relative risk T20:pre T20	95% CI
Head & neck	Fractured facial bones	0.1	0.1	1.24	0.87-1.79
	Other head and facial injuries	0.0	0.0	1.50	0.75-3.00
	Neck injuries	0.0	0.0	0.39	0.19-0.79
Shoulder	Shoulder tendon injuries	0.5	0.5	1.09	0.96-1.23
	Other shoulder injuries	0.4	0.6	1.55	1.35-1.78
Arm/elbow	Arm/forearm fractures	0.1	0.0	0.38	0.24-0.62
	Other elbow/arm injuries	0.2	0.3	2.16	1.77-2.63
Wrist/hand	Wrist and hand fractures	0.5	0.7	1.35	1.21-1.52
	Other wrist/hand injuries	0.2	0.3	1.27	1.05-1.52
Trunk	Side and abdominal strains	0.6	0.9	1.48	1.33-1.65
	Other trunk injuries	0.1	0.2	2.34	1.78-3.08
Lumbar spine	Lumbar stress fractures	1.0	1.7	1.69	1.56-1.84
	Other lumbar injuries	0.7	0.8	1.09	0.99-1.21
Groin/hip/thigh	Groin and hip injuries	0.6	0.7	1.16	1.03-1.30
	Thigh and hamstring strains	0.8	1.6	2.08	1.90-2.27
	Other thigh/buttock injuries	0.0	0.2	6.25	4.33-9.03
Knee	Knee cartilage injuries	0.7	0.9	1.20	1.09-1.33
	Other knee injuries	0.4	0.6	1.46	1.28-1.67
Shin/foot/ankle	Shin and foot stress fractures	0.3	0.6	1.75	1.52-2.00
	Ankle and foot sprains	0.5	0.6	1.15	1.01-1.30
	Other shin, calf, foot and ankle injuries	0.6	0.8	1.25	1.13-1.40
Medical	Heat-related illness	0.0	0.0	0.00	
	Medical illness	0.4	0.2	0.55	0.47-0.66

number of overs bowled, however, with T20 giving rise to far fewer overs than the longer forms of the game. The challenges to bowlers were of rapid changes in weekly workloads as they transition from the different game formats, and an increase in overall number of fixtures rather than an increase in annual workloads.

Injury prevalence (percentage of players missing through injury) increased far more than injury incidence in the T20 era, meaning that average severity (number of games missed per individual injury) increased. The most likely reason for more games being missed in the T20 era is that the games were scheduled in closer proximity to each other to fit the T20 games into the calendar. The greater number of matches in the T20 era has meant that an injury which causes a player to miss a period of, say, 3 weeks, results in the player missing a greater number of games than previously, as in the T20 era, there are more games scheduled in this time period, on average.

Bowling workload has been documented as a risk factor for overuse injury in cricket.[25-28] Acute high one-off workloads,[27] overs or sessions per week[25,26] and workload variability[28] have all been associated with increased risk of bowling injury, with low weekly workloads also documented as a risk factor.[25] Although our understanding of high (and low) workloads in bowlers as risk factors is gradually improving, the ability to avoid high and low match workloads and particularly sudden upgrades of workloads is diminishing. First Class and T20 matches have been scheduled close to each other in the T20 era and players generally play in both formats. In athletics, it would be considered a grave training error for a runner to upgrade from running 10km per week to 100km per week,[29] yet this is the equivalent of the rapid workload upgrade now expected of some bowlers. It has been shown in cricket that sudden increases in workload are associated with increased injury risk[28] because it is difficult to maintain a constant moderate workload (not too high and not too low) to both condition but not overload. The modern schedule does tend to encourage the two extremes (unloading in T20 and overloading in First Class cricket) for bowlers who want to play in all forms of the game. However, our understanding of change of workload being a risk factor for bowling injury has meant that potentially better preparation can be used to reduce injury risks. In particular, managing the transition from bowlers playing in T20 fixtures/tournaments to first class matches needs careful attention.

CONCLUSION

The T20 era was generally associated with slightly increased risk of injury. In addition, injured players missed more games in the T20 era, primarily because the games were scheduled more closely to fit the T20 games into the calendar.

ACKNOWLEDGEMENTS

Data collectors over the entire 18 years are acknowledged including those who collected for the 2013-14 season:

Team Physiotherapists: Alex Kountouris, Kevin Sims, David Beakley (Australia), Murray Ryan, Danny Redrup, Patrick Farhart (New South Wales), John Porter (South Australia), Stewart Williamson (Tasmania), Nick Jones (Western Australia), Martin Love (Queensland), Nick Adcock, Thihan Chandramohan (Victoria)

Team Medical Officers: Trefor James, Stuart Down (Victoria), Mark Young, Neville Blomeley (Queensland), Terry Farquharson (South Australia), David Humphries and Peter Sexton (Tasmania), Sandra Mejak (Western Australia), John Orchard (New South Wales), Justin Paoloni and Peter Brukner (Australia).

Peter Blanch is also acknowledged for his work as Head of Sports Science and Sports Medicine during the 2013-14 season.

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Cervical orthoses in preventing brachial plexus and spinal cord injury: A systematic review

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ABSTRACT

Aim

To systematically review the literature on the effectiveness of cervical orthoses in reducing burners/stingers and cervical cord neurapraxia (CCN).

Data Sources

In accordance with the Preferred Reporting Items for Systematic Review (PRISMA) statement, online databases (Medline, PubMed and Embase) were searched from inception to identify eligible studies.

Study Selection

Studies investigating cervical orthoses in the prevention of burners and CCN were included for review. There were no limitations on study design. The utility of cervical orthoses in reducing burners and CCN was the primary end point.

Data Extraction and Synthesis

Four studies met criteria for inclusion in the review. Only one study reported reduced incidence of burners when a neck collar was used, however, small numbers and non-randomised design limit this finding. All collars significantly reduced hyper-extension, but failed to replicate this limitation for lateral flexion. The Kerr Collar is most effective at reducing compressive load in an axial direction. The A Force Neck Collar, Neck Roll and the Cowboy Collar limited active lateral flexion significantly more than passive lateral flexion.

Conclusions

There remains a paucity of data regarding the efficacy of cervical collars in reducing burners and CCN in contact sports. All studies tested cervical orthoses in the setting of American Football. They suggest that it may be possible to reduce the incidence of injury through limiting cervical range of motion and protecting Erb's point; however, in the clinical setting this has yet to be proven in a game or practice situation and any link to injury reduction is purely theoretical. Further studies are required to determine their efficacy, not only in this setting, but also in Rugby Union and Rugby League.

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INTRODUCTION

Important rule changes in contact sports, including American Football, Rugby League and Rugby Union, have significantly reduced rates of catastrophic spinal injury.[1-3] Despite these rule changes players continue to experience more common transient injuries such as burners/stingers ("burners" will be used throughout this article to refer to this entity, synonymous with "stinger") and cervical cord neurapraxias (CCN). These injuries can be debilitating and disconcerting for the affected individual.

Injuries to the nerve roots (commonly known as burners) are relatively common in contact sport. In American football there is an annual incidence of 3.7% to 7.7%.[4, 5] CCN involves a direct injury to the cervical cord and occurs less frequently with a reported 0.06% yearly incidence.[6] Risk for recurrence for both types of injuries is also high. Those who have previously sustained this type of injury have a 2-3 times increased risk of repeat injury.[4] This risk for CCN is higher in athletes with smaller vertebral canals, but not burners.[5] In a cohort of English Premiership Rugby players, up to 72% (range: 0-20) experienced at least one burner during a single season.[7] Those players who played in the forwards were 2.5 times more likely to experience a burner than the backs. Positions 6-8 (back rowers) reportedly had the highest incidence of burners at an average of 4.4 burners/season.

Rugby League and Rugby Union are well-established contact sports in Australasia and across many of the South Pacific nations. There are large numbers of Maori and Pacific players participating at all levels. Maori and Pacific populations have been shown to have relatively smaller vertebral canals compared to other groups, theoretically predisposing them to CCN.[8, 9]

Burners arise as a result of either direct or indirect trauma to the cervical and T1 nerve roots, trunks, divisions or cords. A traction injury is thought to be the most common mechanism in "younger" players.[10] In this group injury to the neural structures occurs when there is contralateral flexion of the neck away from the affected side with concurrent depression of the ipsilateral shoulder.[10,11] An alternative mechanism, more common in older athletes, involves compression of nerve roots at the intervertebral foramen. Extension usually combined with any of rotation, lateral flexion or compression as seen with spear tackling techniques in American football may illicit symptoms.[10] This should be distinguished from spear tackling seen in rugby codes which describes tacklers lifting and illegally tipping their opposition into a near vertical position head first into the ground. This has far more serious consequences for the tacklee. A third mechanism involving a direct blow to the supraclavicular region (Erb's point) can also produce these symptoms, but is thought to be less common.[12] These injuries are characterised by symptoms of numbness, pain or more commonly 'stinging' or 'burning' sensations of the affected limb, hence its colloquial names. Symptoms usually resolve within minutes but may persist for several days. CCN involves injury to the spinal cord – rather than to the brachial plexus. CCN has an estimated prevalence of 7 per 100,000 player years.[10] The cord is compressed with either excessive neck flexion or extension. The athlete experiences an acute transient neurological episode with sensory changes below the level of the spinal cord injury. They may also have incomplete or complete paralysis. Full recovery is usually quick within the first 15 minutes but may take up to 48 hours.[13]

Some American football athletes and Rugby League players have utilised cervical orthoses in order to continue playing and attempt to reduce these types of injury. It is proposed that cervical collars function by limiting an athlete's cervical range of motion and protecting the brachial plexus from direct impact, thereby reducing the risk of injury.[14]

Despite some authors' claims that collars reduce injury incidence, there is little objective data to support this assertion.[15] The effectiveness of these orthotic devices remains unknown. Therefore, the aim for this study was to systematically review the literature regarding the efficacy of cervical orthoses in reducing the risk of burners/stingers and CCN in contact sports.

METHODS

Search Strategy

In accordance with the Preferred Reporting Items for Systematic Review and Meta Analyses (PRISMA) statement[16] a comprehensive review of the literature was performed by two authors (MDJS and DPL) using the following search terms: "cervical orthoses" OR, "cervical collar" AND "burners" OR, "stingers" OR, "brachial plexus", OR "brachial plexopathy", OR "cervical cord neurapraxia" (Figure 1). Medline, PubMed and Embase were searched from inception to August 2013. References from recovered studies were also manually scrutinised.

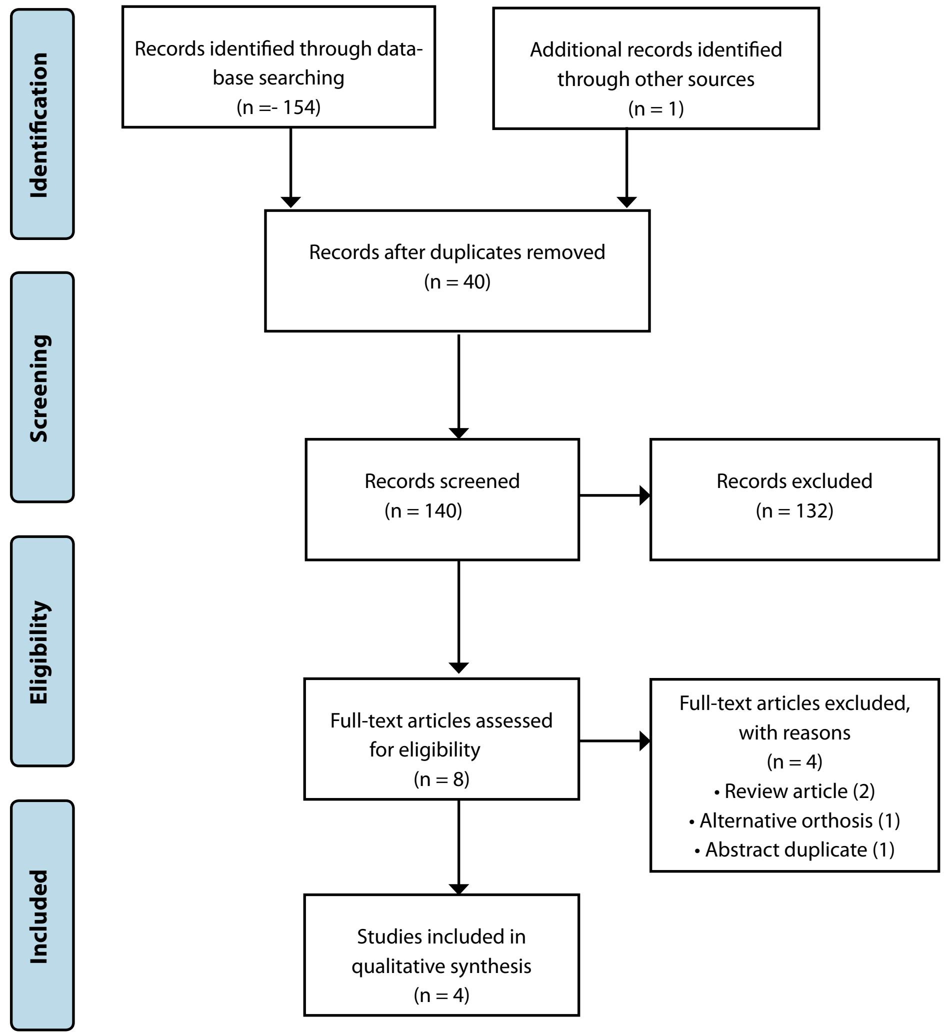

Figure 1 - PRISMA Flow Diagram

Study Selection

Studies investigating the role of the cervical collar in preventing cervical and brachial plexus injuries sustained in contact sports were included in the review. The utility of cervical orthoses in reducing the incidence of burners and CCN was the primary end point. There were no limitations on how these were measured and no limitations on study design. Only English language articles were included for review.

RESULTS

The search identified eight articles that were eligible for study selection. Two review articles and one study investigating the utility of an orthosis post-injury to aid in short-term recovery were excluded.[14,17,18] One conference abstract was excluded as this was a duplicate of another included study.[19] Therefore, in all, four studies were included in the final analysis.[12,20-22] Three of the studies were conducted in a research laboratory,[20-22] and one was a 4-phase prospective clinical trial.[12] The characteristics and main outcomes are summarised in Table 1. Two laboratory studies used college level American football players in their evaluation of the cervical collars; and the other a test dummy (Hybrid III). All studies evaluated cervical collars commonly used in American football players. These included neck rolls (NR), Cowboy Collar (CC) (McDavid™), A Force Neck Collar (AFNC) (Active Ankle Systems™),

Table 1 - Summary of studies included in review.

	Study Design	Subjects	Collar type	Outcomes	Important findings [a]	P value
Markey et al[12] (1993)	4-phase, prospective clinical study	261 tackle football players	Customised neck roll plus total-contact neck-shoulder-chest orthosis	Stinger prevalence Muscle strength EMG and nerve conduction studies	18 of 261 (6.9%) players found to have symptoms of brachial plexus injury Symptomatic players at baseline demonstrated ↑muscle weakness, abnormal EMG and nerve conduction studies (predominantly deltoid, supraspinatus, and coracobrachial muscle groups) At 1-year follow up: 3 of 5 symptomatic players reported fewer stinger episodes and reduced severity with subsequent injury	No statistical analysis performed
Hovis & Limbird[21] (1994)	Research Laboratory	5 asymptomatic male collegiate football players; mean age 22	NR vs CC (McDavid™) vs custom brace	Cervical ROM (passive only) Mean percentage reduction of angular displacement	Hyperextension NR 33.18% (SD ± 7.97) CC 32.36% (SD ± 4.2) Custom brace 48.36% (SD ± 8.6) Lateral flexion NR 28.68% (SD ± 21.6) CC 18.94% (SD ± 21.4) Custom brace 25.15% (SD ± 16.1)	 0.00009[b] 0.0000025[b] 0.0000031[b] 0.18 0.45 0.22
Gorden et al[20] (2003)	Research Laboratory	15 male National Collegiate Athletic Association Division 1 varsity football athletes; mean age 19	NR vs CC (McDavid™) vs AFNC (Active Ankle Systems™)	Cervical ROM (active and passive)	Hyperextension (grand mean) NR 74.59 deg (SD ± 9.42) CC 64.03 deg (SD ± 11.58) AFNC 68.28 deg (SD ± 12.38) Lateral flexion (grand mean) NR 40.22 deg (SD ± 6.42) CC 43.54 deg (SD ± 4.22) AFNC 43.36 deg (SD ± 5.76)	 <0.05[b] <0.01[b, c] <0.05[b] Reported as non-significant difference
Rowson et al[19] (2008)	Research Laboratory	None. Hybrid III test dummy	CC (McDavid™) vs BC vs KC	At 5m/s and 7m/s: Force reduction (FR) Moment (My) Cervical ROM (deg)	Standard SP position at 5m/s Hyperextension (ROM) Control 25 deg CC 23 deg BC 19 deg KC 15 deg Lateral flexion (ROM) Control 39 deg CC 37 deg BC 37 deg KC 25 deg Raised SP position at 5m/s Hyperextension (ROM) Control 19 deg CC 16 deg BC 17 deg KC 12 deg Lateral flexion (ROM) Control 33 deg CC 34 deg BC 33 deg KC 17 deg	No statistical analysis performed. Coefficients of variation were calculated for each outcome measure; neck collars' performance differences were greater than these and therefore could be used to determine inter-collar differences.

[a] Key outcomes only

[b] Reduction in range of motion relative to shoulder pad conditions

[c] Reduction in range of motion relative to neck-roll condition

P value <0.05 reported as statistically significant

EMG = *electromyography*; ROM = *range of motion*; NR = *neck roll*; CC = *Cowboy Collar*; AFNC, *A Force Neck Collar*; BC = *Bullock Collar*; KC = *Kerr Collar*; SP = *shoulder pad*

Kerr Collar (KC) and their own customised cervical orthoses (Table 2). There were no studies investigating effectiveness of collars in other contact sports.

Only one study reported on the clinical implications of a cervical orthosis.[12] Three of five footballers in this study reported reduced recurrences and less severe symptoms when an injury did occur after wearing a customised neck roll plus total-contact neck-shoulder-chest orthotic for one year. This study suggested that burners in American football were commonly a result of direct blow to the nerves rather than from stretching or pinching. The plexus was compressed between the shoulder-pad and the supero-medial border of the scapula in a location where the brachial plexus runs most superficially and is therefore at risk of injury - eponymously named Erb's point.[11]

The laboratory based studies performed biomechanical analysis to evaluate the effectiveness of their respective cervical orthoses in reducing cervical range of motion. Hovis and Limbird tested three different collars in five male college football players.[21] Cervical hyperextension and lateral flexion was video recorded while wearing a standard helmet and shoulder pads in order to simulate 'actual' range of movement in these planes with standard issue equipment. All orthoses significantly (p<0.015) reduced the mean percentage of angular displacement in hyperextension when compared to shoulder pads alone. The custom brace used in their study demonstrated the largest percentage reduction in hyperextension angle (48.36%, SD ± 8.61). Limitations in lateral flexion were less consistent and showed non-significant differences when compared to shoulder pads alone (NR: p=0.18, CC: p=0.45, CB: p=0.22).

Gorden et al investigated the effects of three different collar types (NR, CC and AFNC) on restricting cervical hyperextension and lateral flexion. Similar to Hovis and Limbird, they demonstrated a significant limitation in hyperextension with all cervical orthoses when compared with shoulder pads alone (NR: 74.59 SD ± 9.42, p<0.05; CC: 64.03 deg SD ± 11.58, p<0.01; AFNC: 68.28 deg SD ± 12.38, p<0.05). Collars used in this setting had a non-significant reduction in cervical range of motion when testing lateral flexion. However, what they did reveal was that each

Table 2 - Cervical orthoses investigated in included studies.

Collar type	Model	Features
Cowboy Collar (McDavid™)		**Limits hyperextension** **Moulded polyurethane foam collar that fits into shoulder pads and laced** **Minimal lateral flexion limitation**
Kerr Collar (Kerr Sports™)		**Resists axial compression and motion in multiple planes** **Rigid synthetic mould** **When axial load is applied this comes into contact with base of the helmet and distributes across shoulder pads**
A Force Neck Collar (Active Ankle Systems™)		**Moulded cervical collar held by 2 straps that fasten to the chest wall. It is reinforced anteriorly with 2 additional straps** **This design fixes the collar to the athlete and functions independently of the shoulder pads**
Bullock Collar		**A high-density foam collar with a rigid plastic insert that is strapped to the shoulder pads** **Prevents hyperextension and some lateral flexion**

of the collars limited active lateral flexion significantly more than when tested under passive conditions (p<0.01).[24]

Rowson et al performed biomechanical analysis of football neck collars through dynamic testing.[22] A pneumatic linear impactor was used to strike the helmet worn by a Hybrid III test dummy at two different speeds (5m/s and 7m/s) in two different shoulder pad positions (standard and raised). The impact locations on the helmet were the top, to simulate axial compression; side and front to allow for measurement of lateral flexion and hyperextension, respectively. The KC reduced head acceleration and force transmission with top impact. The BC and CC did not protect the dummy from high neck loads in this setup. The KC also provided most protection when the helmet was struck at the front by the impactor, and more so with the shoulder pads raised. In a side impact, none of the collars tested demonstrated significant load reductions in different configurations.[22]

DISCUSSION

There is very little literature supporting the use of collars for preventing the more common transient neurological injuries experienced by contact sport athletes.

Collars are largely designed on the principles that a burner and CCN injury arise as a result of excessive cervical motion resulting in stretching, compression or direct trauma to plexus and spinal cord. The three laboratory based studies were able to achieve a reduction in cervical hyperextension to a significant degree but did not achieve this for lateral flexion. All authors concluded that this was a limitation of all the cervical orthoses tested as lateral flexion is thought to be one of the most common mechanisms of injury (traction type), particularly in younger athletes.[10] It is important to remember that while it may be possible to reduce cervical ROM this does not necessarily translate to a reduction in injury risk. Furthermore, these studies were performed in a laboratory under controlled conditions which may not accurately reflect the conditions seen on a sports field.

The KC was able to reduce lateral flexion to a greater extent than the other collars tested by Rowson et al. When the shoulder pad positioning was slightly elevated, this would allow the base of the helmet to come into contact with the shoulder pads earlier in the arc of motion.[22] The KC utilises the base of the helmet to limit an athlete's cervical range of movement and allow impact forces to be simultaneously transmitted from the helmet to the shoulders. This unique design has the additional benefit of thereby reducing axial load on the cervical spine. This is an area where the KC could theoretically perform superiorly to other collars in preventing CCN, as other collars are designed to limit cervical lateral flexion and hyperextension only.[20,21] Whether this reduces injury risk for CCN is yet to be confirmed in clinical trials. This device would not be useful in non-helmeted contact sports.

Only one study investigated the use of cervical collars in an American football setting.[12] While the authors report that these devices are effective in reducing the risk of injury the small sample size (five athletes) limits the reliability of these results. These authors also concluded that direct trauma to Erb's point was the most common mechanism for a burner and hence their use of the neck roll to protect this area.[12] This mechanism is in contrast to the majority of the literature which highlights traction and compressive mechanisms as being more common; and hence investigator's attempts at reducing cervical ROM. In Rugby Union and League the use of shoulder pads has been shown to only marginally reduce direct impact forces to the shoulder area (3% on average, p>0.05) and therefore the effectiveness of this device to adequately protect Erb's point is unclear.[23] Employing a neck roll may reduce the force over Erb's point even further, however, in Rugby Union shoulder pads may be no thicker than 1cm and must be soft.; currently making this apparatus illegal in this sport.

Cervical orthoses are currently not widely used in Rugby Union or Rugby League but should be further evaluated as these injuries to the brachial plexus and cervical cord are relatively common in these sports. The International Rugby Union (IRB) has strict rules concerning a player's dress for game play. Regarding shoulder pads, "No part of the pads may be thicker than 1 cm when uncompressed. No part of the pads may have a density of more than 45 kilograms per cubic metre."[24] As yet, the current orthoses would be deemed illegal in Rugby Union. Manufacturers and rule-makers must be cognizant of player positions when attempting to test such interventions. For instance, rugby union players who play in the front row require adequate extension to allow for scrummaging and line out lifting; whereas the backline players would require more freedom in range of movement to allow for increased mobility. A KC would be of little benefit as no helmets are used in this setting. The ideal device would protect both Erb's area and limit cervical range of movement, without impairing an athlete's on field performance. Such research is important, given the large number of athletes of both Maori and Pacific ethnicity that play these sports. These groups are known to be more likely to have narrow cervical canals and therefore may be more prone to experiencing CCN.[9]

A limitation of the review at a study level was that three of the four studies were conducted solely in a laboratory and may not be reproducible in a real-world setting. None of the studies reported conflicts of interest when investigating the efficacy of orthoses reducing the confidence in their results. Also, while the studies demonstrated significant, reductions in cervical range of motion it is difficult to infer an injury risk reduction. Finally, the nature of any review means there is always the possibility of incomplete retrieval of literature on the topic. However, the authors recovered an additional study not covered in a previous review article.[14]

From the evidence available each of the devices which have been investigated appear equivalent in their ability to achieve reductions in cervical range of movement, with greater reductions in hyperextension than lateral flexion demonstrated across all orthoses. The KC, however, has the added advantage of reducing axial load to the cervical spine through its utilisation of the athlete's helmet.

CONCLUSION

Literature on the effectiveness of cervical orthoses in contact sports remains scant. It has been suggested that these devices might reduce the risk of injury in American Football by limiting cervical range of motion and protecting Erb's point. They have been shown in the laboratory to adequately limit hyperextension of the neck during simulated contact; however, the same cannot be said for lateral flexion. It is also not known whether the reduction in cervical ROM is associated with a reduction in injury risk. Knowledge of the different mechanisms of injury, collar type and any underlying cervical anatomical features the athlete may have are important in determining the most appropriate collar. Large, prospective studies are required to determine their efficacy in this setting, but also in other contact sports including rugby union and rugby league.

Practical implications

- Injuries to the cervical cord and brachial plexus are relatively common in contact sport. It may be possible to reduce the risk of injury by using a cervical orthosis.
- Injury risk for burners and CCN should take into account individual anatomical features, mechanism of injury and sporting behaviours. Understanding these aspects will guide the clinician in selecting the most appropriate orthosis.
- Cervical orthoses investigated appear equivalent in reducing cervical range of movement. One orthoses is able to reduce axial load through the cervical spine.
- It is unclear whether any reduction in cervical range of motion (or loading) is associated with a reduction in injury risk.

ACKNOWLEDGEMENTS

The authors would like to thank Mr Tom Geddes, Orthopaedic Spine Surgeon, Department of Orthopaedics, Middlemore Hospital, Counties Manukau Health, Auckland, New Zealand for comments and manuscript revision.

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Competing interests: none.

Contributors: All authors of this paper contributed substantially to conception and design, analysis of the data, drafting and revising of the manuscript.

Funding: No additional funding or financial support was obtained to undertake this study.

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'Strength and conditioning' theory and practice - a need to know

PAUL GAMBLE

INTRODUCTION

Recently the American College of Sport Medicine published a consensus statement entitled 'The Team Physician and Strength and Conditioning of Athletes for Sports'. This free to view article is currently one of the most viewed publications in the prestigious Medicine and Science in Sports and Exercise journal. The consensus statement that was produced by an expert panel representing six organisations in North America provided a very broad overview of strength and conditioning for the health care practitioner that encompassed the following:

- the fundamental principles of training, including approaches to training periodisation
- a brief description of training disciplines, encompassing strength, power, and endurance
- a discussion of modifications to the general approach to training for special populations (youth, females, athletes with disabilities)
- what constitutes 'sport-specific' to strength and conditioning
- considerations for planning and delivery at different phases of the competition calendar
- potential illness and injury issues, in relation to strength and conditioning.

Perhaps more noteworthy is that the consensus statement concluded by listing 'essential' and 'desirable' competencies for the sports physician, in relation to understanding and knowledge in specific areas of strength and conditioning design and practice. The competencies listed as 'essential' mainly dealt with knowledge and understanding of the areas outlined in the article. Desirable competencies included comprehensive knowledge of the specific sport, and direct involvement in the assessment, delivery, and integration of training, as well as contributing to the education of athletes, parents and coaches in these areas.

In view of this, it seems appropriate to explore how different facets of athletic preparation relate to practice in sports medicine and sports physiotherapy. Simply, I will look at the relevance of different 'advanced' training modes (strength training, plyometrics, movement skill training) from a sports injury viewpoint. Then we will explore the competencies outlined in the consensus statement, and discuss the current state of play in New Zealand to tackle the question of what a practitioner needs to know, and how they might acquire the relevant theoretical knowledge and practical expertise .

What is strength and conditioning?

The term 'strength and conditioning' has become widely recognised and is used frequently by those who are involved with treating athletes and sports injuries. Nevertheless, an important first task is to define what strength and conditioning is, and what this term encompasses. Generally 'strength and conditioning' conjures an image of a weights room, and it is easy to make the assumption that this is all strength and conditioning involves. In fact, 'strength and conditioning' encompasses all aspects of training that are employed in the physical preparation of an athlete. It is therefore important to be explicit on what particular aspect of physical preparation (and the specific mode of training) we are referring to, rather than using the blanket term 'strength and conditioning'.

'Strength and conditioning' and sports injuries

Physical preparation has certain protective effects that assist with making those who participate in sport more robust and less prone to injury. For instance, heavy resistance training offers a means to elicit adaptation in muscle, bone and connective tissues, making these structures stronger and more resistant to the stresses of competing in the sport; reflected in corresponding reductions in injury rates during the competition season.[12] Similarly, strength trained muscle is more resistant to micro-trauma caused by strenuous physical exertion and as a result may recover faster.[23] A further general protective effect in relation to metabolic conditioning is that appropriately conditioned athletes are better able to cope with the neuromuscular fatigue that is often implicated in injury causation.[6,16,26]

Conversely, errors in the design and the delivery of training are identified as risk factors for sports injury. Inappropriate prescription and progression of volume load (the product of volume and intensity), and/or training frequency can be causal factors for both overuse and acute injuries. A lack of proper supervision, inadequate coaching, or inappropriate selection of loads or exercises prescribed may all contribute to training injuries. Ultimately it is critical that practitioners working in the fields of sports medicine and physiotherapy have the requisite knowledge to be able to recognise good versus bad practice and are informed enough to contribute to discussions on programme design and implementation.

Specific training modes for injury management, rehabilitation and prevention

A recent meta-analysis of the literature pertaining to injury prevention interventions found strong evidence of the effectiveness of 'specific training programmes' in reducing injury.[14] There is a growing body of evidence indicating that more progressive or advanced forms of training more commonly associated with athletic preparation, such as free weights and plyometrics, are particularly effective for eliciting improvements in core strength and neuromuscular control, and modifying risk factors for injury.[1,19]

In addition to the general benefits of training, targeted application of specific interventions can be used to address particular risk factors in order to guard against injuries that are prevalent in a particular sport.[4] Relevant aspects of physical preparation include metabolic conditioning, strength training, plyometrics, and different forms of neuromuscular training modes, including movement skill coaching. Indeed preventive training programmes that report the greatest success in reducing injuries generally feature a blend of different forms of training – for example, the 'sportsmetrics' protocol that has reported success in reducing lower limb injuries among female athletes.[9] Specific training modes similarly have applications for the management of injuries that do occur, and at different stages of the rehabilitation process.

i Strength training

Strength training represents the most potent means to address intrinsic risk factors for injury. Specifically, targeting strength training interventions can address muscular imbalances that are identified, which can predispose an athlete to various injuries.[10] Such imbalances can develop as a result of the sport, for example the shoulder internal rotation versus external rotation strength profile characteristically found in overhead throwing and striking sports,[27] or may simply be intrinsic to the athlete.

The notion of muscle strength imbalances as an intrinsic risk factor for injury is particularly applicable to female athletes. In the absence of the 'neuromuscular spurt' that naturally occurs in males, females typically show an increasingly imbalanced lower limb strength profile following puberty. Absolute hamstring strength scores plateau around the age of 11 in females,[2] whereas quadriceps strength increases with the gains in body mass at puberty (reflecting its role as an anti-gravity muscle). Consequently, hamstrings:quadriceps strength ratios decrease, which is problematic given the ACL agonist role of the hamstrings in opposing shear force at the knee.[9] The decline in knee flexion strength relative to body mass is mirrored by a decrease in relative hip abduction strength.[21] These trends are similarly likely to diminish the capacity to avoid valgus lower limb alignment during take-off and landing movements. Strength training intervention can therefore be viewed as a necessity for female athletes, and it is identified that the optimal time to begin strength training for young females is prior to puberty.[21] Accordingly, strength training has been shown to be effective in improving indices of lower limb neuromuscular control during jumping and landing in adolescent female athletes.[13]

Forms of strength training can also have an application in the management of different musculoskeletal injuries and chronic conditions. Notably, isometric training and eccentric training are often effective in modifying symptoms and helping to maintain or improve function, particularly for conditions such as tendinopathy.[3] Strength training in particular is becoming recognised as a highly effective treatment modality. A recent study reviewed the results of over 50 investigations employing strength training interventions in different groups of patients suffering with various musculoskeletal conditions, including chronic low back pain, knee osteoarthritis, chronic tendinopathy and those recovering from hip replacement surgery.[11] Collectively the results of these studies showed highly positive outcomes following strength training intervention, both in terms of improving function and ameliorating symptoms. This highlights the importance of practitioners in sports medicine understanding strength training.

ii Plyometrics

Plyometric training interventions have been successfully employed to address risk factors for lower limb injury.[18] In fact the inclusion of high-intensity plyometric training has been identified as a factor that differentiates successful interventions from other studies that did not report significant reductions in ACL injury incidence.[8] Part of the potency of plyometrics for preventing lower limb injury stems from developing the specific ability to absorb force rapidly. This is due to a combination of the rapid eccentric training stimulus provided and the concurrent development of feed-forward control and associated neural strategies prior to and during landing that occurs with repeated exposure to plyometric movements.[15] Once more this is particularly pertinent to females: gender differences are noted in landing force and drop jump performance post puberty. Specifically, adolescent females' landing ground reaction forces are higher than males, whereas their take-off forces are conversely reduced.[20]

There is also growing evidence that plyometrics offer a potent stimulus for developing dynamic stabilisation and postural control, and may be superior to more conventional balance training for eliciting these adaptations.[1] Finally, as a dynamic weight-bearing mode of training, plyometrics along with heavy resistance training, provides a strong osteogenic stimulus for skeletal adaptation. Once more this is particularly applicable to females given the risks of osteoporosis in later life. Studies indicate that following puberty females appear less responsive to skeletal adaptation, which suggests that there is an earlier and narrower window of opportunity for developing bone and associated connective tissues with female athletes.[5] As has been recommended with strength training, there is an apparent need for structured physical preparation that includes plyometrics to be initiated prior to puberty in young females. Equally there is also a need for careful prescription and progression in terms of selection of plyometric training modes and overall volume, underpinned by appropriate coaching and feedback.

iii Coaching athletic movement

Effective training interventions for reducing risk and incidence of lower limb injury generally feature some form of corrective movement skills training.[22] A feature of this approach is the inclusion of specific coaching with feedback regarding 'safe' versus 'unsafe' biomechanics (such as posture and lower limb alignment) for athletic movements.[7] Evidently this necessitates a clear understanding of what constitutes correct movement mechanics, both for generic athletic movements and also the specific movements that feature in the particular sport. Developing an 'eye' for athletic movement is a process that involves extensive observation, ideally under the guidance of a knowledgeable coach, and can be greatly assisted by video recording and slow-motion playback.

One approach to structured physical preparation for children and adolescents that has been advocated recently by authorities in the field of injury prevention is termed 'integrative neuromuscular training'.[17] Specifically, the integrative training approach comprises neuromuscular training, including movement skill instruction, in combination with strength training in a variety of forms. Plyometric training also features prominently, with an emphasis on safe landing mechanics. The common theme emphasised throughout is the mastery of fundamental movement skills.[17] Once more, this requires an appropriate understanding of movement and the ability to not only detect errors, but also the coaching acumen to provide appropriate feedback and cues to allow the athlete to correct them.

Gait retraining is a specific area that particularly relevant to practitioners who treat running injuries. The two main applications are instilling sound running mechanics for novice runners, or athletes in running-based sports who have not been exposed to such instruction, and for correcting aberrant mechanics post injury. A necessary starting point is a proper understanding of sound running mechanics and the ability to assess and identify errors. The success reported by running training clinics for novice runners in reducing injury is highly variable,[24] and to some degree this is likely a reflection of the level of understanding of those delivering the programme and the coaching input provided. When working with those who have a previous running related injury, it is also important to recognise that some of the aberrant kinetics and kinematics observed may have developed as a consequence of the particular injury. [25,28,29] This is likely to necessitate a different approach to address the underlying issues and resolve ongoing symptoms in order to be able to restore proper mechanics and ultimately avoid further injury. Once again, a detailed and practical knowledge is required from practitioners of sports medicine, in order to have an optimal impact.

Summary and a challenge to the sports medicine practitioner

It is clear that advanced forms of athletic preparation that commonly fall under the banner of 'strength and conditioning' are highly relevant to practitioners in the field of sports injury, but which are likely under-utilised in clinical practice. Whilst undergraduate or postgraduate papers in exercise prescription provide a sound starting point for the application of "strength and conditioning" principles, what is commonly lacking is the requisite hands on experience to optimally deliver the advanced forms of training described above. Indeed, one may argue that the limited or variable effectiveness of injury prevention interventions and rehabilitation programmes could in part be attributed to shortcomings in their implementation.

The roles of the doctor and physiotherapist in helping to guide training design and delivery as part of the multi-disciplinary team are contingent on being sufficiently informed in these areas, from both a theoretical and a practical viewpoint. It is important that these clinicians are provided with adequate opportunities to develop these required skills, such that optimal programming is undertaken. Similarly, in the absence of a recognised accreditation in New Zealand, and a general lack of regulation of those working under the title of 'strength and conditioning coach', there is a need for careful scrutiny of both the training environment programmes provided. Optimal interaction between the medical and physiotherapy practitioner (predominantly working at the "injured" end of the spectrum), and the strength and conditioning specialist (predominantly working at the "healthy" end of the spectrum) is a critical element of returning an athlete to play following injury, and an ability to understand each others "territory" is mandatory.

The physiotherapist and medical practitioner have a potentially critical role to play in helping safeguard the athlete; however in order to do so they require dedicated time in the training environment to observe and develop the necessary practical knowledge and expertise. Similarly, strength and conditioning specialists must have a comprehensive grasp of complex injury risks. Understandably many practitioners in both fields might baulk at the time commitment involved; nevertheless, with accumulating evidence for the benefits of appropriate conditioning in injury prevention, this is what is required to fulfil the role of a sports physiotherapist or doctor in the context of performance sport.

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Response to Strength and conditioning theory and practice - A need to know
by Paul Gamble

DUNCAN REID

In the aforementioned article and based on a recent consensus statement published in Medicine and Science in Sports and Exercise,[1] Mr Gamble comments that sports medicine practitioners (doctors and physiotherapists) need consider their competencies with respect to the application of strength and conditioning exercise programmes. In addition, he considers the relevance of advanced training modes from a sports injury view point.The author has demonstrated the benefits of strength training not only in sporting populations but across the lifespan and in particular with female athletes. However, there are a couple of areas that require some comment.

In the summary at the end of the paper Mr Gamble states: 'Arguably these advanced training modes are under-utilised or at least not optimally utilised in practice currently'. Is it the contention that these advanced training modes such as plyometric's are not being utilised by the doctors and physiotherapists? Whilst the MSSE article suggests what the desirable and essential competencies are, the area of 'advanced exercise' should sit with the discipline most trained to do this, perhaps in this case the strength and conditioning (S&C) discipline. Realistically, it is not possible for any practitioner to be highly trained in all areas of injury management and rehabilitation. The way forward is to develop a team of specialists around an athlete that have a wide range of competencies and by using an inter-professional approach can provide programmes that meet the athlete needs.

In the management of an athlete, both to enhance performance and minimise injury, there will be relevant areas of knowledge and overlap between S&C and sports medicine/ physiotherapy providers. Through their training and practice, sports medicine and physiotherapy providers have extensive knowledge of pathology, biomechanics and tissue healing following injury. In the rehabilitation of the injured athlete these skills are essential and the exercise programmes that are delivered are typically in keeping with the pathological state and the underlying healing process. As the athlete progresses there is a transition stage back to full training and competition that requires a different type of programming. From the other end of the spectrum the S&C practitioners are highly trained in dealing with improving power, strength, endurance and periodisation of programmes to improve athlete endeavour. As these practitioners skills improve they often move further down into the injured realm to assist with the development of the rehabilitation programme. Similarly, the sports medicine group are being challenged to move further into the exercise prescription and programming end of the athlete performance. This transition zone is where competencies overlap, boundary blurring can occur and at times confrontation can result.[2]

Within High Performance Sport,an example of the way this has been managed is via the development of the Movement Competency Screen (MCS).[3] The ability to assess correct movement in preparation for high level sport has been eluded to by Mr Gamble in this paper. The MCS allows an assessment of five key movements, squat, lunge and twist, bend and pull, push up and single leg squat. These movement have been chosen by Kritz[3] as nearly all S&C programmes have some element of push and pull movements. To do these well and progress to increased load and complexity requires an assessment of the key movements before the exercise are prescribed. Those that are deemed to move poorly or who are currently injured are then managed by the medicine/physiotherapy end of the competency spectrum. Those who pass all the tests and are deemed to be moving well, willthen working with the S&C team to maximise their strength and performance. Those in the middle are managed by the two groups in an inter-professional manner, often on the gym floor. As stated by Mr Gamble this can be time consuming in the short term but in the long term provides a more balanced and potentially less injurious way forward.

At HPSNZ the physiotherapy and S&C providers found this a helpful way to deal with issues in the competency transition zone described above. The issue for me is not training more practitioners to have more skills but to use the skills of the current practitioners more effectively in a collaborative, team-based approach. This has always been the strength of working in a high performance environment.

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Posterior ankle impingement

MARK L FULCHER

Posterior impingement is a relatively common cause of pain in the achilles tendon/posterior ankle region.[1,2] Patients will typically present with a localised pain felt about the "back" of their ankle. They will often describe having a painful Achilles tendon and may have been diagnosed, or self-diagnosed, as having Achilles tendinopathy. Their pain is classically made worse with ankle plantar-flexion. My patients commonly complain of pain when kicking a ball with their laces (with the front of their foot), putting on shoes (boots especially) and wearing high heeled shoes.

My experience suggests that there are two primary aetiologies of posterior impingement. Some patients present following an ankle sprain. In this setting, patients find lingering posterior ankle pain which persists after their acute, more generalised symptoms settle. However, the majority of my patients present with a more insidious onset of pain, typically caused by activities which involve repeated plantar-flexion of the ankle.[3] For this reason, it is important to consider the patient's sport or activity. For example, I am far more aggressive when treating football players, with their dominant foot affected, or with ballet dancers who spend a lot of time en point or demi pointe.

On examination, the key finding is pain with a posterior thrust test (that is, forcibly plantar-flexing the ankle). While this is generally described as being done with the patient sitting, I find it easier to perform this test with the patient lying prone and their knee bent to 90 degrees. This position also seems more likely to provoke a response. There is often tenderness around the posterior ankle joint – but not over the Achilles tendon. It is also important to look for evidence of ankle laxity, instability and other possible predisposing factors (including foot posture, poor proximal stability and joint stiffness).

An ankle x-ray is a very useful diagnostic test in patients presenting with this problem. The lateral view is especially useful as it demonstrates the posterior process of talus, its size, and the presence of an os trigonum. In addition, a "lazy lateral" view can often demonstrate the posterior process even more effectively. Some radiology practices provide a view with the ankle in plantar-flexion. While I don't find this a useful image it can help with explaining the problem to the patient. An enlarged, or elongated, posterior process or the presence of an os trigonum can contribute to developing posterior impingement. This bony anatomy can also make the condition refractory to treatment. I do not believe that ultrasound is a useful test for posterior impingement and if I am considering injecting the region, I am increasingly using MRI for diagnostics. After x-ray, this imaging study can give information about both the bony anatomy and the soft tissues. The MRI can demonstrate bone oedema within the posterior process, or os trigonum, as well as soft tissue oedema or an ankle joint effusion.[4] The main value of an MRI, in my mind, is to exclude other pathology including a talar dome injury or syndesmosis injury. Both of these diagnoses can present with posterior ankle pain and similar clinical findings. The MRI can also demonstrate the Flexor Hallicus Longus, injury to which can present with a similar clinical picture. This is not a condition which I have diagnosed often – despite working with quite a large number of dancers.

I think that a careful discussion with the patient about the condition is an important part of the treatment. It is important for the athlete to understand that this is related to repeated plantar-flexion and to look for ways to minimise this stress. I have found in football players that taping the ankle to limit terminal plantar-flexion is important. It is also important to address the overall training load and to look for technique faults. It is important to also treat any associated ankle instability including addressing proprioception and peroneal strength. As discussed, many patients have had a diagnosis of Achilles tendon pathology - and have been given a heel raise and it is obviously important to remove this. I offer patients the option of a course of oral anti-inflammatories and suggest that these be used regularly for a ten day period. Realistically though, I do not think that this is a particularly effective strategy. If they fail to improve with these strategies, or have a need to get better quickly, most patients respond very well to a corticosteroid injection. I do this in my clinic using landmark guidance – rather than ultrasound guidance. I inject one ampoule of kenacort-40 mixed with 2mls of 2% lignocaine using a postero-lateral approach. Using the local anaesthetic allows me to repeat the posterior thrust test to see whether there has been any immediate improvement, thereby confirming the location of the cortisone. I suggest 48 hours without any running following the injection and a return to sport with the ankle taped, as symptoms allow. I do not prescribe a specific timeframe for this and allow the athlete to be guided by their symptoms. I would consider a second injection if there was good initial relief but the symptoms returned some time later, however I do not think that repeated injections are sensible.

A small number of patients have refractory symptoms. If the athlete does not respond to a steroid injection, or only has a transient relief of symptoms, I would typically obtain an orthopaedic opinion. I would also consider obtaining an early orthopaedic opinion in an elite athlete. In this group there may be value in surgical management in the off-season to prevent future recurrence. In this setting, surgical removal of the os trigonum or posterior process (if present) and debridement of the soft tissues generally 'cures' the problem.[3] Most kicking athletes can expect to return to sport about 12 weeks after this procedure.

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Posterior Ankle Impingement Physiotherapy

JUSTIN LOPES

Posterior impingement of the ankle joint can be a frustrating and debilitating injury for any athlete. It particularly affects those involved in kicking sports (eg. football and martial arts), cricket bowlers, swimmers (due to the repetitive nature of the kicking) or ballet dancers (who spend time 'en point'). This can cause soft tissues at the posterior of the ankle to be caught or 'impinged' between the tibia, the talus and the calcaneus, resulting in pain.

During the initial assessment a history of either forced plantar flexion at the ankle joint or repetitive plantar flexion, along with the location of the pain – posterior to the calcaneus but more anterior than the Achilles tendon-would raise suspicion for posterior impingement. The differential diagnosis may include Achilles tendinopathy or enthesopathy, severs disease, or the presence of an os trigonom. I usually test for posterior impingement with the client in supine. Using a gentle but "whip like" rapid forced plantar flexion - followed by a quick apology if the test is positive, as it can be quite sensitive! However, a positive test for impingement does not tell me which structure is being impinged, only that the client has posterior impingement. X-rays can be requested to investigate for bony causes of impingement (which may not settle with physiotherapy), such as the presence of an Os trigonum.

After discussing the diagnosis with the client and demonstrating the condition using photos or diagrams on a tablet I educate the client to avoid aggravating activities – they may need a period off training, or to modify their training to maintain their fitness while avoiding aggravating activities. This can be achieved better on an exercycle, rather than a stepper or swimming, due to the risk of ongoing impingement with the latter activities.

As posterior impingement can often be settled conservatively, a trial of physiotherapy is usually warranted before a referral for further investigations or a specialist opinion. However if the client is an elite athlete, or has had repeated episodes of posterior impingement I would usually refer early. Physiotherapists can refer for x-rays and ultrasound scans which are usually all that is required to delineate the specific structures responsible for the posterior impingement. Physiotherapy management of posterior impingement relies on identifying any contributing biomechanical deficiencies. This requires a comprehensive assessment of the contributing factors including the clients' lower limb biomechanics and strength around the hip, knee and ankle. If I think it necessary I use "Ubersense" (http://www.ubersense.com)on a tablet to slow down a video so I can see the client's movement patterns. In particular, I look at a repeated single leg squat (to see whether they have enough strength to maintain their pelvis level, and whether they can control their knee over their ankle), en point position, or bowling landing foot position more clearly.

I would also look at landing control in both double and single leg. Depending on any deficiencies identified I will prescribe strengthening exercises, dynamic and static stretches and active mobilisations of the ankle joint, taping, cryotherapy, acupuncture, rest, proprioception exercises, and positioning to avoid any aggravation of pain.

During the treatment session I use a variety of techniques to increase the mobility at the ankle joint. With the client standing with the affected foot on a chair I use weight-bearing mobilisations with movement with a seatbelt and posterior glide of the distal tibia whilst actively dorsi-flexing the ankle joint; the goal being to increase dorsiflexion at the ankle joint. Similarly, in supine on the table using a towel or wedge I will also glide the subtalar joint anteriorly and get the client in side lying and glide the subtalar joint medially. I will retest the weight-bearing dorsiflexion using the knee from wall test and repeat a few sets of the mobilisations if we have made some range of movement gains.

If the calf muscles are "tight" I prescribe static stretches for the posterior structures. The 'foot up the door jam' calf stretch, the 'long calf' stretch and the 'short calf stretch – 2 repetitions of 25 second holds - after exercise or at the end of the day. I include dynamic 'marching on the spot' calf stretches into the warm up.

Taping can be a very effective means of reducing the end range plantar flexion forces that typically aggravate the condition, both during training or competition, and in acute or irritable cases. After warning the client of the possible adverse effects of taping – (particularly if it is left on for more than 24 hours), I use a base layer of hypoallergenic tape to cover the ankle and mid-foot. With the client sitting with their leg over the end of the plinth and their foot in dorsiflexion I do a basic check reign strip using 38 mm rigid tape running from approximately 5 cm above the ankle to the mid-foot. This has to be placed on with some tension. I overlay 3 or 4 strips over the anterior ankle in an 'asterisk' shape following the contours of the ankle and including another couple of check reins (see Figure 1). These need to be anchored proximally and distally and then the client is asked to check their range of plantar flexion to ensure they have enough functional range to perform the required functional tasks.

In particularly tender cases, and if the patient is willing, I have used acupuncture to help reduce pain and stimulate the bodies healing response. Usually I would trial GB34, Bl54, KI3, ST36 and LR3 on the affected side, leaving the needles in for 20 minutes. Stimulating them a couple of times, I would follow this with ankle mobilisations and calf stretches described above.. Warning the client about the potential for ice burns I would encourage them to use ice massage for 5 minutes, using ice in a paper cup, or a ice cube to massage all about the posterior ankle following exercise or in the acute stage every couple of hours until the pain settles.

Figure 1: Taping to restrict end range plantar flexion.

I will always prescribe proprioception exercises. Initially standing single leg on a firm surface, and progressing to single leg standing on an air cushion catching or kicking a soft ball with the other foot. Theraband exercises into inversion and eversion in plantar flexion can be done so long as they don't aggravate the condition.

I do have a lower threshold for referral of elite athletes involved in sports who are unable (or unwilling) to rest from training or competition. If the impingement in these athletes is soft tissue in nature Sports Physicans may be able to prescribe a course of NSAIDs or consider corticosteroids with a short period of rest from aggravating activities before returning to rehabilitation. Clients may also benefit from a podiatry intervention to assist with the biomechanical assessment or an orthotic intervention.

Late stage rehabilitation involves progressing the client from pain free single knee bends, through hop testing on flat surfaces to hop and stop on "wobbledisc" or "bosu" type surfaces. This is then progressed to running drills or slow return to sport specific drills such as kicking with a soft ball or smaller size football. Modifying kicking techniques to reduce the forced plantarflexion and taping during the return to sport phase as described above often helps return the athlete to full training.

Return to sport timeframes will vary depending on the clients' severity of impingement, the response to treatment, and the specific requirements of the sport.

Posterior Ankle Impingement Podiatry

JUSTIN CHONG

Clients presenting with posterior ankle impingement are typically referred to podiatry after a period of no improvement inphysiotherapy or after a failed corticosteroid injection. The diagnosis has usually been made prior to assessment and any osseous impingement (eg, os trigonum), bone odema or soft tissue pathology has been identified from x-ray and/or MRI.

My best results have come when I know the structures affected. The focus for podiatry is to minimise kinematic or kinetic loading on the affected tissue(s). As a podiatrist I work along a tissue stress model which implies for every force there is an equal or opposing force, and where there is a disproportionate force, the tissue becomes "stressed". My role is to equalise the forces and bring back equilibrium to the tissue(s).

The key areas I review are:

1 Is plantarflexion the primary stressor? - is the client being put into ankle plantar flexion and how can we minimise this. As Mark has mentioned, often a heel raise is issued to manage an Achilles pain when in fact this could be stressing the osseous/sub talar joint/soft tissues in the posterior region. These must removed and any orthotic that has a high medial rearfoot post/lift, either re-adjusted or removed. This is a situation where less is better.

2 Footwear; sports shoes range in pitch (difference in heights from the heel to toe) from 0-12 mm . I recommend clients choose a sport shoe with a low pitch for posterior ankle impingements. Football boots are often set on a 0 mm pitch, although some have a 10 mm inbuilt raise. These work well in managing other injuries but can aggravate a sensitive posterior impingement and I tend to change these for footballers. Most of the footballers I treat are using Nike or Adidas which all have 0mm pitch. The introduction of rocker systems in running shoes (eg, Hoka One One) can assist in resisting ankle plantar flexion but maintaining forward momentum and I have prescribed these for my runners. Dancers are very hard to treat and I have used an "X-Brace" with taping on some dancers and gymnasts while en pointe.

3 Is overpronation stressing the posterior soft tissue in midstance and early propulsion. Where I suspect a posterior capsule stretch or subtalar joint component that is not affected as much by ankle plantar flexion, I will use an orthotic in conjunction with manual therapy and/or acupuncture. However, I won't use orthotics when there is an osseous component.

4 Gait changes can be adopted in runners. The focus is dependent on what movements stress the posterior impingement. The most common is to reduce ankle plantar flexion at early propulsion by recruiting the hamstrings/gluts at propulsion with a lifting action and depowering the plantar flexion force of the calves. This can work well in clients who are able to adopt the technique. Gradients also need to be considered, and my recommendation is to run on a flat surfaces, treadmills or running tracks. Both uphill and downhill gradients will load the posterior ankle and should be avoided.

Row, row, row your boat ...
The First International Conference on Rowing Science and Medicine

CRAIG NEWLANDS

With the support of a Prime Ministers Scholarship I was pleased to attend the rowing specific "Improving Performance Naturally" conference in Marlow, London in January this year. This was the first ever Sports Medicine and Science Conference of its kind in the world for rowing, being hosted by British Rowing with the support of the World Rowing governing body, FISA. The conference hosted an impressive list of speakers from the leading edge of rowing research and clinical practice. The topics covered over the three days included a wide range of topics from rib stress fractures and cardiovascular health, to "what we know makes the boat go faster from 150 years of research". The latter considering skiff and oar design, technique and training changes, and the changes in body types of champion rowers over time.

Day one began with a presentation by Professor Alison McGregor, who, after initially training as a physiotherapist, went on to gain an MSc in Biomedical Engineering and a PhD in spinal mechanics. Over the past fifteen years she has investigated low back pain in rowers and rowing mechanics from the perspectives of kinematics, muscle function and neurophysiology. She discussed her team's findings with regard to lumbo-pelvic positioning during the rowing stroke where they found that the magnitude of lumbar flexion increases with both fatigue and rowing intensity. Overall, rowers under-utilise pelvic rotation to achieve the catch and finish positions, rather they rely predominately on lumbar rotation. From my perspective, this increased lumbar rotation or flexion at the front of the stroke, where the load on the oar and therefore the low back is high, increases the risk of low back injury. McGregor has found that the more experienced the athlete, the less the change in technique with increasing training intensity. She also highlighted the important relationship between hip flexion range and the lumbo-pelvic positioning at the catch. This had a particular resonance with me as this is a relationship that I have recognised over the past few years, and something that I believe is very important in maintaining low back health in rowers. Addressing hip flexion range of movement and pelvic positioning during the rowing stroke is an essential component of rehab and injury prevention. A further interesting concept of hers was the measurement of the rower's centre of pressure (CoP) on the seat in the boat. They have found that minimising the variability of this during the rowing stroke is important in reducing low back injury risk. Ideally you want to observe a pure anterior-posterior movement of the CoP on the seat, rather than medio-lateral movement. Variation from the ideal may be due to leg length and other structural issues and/or motor control and techniques issues. Although this would be difficult to assess clinically without the force measurement equipment available at Imperial College, this concept is something worth considering in rowing athletes you may be treating with low back pain – or in those you are trying to prevent the development of lumbar issues!

Rib stress fractures (RSF) are one of the most serious injuries sustained by rowers. They have been reported at all levels of rowing, and with a recovery time of between two to eight weeks they account for the most time lost from on-water training and competition of any rowing injury. The lifetime prevalence of RSF is thought to be between 6% and 12% of rowers. Dr Anders Vinter is a physiotherapist from Denmark who completed his PhD studying these injuries in elite rowers. Vinter has found that upper body dominant rowers have a higher risk of RSF than lower body dominant rowers. Rowers who have relatively stronger arms and upper bodies than legs will use upper body strength more when rowing, and therefore load their ribs more. He talked about his study that looked at elbow flexor strength compared to knee extensor strength as a ratio, where they found that the RSF group were significantly stronger in their arms relative to their legs in comparison to the controls group. Vinter has also found that rowers with a history of RSF have lower bone mineral density (BMD) than those without a RSF history. However, those rowers with a history of RSF have a BMD that is considered normal in the general population, whereas rowers without a history of RSF have a BMD 15% higher than normal. Therefore you would expect that in most rowers you would see a higher BMD than normal. He hypothesised that rower's need a BMD higher than normal to avoid RSF. Although uncommon in the general population, the diagnosis of RSF should be considered in any rower that presents with rib cage pain, and assessment of their rowing technique in regards to upper body dominance, and their BMD should be considered as part of their rehabilitation

FISA has recently introduced a Pre-Competition Health Screening policy that requires all rowers who attend a World Championship event at either junior, under 23 or senior level to undergo a cardiac screen. The cardiac screen should include a questionnaire, examination and ECG. Subsequently, there were a number of talks on cardiovascular health and sudden cardiac death, including a talk by Professor Sanjay Sharma, who was the lead cardiologist for the 2012 Olympic Games and who has been the medical director of the London Marathon for many years. He discussed in detail the structural adaptive changes that a rowing athlete's heart undergoes due to the endurance training.

Overall, the conference was very interesting and it is to be hoped that a second rowing specific sports medicine meeting will be organised at some stage in the future.

I would like to acknowledge the support of the Prime Ministers Scholarship, Rowing NZ and High Performance Sport NZ in facilitating my attendance at this international conference.

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