<u>Why Australia needs a Federal government body devoted to monitoring and preventing sports injuries</u>

By John Orchard, MD PhD

I have been campaigning for the Federal government to set up a body devoted to sports injury surveillance and prevention for the last seven years, with the support of bodies like *Sports Medicine Australia*. The attached papers represent some of the journal articles and editorials I have written on this topic dating back to 2002, along with some of the important studies showing successes in other countries. Australia needs to replicate the successes of the countries that are ahead of us in the prevention of sports injuries.

Hopefully on reading the attached papers it can be seen that:

(1) **Sports injuries represent a major barrier**, perhaps *the* major barrier, **to increased sports participation** in Australia. Just because the Federal government has been ignoring sports injury as an issue for the past decade does not mean that people have not been getting injured! Until we pay proper attention to sports injury prevention, it will remain one of the major barriers to increased participation.

(2) Other countries, such as <u>Norway, Sweden, Switzerland, New Zealand and the province of Quebec in Canada</u>, have shown that a nationwide approach to sports injury surveillance and prevention *can* actually work and **save net dollars**. Through Medicare, the private health insurance subsidy and grants to state governments for public hospitals, the Federal government is spending a huge amount of money on sports injuries already. Just because this huge amount isn't being counted doesn't mean it isn't being spent! Although there would be some start up costs in creating a body devoted to sports injury by the Federal government, the cost/benefit equation would be similar to "Quit Smoking" bodies – small outlays would lead to big savings. New Zealand has already shown that in some of their government sports injury prevention policies they have saved over 20 times the government outlay. The attached papers include a blueprint for what such a body could quickly do in a **cost-effective manner** to achieve the successes that have been achieved elsewhere.

Australia urgently needs a federal government body dedicated to monitoring and preventing sports injuries

John W Orchard, Stephen R Leeder, Gary E Moorhead, Jessica J Coates and Peter D Brukner

Financial motivation can encourage greater sports injury prevention efforts

A landmark study published recently in the *BMJ* has shown that the rate of catastrophic spinal injury in rugby union in New Zealand has halved.[1] For the period 2001–2005, the rate was 1.3 spinal injuries per 100 000 players per year, compared with 2.7 per 100 000 players per year in the period 1996–2000, which was typical of the previous 25 years.[1] This drop coincided with the introduction of "RugbySmart" (http://www.rugbysmart.co.nz), a 10-point annual injury prevention program that was made compulsory from 2001 for all coaches and referees in New Zealand.[1,2] While the observational study does not claim that the drop in catastrophic spinal injuries can be unequivocally attributed to RugbySmart, an accompanying editorial in the *BMJ* stated: "The beauty of the RugbySmart programme is that it can do no harm, and according to the results of this study may do great good".[3]

What is the current state of play with respect to catastrophic spinal injuries in rugby in Australia? Although comparisons of spinal injury rates between New Zealand and Australia are difficult,[1] recently published rates in Australia are substantially higher (between 3.2[4] and 6.8[5] injuries per 100 000 players per year). New Zealand is in a much better position to accurately determine incidence rates because compensation for all injuries (both sporting and from other causes) is available through a universal, government-funded scheme operated by the Accident Compensation Corporation (ACC).[6]

From 2005, the Australian Rugby Union (ARU) instituted a similar (but less extensive) program called "SmartRugby" for its referees and coaches. Tests of its effectiveness have not been reported, but it should be noted that the ARU does not have nearly the same financial motivation as the ACC to make it successful. In New Zealand, the ACC compensates for all catastrophic spinal injuries with lifetime medical care and annual replacement of 80% of wages, which can be up to NZ$14 million per case.[2] In Australia in 2005, the maximum compensation paid to a rugby player rendered quadriplegic was A$300 000, accurately described by Carmody et al as "grossly inadequate".[4] This is particularly so when compared with a median payout of A$7.6 million for quadriplegia in recent negligence cases in Australia.[7]

Orchard and Finch argued in 2002 that, from a public health viewpoint, New Zealand's system of maintaining a government body that monitors, compensates and seeks to prevent sports injuries is superior to Australia's lack of any comparable system.[6] Noakes and Draper suggested that New Zealand's drop in spinal injuries "would not have been possible if the New Zealand government did not provide a national insurance policy that also covers sports injuries".[3] The ACC can also claim other successes in preventing sports injuries that we have not yet achieved in Australia. Mouthguard use in rugby in New Zealand has increased from 67% to 93%, reducing rugby-related dental claims to the ACC by 43%.[8] A similar analogy can be used — in Australia there is no organised body paying dental claims, so there is no strong financial motivation to encourage increased mouthguard usage.

The ACC is already in the position where it is evaluating New Zealand's national sports injury prevention programs (in many sports) for cost-effectiveness, in terms of reducing injuries and claim payments.[9] By comparison, in Australia there is generally no monitoring of sports injury rates, let alone well coordinated national sports injury prevention programs in place. If a national body was created in Australia to take on this role, even if it was not fully funded out of general revenue like the ACC, at the very least it could insist that federal government funding for sports be tied to minimum standards of monitoring injury rates and instituting injury prevention programs.

Reducing work-related and traffic accidents have been listed as two of the top 10 public health achievements of the 20th century.[10] These achievements would not have been possible without major bodies having responsibility for monitoring injury rates and instituting preventive measures. New Zealand is already showing that this model works equally well for sports injuries, so why should it not be applied in Australia? A new federal government body would cost money to establish and maintain, but the New Zealand experience suggests that subsequent savings may soon cover the costs of establishment and operation.[2]

In conclusion, the following matters deserve our urgent attention in Australia:

- The creation of a federal government body either primarily responsible for monitoring and preventing sports injuries or, at the very least, delegating these responsibilities to sporting bodies in a coordinated fashion.
- This body should compensate for injury, either (1) totally, as is the case in New Zealand; or (2) partially, in conjunction with sporting bodies, private insurers, public hospitals and Medicare.
- The minimum compensation for complete quadriplegia occurring in sport in Australia should be increased at least tenfold, both (1) to bring compensation for sporting quadriplegia more into line with compensation for quadriplegia arising from other causes; and (2) to give compensating and sporting bodies a much stronger financial motivation for prevention, as is the case in New Zealand.

Competing interests

John Orchard is a board member of the New South Wales Sporting Injuries Committee (NSWSIC), but the views expressed here are his own and not reflective of the NSWSIC.

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Draft Consensus statement about Sports Injury Surveillance and Prevention in Australia

By John Orchard, Caroline Finch & Gary Moorhead

This statement is in draft form only, for discussion and response. It is hoped that it can be amended by stakeholders over the following months to a version where multiple sports medicine and sporting bodies in Australia would be prepared to agree to it. Please direct any feedback to John Orchard via SMA at lesley.crompton@sma.org.au .

1. **The rationale for sports injury prevention as an important contributor to fighting inactivity.** Inactivity will soon surpass smoking as the most costly preventable risk factor for premature death in Western countries [1]. Despite this, up to 50% of the potential health gain of increased sport and exercise may be lost because of the effects of injury [2]. Therefore sports injury prevention is a critical component to successful exercise promotion [3-5]. An increasing number of countries are recognising this important link and establishing or improving national sports injury surveillance systems [6]. Preventing obesity has just been announced as a new National Health Priority Area in Australia[7]. Injury prevention and control is already one of the seven established National Health Priority Areas, although within this category, sports injury is not currently considered[8]. The nexus between there two areas should no longer be ignored. Preventing sports injury should also be seen as a national priority with respect to both categories: avoiding injury and preventing inactivity and obesity.
2. **Australia does not currently follow world's best practice in sports injury surveillance.** Australia has no national system for monitoring and preventing sports injuries [6 9-11]. This deficiency, whilst it persists, is causing us to fall further behind world's best practice in this area. We are in a strong position to copy some or all of the system(s) of our close neighbour New Zealand. Popular sports in Australia are also popular in New Zealand, which has had a national sports injury surveillance system in place for many years. As a result, New Zealand is far more advanced than Australia in successfully achieving sports injury prevention[12]. Other countries, in particular those of Western Europe and Scandinavia, currently have much more advanced systems than Australia[6].
3. **The Federal government is the most appropriate body to coordinate sports injury prevention.** The Federal government, through its Department of Health, is in the best position to set up and fund a national sports injury surveillance and prevention body [6 11 13]. This could follow the New Zealand (or Scandinavian) model, where a government funded body (as opposed to the multitude of sports) is responsible for national coordination of sports injury data. In Australia the Federal government is the body which bears the greatest cost of sports injuries [13] (through, collectively, Medicare, private health insurance rebates, and indirectly through public hospital subsidies to state governments). Therefore the Federal government would potentially have the most to gain financially from successful sports injury prevention, as has been the case in New Zealand [12]. There are very few sports in Australia, if any, which would be wealthy enough to be able to fund their own national injury surveillance schemes as the vast majority of people playing sport are amateurs. There is also little financial incentive for sports to fund injury surveillance given the reality that government institutions (along with individuals) pay for most of the cost of sports injuries. The costs of sports injuries in Australia, whilst not specifically known, are substantial. In New Zealand the costs of sports injuries actually exceed those of traffic accidents [14]. In Australia, traffic accidents are known to cost A$17 billion annually [15]. In Switzerland, a country with one third of Australia's population, there was an annual cost for sports injuries in 2003 of €1.3 billion with indirect costs being €8 billion[16] and with 5.6 million working days lost. Extrapolating from these recent figures it is very likely that previous calculations of the costs of sports injuries in Australia were gross underestimations. The total annual cost of sports injuries in Australia would be likely to exceed A$10 billion.
4. **The benefits, even in the short term, would easily outweigh the costs of improved sports injury prevention in Australia.** Sports injuries are already very costly for the Australian health system and for the individuals who suffer from them. It would be even more costly for the Federal government to compensate sports injuries to the level evident in New Zealand. This would require careful consideration of the huge costs involved and the relative benefits. However, in the interim, a surveillance and prevention body could be created with a significantly more modest budget. It is likely that such a body would demonstrate, as in New Zealand [12], cost savings to the government (far exceeding implementation costs) from programs such as:

a. Coordinating expansion of the Australian Spinal Cord Injury Register (ASCIR) [17] to include a section which reports annually on spinal injuries specifically in sport, reflecting the success New Zealand has had in prevention of spinal cord injury in sports such as rugby union [18-20].

b. Creation of a national knee Anterior Cruciate Ligament (ACL) registry, modelled on the successful registries in the Scandinavian countries [21]. This could use data from Medicare and public and private hospitals. ACL injuries perhaps account for 10% of the cost of *all* sporting injuries in Australia and therefore should be a priority for prevention. A substantial proportion (estimated at over 20%) of the 25,000 or more knee replacements performed annually in Australia have their genesis in ACL injuries.

c. Creation of a program to substantially increase the rate of mouthguard usage in contact sports, by encouraging rule changes and perhaps targeting a rebate for dental injury treatment for those players who are injured whilst wearing a mouthguard. This would also replicate the success of New Zealand in increasing mouthguard usage [22].

d. Compulsory compilation, in return for a fee, of de-identified injury data from those bodies which already collect sports injury data in Australia (private health *and* sports insurers *and* public hospitals). This data would form the basis of an annual report into trends regarding sports injuries in Australia.

e. Arising out of item d., recommend and activate research and prevention based on annual statistics of sports injury in Australia.

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How a national sports injury body could work in Australia

John Orchard, Jessica Coates, Gary Moorhead

Background

Sports injuries are a substantial cost to the health system in Australia. Financially, the burden may now be close to $2 billion in direct costs [1]. Sports injuries also have a negative impact on the amount of exercise that Australians undertake. Currently almost half the population (47 percent) do not meet the minimum amount of physical activity for preventing those diseases associated with inactivity [2]. Those who are injured are often unable to exercise and, in addition, fears of injury and/or injury costs are barriers to Australians who are considering taking up exercise. Most importantly, there is increasing evidence that some sports injuries are preventable if managed systematically by government[3]. The basic template for systematic sports injury prevention was described by Van Mechelen in 1992. This involves four stages as shown in Table 1

Advancements on the Van Mechelen paradigm have been described, including a Translating Research into Injury Prevention Practice (TRIPP) paradigm (Table 1) [4]. However, the basic Van Mechelen formula is behind the successful approach of the New Zealand government body the Accident Compensation Corporation (ACC, http://www.acc.co.nz/index.htm) which has demonstrated cost savings from such an injury prevention approach[3].

On this basis, there is a strong argument for Australia to implement a Federal government body with responsibility for monitoring and preventing sports injuries [1, 5]. What is less clear is how to deliver such a body in a way that makes it functional, rather than an overseeing committee with little power or influence on sports injuries. We can look to New Zealand and identify that their system for monitoring, compensating and preventing sports injuries is superior to Australia's position, given our lack of any comparable system[1]. There are some other useful international comparisons, such as Switzerland and Finland (which have national government owned insurers), Quebec in Canada (with has a regulatory board), the USA (which has some national injury surveillance registers) and Norway which has recently implemented a national knee reconstruction register [6].

However, New Zealand is logically where we should look to first, given our proximity, cultural and sporting similarities, the fact that their ACC system has been functioning successfully for over 20 years and also that it has recently demonstrated cost effectiveness of injury prevention programs in sports that are commonly played in Australia[3]. New Zealand also has a much greater proportion of government health spending on public health and prevention than in Australia (7.4% compared to 2.1%)[7] and is not showing the same rate of increase in obesity being exhibited in Australia [7]. As certain sports injury rates in New Zealand also appear to be lower than Australia[5], there is a strong argument to use the New Zealand system as a benchmark for comparison.

Table 1 – TRIPP framework (developed from Van Mechelen)

Stages of injury prevention (TRIPP)	Van Mechelen stage
1. Injury surveillance	Stage 1
2. Establish aetiology and mechanisms of injury	Stage 2
3. Develop possible preventive measures	Stage 3
4. 'Ideal conditions' scientific evaluation of preventive programs	Not included
5. Describe implementation of preventive programs into 'real world'	Not included
6. Monitor success of intervention	Stage 4

Comparison with New Zealand system

A quick glance at the current Australian and New Zealand system leads to the view that it would be difficult to import the New Zealand ACC structure in its entirety (Table 2). Sporting bodies might find some advantages with this option, but there would be plenty of opposition to such a proposal in Australia from powerful lobby groups including the following:

- Sports insurers, who would instantly lose all of their business overnight to a government monopoly.
- Private health insurance companies, who would lose one of the major incentives for younger members to join (that, currently, operations for sports injuries are able to be performed in a more timely fashion in the private system)
- Some health care providers may also object if the fee schedule for a sports compensation system was lower than their standard charges. The ACC, like the Workers Compensation systems in Australia, funds patients 100% for their health care, but caps payments. Workers Compensation bodies in Australia keep the peace with health care providers by making their capped payments very generous. However, the Australia public would be unlikely to fund generous payments to all providers out of general revenue, with health care providers unlikely to be happy with capped payments that weren't lucrative.

Table 2 – comparison of New Zealand and Australian systems

Characteristic	New Zealand system currently	Australian situation currently	Desired Australian situation (?)
National surveillance of all sports injuries by a single body	Has been implemented for >20 years	Very little data kept with no monitoring of this data	Highly desirable in the longer term. However, if a single government payer was not implemented, the more cumbersome option of paying multiple bodies (Medicare, sports insurers, private insurers, sporting bodies, public hospitals) for their data would be required.
Preventive programs to lower the rate of sports injuries	Already in place for 8-9 major sports with some very effective [3]	Haphazard at best and non-existent in many cases	We must move in this direction, but as per the Van Mechelen [8] and TRIPP [4] paradigms, successful injury surveillance is a crucial stage towards this.
Full government compensation for immediate treatment of all health care costs associated with sports injuries	Already in place for all sports. However, covers 'acute onset' injuries only	No Federal government compensation other than Medicare (+indirectly through public hospitals and private health rebate)	Full compensation may not be affordable or necessary (given that it is not currently taken for granted by Australians). However, partial compensation may be affordable (and in fact a necessary incentive to obtain sports injury data)
Full government compensation for lost wages when unable to work due to a sporting injury	Already in place for all sports. At an extreme, this means that someone totally permanently disabled by a sporting injury could receive lifetime compensation payments of up to NZ$14 million [5, 9].	Not available. Lump sum insurance payments for total and permanent disablement (e.g. quadriplegia) from sport are currently not greater than A$300,000 [5, 10]	Similarly this may not be considered affordable. However, partial compensation, if affordable, may be an incentive towards encouraging physical activity. Such a government body must also contribute to solving the inadequacy of current insurance payments for total and permanent disablement from sport.

- Plaintiff law groups, who would fear that any move towards a no-fault universal sports injury compensation system would also be accompanied by the New Zealand style restrictions on right to sue for negligence involved in sports injuries.
- Fiscal conservatives in the Federal government who saw government support of sports injury insurance as substantially a form of 'middle-class' welfare would also need convincing that such a system was cost effective.

The potential objectors listed above makes the problem of implementing a national sports injury insurance scheme in Australia somewhat analogous to the much bigger issue of the entire health care system in the United States. From the outside, it is easy to point the finger at the USA's inefficient privatised health system and insist that they should implement a nationalised government system to replace it. However, with the pre-existing massive private health infrastructure in the USA, starting from scratch with a government system appears to be close to impossible to achieve. Many Americans, along with their associated lobby groups, would be certain to object to the job losses, tax increases and waiting lists that would be part of a government monopoly system, despite the potential advantages of better health outcomes for much of the population.

It is not constructive just to assert that it would impossible for the New Zealand system to be translated over to Australia and therefore to conclude that nothing better could be done in this country. Table 2 lists the advantages of the New Zealand system showing which features should be a high priority for implementation in Australia and those which may be considered less feasible or affordable. An important aspect of Table 2 is the concept that a 'partial compensation' model may be a 'middle ground' which could make a national system acceptable. A Federal government contribution towards sports insurance claim payments and private hospital episode payments, payable only on receipt of episode injury data, solves many problems in one hit. It is a government contribution towards those playing sport (and hence a 'rebate' for the physically active), it forces recording of basic injury data details and it would put sports insurers and private health insurers 'on side' with the new system. In a similar fashion, the government would need to add an additional rebate within its own Medicare system to facilitate collection of data (for example, a 'bonus' rebate per attendance payable on receipt of diagnosis, sport and basic mechanism information). The amount per episode needs to be calculated as a trade-off of cost vs. compliance (i.e. what is the minimum cost to government which would lead to acceptable compliance by data providers). It may be sensible to trial such a scheme in a pilot region (e.g. ACT) to gauge whether a small co-payment is enough to capture the majority of data or whether more generous payments are needed.

An alternate option would be to make sports (and perhaps other non-traffic and non-work) injuries ineligible for Medicare payments, but to create a parallel Federal government system. This system could differ from Medicare in that (1) rebates were slightly more generous, giving an incentive for this system to be used over Medicare with a qualifying injury, but (2) rebates were only paid on receipt of basic injury data. Finally, consideration would need to be given to partial government funding of paramedical presentation for sports injury, such as physiotherapy, podiatry and exercise physiology. The most effective model for this in Australia would probably be in a similar vein to physiotherapy rebates after 'chronic care' plans have been completed by the GP, using GPs as a gatekeeper for appropriate referrals (for limited visits).

Weaknesses of the New Zealand system

Table 3 lists some of the weaknesses of the New Zealand system, with a view that some of these structural weaknesses could be prevented when designing an Australian system from scratch. One of the biggest strengths of the New Zealand system is that by generously funding sports injury, the New Zealand government is providing a government support or 'rebate' for sports and physical activity. Just as all Western governments now heavily tax smokers, it would theoretically be sound for governments to 'tax' inactivity, as inactivity is closing in on smoking as the greatest preventable cause of disease in Western society [11, 12]. However, the New Zealand system, by rebating on an injury-by-injury basis, is giving relatively higher rebates to the riskier sports. The theoretically-perfect sport or exercise which provided all of the health benefits of physical activity but with a zero risk of injury would therefore receive no rebate under the ACC system. By contrast, sports which are so likely to cause major injury that their net health risks exceed their benefits are those which are most generously funded under the ACC model. It is perhaps not coincidental that 'extreme' sports seem to have greater popularity in New Zealand than in other countries.

The realistic model for Australia: implementation in stages

A premium model, with semi-fixed government contributions for all active individuals, would give stronger incentives towards participation in the safest sports. By capping government contributions to riskier sports, such a system could reduce the amount of government funding required, compared to the New Zealand model, and arguably gives greater incentive towards participation in safer sports. Those individuals who are regularly active in sports that are proven by claims received data to be highly safe (for example, power walking, indoor cycling, swimming, golf, pilates) may have their entire premium and injury payments funded by the government system, as a reward for participating in exercise with excellent risk-benefit profile. Generous government contributions (but perhaps not 100%) could be awarded to sports with a 'healthy' profile but low-medium risk (for example, tennis, surfing, touch football, basketball, cricket). Contributory payments could be made to high risk sports (for example, rugby league and union, skiing, horse rising) which would still require substantial individual funding of injury episodes and/or premiums, with a strong incentive for these sports to devote major resources towards lowering injury rates to move downward in injury incidence to a more generous level of government funding.

However, in the short-term the Australian government may not be in a position to commit substantial funds to sports injury surveillance and prevention. A model which is more likely to be embraced by our government is spelt out in Table 4. This involves implementation of sports injury surveillance and prevention in stages. Stages 1 & 2 may be acceptable to the government at comparatively low cost, with the expectation that stage 2 may be able to lead to demonstrated prevention of injuries in the medium term. Areas that are suggested as priorities for stage 2 include spinal injuries in sport, dental injuries in sport and knee ACL injuries. The New Zealand experience suggests that spinal injuries in rugby are somewhat preventable[3, 9, 14] and it would not require a great deal of government funding to expand Australia's existing spinal cord registry[15] to include an annual assessment of injury incidence rates in the major high-risk sports. Dental injuries have been shown to be highly preventable under the New Zealand model [13]. Knee ACL injuries are one of the strongest risk factors for knee osteoarthritis, which is one of the most prevalent chronic medical conditions in Australians [16]. Norway has recently successfully instituted a national ACL register [6] based on a similar model to international registers on joint replacements. It is noteworthy that the recent report on Osteoarthritis in Australia[16] highlighted both regular

Table 3 – strengths and weaknesses of the New Zealand system

Strengths of the New Zealand system	Weaknesses of the New Zealand system
• Excellent data collection for all sports injury episodes • Generous compensation for those injured during activity (a government 'rebate' for the active, providing an incentive for physical activity and sport) • Strong incentive for the ACC to fund prevention programs to reduce claims • Prevention model is able to be applied, although with some limitations • Cost effectiveness of preventive programs can be tested	• Weak collection of exposure data (best estimate is number of active participants in each sport, but no record is made of participation time for each individual) • Very little measurement of intrinsic or extrinsic risk factors for injury in the ACC model (for example ACC does not receive data to detect if there are more injuries than expected at a certain playing venue) • As sports and players don't pay premiums themselves (or even contributions to injury episodes), there is little financial incentive for the sports themselves (as opposed to the ACC) to reduce injuries • 'Acute' injuries are funded by ACC model but not 'overuse' or gradual onset sports injuries, providing an incentive for players to falsify mechanism data in order to gain funding.

Table 4 – possible stages of implementation of a national sports injury body

Stage	Additional responsibilities of national body	Specifics	Relative cost
1.	Creation of a body with responsibility for sports injury prevention and monitoring.	National board reporting to sports and/or health ministry.	Minimal and recommended immediately[1, 5].
2.	National monitoring and prevention programs for a specific small number of conditions for which successful prevention programs have already been demonstrated.	(1) spinal injuries in sport[3]; (2) dental injuries in sport[13]; (3) knee anterior cruciate ligament (ACL) injuries[6].	Moderate, although New Zealand has already demonstrated cost effectiveness[3].
3.	Local implementation of a pilot for monitoring of all sports injuries (and then further prevention efforts arising from this monitoring).	Perhaps ACT would be a good size jurisdiction for such a pilot.	More substantial. Would be an appropriate investment if stage 2 has proven effective.
4.	National implementation of monitoring of all sports injuries.	Expansion of stage 3 pilot.	High, so appropriate when stage 3 has proven cost effectiveness.
5.	Full government compensation for all sports injuries (both organised sport and casual activity).	System already in place in New Zealand.	May be appropriate later when funded national physical activity targets are in place.

exercise (to avoid obesity and muscle weakness) and avoidance of joint injury when playing sport as important ways to prevent osteoarthritis. It is clear from this example that in promoting exercise, which is critical, Australia must not neglect sports injury prevention.

If successful prevention of injuries from stage 2 (and the resultant decrease in costs to Medicare and the public hospital system) can be demonstrated, further stages may be approved for funding.

Link with physical activity promotion

A further advantage of getting better data on the activities that individuals are participating in (despite its cost) would be that this information could drive greater government action on promoting physical activity. A national sports injury system should have the triple aims of: (1) enrolling as many members of the public on to a register of regular participation of sports and exercise in some form (2) encouraging individuals to choose sports with relatively safe benefit-risk profiles in terms of disease prevention through fitness compared to injury risk (3) encouraging the sports themselves to make as many interventions as possible to improve their own benefit-risk profile in order to further recruit participants to the sport.

Although not related to the core aims of such a body (i.e. injury surveillance and prevention) because of the potential to record realtime sports and exercise participation statistics, such a body could assist with exercise promotion objectives. For example, a potential vehicle for promoting participation in physical activity could be the Federal government's private health insurance rebate. Currently this rebate is 30% of all premiums paid for young and middle aged citizens but up to 40% of all premiums paid for older individuals. The 40% benefit for the elderly is extremely generous and perhaps a 'sop' to the grey vote, when it is remembered that the enforced principle of community rating is already a massive subsidy to the elderly. Community rating means that all members pay the same premiums regardless of risk, so the elderly (whose true risk-rated payments may be over ten times higher than some younger members) are very generously looked after even prior to the bonus 10% extra rebate. Perhaps the 10% bonus for the elderly could be phased out and replaced with a 30 vs 40% distinction based on proof of low patient risk through modifiable factors. To be eligible for the 10% further bonus on the rebate, a member may need to prove that he or she: (1) is a non-smoker (2) has maintained health body weight (e.g. BMI <30) (3) undertakes regular physical activity. Such a policy would further encourage healthy behaviour and would provide justification for physical activity statistics to be collected for individuals that could be used to judge eligibility under part (3).

Conclusion

Irrespective of the final powers and structure of a national sports injury surveillance and compensation system, establishment of a working party should be a new Federal government priority[5]. Such a working party could:

- Debate the possible systems that could be implemented in Australia.
- Assess funding models for the various options.
- Assess likely beneficial effect (or otherwise) on physical activity levels in Australia based on the various models.
- Receive submissions from interested stakeholders, such as national sporting bodies, the private health and sports insurance industries, Sports Medicine Australia and health provider organisati ons such as the AMA and APA.
- Make recommendations to the Ministers for Health and Sport.

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Preventing sports injuries at the national level: time for other nations to follow New Zealand's remarkable success

John W Orchard

Imagine yourself reading an editorial in *Traffic Injury Prevention* about the best system for preventing and managing traffic accidents. The editorial suggests that it is wrong for national governments to take an interest in preventing and managing road trauma. It argues that competition among car manufacturers, local governments and trauma hospitals can be relied upon to ensure road safety. It asserts that driving a motor vehicle is an inherently risky activity and that motor vehicle users should not expect non-driving taxpayers to help fund national government involvement.

As you read that editorial you disagree vehemently, perhaps even feeling outrage. You are aware that the countries in which national government bodies are dedicated to preventing and managing traffic accidents have excellent records at lowering mortality and have lower rates of injury than those countries without organised systems.[1] You appreciate that the editorial mounts an argument that may sound good in theory, but in the real world it has been proven wrong. The *laissez-faire* ("do nothing") approach to traffic injuries costs countries like India (which lack necessary government infrastructure) thousands of deaths per year compared with countries that have nationwide systems dedicated to lowering traffic injuries.[2]

Now imagine a similar editorial about sports injuries in the *British Journal of Sports Medicine*. Very few countries have a national government body taking responsibility for sports injuries. Generally, countries rely on the general health system, sports organising bodies and individuals themselves to manage and prevent sports injuries (the *laissez-faire* government approach). Some countries (particularly in Western Europe) have elements of a nationwide approach to managing and preventing sports injuries.[3–10] However, only one country—New Zealand—has a completely socialised and universal approach to managing and preventing sports injuries; it uses the same template that is used for traffic injuries.[11] Have we reached a point where we can assess the relative value of the widespread government *laissez-faire* approach versus a socialised approach to managing and preventing sports injuries?

In 2002 Finch and Orchard argued that New Zealand's socialised approach to preventing sports injuries should, in theory, be superior to the approach of countries like Australia which has a *laissez-faire* national government approach.[12] This argument was largely based on the fact that such an approach had proved superior for traffic injuries.[12] In 2008 there is evidence to say "case proven"—what works for traffic injuries *does* work for sports injuries.[11] Researchers working with the New Zealand Accident Compensation Corporation have reported that:

- With the benefit of a nationwide prevention programme,[13] New Zealand has lowered the incidence rates of catastrophic spinal injuries in rugby union by over 50% for the entire country.[14] The incidence rates in New Zealand are now far lower than the latest reported rates for rugby union in countries such as Australia, South Africa and England.[11 14 15]
- With the benefits of nationwide prevention programmes, the rates of mouthguard usage in contact sports have substantially increased and the rates of dental injuries have substantially decreased.[16]
- The costs of administering and implementing major nationwide sports injury prevention programmes have been shown in most cases to be far cheaper than the direct and indirect medical costs for the sports injuries prevented.[17]

Can we compare the scoreboard in New Zealand with other countries? For the most part we can't, because countries with a government *laissez-faire* approach to sports injuries generally don't keep *any* records (let alone comprehensive ones) of national sports injury rates.[12] However, to use this lack of comparative data as an excuse for inaction would be a "head in the sand" approach.[12] There are examples in other countries where good national injury databases are kept and some preventive measures instituted.[3–5 9 18 19] Unfortunately, there is still a feeling that in most situations in other countries we are losing the battle against sports injuries. Why is this still the case?

It is now over 15 years since van Mechelen outlined the sequence of steps towards sports injury prevention in *Sports Medicine*.[20] What seemed like an easy blueprint has not, however, led to widespread success in sports injury prevention. One barrier to progress has been the lack of conformity in injury definitions among authors, and this has led to the publication of consensus statements.[21–23] Finch has also recommended that additional stages should be added to the van Mechelen paradigm.[24] In this TRIPP (Translating Research into Injury Prevention Practice) paradigm, steps are added to ensure both that experimental research is applicable in the real world and also that proven preventive measures are actually applied by sports and individuals.[24] This final additional step may involve lobbying for rule changes and using the media to encourage uptake of preventive measures.

Perhaps, for most countries, the lobbying needs to come at the start rather than the finish. New Zealand (and perhaps a few Western European countries) can currently apply the van Mechelen and TRIPP paradigms to sports injuries nationwide as they have national injury surveillance systems in place. Most other countries of the world cannot. If it is recognised that the New Zealand approach is superior—which it now should be[13 17]—other countries need to lobby to have their national governments form sports injury surveillance and prevention bodies.[11] It is difficult to convince governments to spend money on new ventures, but perhaps the twin approach of presenting the successes of New Zealand and promoting safe sport as a key government obligation in the prevention of obesity will have an impact.[11] We can also learn from the fight against cigarette smoking that there can be a delay of decades between the identification of the correct action to take and the successful lobbying of governments to implement the required action.[25]

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This month Norway hosts the 2nd World Congress on Sports Injury Prevention and we are reminded that this sparsely populated country arguably leads all nations in the science of preventing sports injuries.[26–31] It is a remarkable coincidence that a similar size country, on the opposite side of the world but also replete with fjords and glaciers, is emerging as the leading challenger to the world title in this most important competition! New Zealand's system for preventing sports injuries is not perfect[8] but, in 2008, it is the home of the world's best nationwide system for preventing sports injuries and this deserves recognition.

There is global agreement that universal national efforts prevent traffic injuries. In the future, it is logical that this approach will be seen to be just as essential for sports injuries in enlightened countries. The majority of us, living in countries with systems inferior to the New Zealand approach, have a hard task over the next few years to lobby in favour of nationwide systems. We cannot all have fjords and glaciers, but we can try to emulate world's best practice at preventing sports injuries.

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FOR DEBATE

Australia needs to follow New Zealand's lead on sports injuries

John W Orchard and Caroline F Finch

Sports injuries result in substantial costs to the Australian community and also act as a barrier to increased participation in physical activity. However, the Australian healthcare system has no coordinated approach for monitoring or preventing sports injuries. This is in contrast to New Zealand, which has a specific body responsible for managing sports injuries, in a similar way to work injuries and traffic accidents. ***(MJA 2002; 177: 38-39)***

AS LACK OF EXERCISE is an established major risk factor for many chronic illnesses (particularly heart disease) and premature mortality, it is incumbent on government bodies to promote physical activity.[1] However, one in five adult Australians is prevented from being more physically active by injury or disability.[2] Thus, minimising injury associated with sports and physical exercise also needs to be a government priority.

Sports injuries in Australia are treated by a combination of medical and paramedical services, occasionally in public or private hospitals, but mainly in an outpatient setting. Although the Australian healthcare system provides universal "safety net" coverage for sports injuries at a relatively affordable cost, it has no plan for *prevention* of sports injuries. Perhaps this is because the government departments concerned with sport and health consider there is insufficient evidence to show that the burden of sports injuries is substantial and that many of these injuries could be prevented. But government bodies would be unwise to ignore the recent trend in Australia towards the regular occurrence of serious sports injuries that are leading to an increase in liability claims. The flow-on increases in insurance premiums are placing many community sports events, active recreation facilities and voluntary service providers under great financial pressure.

The burden of sports injuries

The cost of sports injuries in Australia was an estimated $1 billion a year in 1990[3] (we are not aware of any more recent published figure). Extrapolating from cost estimates made in a 1998 Victorian study,[4] we estimate that sports injuries now directly cost the Australian community at least $1.65 billion a year. Although this figure may be disputed, it is a circular argument to suggest that no resources should be devoted to accurately counting the costs of sports injuries in Australia because there is no hard proof that the costs are substantial. Both injury frequency and associated costs need to be counted to derive cost–benefit ratios for any countermeasures implemented.[5,6] Moreover, injury surveillance is the first stage in any program of sports injury prevention.[7]

Various factors conspire to prevent the incidence and public health burden of sports injuries in Australia from being adequately monitored.[6] The Burden of Illness and Injury estimates for Australia[8] do not reflect the true burden of sports injuries because (a) such injuries are rarely fatal;[9] (b) limitations of the *International Classification of Diseases* (*ICD-9*),[10] upon which they are based, prevent adequate identification of sports injuries;[11] and (c) most sports injuries are not treated in hospital settings, where patient data would be retained centrally.[11] The Medicare system that operates outside hospitals does not collect information about diagnosis or associated factors for patient consultations. It also prevents any other body from providing rebates for outpatient doctor visits, so there is no other organisation that could easily collect information about the number and cost of sports injuries treated by doctors in private practice.

Moves towards national injury surveillance and prevention in Australia

The Australian Sports Injury Data Working Party was established in 1997 to draw up guidelines for sports injury surveillance, but, despite the release of a working data dictionary,[12] no national body has since been funded to implement an Australia-wide approach to sports injury surveillance.

In 1997, a Federal Government partnership led to the development of a national sports safety framework.[13] However, since the late 1990s, there has been a notable lack of national leadership to implement this framework.

The Strategic Injury Prevention Partnership, a group set up in August 2000 that represents health departments in all jurisdictions, is responsible for implementing the *National injury prevention plan: priorities for 2001–2003*. However, the Plan does not list the prevention of sports injuries as a priority.[14] One major reason for this is that considerably less is known about sports injuries and their risk factors than other injuries such as falls, drownings and road trauma.[5,15]

New Zealand's sports injury compensation scheme

For a model of sports injury surveillance, Australia could look to New Zealand, which already has in place the infrastructure to monitor sports injuries. New Zealand's Accident Compensation Corporation (ACC) monitors sport, traffic and work injuries as a distinct segment of the healthcare system. The ACC can accurately determine the

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cost of treating sports injuries in New Zealand (eg, the cost was NZ$100 million in 2000).[16] Furthermore, ACC statistics have shown that the number of sports injuries in New Zealand has fallen over recent years.[16] Perhaps this decline is partially due to the preventive efforts of the ACC. It is quite possible that, in relative terms, the cost of sports injuries in New Zealand is lower than the cost in Australia, as New Zealand's scheme focuses on *preventing* injuries.[16]

The New Zealand system also has the advantage of being a "no-fault" insurance scheme that prevents sporting participants taking common law action against either the doctors or administrators associated with sporting events. Similar restrictions to liability actions from sporting participants are needed in Australia to prevent the cost of running sports events from becoming prohibitive, and to remove the fear of lawsuits that is developing among volunteers (including doctors) who cover sporting events. Plaintiff advocate groups currently argue that common law actions should not be restricted because injured athletes in Australia have no form of redress other than through the courts.

Australian initiatives

■ Anterior cruciate ligament (ACL) injuries to the knee, which occur primarily during sporting activities, provide a concrete example of the way that preventive measures could result in huge cost savings to the community. The Australian Football League (AFL), which monitors the number and circumstances of ACL injuries, has estimated that these injuries cost the AFL well over $1 million a year.[17] The AFL has found that ACL injuries are twice as likely to occur in the more northern States of Australia as in Victoria.[17,18] Research into the reason for this difference is helping to develop ways to prevent these injuries among professional footballers.[18] By the same token, any differential patterns of injury observed in the general population would become an important public health issue. However, because of the lack of national injury surveillance, it is not known whether there are significant regional or other differences in injury patterns at the community level.

■ One Australian State government has established a body specifically for compensating serious sports injuries, the New South Wales Sporting Injuries Insurance Scheme. This is a successful, non-compulsory, non-profit government insurer for catastrophic sports injuries (ie, those involving more than 35% permanent loss of use of a body part). The Scheme is cost-neutral and provides an incentive to actively prevent injury through promotion of safe sport practice and funding of injury prevention research. It is possible that the existence of the Scheme has lowered the risk of catastrophic injury in New South Wales relative to other States, but, once again, comparisons are not possible with incomplete data — the NSW Scheme is not compulsory for all sports and no other State has good records of catastrophic sports injuries.

■ The Federal Government body devoted to sport, the Australian Sports Commission (ASC), has been extremely successful in promoting and developing Australian sport at the elite level. However, it does not consider itself responsible, in any major way, for the promotion of safe sport at the community level, and devotes most of its resources to the areas for which it is accountable, such as Australia's performance in elite sporting events.

■ The approach to road trauma in Australia is a good example of how the healthcare system could better manage sports injuries. Traffic accidents are managed entirely outside the Medicare system, through bodies such as the Transport Accident Commission in Victoria. These bodies provide an infrastructure to support and develop preventive measures and actively engage in data collection to monitor injury trends. That Australian roads are much safer today than they were 20–30 years ago is testament to the success and extent of this preventive approach.

Conclusion

The New Zealand approach to managing the problem of sports injuries may not be perfect, but it is surely better than the Australian approach of having no overall plan. Australian government bodies concerned with health and sport need to establish a body with national responsibility for sports safety and injury surveillance, exploring options such as a New Zealand-style national sports injury insurance scheme. It is only with an established infrastructure for monitoring sports injuries that significant advances will be made towards preventing sports injuries and ensuring safe, lifelong participation in physical activity for all Australians.

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OPINION PIECE

Time for sport and health to be formally linked in a positive way

John Orchard[1]

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KEYWORDS
Obesity;
Sports injury;
Catastrophic spinal injury;
Rugby;
Football

Summary Preventing sports injury has rarely been cited as an appropriate action to respond to the obesity epidemic, and in fact a recent letter has suggested that those playing sport are as responsible for their predicament as those who are obese. This opinion piece argues that it is time for better prevention and management of sports injury to be seen as part of the complex solution to preventing obesity, rather than being a self-inflicted problem that governments should continue to ignore.

As physical activity levels in our society continue to fall, the 'science' of obesity prevention has evolved from suggestions on how to fix the problem into attempting to explain why the suggestions of 5—10 years ago have not worked. Hopefully the major focus areas of the *Journal of Science and Medicine in Sport* (which currently include sports injury epidemiology and prevention *and* physical activity promotion) can help illustrate a natural link that needs further exploitation. For example, an opinion piece in the MJA has listed 18 different factors as potentially contributing to the obesity epidemic.[1] It did not mention inadequate prevention or management of sports injury, despite that it has been shown that injury is a barrier to greater physical activity for approximately 20% of the population.[2]

By contrast, a recent letter to the BMJ has made mention of both the obesity crisis and sports injuries, but unfortunately in the opposite context to that in which the discipline of sports medicine would like to position itself.[3] Nicholas Finer, a consultant in obesity medicine, wrote to complain about the East Suffolk primary care trusts' decision to not fund joint replacements unless the patient has a body mass index (BMI) below 30. He correctly pointed out that this policy is based on a perception that obese people are to blame for their predicament and could voluntarily do/have done something to reverse it. This dilemma is one for another editorial. Here I would like to draw attention to the final line of Dr. Finer's letter, in which he states (in order to further defend overweight patients' right to be funded for joint replacement), ''Logically extended, such a policy would deny treatment to, among others, smokers, most patients with HIV infection, and those who sustain sports injury''.[3]

Sports injury seems to be a paradox on the landscape of obesity prevention. On the one hand, exer-

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[1] Member of the NSW Sporting Injuries Committee, yet his views expressed in this article are personal and do not necessarily reflect those of the Committee. NB also a JSMAS editorial board member!

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cise and sport are vital components in maintaining energy balance (and therefore protecting against weight gain, in addition to other health benefits).[4] On the other hand, superficially a sports injury can appear to be a self-inflicted problem, as Dr. Finer points out, in the same fashion that lung cancer in a smoker appears to have been self-inflicted. This comparison can, for the most part, be immediately declared an unfair analogy when it is shown that those who are active actually cost the health system less than those who are not.[5] There are no studies showing cost savings associated with being obese, being a smoker, being a promiscuous male homosexual or being an intravenous drug user. Yet ironically, in Australia, there is far more (albeit still less than optimal) government funding and infrastructure devoted to the problems of smoking, HIV sufferers and obesity management, than there is to either promoting physical activity or preventing or managing sports injuries.

The discrimination against sports injury in Australia (in that it is not viewed as a problem worthy of any government attention[6,7]) is probably based solely on the public perception of the professional football codes. For 9 months of the year, the Australian media constantly promotes the subliminal message that ''all'' professional footballers are earning thousands of dollars per week, having physiotherapy five times a day, surgery every couple of months, and thereby retiring as 30-year-old millionaires in urgent need of joint replacements. In this context, the average person on the street (which politicians pander to) thinks to him or herself, ''why should the government pay for physiotherapy for sports injuries?'', ''why should there be a national sports injury insurance scheme?'' and ''why should the doctors who look after pro football teams be considered specialists?''

The ''problem'' of sports injury needs to be approached from many angles (better prevention, better management of injuries) but not the angle of discouraging people to play sport. It would be a welcome initiative for our Federal and state governments to sign some sort of physical activity version of the Kyoto protocol, such as a pledge that by 2012, 75% of Australians should be meeting recommended physical activity levels. In such an environment, sports injury might be seen as a barrier to achieving the proposed goal, and our governments might start to take the issue seriously.

With respect to those sports injuries which are already occurring, funding is inadequate at many levels. The worst and saddest example of this is the insurance payments for anyone suffering quadriplegia as a result of sports injury.[8] The *maximum* payment currently available from insurers is a lump sum (only) of US$ 300,000, which is grossly inadequate for someone young who will be permanently and totally disabled.[8] The comparative payment for someone similarly injured in a traffic accident would be US$ 7—9 million.[8] Obviously the contact sports are far from free of obligation in this regard, with the ongoing heavy contesting of scrums at adult level in rugby union being particularly indefensible (as it has long been cited as an obvious way that quadriplegia can be prevented[9]).

Governments in Australia perceive a strong need to legislate to protect the rights of injured workers and victims of traffic accidents, yet there is no similar will to protect those injured playing sport.[6] I propose that the Federal government in Australia legislate to prevent anyone playing a contact sport without a minimum adequate level of catastrophic insurance. To provide adequate funding of such insurance (with a view that US$ 2 million may need to be the ball park figure for an 'average' case of quadriplegia), premiums for the football codes may need to rise to a level of (by my estimate) approximately US$ 50—100 per participant per year (soccer football, Australian football) and US$ 200—300 per year (rugby league and union, respectively). Bridging finance may need to be provided by the government to avoid a massive drop in participation from such a rise in insurance premiums. Perhaps a 10-year phasing-in period is needed in which the government works towards a national sports injury insurance scheme and the football codes work towards improvements in safety, all in the background of a commitment to maintain current levels of sports participation. Yes, there may be safer sports to play that the rugby codes, but in addition to the health benefits of exercise, isn't it better to have our young, testosterone-fuelled males battling it out on the football fields than on the beaches in Cronulla?

The biggest problem with all of the above proposals is that there is no one in Australia to suggest them to. If I sent a copy to the Health Minister and a copy to the Sports Minister, the two article manuscripts would be both stamped ''not this department'' by the bureaucrats who screen them. They may even have a head-on collision whilst being forwarded to the 'other' department (sadly, shortly before being permanently filed in the rubbish bin). I particularly like the recent suggestion that governments should appoint ministers for Public Health.[10] If there was a government minister with a portfolio of actually trying to preserve the health of the public (rather than to treat illness), then he or she would be responsible for both making Australia more active and for improving prevention and management of sports injuries, which are synergistic aims.

The Howard government has been in power for 10 years and has overseen unprecedented growth in the Australian economy over this time period. Unfortunately it has also overseen unprecedented growth in the size of Australian waistlines in the same decade.[1,11] The Howard years will therefore be seen as golden years by most economists, but time is running out for this government to prove that it has not wasted its chance to make a difference in preventive health.

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RESEARCH

Effect of nationwide injury prevention programme on serious spinal injuries in New Zealand rugby union: ecological study

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ABSTRACT

Objective To investigate the effect of RugbySmart, a nationwide educational injury prevention programme, on the frequency of spinal cord injuries.

Design Ecological study.

Setting New Zealand rugby union.

Participants Population at risk of injury comprised all New Zealand rugby union players.

Intervention From 2001, all New Zealand rugby coaches and referees have been required to complete RugbySmart, which focuses on educating rugby participants about physical conditioning, injury management, and safe techniques in the contact phases of rugby.

Main outcome measures Numbers of all spinal injuries due to participation in rugby union resulting in permanent disablement in 1976-2005, grouped into five year periods; observed compared with predicted number of spinal injuries in 2001-5.

Results Eight spinal injuries occurred in 2001-5, whereas the predicted number was 18.9 (relative rate=0.46, 95% confidence interval 0.19 to 1.14). Only one spinal injury resulted from scrums over the period; the predicted number was 9.0 (relative rate=0.11, 0.02 to 0.74). Corresponding observed and predicted rates for spinal injuries resulting from other phases of play (tackle, ruck, and maul) were 7 and 9.0 (relative rate=0.83, 0.29 to 2.36).

Conclusions The introduction of the RugbySmart programme coincided with a reduction in the rate of disabling spinal injuries arising from scrums in rugby union. This study exemplifies the benefit of educational initiatives in injury prevention and the need for comprehensive injury surveillance systems for evaluating injury prevention initiatives in sport.

INTRODUCTION

Rugby union is a type of full contact football most commonly played between two teams of 15 players. The sport has an international following—the International Rugby Board, which is the sport's governing body, lists 95 countries in its online world rankings, although rugby is a major sport in fewer than 20. Box 1 gives a glossary of rugby related terms.

Spinal cord injuries, although rare on the basis of exposure per player, are a major cause of serious morbidity and mortality in rugby.[1] During the 1970s and 1980s an increase in the reported frequency of catastrophic spinal injuries associated with rugby was documented in medical journals from several countries in which rugby is a popular sport. The attention generated by letters to journals,[2 3] case reports,[4-6] and case series studies[7-10] prompted rugby administrators to act during the 1980s and 1990s to decrease the risks of spinal cord injuries, especially those related to the scrum. Measures to prevent injury have included changes to laws on scrum procedures, stricter application of existing laws, and educational initiatives.[11 12] Further case series studies have appeared recently.[11 13-19] Legal actions by injured players against referees, other players, and administrators have also contributed to raising the awareness of the importance of minimising the risks of rugby players sustaining permanently disabling injuries.[20 21]

A review of papers published up to 2001 reported that 40% of spinal injuries occurring in rugby were the result of the scrum, 36% were from the tackle, 18% from the ruck/maul, and the remainder were from either other or unknown causes. The definition of injury used in the studies reviewed, however, varied from admissions to spinal units (of which a proportion of players made full recoveries) through to tetraplegia.[1]

Ascertaining the numbers of spinal injuries occurring in rugby and the risks faced by players both in the scrum and in other facets of the game has been hampered by the relative rarity of the events and a lack of standardised procedures for collecting data.[1-12 22] In some countries, registers of spinal cord injuries exist on a national basis; in others, only regional data are available. A further impediment to evaluating the risks of spinal injuries in rugby has been a lack of reliable "denominator" data—the number and exposure of participants from which the cases result over a specified period.[22]

A recent call by a consultant general surgeon in the United Kingdom to ban the rugby scrum, which was based on his personal experiences as a rugby medical officer,[23] generated a flurry of correspondence in the electronic pages of the *BMJ*. The article cited evidence from an Australian survey that reported the elimination of scrum related spinal cord injuries in rugby league after the adoption of non-contested scrums in 1996.[14] Correspondents expressed widely divergent opinions as to the merits or otherwise of such an action being taken in rugby union.

Our study had two aims. The first was to document the number of permanently disabling spinal injuries in New Zealand rugby union from 1976 to 2005. The second was to investigate whether the incidence of spinal injuries in New Zealand rugby union changed after the introduction in 2001 of RugbySmart, a nationwide injury prevention programme.

METHODS

Number of spinal injuries

To examine trends in the incidence of rugby related spinal injury in New Zealand, we collated and analysed data from 1976 to 2005 on the frequency and circumstances of rugby related spinal injuries. We extracted incidence data from the Accident Compensation Corporation database for serious rugby related spinal injury claims. The Accident Compensation Corporation is a no fault insurance system funded from taxes, which provides personal injury cover for all New Zealand citizens, residents, and temporary visitors. In return, people do not have the right to sue for personal injury, other than for exemplary damages. People make a claim at the time of seeking treatment. Across the population of New Zealand (4 million) approximately 1.6 million claims are made annually from all causes. Any serious injury that requires medical assistance automatically generates an Accident Compensation Corporation claim. The Accident Compensation Corporation uses the American Spinal Injury Association scales A to D to classify serious spinal injury claims that involve permanent functional impairment resulting from damage to the spinal cord.[24]

In addition to Accident Compensation Corporation data, we cross checked files from the New Zealand Rugby Foundation (using name, date of birth, and date of injury) to provide additional information about the phase of play in which the injury occurred. The New Zealand Rugby Foundation is part funded by the New Zealand Rugby Union and provides assistance beyond that delivered by the Accident Compensation Corporation to permanently disabled rugby players in New Zealand. For the purposes of modelling injury rates, we categorised the phase of play as scrum and other (tackle, ruck, and maul).

Box 1 | Glossary of rugby terms

Rugby union—A type of full contact football, usually played between two teams of 15 players. Players may carry the ball and pass or kick it. Points are scored by placing the ball over the opposition goal line or by kicking goals. Ten and seven a side versions of the sport are also played. The rules of the game are termed laws and are available at www.irb.com/EN/Laws+and+Regulations/

Rugby league—A variant of rugby played between two teams of 13 players and governed by a separate administrative body from rugby union. Rugby union and rugby league developed from the same parent game; although they have many similarities, some important differences exist. After a tackle in rugby league, the tackled player is allowed to stand up and restart play by placing the ball on the ground and hooking it back to a team member standing behind him. There are no rucks or mauls of the type that occur in rugby union. Scrums in rugby league involve minimal pushing, whereas pushing is a major feature of rugby union scrums

International Rugby Board—The governing body of the sport of rugby union internationally

New Zealand Rugby Union—The governing body of the sport of rugby union in New Zealand

New Zealand Rugby Foundation—A charitable body that provides financial and other assistance to permanently disabled rugby players in New Zealand

Forwards—Player numbers 1 to 8. The main role of forwards in rugby union is to win and retain possession of the ball

Backs—Player numbers 9 to 15. The main role of the backs in rugby union is to attempt to gain field position and score points

Scrum—A means of restarting play after minor infringements. The forwards from each team form together in three rows and close up with their opponents so that the heads of the front row players interlock. This creates a tunnel into which the ball is thrown. The front row players contest possession of the ball by hooking the ball back with their feet

Tackle—When a ball carrier is held by one or more opponents and is brought to the ground. Following a tackle in rugby union, play continues

Ruck—In rugby union, a ruck is a phase of play (often after a tackle) that occurs when the ball is on the ground. One or more players from each team, who are on their feet and are in physical contact, close around the ball and contest possession

Maul—Similar to a ruck except that the ball is off the ground and is held by a player who is simultaneously held by one or more opponents and a team mate

Bledisloe Cup—A rugby union trophy contested between the international teams of Australia and New Zealand

Spinal injury rates

We used records of numbers of players, available from the New Zealand Rugby Union from 1998 onwards, to estimate the average incidence of spinal injury per 100 000 players per year for the periods 1996-2000 and 2001-5 (table). We estimated the player numbers in 1998-2000 by using a combination of player registrations and evaluation of competition draws. From 2001, the New Zealand Rugby Union put in place a new registration system and the player numbers represent registered players only. To calculate the rate in 1996-2000, we used the average number of players from 1998-2000 as the denominator for the entire period, assuming that the numbers in 1996 and 1997 did not differ substantially from those in the following three years.

RugbySmart programme

Since January 2001, RugbySmart (www.rugbysmart.co.nz) has been the vehicle for delivering information on injury prevention to rugby coaches, referees, and players in New Zealand. The RugbySmart programme derives its approach from van Mechelen's sequence of prevention model.[25] The four steps of the model involve establishing the size of the injury problem (generally through surveillance), identifying the risk factors and causes of the injuries sustained in the activity, implementing preventive measures, and continuing injury surveillance or monitoring programmes.[25] Such ongoing injury surveillance programmes are designed to investigate whether the changes implemented have had a beneficial role in reducing the injury burden.

Establishing the size of the injury problem and identifying risk factors/causes

In New Zealand, information on the size of the injury problem in rugby has been derived primarily from the number and costs of claims to the Accident

Compensation Corporation. Risk factors for and causes of rugby injuries have been derived from both case reports[4-6] (primarily describing injury mechanisms) and prospective cohort studies designed for this purpose, both in New Zealand[26-28] and from other countries.[29 30]

Implementing preventive measures

The RugbySmart programme builds on work to prevent rugby injuries that has taken place in New Zealand since the early 1990s. A summary of the strategies used has been presented elsewhere.[31] RugbySmart represented an increase in the level of partnership between the Accident Compensation Corporation and the New Zealand Rugby Union and a substantial increase in financial resourcing of injury prevention in rugby. A full time position (manager of research and injury prevention) was created within the New Zealand Rugby Union to act as a driver for the development and delivery of RugbySmart.

RugbySmart is a multifaceted injury prevention programme and has developed over time as new information about risks has emerged. Research into the epidemiology of sports injury generally, and rugby injury especially, is monitored and evaluated in terms of relevance for inclusion in the updated RugbySmart materials in an attempt to provide evidence based best practice information on injury prevention to rugby participants.

Both players and coaches in New Zealand have identified rugby coaches as having a key role in communicating information on injury prevention and attitudes to players' safety.[31] In recognition of this, the board of directors of the New Zealand Rugby Union mandated that all coaches must complete RugbySmart on an annual basis. Coaches who did not comply with this directive were threatened with having their team withdrawn from competition. Players also saw referees as having an important role in maintaining safety.[31] Referees who did not complete RugbySmart were not assigned matches. Trained personnel deliver the programme at a local level. Most of the people who deliver the seminars are rugby development officers and referee education officers employed by provincial unions or clubs. More than 8000 coaches and 1500 referees have attended RugbySmart annually since it was introduced. Because completing RugbySmart is compulsory, the reach of the programme to coaches and referees is close to 100%.

Information and resources have been made available through compulsory seminars, the production of DVDs, a dedicated website, and provision of injury prevention "tools," such as a sideline concussion check card, to coaches and referees. Opinion pieces on various aspects of injury prevention have been a regular feature of the New Zealand Rugby Union coaching magazine (distributed free of charge to all New Zealand coaches three times a year). The principles espoused in RugbySmart with respect to safety in contact have been integrated throughout New Zealand Rugby Union coaching courses. Key messages on injury prevention, such as the relation between injury prevention and performance, techniques to minimise injury risk in the contact situations of rugby (box 2), the importance of progressive physical conditioning (especially with respect to building up to contact during the preseason period), and management of acute injuries, have been heavily marketed so that they will be acceptable to participants. This has been done in part by using high profile coaches, medical staff, and physical conditioning experts to feature in the DVDs. These people have widespread credibility with the audience to which the programme is primarily directed.

Monitoring and surveillance

Ongoing research into risks and monitoring of the incidence of rugby injury has occurred at various levels over the period of the programme. Beyond the nationwide injury data captured by the Accident Compensation Corporation, the Injury Prevention Research Unit from the University of Otago had injury surveillance projects in 2003-5 to examine self reported injury rates and injury prevention behaviours and attitudes among nationwide samples of players. A video based system for capturing injury data has been used to identify risks and circumstances of match injuries in professional rugby competitions in which New Zealand teams competed in 2002-5.

Statistical analysis

To examine the effect of the RugbySmart programme, we used the generalised linear modelling procedure (Proc Genmod) in SAS version 9.1 to calculate changes in numbers of scrum related and other spinal injuries before and after the introduction of RugbySmart. The aim of the modelling was to estimate the linear effect of time period on the number of injuries per five year period. The model was of the form injury number= RugbySmart period, where RugbySmart was coded as 1 for the period 2001-5 and 0 otherwise, and period was the five year period presented in the figure. We did not build participation level (number of players) into the model, because accurate estimates of numbers of players were not available before 1998. The model

Player numbers and injury rate per year

Year	No of players (thousands)	Change from previous year (%)	Scrum injuries	Other injuries	Injury rate (per 100 000 players per year)
1996	NA	NA	3	1	NA
1997	NA	NA	0	1	NA
1998	122	NA	0	2	1.6
1999	130	6	4	1	3.9
2000	129	−1	2	3	3.9
2001	120	−7	0	2	1.7
2002	122	1	0	1	0.8
2003	121	−1	0	2	1.7
2004	129	6	1	1	1.6
2005	138	6	0	1	0.7

NA=not available.

implicitly assumes constant player numbers over the entire period.

Owing to the nature of the dependent variable (count of injuries per five year period), we chose the Poisson response probability distribution. We made magnitude based inferences about true (population) values of effects by expressing the uncertainty in the effects as 95% confidence intervals.[32] We deemed an effect to be unclear if its confidence interval overlapped the thresholds for substantiveness (that is, if the likelihood of the injury rate ratio being substantially greater than 1.2 and less than 0.83 were both 2.5%).[33] To estimate the minimum clinically important difference, we calculated the typical number of spinal injuries occurring from scrums per five year period. A factor decrease of 1.2 equated to one person not being permanently disabled through a scrum related spinal injury per five year period, which we believed was a worthwhile clinical outcome. We aggregated counts into five year periods to avoid problems of zero cell counts[34] and to give a single prediction for the last five years for comparison with the observed incidence.

RESULTS

Seventy seven permanently disabling injuries were recorded in 1976-2005. In 1976-2000 the scrum accounted for 48% (33/69) of spinal injuries; in 2001-5 the percentage was 12.5 (1/8). Tackles accounted for 36% (25/69) of spinal injuries in 1976-2000 and 87.5% (7/8) in 2001-5. The remaining 11 injuries resulted from the ruck or maul. The figure shows the frequency of permanently disabling spinal cord injuries in New Zealand rugby grouped by five year period from 1976.

In 2001-5 eight spinal injuries occurred in New Zealand rugby, whereas the predicted number based on the rate from the previous periods was 18.9 (relative rate=0.46, 95% confidence interval 0.19 to 1.14). Only one scrum related spinal injury occurred in 2001-5, which was clearly less than the predicted number of 9.0 (relative rate=0.11, 0.02 to 0.74). Seven spinal injuries occurred as a result of tackles, rucks, and mauls in 2001-5; the predicted number was 9.0. The difference in the number of observed spinal injuries resulting from tackles, rucks, and mauls relative to the predicted number was rated unclear (relative rate=0.83, 0.29 to 2.36).

The average annual number of players registered was 126 800 in 1996-2000 and 125 900 in 2001-5. The rates of spinal injuries from scrums and from other phases of play per 100 000 players per year were therefore 1.4 and 1.3 in 1996-2000 and 0.2 and 1.1 in 2001-5.

DISCUSSION

RugbySmart and spinal injury numbers

A major goal of the New Zealand Rugby Union and the Accident Compensation Corporation in establishing RugbySmart was "to eliminate spinal injuries within the context of a contact sport." The results are consistent with a decrease in spinal cord injuries in New Zealand rugby since 2000, primarily owing to a reduction in injuries occurring in scrums. This decrease coincides with the introduction of the RugbySmart programme. The ability of the governing body of New Zealand rugby to require completion of RugbySmart as a prerequisite to being able to coach or referee has led to the programme having extensive reach among people identified as important for communicating messages on injury prevention to improve players' safety.

If the true rate of scrum related spinal injury was the observed average rate of 6-7 per five years, the chance of observing one or zero scrum related spinal injuries in 2001-5 if the underlying rate of injury to players had not changed and the total exposure of players to rugby had remained constant was only 1%. Thus a small chance exists that the decrease observed in this study reflects expected statistical variation, but a real decrease in the rate of spinal injuries from scrums occurred in New Zealand over the period 2001-5 is much more probable.

Although the number of sports injury prevention programmes running worldwide has greatly increased over the past two decades, few have completed all four steps inherent in the "sequence of prevention" model.[25 35] RugbySmart is one of the first examples of a nationwide programme to have evaluated the effects of the injury prevention initiatives introduced through ongoing nationwide surveillance. The RugbySmart programme was designed to be an injury prevention system that provides participants with up to date information about risks of rugby injury and preventive techniques. Evaluation of the programme, which will be discussed in depth in a paper in preparation, consists of targeted injury surveillance projects; examination of participants' knowledge, attitudes, and behaviours; and monitoring of Accident Compensation Corporation claims.

One of the weaknesses of this study is the lack of a control group. Because the New Zealand Rugby Union wanted to implement a nationwide injury prevention programme from the beginning, we were unable to create a control group to which RugbySmart was not delivered. Although the finding that numbers of spinal injuries in New Zealand rugby have decreased is positive regardless of the reasons for the drop, examining factors besides the RugbySmart programme that may have contributed to the decline can help us to assess how much weight we should place on the apparent impact of RugbySmart.

Box 2 | **Common principles for safe technique in contact in rugby union promoted in RugbySmart**

- Eyes focused on target area
- Chin up, eyes open
- Low body position
- Keep back flat
- Shoulders above hips
- Use legs to drive powerfully into contact

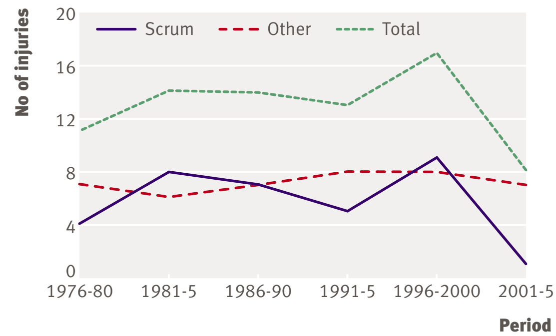
Changes in law are a means of altering behaviour that have the potential to decrease the risk of injury. In 1992, the International Rugby Board introduced a change that altered the sequence of events in scrum engagement. Little evidence suggests that any decrease in scrum related spinal injuries in New Zealand that followed this change was sustained through the subsequent five year period (see figure). No substantive changes occurred to the law relating to the scrum, ruck, maul, or tackle through the period of the RugbySmart intervention (2001-5) that would have been expected to affect players' risk of sustaining a spinal injury.

Players' exposure to scrums, tackles, and rucks

A decrease in exposure to scrums could have contributed to the decrease in the number of scrum related spinal injuries seen in 2001-5 compared with previous periods. Such a decrease in exposure to scrums could have resulted from fewer players participating in rugby, fewer matches a year for those who did participate, fewer scrums per match, or some combination of the three. The amount of confidence we can have in discounting these varies. For example, although an overall decrease in scrum related spinal injuries between 1996-2000 and 2001-5 similar to that seen could have resulted with no change in risk per player had the number of players decreased enough, the actual number of players needed before the intervention to allow a large enough decrease is unfeasibly high. This would have required a playing population in 1996 and 1997 of 2.6 million, or around 20 times higher than the number of players recorded in the following years. Over the longer term, we have little evidence on which to base any conjecture of the possible impact of numbers of players on numbers of injury.

Decreases in the typical exposure per player (assuming that the number of players remained constant), commensurate with fewer matches being played in a season, could also result in a lower number of spinal injuries being seen. Across all levels, the number of competitions and the number of matches played per competition have not, to our knowledge, changed substantially in New Zealand over the past decade. The New Zealand Rugby Union has no information to suggest that this has been the case, although the relative balance between numbers of competitions in rural and urban areas has shifted, mirroring population trends in New Zealand.

Neither of the above scenarios—a large decrease in player numbers or in typical exposure per player—would account for the differential decrease in numbers of scrum related spinal injury compared with those from other phases of play. However, at least part of the decrease in scrum related spinal injury numbers is probably due to a decrease in the number of scrums per match. Evidence from international matches indicates a long term decrease in the number of scrums per match. A comparative analysis by the International Rugby Board of international matches played in the early 1980s and the early years of the 21st century



Permanently disabling spinal injuries (American Spinal Injuries Association scale A to D) in New Zealand rugby union, 1976 to 2005

found that the average number of scrums per match had dropped from 31 to 19. In Bledisloe Cup matches, the number of scrums showed a decrease of 17% per decade from 1972 to 2004, with an additional 8% decrease coincident with professionalism in 1995.[36]

We do not have figures for typical numbers of scrums per match throughout all grades of rugby in New Zealand. In our experience, junior grades tend to follow the patterns of play at higher levels. We would be surprised if the number of activities per match at lower levels was following markedly different trends over time than at the higher levels, but we have no historical measurement of these. At international level, the number of scrums per match in under 19 and under 21 competitions does not differ noticeably from that at senior level. International Rugby Board statistics indicate that the numbers of scrums per 80 minutes of match play at international level in 2003 for seniors and in 2004 for under 21 and under 19 grades were 21, 22, and 22.[37] Given the above, we can attribute approximately 8-10% of the decrease in scrum related spinal injuries to a decrease in exposure as a result of fewer scrums per match in the 2001-5 period than occurred in 1996-2000.

Although the effect is not clear, the RugbySmart programme seems to have been unsuccessful in reducing the number of spinal injuries unrelated to the scrum. Compared with the relatively controlled environment of the scrum, the direction and size of forces applied to players' bodies in the tackle, ruck, and maul are much less predictable. The scrum may thus be more amenable to education based injury prevention initiatives than the tackle, ruck, or maul.

Whether the underlying risk to players (as opposed to the number of injuries observed) has changed in the tackle, ruck, and maul is difficult to determine. For example, the injury data do not take into account possible changes in the frequency of tackles and rucks in rugby. Substantial increases in both of these phases of play have been noted in professional rugby.[36] In Bledisloe Cup matches between New Zealand and Australia, the mean number of tackles per match increased from 150 (SD 32) in 1995 to 270 (25) in 2004. The average number of rucks per match increased from

WHAT IS ALREADY KNOWN ON THIS TOPIC

Spinal cord injuries, although rare on the basis of exposure per player, are a major cause of serious morbidity and mortality in rugby

WHAT THIS STUDY ADDS

The number of permanently disabling spinal injuries in New Zealand rugby has markedly decreased following the introduction in 2001 of RugbySmart, a nationwide injury prevention programme

This study exemplifies the benefit of educational initiatives in injury prevention and the need for comprehensive injury surveillance systems for evaluating such initiatives in sport

72 (18) to 178 (27) over the same period.[36] We do not know whether or to what extent such increases have been reflected in lower grades. However, if we presume that the style of play at the community level of the sport has moved in the same direction as that at the international level, the risk per event for these phases of play may have decreased. Further research into the risks and circumstances of injuries in tackles (both spinal and other injuries) is warranted.

Spinal injury rates in New Zealand and Australia

The rate of spinal injuries in New Zealand rugby in 1996-2000 was 2.7 per 100 000 players per year (including both scrum related and other injuries). The rate in 2001-5 decreased to 1.3 per 100 000 players per year. Studies from Australia have also reported annual incidences of spinal injury.[11 14 15] The rate of spinal injuries in New South Wales rugby in 1996-2000 was 5.1 per 100 000 players per year (calculated from information provided by Berry and colleagues[11]). Over the following three year period, the rate increased to 9.8 per 100 000 players per year. The Australia-wide rate in 1986-96 was 3.5 per 100 000 players per year (based on estimates of player numbers from 1985, 1990, and 1996). The rate in 1997-2002 was 3.2 per 100 000 players per year.[14 15]

The apparent differences between the rates in New South Wales and those for Australia as a whole can be partially accounted for by the fact that the denominator used for calculating the rates in New South Wales does not include school age players who play only at school and do not register with a club. The authors of these studies have pointed out that the data for player numbers on which the injury rates are based are less than optimal. In New Zealand, the denominator figure includes all school and club players. Given the limitations of the denominator data from Australia, concluding whether the risks of spinal injury involved in New Zealand rugby are lower than those in Australia is difficult.

Reported differences in rates resulting at least partly from different denominators raises an important question about which players should be included when calculating the incidence of serious spinal injuries within a region or country. In New Zealand, no case of a permanently disabling spinal injury to a player under the age of 14 has been reported in the past 30 years. Should players aged 13 and under be included in or excluded from the denominator? We have included such players in the figures presented in this paper because they are presumably at some risk of sustaining such injuries, even though none has occurred over the period studied. On the other hand, if young players have a much lower risk of spinal injury, then including the large number of these players in the count of those at risk may produce artificially low rates of spinal injuries. The variation in rates between Australian and New Zealand studies reported in this paper provides an example of the importance of agreeing definitions and procedures for the collection of such data between regions and countries.

Injury prevention in rugby

Several avenues for injury prevention are available to rugby administrators, including changes in law and educational programmes. Although changes in law can effect change quickly, we believe that research into their probable effects on patterns of match activity and the overall risk of injury to participants should be done before their introduction. Historical evidence shows that changes in law have resulted in changes in the relative frequency and nature of match activities, characteristics of players, and epidemiology of injuries that were not foreseen when the changes were introduced.[36 38]

The results presented here provide evidence that educational programmes are a viable option for decreasing the rate of serious spinal injuries in rugby union scrums. In the absence of evidence that other factors have had a major role, we believe that the RugbySmart programme has probably played a positive part in decreasing the risks to players in New Zealand of sustaining serious spinal injuries through participation in rugby.

Conclusion

Although serious spinal injuries in rugby are an emotive issue, we believe that decisions on prevention of injuries in this area should be based on evidence rather than opinion. The introduction of the RugbySmart injury prevention programme in New Zealand has coincided with a drop in the number of spinal injuries over the past five years. A decrease in injuries from scrums has been the major contributor to this reduction. Whether the programme has had an effect on injuries from other phases of play (tackles, rucks, and mauls) is unclear. Educational initiatives seem to represent a viable option for decreasing the rate of serious spinal injuries in rugby union scrums.

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Contributors: KLQ reviewed the literature, led the writing of the paper, and contributed to the design and analysis. He was responsible for the development and delivery of RugbySmart on behalf of the New Zealand Rugby Union from the inception of the programme. SMG was responsible for extracting and

verifying injury data from Accident Compensation Corporation records and writing the section of the methods on the Accident Compensation Corporation system; he contributed to the writing of the remainder of the paper. He was responsible for the development and delivery of RugbySmart on behalf of Accident Compensation Corporation from 2002 onwards. WGH provided statistical advice and contributed to analyses. He provided editorial comment on a draft version of the paper. PAH led the development of the 10 point action for sports injury prevention that was used as a template for RugbySmart. She provided editorial comments on a final draft of the paper. KLQ is the guarantor.
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Preventing spinal cord injuries in rugby union

Other countries should follow New Zealand's lead

ROSS LAND/GETTY IMAGES

RESEARCH, p 1150

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Spinal cord injuries were first identified as an important sporting problem in the early and mid-1970s in rugby union,[1 2] American (gridiron) football,[3] and ice hockey.[4] Subsequent studies have identified the most common mechanisms that cause these injuries.[5 6] In some sports, such as American football, single mechanisms that cause spinal injury, such as the spear tackle, have been identified,[7] which has allowed effective preventive measures to be swiftly implemented (the spear tackle has now been banned in gridiron football).[8] But in other sports progress in preventing spinal injury has been slow and difficult to measure.

In this week's *BMJ*, a before and after study by Quarrie and colleagues assesses the effect of RugbySmart, a nationwide educational injury prevention programme, on the frequency of spinal cord injuries in New Zealand rugby union.[9] It found that the introduction of the programme in 2001 coincided with a reduction in the number of spinal injuries (19 injuries were expected between 2001 and 2005 compared with eight reported). Furthermore, only one such injury occurred in the scrum, whereas nine were predicted. The data are robust as they originate from appropriately processed insurance claims. The authors conclude that their educational programme can decrease the rate at which serious spinal cord injuries occur in the scrum. Whether this intervention has the same effect in less controlled phases of the game—the tackle, ruck, and maul—remains unanswered.

To date, not a single complete data set for all spinal cord injuries has been reported in any major rugby union playing country, despite repeated calls for such information for the past 20 years.[2] Without such data, the impact of spinal cord injuries and the effect of preventive measures in any rugby playing nation remains unknown. Regrettably, the number of these injuries in South Africa may not have decreased even 22 years after the problem was first identified.[10]

The study by Quarrie and colleagues provides a reason for renewed hope. The importance of the study is that it is unprecedented. Firstly, it shows that relevant data can be collected and used. Secondly, it establishes that at least some spinal cord injuries are preventable, as had previously been assumed.[1 10 11] Thirdly, it sets the new standard. The study does have limitations though. It has a before and after design, which could be confounded by changes in the nature of the game or its players over the past five years that are unrelated to the introduction of the RugbySmart programme. A randomised controlled trial would have confirmed that the findings were not purely the result of a chance association.

Despite these limitations the results of the study are promising. Yet the study also highlights the need to do more; for example, to investigate other ways to prevent these injuries. These include training to improve neck strength and to enhance rugby related skills, increased medical supervision at matches, using protective gear, changes in the law, and continuing advocacy. Although the use of protective gear is actively enforced in certain sports,[5] no such gear exists to prevent spinal cord injuries in rugby, and it may never do so. Changes in the law remain an option to reduce, for example, the possibility of vertex impact in front-on tackling. However, Quarrie and colleagues[9] stress that although changes to the law can alter the way the game is played, such changes may not necessarily produce the desired outcomes.

All of the above methods for reducing injury are reasonable for developed countries whose players usually have sufficient access to quality training, coaching, and medical services. However, players in developing countries such as South Africa and Fiji,[12] both of which have high rates of spinal cord injuries, are less likely to have access to such services. Rectifying this remains a challenging objective in these countries.

Advocacy is the final important strategy. Quarrie and colleagues' study would not have been possible if the New Zealand government did not provide a national insurance policy that also covers sports injuries. This raises the question of whether these injuries will ever be entirely preventable without the active support of national governments.

The beauty of the RugbySmart programme is that it can do no harm, and according to the results of this study may do great good. Given the relative infrequency of these injuries, a randomised controlled trial may be desirable but financially impractical. Wise rugby administrators should procrastinate no longer, awaiting the outcome of a definitive randomised controlled trial. They should follow the lead of the New Zealand Rugby Union.

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ORIGINAL ARTICLE

An evaluation of mouthguard requirements and dental injuries in New Zealand rugby union

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Objectives: To document the effects of compulsory mouthguard wearing on rugby related dental injury claims made to ACC, the administrator of New Zealand's accident compensation scheme.
Methods: An ecological study was conducted. Estimates of mouthguard wearing rates were available from prospective studies conducted in 1993, 2002, and 2003. Rugby related dental injury claims were available for the period 1995–2003. Player numbers were available from 1998. Mouthguard wearing was made compulsory during match play for rugby players at under 19 level and below at the beginning of the 1997 season, and for all grades of domestic rugby at the beginning of the 1998 season. Greater powers of enforcement were provided to referees at the beginning of the 2003 season.
Results: The self reported rate of mouthguard use was 67% of player-weeks in 1993 and 93% in 2003. A total of 2644 claims was reported in 1995. There was a 43% (90% confidence interval 39% to 46%) reduction in dental claims from 1995 to 2003. On the reasonable assumption that the number of players and player-matches remained constant throughout the study period, the relative rate of injury claims for non-wearers versus wearers was 4.6 (90% confidence interval 3.8 to 5.6). The cumulative savings in claim costs compared with the cost per year if claim numbers had remained constant from 1995 is $1.87 million NZD.
Conclusion: Although ecological studies have acknowledged weaknesses, the findings provide evidence that mouthguard use is a simple and effective injury prevention strategy for rugby players. The use of mouthguards for all players in both matches and contact practice situations is strongly recommended.

Rugby union is a widely played physical contact sport that enjoys particular popularity in the United Kingdom, France, South Africa, Australia, New Zealand, and some Pacific Island nations. Injuries are common, primarily because of the physical contact during tackles, rucks, scrums, and mauls. A number of studies have described the injury epidemiology of specific cohorts of rugby players.[1–7] Typical patterns of injury have emerged from these studies. Overall, the findings suggest that injuries from rugby are distributed throughout the body. Most reported injuries have been to the soft tissues of the body (sprains, strains, and haematomas), and the tackle has generally been reported as the phase of play in which injuries most commonly occur. It appears that the rate of injury increases with higher levels of play,[1 2 4 8] perhaps because of the greater energy developed in the contact phases of the sport between larger and more powerful athletes.[9] Specific injury types, such as spinal injuries, have also received attention; the mechanisms associated with these have been documented through case reports and case series studies.[10]

Various pieces of protective equipment are permitted within the laws of the game of rugby.[11] These include padded headgear, shoulder pads, shin guards, and mouthguards. Little research on the effectiveness of the permitted equipment in preventing injuries has appeared in the scientific literature, although some appraisals of the various types of equipment have appeared.[12–18] Garraway and colleagues[4] speculated that protective equipment may lead to an increase in competitiveness in the contact phases of the sport, and a subsequent increase in injury rates, and called for a moratorium on the use of such equipment in competitive matches until the International Rugby Board (IRB) had assessed its effect on player morbidity.

At present, the wearing of mouthguards is permitted in rugby, but under the IRB laws of the game their use is not compulsory. In New Zealand a ''domestic safety law variation'' was introduced over the 1997–1998 seasons to require all players to wear mouthguards during matches. In 1997, mouthguard use became mandatory for all players at under 19 level and below, and in 1998 this was extended to players of all grades (levels of play). Although mouthguard use was mandated, there was no specific sanction available to the referee under the domestic safety law variation to ensure compliance with this law. A minor modification to the laws at the beginning of the 2003 season allowed referees greater powers in enforcing the laws, including the ability to send players from the field should they not be wearing a mouthguard in the prescribed fashion. These domestic safety law variations apply to all rugby played in New Zealand except for international competitions. Mouthguard use during team practices is optional, although it has been promoted through educational seminars. The primary purpose of this study was to document the effects of these rugby law changes in mouthguard use on rugby related dental injury claims made to ACC, the administrator of New Zealand's accident compensation scheme. A secondary purpose was to estimate the relative risk of dental injury claims for wearers and non-wearers of mouthguards.

METHODS

ACC is a public sector organisation charged with the administration of New Zealand's 24 hour, no fault accident compensation and rehabilitation scheme. ACC is required by statute to endeavour to prevent injuries, and compensate those in New Zealand who are injured. ACC insures all forms of personal injury including worker's compensation and

Abbreviations: IRB, International Rugby Board; NZRU, New Zealand Rugby Union; RIPP, Rugby Injury and Performance Project; RISP, Rugby Injury Surveillance Project compulsory third party insurance for motor vehicle injuries. Injury claims are paid out over time in the form of income replacement, medical costs, and rehabilitation expenditure.

The criteria for the rugby related dental injury claims reported in this study were that the claim had a sport code of rugby union (ACC Sport Codes = 25 or 79), an activity before the injury of recreation or sporting activity (ACC ap Code = 19), and a forecast injury group of dental treatment (ACC fg = 15). Hence dental injuries that occurred during rugby practices or matches could become claims. To allow comparisons in dental injury claim numbers from year to year to be made, the above criteria for claims acceptance were applied retrospectively to the ACC records. Information on rugby related dental injury claims was obtained from ACC over the period 1995–2003. The number of rugby players in New Zealand was obtained from New Zealand Rugby Union (NZRU) records.

Typical rates of mouthguard use were obtained from studies that surveyed mouthguard wearing rates before (1993)[19] and after (2002 and 2003)[8 20] the law changes took place. These studies used the same basic design for the collection of information, and the distribution of male players across the grades was similar. However, there were differences in the wording of the questions about mouthguard use.[8 19 20] Players were selected for the studies, and regular telephone interviews were used to enquire about exposure to rugby, injuries sustained, and protective equipment used.

The 1993 study involved a cohort of players from Dunedin, and was entitled the New Zealand Rugby Injury and Performance Project (RIPP). The methods[21] and results[1 19 22 23] from RIPP have been reported. In summary, 345 players (258 male and 87 female) from a range of grades were contacted weekly by telephone throughout an entire rugby season. Use of mouthguards was reported for 327 players (240 male and 87 female) actively participating in rugby through the season.[19] Active participation in rugby was defined as participation in at least one team practice or match during a particular week. The question relevant to mouthguard use asked in RIPP was: ''Did you use any protective gear or strapping during team practice(s) or games last week? If yes, what did you wear? ''Mouthguard'' was one response category. Thus the rate reflected whether the player used a mouthguard during matches or team practices or both, but did not distinguish the rate of wearing during matches from that during practices.

Although the 2002[20] and 2003[8] Rugby Injury Surveillance Projects (RISPs) also used telephone interviews, there were a number of differences in design from the RIPP study. Firstly, players were selected from throughout New Zealand, and secondly the distribution of players by grade differed from that in RIPP; in the RISPs there were no female players.

The surveillance projects coincided with the modification in the powers available to the referee to mandate the use of mouthguards during matches noted above. The RISP studies used the NZRU player registration database to obtain representative samples of players aged 16 and over from various grades throughout the country. Different samples were obtained for each year. In 2002, 560 players were placed into two groups, one of which was contacted weekly, and the other was contacted fortnightly. The relevant question asked was ''Did you wear any protective gear or strapping?'' ''Mouthguard'' was one response category. This was asked for each game played and each practice attended. In 2003, information was collected from 774 players by weekly telephone interviews. The following question was asked: ''Did you wear a mouthguard?'' with the response categories ''Yes/No/Did not answer''. This was asked for each game played but not asked for practices.

For the purposes of estimating relative risks of dental claims for wearers compared with non-wearers of mouthguards, the female players in RIPP were excluded from the analysis. To estimate the relative risk of dental injury claims for non-wearers compared with wearers of mouthguards, we assumed that the rates of injury for wearers and non-wearers did not change between 1993 and 2003. We then solved the two simultaneous equations provided by the rate of claims for the two years to obtain the rates: (proportion of wearers) $\times$ (rate of injury for wearers) + (proportion of non-wearers) $\times$ (rate of injury for non-wearers) = rate of claims. Confidence intervals for the relative risk were estimated by simulation: random error was added to the proportions consistent with the sample size from which they were derived (assuming a binomial sampling distribution), random error was added to the claim rates consistent with their totals (assuming a Poisson sampling distribution), and the equations were solved again; this process was repeated 400 times, and the confidence intervals were derived from the resulting values by assuming that the logarithm of the relative risk was normally distributed.

RESULTS

Mouthguard use

Over the period 1993–2003, the self reported rate of mouthguard use among male rugby players increased by 26%.[8 19] Through the 1993 season, mouthguards were worn for 67% of player-weeks among the 240 men in a cohort of 327 Dunedin players from various grades who were enrolled in the RIPP.

In 2002, mouthguards were reported to be worn by players in the RISP in 85% of games and 38% of practices. In 2003, they were reported to be worn in 93% of games. Mouthguard use during practices was assessed at the conclusion of the 2003 season. Most (59%) players reported wearing mouthguards during practices at least sometimes. Of these players, 46% reported that they always wore mouthguards during practices involving contact.

Player numbers

Although accurate player numbers were not collected before 1998, the consensus view of NZRU staff was that they had remained reasonably constant throughout the mid-1990s. From 1998 onwards, numbers ranged between 120 000 and 130 000 (table 1). There was a recorded decrease in players of 8800 between 2000 and 2001. This coincided with a change in the method of measuring player numbers. Before 2001, player numbers were estimated from a combination of registered players and number of teams enrolled in competitions. From 2001 onwards, numbers were taken solely from the NZRU player registration database. From 2001 to 2003 there was little change in player numbers.

Table 1 Number of rugby players in New Zealand by year

Year	Player numbers
1998	121900
1999	129800
2000	128700
2001	119900
2002	121600
2003	120900

Source: New Zealand Rugby Union. Player numbers are rounded to the nearest hundred.

Dental injury claims

Since the introduction of mandatory mouthguard wearing among New Zealand rugby players, there has been a 43% (90% confidence interval (CI) 39% to 46%) reduction in rugby related dental injury claims to ACC (fig 1). In 1996, the year before mouthguards became compulsory for under 19 grades, 2690 rugby related dental injury claims were made to ACC. This represented a 2% increase in number of claims over the previous year. In 1997, this number dropped to 2316, a reduction of 14%. The following year, there were 2136 claims, a further 8% reduction. From 2002 to 2003, when referees were provided with additional sanctions to enforce the wearing of mouthguards, there was a reduction in claims of 5%. The cumulative number of claims saved compared with the number of claims per year if claim numbers had remained constant from 1995 is 5839. The average cost of a dental injury claim to ACC is $321 NZD. The cumulative savings in claim costs compared with the cost per year if claim numbers had remained constant is $1.87 million NZD. Using the methods and assumptions outlined above, the estimate for the relative risk of claims for wearers was 4.6 (90% CI 3.8 to 5.6) times that of non-wearers.

Although claims could result from either matches or practices, mouthguard use is only compulsory during matches. The 2003 RISP study of rugby injuries in New Zealand[8] indicated that injuries to the teeth and jaw made up only 1% of total injuries reported in both practices and matches. The rate of orofacial injuries was 0.7 per 1000 player-hours during matches, and 0.1 per 1000 player-hours during practices.

DISCUSSION

As with other studies using ecological methods, caution must be taken to ensure that the conclusions reached are not compromised by ecological fallacies, confounding, or bias. As far as possible, efforts have been made to account for other factors that may have contributed to the results observed. Although it is tempting to take the above findings at face value, issues that may have biased the findings must be addressed. Firstly, accurate records of player numbers were not available over the early period of the study. A large reduction in player numbers and/or in the typical amount of rugby exposure per player would obviously weaken the inference that the observed decrease in dental injury claims was associated with increased mouthguard use. Although the NZRU did not have all players recorded on a registration database throughout the study period, it unlikely that player numbers changed substantially over that period, and any

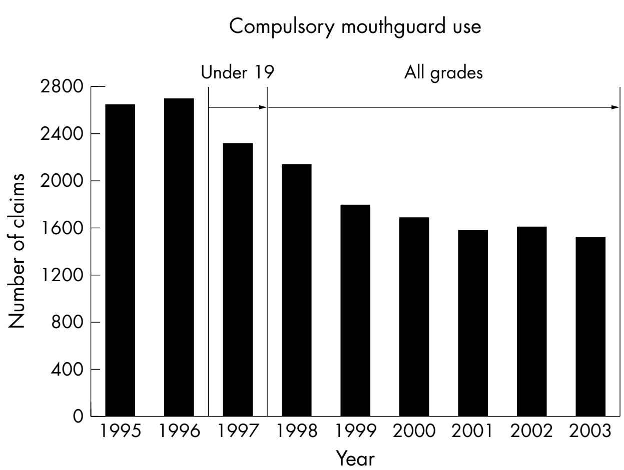

Figure 1 Rugby related dental injury claims in New Zealand.

changes would certainly not have been of the order of a reduction of 40%. Since 1998, variations in recorded numbers have been within 10%, with the difference being primarily associated with a change in measurement methods as described above.

Secondly, the rate of mouthguard wearing in players throughout New Zealand in 1995 was assumed to be the same as that recorded for a sample of players from Dunedin in 1993. If the actual difference in wearing rates between the sample and the population over this time was large, the true relative rate of injuries to wearers and non-wearers would also be different from that estimated. A related problem is the fact that the wearing rates in practices and matches could not be distinguished in the RIPP study. The data collected on player wearing rates during practices at the end of the 2003 season indicate that these rates are substantially lower than for matches. In addition, mouthguard wearing rates were derived from studies that differed in terms of the questions used to investigate the rate of mouthguard wearing.

A fourth factor that may have had an effect is the type of mouthguard typically worn. If there were differences in the protection afforded by one type of mouthguard compared with another, and the proportions of players wearing the various types changed substantially, the relative risk of injury in the players who wore mouthguards may have changed over the period of the study. Finally, changes to the nature of the sport itself—for example, a large increase or decrease in the typical numbers of tackles per match—may have altered the risk of being injured. However, whether any such changes would have differentially modified the risk for non-wearers compared with wearers is not known.

To confidently assess the relation between mouthguard use and dental injuries would require much larger sample sizes than have been used in most of the previous studies on mouthguard use in rugby.[24–31] A 1987 study by Blignaut and coworkers[25] that examined 321 players who participated in 555 player-matches concluded that there was no difference in oral injury rates between wearers and non-wearers of mouthguards. However, given the size of the sample and the frequency of oral injuries in rugby, the validity of such a conclusion must be questioned. A retrospective study in England examined self reported orofacial injuries in 114 senior players and 69 junior players.[32] Among the senior players, 64 orofacial injuries were reported in the 54 players who did not typically wear mouthguards, compared with 18 injuries in the 60 players who did. This yields a relative rate of injury of 3.95 (90% CI 2.5 to 6.1) for non-wearers versus wearers. Among the junior players, 23 orofacial injuries were reported by 24 non-wearers and 16 injuries by 45 non-wearers. The relative rate of injury among the junior players was 2.7 (90% CI 1.6 to 4.6) for wearers versus non-wearers. Although the sample size in this study was small, the risk estimates are consistent with the relative risk calculated in the New Zealand situation.

The relative effectiveness of the various types of mouthguards available has also received little attention. Reviews of the role of mouthguards in preventing dental injuries in sports have suggested that dentist fitted mouthguards offer superior fit, comfort, and ability to breathe over the mouth fitted type.[33] Chalmers[12] recommended that mouthguards should be used in both practices and games and replaced often (about every two years). He stated that, although a number of factors would necessarily be taken into account in choosing a mouthguard (such as relative cost, age of the player, and the effectiveness of the different types), players in higher grades and in more vulnerable positions should invest in a dentist fitted mouthguard. However, despite the belief of dental experts that dentist fitted mouthguards offer superior protection because of less variability in thickness during the

What is already known on this topic

There is a lack of epidemiological evidence about the effect of wearing mouthguards on dental injuries in contact sports.

What this study adds

The introduction of compulsory wearing of mouthguards for rugby players in New Zealand has been associated with a 43% reduction in rugby related dental injury claims. The relative risk of making a dental injury claim for non-wearers was estimated to be 4.6 times that of wearers.

process of construction and greater coverage of the teeth,[33] there have been no studies with sufficient sample sizes and injury numbers to confirm a difference in rugby injury rates in practice. For example, in a study of 120 rugby players, 55 were provided with mouth fitted "boil and bite" type mouthguards, and 65 were provided with laboratory made mouthguards. Of the 98 players who were followed up at the end of the season, none had sustained damage to the teeth while wearing either type of mouthguard.[28] Further research examining the rates of claims among players wearing various types of mouthguards would help to clarify the relative effectiveness of the mouthguards currently available to players.

The logistics of further investigating the effects of wearing mouthguards, or comparing one type of mouthguard with another, would be less complicated in an experimental study than an observational study, especially with current wearing rates reported to be about 93% of player-weeks, but in the light of the findings presented, it is highly unlikely that ethical approval would be granted to assign players to a non-wearers group.

The changes to the laws of the sport in New Zealand have been supported by educational initiatives. Since 1996, all New Zealand coaches and referees of all grades of tackle rugby (typically under 9 and above) have been required to attend compulsory safety seminars. From 2001 onwards, these seminars have gone by the name "RugbySmart", and have focused on aspects of injury prevention such as technique, physical conditioning, injury management, and protective equipment (http://www.acc.co.nz/injury-prevention/safe-in-sport-and-recreation/sports-codes/rugby/rugbysmart10points/). Mouthguard use as a means of preventing dental injuries has been promoted in these seminars and their accompanying resources.

A recent injury surveillance report indicates that, although the rates of both mouthguard wearing and orofacial injuries during practices are substantially lower than during matches, players spend more time in practices than in games.[8] Although the wearing of mouthguards is optional during practices, we recommend that they should be worn during practices that involve contact.

The relative claim rate of 4.6 for non-wearers compared with wearers calculated above should be interpreted with some caution because the rates of mouthguard wearing were derived from studies that asked about mouthguard use in slightly different ways. In addition, there was a lack of certainty about player numbers in New Zealand and mouthguard wearing rates on a year by year basis. Even so, it is a step towards estimating the protective effect of mouthguards in rugby, and the large number of both players and claims allows greater confidence to be placed in the effect of mouthguards than was previously possible. The finding that mandating mouthguard use in New Zealand rugby has coincided with a 43% reduction in dental injury claims indicates that compelling players to wear mouthguards represents a simple and effective strategy to prevent dental injuries in rugby.

CONCLUSION

Despite the acknowledged weaknesses in ecological study designs, the findings presented provide evidence that compelling rugby players to wear mouthguards is a simple, effective injury prevention strategy. On the basis of the New Zealand experience with compulsory mouthguard use and the commensurate decrease in dental injuries, we strongly endorse mouthguard use for rugby players at all levels in both match and contact practice situations.

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ORIGINAL PAPER

A cost-outcome approach to pre and post-implementation of national sports injury prevention programmes

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Summary In New Zealand (NZ), the Accident Compensation Corporation (ACC) has developed a pre and post-implementation cost-outcome formulae for sport injury prevention to provide information regarding the success of a prevention programme. The ACC provides for the cost of all personal injuries in NZ and invests in prevention programmes to offset 1.6 million annual claims that cost $NZD 1.9 billion. The ACC invests in nine national community sport injury prevention programmes that represent 40% of sport claims and costs. Pre-implementation is used to determine the decision whether to invest in implementation and to determine the level of such investment for the injury prevention programme. Post-implementation is calculated two ways: unadjusted, assuming *ceteris paribus*; and adjusted assuming no prevention programme was in place. Post-implementation formulae provide a return on investment (ROI) for each dollar invested in the programme and cost-savings. The cost-outcome formulae approach allows ACC to manage expectations of the prevention programme as well as when it will provide a ROI, allowing it to take a long-term view for investment in sport injury prevention. Originally developed for its sport injury prevention programmes, the cost-outcome formulae have now been applied to the other prevention programmes ACC invests in such as home, road and workplace injury prevention.

Introduction

The need for cost analysis of injury prevention initiatives

The van Mechelen et al. 'sequence of injury prevention' model[1] has been documented in the

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literature[2–4] as a framework to describe the development, implementation and effectiveness of sport injury prevention. A key part to this model is stage three, 'introducing prevention measures'. Despite the prevalence of the model and its wide acceptance there is little in the sport injury prevention literature discussing how the prevention measures are funded. Ensuring injury prevention funding is available is central to enable implementation. The level of injury prevention funding should be commensurable to the number and cost of injuries that the programme will be preventing. Gold et al.[5] acknowledged the challenge of predicting returns on investment in any field, but suggested there is a need for prevention to provide evidence to generate cost-savings prior to seeking funding or initiation of implementation. In a resource-constrained world, decision makers want to know if a programme produces the desired result less expensively than alternative approaches.[6] Despite mounting evidence that prevention initiatives for injuries, heart diseases, stroke, diabetes, and cancer are effective, prevention is at a competitive disadvantage for time and money.[5] If funding for sports injury prevention is to continue long term, outside randomised control tests, or at a national level, cost-outcomes such as return on investment (ROI) and cost-savings are required.

Evidence to date for injury prevention cost-outcome initiatives

Cost-outcome studies of injury prevention programs are scarce in the published literature. A meta-analysis[6] of 84 injury prevention studies with cost-outcome measures in the United States of America, found only a few cost-outcome studies for a variety of injury prevention areas, with none identified for sport and recreation. Cost-outcomes studies have been conducted for the effectiveness of protective equipment such as cycle helmets,[7] prophylactic ankle taping versus bracing,[8] and proprioceptive balance board training.[9] In addition there have been studies that have reported the cost-outcomes of medical procedures such as magnetic resonance imaging.[10] Miller and Levy[6] argued that the major barrier to the number of studies having cost-outcomes appears to be a lack of information about the costs of injury and the costs of injury prevention countermeasures. This may account for the limited number of cost-outcome studies in sport injury prevention evident in the literature so far. Despite some literature that discusses cost-outcomes[6] there has been no definition provided. Drummond[16] identified four main forms of economic evaluation: cost analysis, cost-effectiveness analysis, cost-utilisation analysis and cost—benefit analysis. Each form of economic analysis deals with costs but differing in the way that the consequences of programmes are measured and valued. While the model chosen will depend on what is being measure, the approach taken in this paper is aligned to a cost-outcome description since it is unable to undertaken a full comparison of alternative programmes.

The use of cost-outcome analysis for sport injury prevention by ACC

In New Zealand (NZ) the Accident Compensation Corporation (ACC) has applied cost-outcome formulae since 2003 for its national sports injury prevention programmes. Originally developed for sport, the same formulae have subsequently been applied for ACC's work, home, falls and road injury prevention programmes. ACC is a government taxpayer-funded monopoly, in existence since 1974 providing a 24 h no-fault personal injury scheme, currently legislated by the Injury Prevention, Rehabilitation and Compensation Act 2001 (IPRC). ACC provides for the associated injury costs including medical treatment, income replacement, social rehabilitation and vocational rehabilitation and ancillary services such as transport and accommodation. There is no disincentive for making a claim, people are not discriminated, risk rated or penalised for the number of claims made. From approximately 4 million people (estimated population of NZ), there were over 1.6 million personal injury claims registered with ACC costing $NZD 1.9 billion in the last financial year (1 July 2004 to 30 June 2005). The guarantee of personal injury coverage is offset by the restriction to sue for personal injury except in the rare circumstances of exemplary damages, e.g., mental trauma or stress. The national coverage and no-fault 24 h system makes the ACC dataset useful for measuring injury prevention initiatives. ACC has developed its cost-outcome model to show a return on investment in its injury prevention programmes.

ACC currently assesses moderate to serious claims (MSC) for its sport cost-outcome model. This is for four reasons; The first of these being cost. Of the 294,960 sport claims made in the last financial year, 8% were MSC, but represented 80% of the $NZD 222 million sport claims cost to ACC. Secondly, the IPRC gives provision for ACC to promote measures to reduce the incidence and severity of personal injury as a primary function. As result of section 263 (3) (a), the measures are targeted to result in a cost-effective, reduction in actual or projected rates. Thirdly, in practical terms better data are gathered for MSC than minor claims, particularly in relation to key sport information and 'how the injury occurred'. Currently ACC has initiated a process to capture into the system minor claim data. This process has been in place for 2 years and approximately 78.2% of the minor claims are now entered. Once all claims are entered then an adaptation of the model will be made to include minor claims. An adapted model has been developed but has not been sufficiently tested. Finally, combining low cost claims with high cost claims, creates clusters of costs and makes analysis using mean and standard deviations (S.D.) difficult. The annual mean $\pm$ S.D. for sport MSC is \$ 5262 $\pm$ 52.62 and for minor sport claims is \$ 164.15 $\pm$ 237.69. This makes combining the two claim types difficult and is a limit of using cost data that is not separated. The cost of MSC, the provision of the IPRC, the quality of MSC data compared with minor data in terms of cost and detail, and to avoid cost clusters, leads ACC's national sport injury prevention programmes to be designed to reduce the number and severity of MSC.

Although ACC had been investing in prevention programmes for a number of years, it wanted to select an appropriate level of investment based on activity suitable for the prevention programme. To provide a level of external validity to the process, the cost-outcome model was developed and reviewed by three internal ACC groups who work closely with the claims data, and an external consultancy firm and an academic. Recommendations were adopted to enhance the model, but the original working and logic remained intact. In addition ACC undertakes a number of quantitative and qualitative evaluations to asses the impact of the programmes.

Aim

To outline the ACC cost-outcome formulae for pre and post-implementation of its national sports injury prevention programmes.

Methods

The nine sport injury prevention programmes supported by ACC

During 2005 there were nine national sport injury prevention programmes ACC invested in. These nine sporting activities were high in participation and collectively represented 40% of the sport MSC to ACC in the last financial year. van Mechelen[1] argued that any cost-analysis must identify the sports that are most expensive for the community, so that the first intervention can be focused there. This is also consistent with the direction of section 263 of the IPRC. ACC through the no-fault system has a census of claims made. As a result ACC is able to show the costs for different sports and different injury types. This allows ACC to measure the cost of injury against the cost of intervention.

The data base information used by ACC for the nine sports with injury prevention programmes

The definition of injury for coverage by ACC is currently legislated by the IPRC and must satisfy three criteria: it must be a personal injury; it must be the result of an accident; and there must a link between the two. People who have a personal injury make a claim at the time of seeking medical treatment from over 30,000 registered medical professionals throughout NZ. When making a claim all information about the injury is collected using a standard form, ACC45, to ensure levels of consistency for data analysis. The injured person (unless impaired) completes information about the activity surrounding the injury (scene, cause, mechanism, sport) along with their personal details. The registered medical professional completes the form by providing information regarding diagnosis and other relevant medical information. The claim is then filed with ACC and details entered into a central database, with a preference for MSC data being entered. Key data such as diagnosis and personal details for minor claims are entered, but key sport information is less likely to be entered. Table 1 shows the nine programmes and the areas targeted by that programme such as the activity prior to the injury, the scene of injury and demographic characteristics.

Pre-implementation cost-outcome formulae

The pre-implementation formula calculates the number of MSC the prevention programme must reduce to break even, i.e., for each dollar invested in the injury prevention programme it must return one dollar of savings (\$ 1:\$ 1). The calculation provides an injury rate (IR) as a percentage of the number of participants the programme will be targeting (T). This is useful to determine if a programme is feasible or not. Pre-implementation is applied to the forthcoming ACC financial year (e.g.,

Table 1 The specific search terms used in the ACC database for analysis of the nine sports targeted with injury prevention programmes

Sport	Activity prior to injury	Scene of injury	Sport	Person's age on date of injury	Financial year programme implemented	Type of IP programme; example components	Key injury focus
Horse Riding (Horse)	Sport and recreation		Horse Riding		2004/2005	Rider education on handling horse, concussion, video clips on safety tips	Spinal cord damage, traumatic brain injury, neck/back/spine, falls
Rugby League (League)	Sport and recreation	Sport and recreation	Rugby League	Between 15 and 44 years	1998/1999	Currently being revamped to become LeagueSmart, will include concussion, tackle technique	Spinal cord damage, traumatic brain injury, neck/back/spine, shoulder, knee, ankle, concussion
Mountain Biking (MTB)		Off-road	Cycling	Aged 15 years or older	2005/2006	Rider resources and MTB code of conduct	Shoulders, soft tissue, falls
Netball	Sport and recreation	Sport and recreation	Netball		1999/2000	Player and coach education, NetballSmart,	Soft tissue, knees ankles
Rugby Union (Rugby)	Sport and recreation	Sport and recreation	Rugby Union	Between 15 and 44 years	1997/1998	Education; RugbySmart tackle video, concussion cards. Enforcement; tackle rules, mouthguard use	Spinal cord damage, traumatic brain injury, neck/back/spine, shoulder, knee, ankle, lower limbs, concussion
Skiing and Snowboarding (Snow)			Snowboarding or Snow skiing		2001/2002	Snow code and player resources, concussion, promoting of protective equipment, e.g., wrist guards	Knees, wrists, concussion
Football/Soccer (Soccer)	Sport and recreation	Sport and recreation	Soccer		1999/2000	Player and coach education, SoccerSmart, shin guards, FIFA's ''The 11'' programme, concussion	Soft tissue, knees, ankles
Touch Rugby (Touch)	Sport and recreation	Sport and recreation	Touch Rugby		1999/2000	Player and coach education	Soft tissue, knees, knees ankle
Water-related activities (Water)			Boating, fishing, kayaking, swimming (rivers, pools, lakes or beaches), surfing, underwater diving, water-skiing or windsurfing		2000/2001	Public education campaign, including resources and television to raise awareness	All

1 July 2005 to June 2006—2005/2006), reflecting the expectation in the next financial period. As the calculations conducted are either in the current period or just before the current period, discounting is not required. Typically discounting is a process of converting future dollars and outcomes into their present values.[5]

Pre-implementation utilises the following variables in the formulae:

- PC = programme costs to implement at the national level for the year of analysis.
- ALC = average lifetime cost. This represents the cost to ACC of a MSC in the area targeted for implementation, over the time length of the claim. This is important as treatment for some injuries can occur across more than one financial reporting year, particularly MSC. ACC has 30 years of injury data and is able to determine the length and cost of a particular injury type, and the last 10 years is used as the best indicator. The size of the data set can estimate the number of treatments, visits, time off employment and other factors to provide what services from ACC the person may require. While the mid point is used, a 95% confidence level is generated. The ALC is the amount paid to either the injured person or to treatment providers. It does not include a portion of ACC operating costs. The ALC is presented at current costs and reviewed each year to reflect changes in costing that may occur, from year to year.
- M = maximum number of participants in the sport. This is the number of participants defined by a demographic (e.g., gender, age, ethnicity) and will determine the extraction criteria for the ALC.
- H = historical number of MSC for the participants in the sport that a prevention programme is intending to be implemented. Similar to ALC, the last 10 years provides the best historical data, but this is dependant on the injury, e.g., a serious injury such as tetraplegia or paraplegia can be tracked back to 1974, when ACC came into existence.
- T = number of participants in the sport being targeted. This is matched to the type of intervention.

To determine the IR, the number of MSC to break even (BE) needs to be established using the following formulae:

$$\mathrm{BE} = \frac{\mathrm{PC}}{\mathrm{ALC}}$$

The BE is then used to determine the IR as a percentage based on the estimated number of MSC in the targeted group:

$$\mathrm{IR}\,(\%) = \frac{\mathrm{BE}}{(\mathrm{T}(\mathrm{H}/\mathrm{M}))}$$

While the IR is expressed as a percentage it is an indication, not a precise figure. The IR is then subject to a sensitivity analysis, determining upper and lower parameters. This can easily be achieved as the only variables that can be modified are programme costs (PC) and number of participants in the sport being targeted (T). All other formulae variables (ALC, M and H) are static and only change annually.

Once the IR is calculated and sensitivity analysis is conducted, a comparison against pilot studies, existing studies in the literature or similar prevention programmes is made to determine if the IR is achievable or not. If no research or similar programmes exist, the IR is compared to sports or demographics with similar injuries. The IR is then subject to peer-review including the sensitivity analysis. The IR is used in the pre-implementation stage as it determines whether the programme is feasible or not. In determining the change in claims post-implementation cost-outcome formulae are used.

Once the final IR is determined it forms part of a business case to seek ACC funding for the prevention programme. The funding of the programme also relies on other business case supporting data such as literature, risk factors, current funding levels and whether the programme can actually be implemented as intended. Due to the ACC system having injury data for 54 sports, all sports have the potential to have a pre-implementation model developed. Which sports have a prevention programme depends on the strength of the business case and includes cost-outcome formulae.

Post-implementation cost-outcome formulae

Post-implementation is an annual exercise and calculates any change in the number of MSC to ACC in two ways. The first, unadjusted, is against the difference in MSC from baseline before implementation to the point in time being measured, typically a number of years and assumes the principle of *ceteris paribus*. The second, adjusted, is based against forecast as to the number of MSC that would have occurred if no prevention programme were implemented. Having a forecast allows factors outside the control of a prevention programme to be taken into account such as changes in ACC policy or population growth. Post-implementation is conducted annually rather than seasonally as ACC receives sport MSC throughout the year, but a higher concentration occurs in the months the sport is traditionally played. MSC can be matched to the programme by region, demographic, or injury type. The cost-outcome for both unadjusted and adjusted is expressed as a ratio for each dollar invested. Post-implementation is presented by the last full financial year (e.g., 1 July 2004 to 30 June 2005—2004/2005), and is conducted at the end of each financial year.

Post-implementation uses the following variables in the formulae:

- U = unadjusted claims, the difference between the number of MSC before implementation and post-implementation at a particular point in time.
- A = adjusted claims. The claims are adjusted to show what would happen if no programme was in place. This is achieved by using a forecast made based on factors that would have impacted on the ACC claims database that need to be taken into account. Analysis by external consultants identified 28 factors[11,12] and these are weighted based on the prevention programme, i.e., aging population has less impact on sport MSC than a programme targeting falls in older adults. This analysis produces an adjusted number of MSC that is used to calculate a cost-outcome analysis. The identification of the 28 factors[11,12] helps address the concern that it is not possible to rule out the effect of a change of variables over time other than the preventive measure, which may also influence the outcome variable.[1] Factors were first identified from within ACC based on changes in the environment (e.g., policy changes) and these were then assessed to determine the effect.
- TPC = total programme costs since implementation. This includes only programme costs invested by ACC and excludes associated costs such as overheads and staff salaries.
- ALC.

$$\text{Unadjusted cost-outcome} = \frac{\text{U} \times \text{ALC}}{\text{TPC}}$$

$$\text{Adjusted cost-outcome} = \frac{\text{A} \times \text{ALC}}{\text{TPC}}$$

Post-implementation formulae provide cost-savings and are presented over a ratio of $NZD 1 reflecting ROI.

Results

The results for the cost-outcome analysis for the nine prevention programmes are presented in Table 2 (pre-implementation) and Table 3 (post-implementation). The upper and lower bounds used in Tables 2 and 3 represent that the ALC is calculated using a 95% confidence interval. It is present to provide a range for the ROI. The stage of injury prevention programme implementation and the variety in ALC to ACC, depicting the severity of injuries in each sport, is evident in the table data. A worked example with variables derived from Tables 2 and 3 is provided from the Netball programme.

Pre-implementation cost-outcome application to netball

$$\text{BE} = \frac{\text{PC}}{\text{ALC}} = \frac{150,000}{5035}$$
$$= 29.79 \text{ claims to break even (BE)}$$

$$\text{IR}\,(\%) = \frac{\text{BE}}{(\text{T}(\text{H}/\text{M}))} = \frac{29.79}{(50,000(1310/150,000))}$$
$$= \frac{29.79}{(50,000(0.0087333))} = \frac{29.79}{436.665}$$
$$= 6.82\% = \text{IR}$$

Post-implementation cost-outcome application to netball

Unadjusted cost-outcome

$$= \frac{\text{U} \times \text{ALC}}{\text{TPC}} = \frac{47 \times 5035}{377,300} = \frac{236,645}{377,300}$$
$$= \text{return of 63 cents for every dollar invested}$$

Adjusted cost-outcome

$$= \frac{\text{A} \times \text{ALC}}{\text{TPC}} = \frac{947 \times 5035}{377,300} = \frac{4,768,145}{377,300}$$
$$= \text{return of 12.64 cents for every dollar invested}$$

Pre-implementation cost-outcome results

Most sport programmes are expected to provide a ROI and cost-savings to ACC. In 2005/2006 the two exceptions will be Mountain Biking (MTB) and League. MTB is in its first year of implementation, whereas League had an injury prevention programme restructure and was re-focused to be

Table 2 Pre implementation cost-outcomes for the 2005/2006 ACC financial year using a mid point average lifetime cost

Sport	Programme costs (*P*)	Average lifetime cost (ALC)	Break even point (BE) rounded	Maximum number of participants in sport (*M*)	Historical number of moderate to serious claims (H)	Number of participants in the sport being targeted (T)	Injury rate (IR) (%)	Projected IR (%)	Projected number of claims reduced	Projected savings	Projected return on investment (ROI) per $ 1 (lower; upper bounds)
Horse	$ 30,000	$ 17,478	2	76,000	457	16,000	1.78	5.0	4.81	$ 54071	$ 2.80 (2.53; 3.08)
League	$ 120,000	$ 13,959	9	21,000	564	5000	6.40	0.0	0.00	−$ 120000	$ 0.00 (0.00; 0.00)
MTB	$ 50,000	$ 8,782	6	177,200	785	30,000	4.28	3.0	3.99	−$ 14958	$ 0.70 (0.61; 0.79)
Netball	$ 150,000	$ 5,035	30	150,000	1,310	50,000	6.82	7.0	30.57	$ 3927	$ 1.03 (0.99; 1.06)
Rugby	$ 300,000	$ 7,951	38	55,000	3,164	52,500	1.25	4.0	120.81	$ 660510	$ 3.20 (3.07; 3.33)
Snow	$ 120,000	$ 8,083	15	300,000	625	234,000	3.05	3.1	15.11	$ 2132	$ 1.02 (0.96; 1.08)
Soccer	$ 150,000	$ 6,117	25	200,000	1,261	130,000	2.99	5.0	40.98	$ 100692	$ 1.67 (1.53; 1.81)
Touch	$ 25,000	$ 5,523	5	200,000	590	32,500	4.72	5.0	4.79	$ 1456	$ 1.06 (1.01; 1.11)
Water	$ 668,000	$ 32,449	21	1,872,000	725	1,179,360	4.51	5.5	25.12	$ 147116	$ 1.22 (1.09; 1.35)

Table 3 Cost-outcome analysis post-implementation to 2004/2005 ACC financial year using a mid point average lifetime cost

Sport	Total programme costs (TPC)	Average lifetime cost (ALC)	Number of claims reduced unadjusted	Number of claims reduced adjusted	Programme savings unadjusted	Programme savings adjusted	Return on investment (ROI) per $ 1 unadjusted (lower; upper bounds)	Return on investment (ROI) per $ 1 adjusted (lower; upper bounds)
Horse	$ 20,000	$ 17,478	−92	0	−$ 1608018.32	$ 0.00	−$ 80.40 (−72.55; −88.26)	$ 0.00 (0.00; 0.00)
League	$ 152,130	$ 13,959	−18	165	−$ 251256.42	$ 2303183.85	−$ 1.65 (−1.53; −1.78)	$ 15.14 (13.98; 16.30)
MTB	N/A	$ 8,782	N/A	N/A	N/A	N/A	N/A	N/A
Netball	$ 377,300	$ 5,035	47	947	$ 236655.81	$ 4768362.81	$ 0.63 (0.61; 0.65)	$ 12.64 (12.25; 13.03)
Rugby	$ 1,425,234	$ 7,951	588	1,287	$ 4674941.04	$ 10232396.46	$ 3.28 (3.15; 3.41)	$ 7.18 (6.89; 7.47)
Snow	$ 336,234	$ 8,083	71	216	$ 573884.48	$ 1745902.08	$ 1.71 (1.61; 1.81)	$ 5.19 (4.88; 5.50)
Soccer	$ 250,800	$ 6,117	−260	99	−$ 1590529.20	$ 605624.58	−$ 6.34 (−5.81; −6.88)	$ 2.41 (2.21; 2.62)
Touch	$ 143,000	$ 5,523	−56	63	−$ 309298.64	$ 347960.97	−$ 2.16 (−2.06; −2.27)	$ 2.43 (2.32; 2.55)
Water	$ 2,199,900	$ 32,449	−167	16	−$ 5418961.29	$ 519181.92	−$ 2.46 (−2.20; 2.72)	$ 0.24 (0.21; 0.26)

consistent with other similar sport prevention programmes. This required additional funding ($NZD 100,000) justified by the previous ROI and cost-savings (see Table 3). As such both programmes are not expected to show a ROI till 2006/2007. Typically, new or refocused prevention programmes take 12—18 months to show a return, especially at the national level. As large-scale national prevention programmes require a behaviour change and are outside the laboratory situation, a greater variation of uptake of prevention principles and change in behaviour will occur.

Post-implementation cost-outcome results

Post-implementation (Table 3) is measured against unadjusted MSC assuming a level of *ceteris paribus* applies, and adjusted MSC reflecting the forecast if no prevention programme was in place. The variation between the two clearly shows without adjustment only two programmes (Rugby and Snow) are providing a positive ROI, i.e., for every $ 1 invested the programme returns at least $ 1. Programmes such as Horse are in their first year of implementation and did not provide a ROI, or cost-

Table 4 Factors that impacted on moderate to serious claims to ACC that relate to Netball for the purposes of calculating the adjusted MSC

Factors (no impact factors are excluded)	Impact value—high/medium/low
The growth in the population. There has also been an increase in the workforce population. This impacts on the number of people who makes claims, the type and nature of those claims.	Medium
Increased awareness of ACC entitlements and service. ACC actively encourages people to claim and runs public campaigns to ensure people access the services they are entitled to.	Low
Proactive contact with claimants by contact centres. When a person has been injured, particularly MSC they are managed to ensure they receive entitlements.	Low
Change in entitlements, e.g., the re-introduction of lump sums payments. People may not have claimed if they received a weekly payment, but would as a lump sum.	Low
Extension of gatekeeper from doctors to include allied health providers. Previously to access additional medical service such as physiotherapy, a person had to be referred by a doctor. This meant that people no longer had to visit a doctor in order to access the most appropriate treatment provider for their injury, but could go directly to an allied health provider.	High
Elective surgery changes. ACC moved to have people who needed elective surgery receive it quicker by using private hospitals to provide such services. ACC commenced purchasing and fully funding elective surgery directly under contract. ACC previously funded elective surgery, at 60% of cost.	Low
Claim escalation rates (conversion from a claim receiving only acute primary health care benefits to one receiving compensation and other benefits).	Low
Awareness campaign to specific demographics that are underrepresented in claim statistic. ACC is targeting these groups to ensure they are aware of their entitlements under the scheme.	Medium
Relaxation of the requirement to identify an external force as part of the definition of accident. For an injury to be considered as caused by external force or resistance, it must be the direct result of a specific event or series of events. These must involve the application to the human body of an external force or resistance, or the sudden movement of the body to avoid an external force or resistance.	Low
Changes in funding. Direct payments of some health expenses by ACC rather than bulk funding.	Low
Changes in medical and vocational rehabilitation process and programmes.	Medium
Health provider co-payments, Capitated Primary Health Organisations and the incentive to claim.	Medium
Current Injury Prevention programmes.	High
Changes to allow health providers to electronically lodge claims making the process more efficient and decision made quicker.	High
Impact of winning the world championship on participation.	Medium
Television and semi-profession growth of the sport that impacts on participation.	Low

savings. The MTB prevention programme was not in existence in 2004/2005 so does not provide any results, but is expected to provide results by the end of 2006/2007. The Water prevention programme shows that even with adjusted MSC it is not providing a ROI or cost-savings to offset programme costs.

In the Netball example provided, there are a number of factors that specifically impacted on this programme. This is reflected in the adjusted MSC. To provide an indication of the factor, some specific to ACC, some to NZ and some to netball, Table 4 presents these with an indication of the impact, high, medium, low.

Discussion

ACC has the benefit of a system that has well-documented and carefully measured effectiveness that Miller and Levy[6] called for in determining cost-outcomes. ACC has the ability to provide a level of cost-outcome analysis required under the IPRC. This has resulted in pre and post-implementation cost-outcomes. While the examples used in this analysis are focused on the entire national programme, the formulae can be, and are, applied to specific injuries (such as dental claims, concussion, spinal injuries, strains and sprains) and also to regions or particular demographics.

ACC invested in injury prevention programmes before the development of the pre-implementation cost-outcome framework. ACC decided to focus its prevention programmes on areas that were high in cost and numbers of MSC. This retrospectively has provided positive ROI and cost-savings (see Table 3). The development of a cost-outcome framework has allowed ACC to continue to invest and increase its investment, e.g., Netball and Soccer had a $NZD 100,000 programme increase, respectively, from 2004 to 2005. The framework has also allowed ACC to extend the range of other programmes that it may not have considered implementing before (e.g., Horse and MTB), as well as indicating the level of investment suitable for a prevention programme (e.g., League). One of the benefits from this type of cost-outcome framework is that the IR assists decision makers by providing an objective analysis that helps determine the likelihood of the programme achieving a reduction in MSC to ACC, before investment. In the Netball example provided, a IR of 6.82% is required. The focus shifts to whether the 6.82%, or IR, is achievable and the supporting evidence for this.

Pre-implementation formulae ensure smart targeting by calculating the IR from only the injuries from the target group (T) rather than all possible MSC for the sport. The emphasis moves to whether those people can be reached and the quality of the intervention. This is a crucial factor for implementing prevention programmes at the national level.

Central to the decision of implementation is the national sporting organisation (NSO). This is an essential part as it is only in partnership with the NSO that a prevention programme at the national level has any likelihood of success. Pre-implementation provides a useful framework for providing a starting point for dialogue before implementation, by highlighting the factors needed to reduce MSC as part of the prevention programme. If the IR is considered high and/or not supported by other evidence, this is then used to discuss more cost effective measures with the NSO. Typically cost (PC) and size of target (T) group is analysed to determine if either can be modified, subject to peer review, ensuring the variables used are correct at time of calculation. Other variables in the pre-implementation formulae (M, H and ALC) remain constant. This is then used to discuss more cost effective measures. The advantages are that it makes parties aware of the factors needed to make the programme a success. However, the formulae are reliant on a strong approximation of playing numbers (M). If this is incorrect then the IR will also be incorrect. In NZ there are few NSOs that have an accurate database of playing numbers. Participation studies can provide some insight, but these are usually not conducted annually. This is a limit of the formulae used.

Post-implementation results show a wide range occurs when comparing unadjusted and adjusted ROI and cost-savings (see Table 3). Having only one perspective would provide a limited view. Certainly having only unadjusted cost-outcomes is ignoring the real world and epidemiologic factors that affect injuries. For example, Rugby has had an increase in playing numbers of 6.9 and 6.3% in 2004 and 2005, respectively,[13] and volcanic activity has reduced the number of days available for skiing in a season. Adjusted cost-outcomes rely heavily on the accuracy of the forecasts. An understanding of how post-implementation formulae are calculated is required otherwise the analyses generated are used in isolation and do not present a true and fair view. A positive post-implementation should be taken as just that, rather than an exact or precise figure. The longer the prevention programme returns a positive ROI and the larger the figure, the greater confidence surrounding it.

Both pre and post-implementation cost-outcomes for sport are centred on the reduction of MSC. While the rationale for this is logical (MSC are high in cost and severity) it does ignore the minor claims that make up 92% of sport claims to ACC. The prevention programme could be having an influence in these areas, certainly if MSC are reducing, but this is unknown as it is excluded in the analysis.

The calculations applied in this cost-outcome analysis only include treatment costs paid by ACC to either the injured person and/or the treatment provider. It does not include the value of pain, suffering, or loss of productivity to the country as a result of the personal sports injury. Other cost-outcome models usually incorporate a measure of the impact an injury has on the quality of life, costs to society, morbidity and mortality costs. These are typically the largest component of costs.[14] Placing a value on these can be subjective and difficult to measure from an injury perspective. As such ACC does not incorporate these into its model as it is primarily interested in the benefit to the organisation. Including quality of life and costs to society, if they were able to be quantified, into the formulae will only have a greater positive impact on the cost-outcome model.

The Water programme would benefit from the inclusion of cost-outcome formulae using aspects such as cost to society or quality of life. This is due to the programme's focus being the reduction of drowning, not injury. As such the post-implementation formulae are not suitable for the Water prevention programme as arguably it measures the wrong variables. The Water programme would be better suited to using another measure, such as a change in the number of drownings as an effective measure as opposed to MSC. Alternatively ACC could adjust the Water ALC to reflect quality of life or costs to society, morbidity or mortality costs and replace MSC with the number of drownings. There is a compensation component for next of kin for Water deaths from ACC, but this does not represent the cost to society. A future model for the Water programme will need to consider these costs.

Excluded from the formulae is the operating cost of ACC and legal implications. Tolpin et al. argued that these societal costs are relevant since they consume resources channelled into alternative uses.[14] While legal implications are incorporated into other cost-outcome models, the IPRC and the no-fault system means this is moot. Some operating costs would need to be incorporated into the cost-outcome formulae only if the programme was in place (e.g., injury prevention staff salaries). However, following Tolpin et al.'s line of thinking[14] there would also have to be an amount allocated to the ALC as a reduction in MSC would require less resources and services from ACC to manage the injuries (e.g., 100 less MSC would require less operating costs). ACC is using a simple input—output model. Including a proportion of the operation cost will require additional assumptions and increase subjectivity into the cost-outcome formulae. Having a simple model that reduces elements of subjectivity provides the ACC cost-outcome model with greater credibility.

A clear limit of the ACC approach is the absence of discounting on the post-implementation formulae. This is currently subject to further analysis within ACC. While discounting is not relevant for pre-implementation, given that some prevention programmes have and will cover a number of years, discounting would benefit the model. Discounting is a standard accounting practice worldwide and has recognised and established tables for such calculations. Thus, discounting is not open to the same level of subjectivity and interpretation as cost to society. While discounting will lower TPC, increasing the ROI and cost-savings, it should be undertaken to be consistent with literature and best-practice cost-outcome modelling.

ACC has not incorporated all possible factors into its simple cost-outcome formulae. Some of these factors may be found in cost-outcome models (e.g., cost to society, morbidity, mortality, discounting or operating costs). There are examples of omitting outcomes and costs if they are not of interest to the decision maker[5] and this has been for case for ACC which has only focused on areas relating directly to their core business. This approach can reduce subjectivity, and can ensure expectations of the programme (i.e., reductions in MSC are achievable before investment has commenced).

The cost-outcome formulae show the value of injury prevention, albeit to ACC. As ACC meets the cost of the injury, it has a vested interest in funding successful injury prevention programmes. Having a cost-outcome framework allows ACC to select prevention programmes that fit with its goals, have a level of certainty before implementation, as well as focusing all stakeholders on the same variables to achieve success. The results of the ACC cost-outcome model do make a strong case for other countries contemplating sports injury prevention programmes or initiatives.

While initially developed for sport prevention programmes, the cost-outcome model had been integrated into other areas of ACC national prevention programmes, e.g., workplace, home, road, falls. This is the distinct advantage of having a centralised injury database that collects injury information. An adequate injury registration system is essential to any assessment of the total cost associated with sports injuries.[14] It also reduces an element of pre-selection regarding whether a person decides to seek treatment. Pre-selection may occur using hospitalisation data as less severe injuries or those with a delayed effect could likely be under reported.[15,16] Given the population of New Zealand (4 million) and the number of personal injury claims to ACC (1.6 million) in the last financial year, there seems to be little pre-selection occurring. This might not be the case in other countries intending to implement prevention programmes.

Conclusion

ACC has developed its cost-outcome formulae to reflect its needs for continued investment in injury prevention programmes. It has, where possible, followed principles in the literature, but has opted for variables that reduce the element of subjectivity and speculation. This puts ACC in a position to investment wisely in sports injury prevention ensuring correct funding levels and justification for that funding.

Practical implications

- Cost-outcome formulae can be used to evaluate the effectiveness of injury prevention investment.

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Papers

Exercises to prevent lower limb injuries in youth sports: cluster randomised controlled trial

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Abstract

Objective To investigate the effect of a structured warm-up programme designed to reduce the incidence of knee and ankle injuries in young people participating in sports.
Design Cluster randomised controlled trial with clubs as the unit of randomisation.
Setting 120 team handball clubs from central and eastern Norway (61 clubs in the intervention group, 59 in the control group) followed for one league season (eight months).
Participants 1837 players aged 15-17 years; 958 players (808 female and 150 male) in the intervention group; 879 players (778 female and 101 male) in the control group.
Intervention A structured warm-up programme to improve running, cutting, and landing technique as well as neuromuscular control, balance, and strength.
Main outcome measure The rate of acute injuries to the knee or ankle.
Results During the season, 129 acute knee or ankle injuries occurred, 81 injuries in the control group (0.9 (SE 0.09) injuries per 1000 player hours; 0.3 (SE 0.17) in training *v* 5.3 (SE 0.06) during matches) and 48 injuries in the intervention group (0.5 (SE 0.11) injuries per 1000 player hours; 0.2 (SE 0.18) in training *v* 2.5 (SE 0.06) during matches). Fewer injured players were in the intervention group than in the control group (46 (4.8%) *v* (76 (8.6%); relative risk intervention group *v* control group 0.53, 95% confidence interval 0.35 to 0.81).
Conclusion A structured programme of warm-up exercises can prevent knee and ankle injuries in young people playing sports. Preventive training should therefore be introduced as an integral part of youth sports programmes.

Introduction

Regular physical activity reduces the risk of premature mortality in general and of coronary heart disease, hypertension, colon cancer, obesity, and diabetes mellitus in particular.[1 2] However, participation in sports also entails a risk of injury for all athletes, from the elite to the recreational level. Studies from Scandinavia document that sports injuries constitute 10-19% of all acute injuries seen in emergency departments, and the most common types are knee and ankle injuries.[3] Serious knee injuries, such as injuries to the anterior cruciate ligament, are a growing cause of concern. The highest incidence is seen in adolescents playing pivoting sports such as football, basketball, and team handball. In these sports, women are three to five times more likely to contract a serious knee injury than men.[4-6]

Injuries to the anterior cruciate ligament may require surgery, always entail a long rehabilitation period, and drastically increase the risk of long term sequelae.[7] Although treatment methods have advanced notably, there is no evidence to show that repair of a ruptured anterior cruciate ligament or isolated cartilage lesions prevents early development of osteoarthritis.[7] Effective methods for preventing injuries therefore need to be developed.

Some studies report promising results, indicating that it may be possible to reduce the incidence of knee and ankle injuries among adults[8-10] and adolescents.[11-14] However, these studies are small and mainly non-randomised, with important methodological limitations. Prospective randomised intervention studies are therefore needed, especially among children and adolescents, to assess the efficacy of interventions aiming to reduce injuries.

We conducted a randomised controlled trial to investigate the effect of a structured programme of warm-up exercises used to prevent acute injuries of the lower limb in young people playing sports. To minimise overlap within clubs, we used a cluster design.

Methods

One hundred and twenty three clubs agreed to participate in the study, and we block randomised these, with four clubs in each block to an intervention or control group. To reduce potential confounding, we matched the clubs by region, playing level, and sex and number of players. The statistician (IH) who conducted the randomisation was not involved in the intervention. Box 1 gives details of the procedure used to recruit clubs.

We informed clubs allocated to the intervention group that they would receive a programme of warm-up exercises used to prevent injuries. We asked the clubs in the control group to do their training as usual during the season and informed them that they would receive the same programme as the intervention group at the start of the subsequent season.

Box 1: Recruiting clubs to the study

- All 145 clubs in the 16 year and 17 year divisions from central and eastern Norway, organised by the Norwegian Handball Federation, received an invitation to participate in the study during one eight month season (September 2002 to April 2003)
- The clubs practised one to five times per week and played between 20 and 50 matches during the season, depending on their ability and ambition
- The clubs were recruited from June to August 2002 through the website of the Norwegian Handball Federation, and a letter with information about the purpose and the design of the study went to the coaches, who also informed the players

Intervention

The warm-up programme was developed by medical staff from the Oslo Sports Trauma Research Center and coaching staff from the Norwegian Handball Federation, and its feasibility had been tested in four clubs during the previous season. The programme included four different sets of exercises, each of increasing difficulty.

At the start of the league season (September), the clubs in the intervention group received one visit from an instructor from the handball federation. In addition, instructors followed up the clubs with a visit midway through the season (January). The instructors had been familiarised with the programme during a two hour seminar, in which they received theoretical and practical training on how to conduct the programme. The clubs received an exercise book, five wobble boards (disc diameter 38 cm; Norpro, Notodden, Norway, 2000) and five balance mats (40×50 cm^2, 7 cm thick; Alusuisse Airex, Sins, Switzerland, 2000). The coaches were asked to use the programme at the beginning of every training session for 15 consecutive sessions and then once a week during the remainder of the season.

The main focus of the exercises was to improve awareness and control of knees and ankles during standing, running, cutting, jumping, and landing. The programme consisted of exercises with the ball, including the use of the wobble board and balance mat (box 2, fig 1, and fig 2), for warm up, technique, balance, and strength.

The players were encouraged to be focused and conscious of the quality of their movements, with emphasis given to core stability and position of the hip and knee in relation to the foot (the "knee over toe" position). They were also asked to watch each other closely and give each other feedback during the training. They were instructed to spend 4-5 minutes on each exercise group for a total duration of 15-20 minutes.

Box 2: Programme of warm-up exercises used to prevent injuries

Warm-up exercises
(30 seconds and one repetition each)
Jogging end to end
Backward running with sidesteps
Forward running with knee lifts and heel kicks
Sideways running with crossovers ("carioca")
Sideways running with arms lifted ("parade")
Forward running with trunk rotations
Forward running with intermittent stops
Speed run

Technique
(One exercise during each training session; 4 minutes and 5×30 seconds each)
Planting and cutting movements
Jump shot landings

Balance
(On a balance mat or wobble board, one exercise during each training session; 4 minutes and 2×90 seconds each)
Passing the ball (two leg stance)
Squats (one or two leg stance)
Passing the ball (one leg stance)
Bouncing the ball with eyes closed
Pushing each other off balance

Strength and power
(2 minutes and 3×10 repetitions each)
One quadriceps exercise:
Squats to 80° of knee flexion
Bounding strides (*Sprunglauf*)
Forward jumps
Jump shot—two legged landing
"Nordic hamstring lowers" (2 minutes and 3×10 repetitions each)

Data on injury and exposure were reported by the physiotherapists using a web based database in which all the data were coded anonymously. At the end of the season, the recorded data were confirmed, or if necessary corrected, by the coaches. Box 3 shows the definitions we used in registering injuries.

Outcome measures

We defined the primary outcome as an acute injury to the knee or ankle. A secondary outcome was defined as any injury to the lower limbs. We also included secondary analyses of injuries overall (including all injuries) and injuries to the upper limb. We included all injuries reported after an intervention club had completed the first session of the training aiming to prevent injuries (and from the same date in the control clubs randomised in the same block), to compare the number of injured players and incidence of injury between the intervention group and the control group.

The number of injured players was based on data from individual players and the incidence of injuries on summary data of injuries and exposures for the whole group. Data on players who dropped out during the study period were included for the entire period of their participation.

Ten research physiotherapists who were blinded to group allocation recorded injuries in both groups, using definitions (box 3) and a standardised injury questionnaire described in our earlier study (Olsen OE, Myklebust G, Engebretsen L, Bahr R. Injury pattern in youth team handball: a comparison of two prospective registration methods. Submitted for publication to *Scand J Med Sci Sports*).

The physiotherapists were in contact with the coaches at least every month to record injured players and exposure data. They interviewed injured players, either in person or by telephone, and in most cases within four weeks (range one day to four months). They were responsible for roughly the same number of clubs from each of the groups (11 to 13 clubs each).

The coaches of the clubs receiving the intervention recorded compliance on a designated form as the number of injury prevention sessions, the duration of each session in minutes, and the average attendance of the players (in per cent). At the end of the season we also obtained information on prevention training conducted by the control clubs, including the types and volume of exercises used.

Sample size

In youth team handball, the incidence of acute injuries to the knee and ankle is estimated to be 12 per 100 players per league season.[11 15] From a pilot study conducted to determine the incidence of injury during the previous season (submitted for publication), we estimated that the cluster effects for club randomisation gave an inflation factor of 2.0 based on a cluster size of 15 and an intracluster correlation coefficient of 0.07. We then calculated that to achieve 90% power with $\alpha = 5\%$ to detect a relative risk reduction of 50%, we would need 915 players in each group. Therefore, when we initiated the trial, we were hoping to include 60 clubs in each group (a total of 120 clubs; with an average of 15 players in each club).

Statistical methods

We used Stata, version 8.0 (Stata Corporation, Lakeway Drive, Texas, 2003), for the statistical analysis. We undertook all statistical analyses according to a prespecified plan. We used the

Fig 1 Top: mat exercise. Middle: wobble board exercise. Bottom: mat pair exercise

Fig 2 Example of a strength exercise ("Nordic hamstring lowers"). Top: start position; a partner holds around the player's ankles. Bottom: The player falls slowly forwards, using hamstrings to resist the fall against the floor as long as possible

relative risk of the number of injured players according to the intention to treat principle to compare the risk of an injury in the intervention and control groups. Cox regression was our analysis tool for the primary outcome as well as the secondary outcomes, and we used the robust calculation method of the variance-covariance matrix,[16] taking into account the cluster randomisation. We tested rate ratios with Wald's test. We used one way analysis of variance to estimate the intracluster correlation coefficient to obtain estimates of the inflation factor for comparison with planned sample size. We used the inverse of the difference between percentages of injured players in the two groups to calculate the number needed to treat to save one injury. We calculated exposures to training and matches and incidence of injury as described in our earlier study.

We used a z test based on the Poisson model to compare the rate ratio between the two groups (intervention *v* control), sex (female *v* male), severity of injury (slight, minor, moderate, major), and club activities (match, training).

Compliance and incidence of injury are presented as means with standard errors. Relative risk and rate ratio are presented with 95% confidence intervals. We regarded two tailed P values ≤ 0.05 as significant.

Results

Figure 3 shows the flow of clubs and players through the trial. Players in the two groups were similar in sex distribution, age, and dropout rates (table 1). All but eight (13%) of the clubs in the intervention group used the programme of warm-up exercises used to prevent injuries during the study period. Also, 13 (22%) of the clubs in the control group used specific exercises intended to prevent injuries (including training on the balance mat and wobble board) as a part of their training.

Table 1 Characteristics of participants and compliance of clubs. Values are numbers (percentages) of participants unless otherwise indicated

Characteristic	Intervention group (n=958)	Control group (n=879)
Girls	808 (50.9)	778 (49.1)
Boys	150 (59.8)	101 (40.2)
Mean (SD) age in years*	16.3 (0.6)	16.2 (0.6)
Dropouts	68 (7.1)	51 (5.8)
Injury prevention programme:		
Clubs	61†	13
Training sessions (SE, range)	27 (12, 1-55)‡	26 (7, 14-35)§
Average time spent per session in minutes (SE)	18 (6)¶	18 (9)**
Average attendance per session in %	73††	81‡‡

*Range 15-17 years in both groups.
†Eight (13%) of the clubs did not continue using the programme of warm-up exercises used to prevent injuries after the initial intensive introduction period. They used the programme at 5 (SE 5, range 1-13) sessions during the first part of the season and then discontinued the programme.
‡14 (SE 7, 1-30) in the first part of the season (September to December) and 13 (SE 7, 0-26) in the second part (January to April).
§14 (SE 4, 7-20) in the first part and 12 (SE 3, 7-15) in second part.
¶20 (SE 5) in the first part *v* 16 (SE 7) in second part.
**18 (SE 9) minutes in both first and second part.
‡‡78% in the first part *v* 69% in second part.
††85% in the first part *v* 78% in second part.

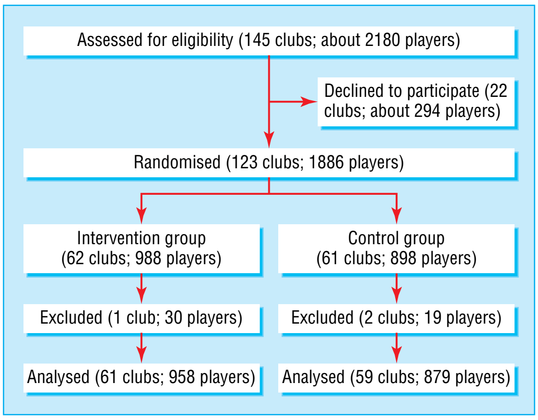

Fig 3 Flow of club clusters and players through the study. After randomisation, two clubs in the control group withdrew from participating in the Norwegian Handball Federation league (no players played for these clubs), and one club in the intervention group declined to participate in the study. The players (n=49) in these clubs were excluded from the study

Box 3: Operational definitions used in the registration of injury

Reportable injury
An injury occurred during a scheduled match or training session, causing the player to require medical treatment or miss part of or the next match or training session

Player
A player was entered into the study if she or he was aged 15-17 years (born between 1 January 1985 and 31 December 1987), was registered on the club roster by the coach, and did not have a major injury at the start of the study

Return to participation
The player was defined as injured until he or she was able to participate fully in club activities (match and training sessions)

Type of injury
Acute—injury with a sudden onset associated with a known trauma
Overuse—injury with a gradual onset without any known trauma

Severity†
Slight—0 days of absence and able to participate fully in the next match or training session
Minor—absence from match or training for 1-7 days
Moderate—absence from match or training for 8-21 days
Major—absence from match or training for >21 days

Exposure*
Match exposure—hours of matches
Training exposure—hours of training
In nearly all cases, players sustaining moderate or major injuries were examined by a doctor. If there was any doubt about the diagnosis the player was referred to a sport doctor or a sports medicine centre for follow up, which often included imaging studies or arthroscopic examination. In case of a slight or minor injury, the player was often examined only by a physical therapist or coach or not at all. None of the injured players was examined or treated by any of the authors, and we had no influence on the time it took a player to return to club activities.

Injury characteristics

During the eight month season, 262 (14%) of the 1837 players who were included in the study contracted a total of 298 injuries. Of these, 241 (81%) were acute injuries and 57 (19%) were overuse injuries. Table 2 shows the location of the most common body part injured, the type of acute and overuse injuries, and the age of the injured players.

Effect of prevention

Significantly fewer injured players were in the intervention group than in the control group for injuries overall, lower limb injuries, acute knee or ankle injuries, and acute knee and upper limb injuries, whereas a 37% reduction in acute ankle injuries did not reach significance (table 3). The degrees of clustering at the club level (intracluster correlation coefficient) were estimated to be 0.043 to 0.071. The number needed to treat to prevent one injury varied from 11 to 59 players.

The exposure in hours for the intervention group was 93 812 (11 210 hours spent in matches, 82 602 hours in training) and in the control group 87 483 hours (10 783 hours in matches,

Table 2 Most common body part injured, most common type of acute and overuse injuries, and age of the injured players. Values are numbers (percentages) of participants unless otherwise indicated

	Intervention group (n=958)	Control group (n=879)
Body category:		
Ankle	31 (30.1)	47 (24.1)
Knee	25 (24.3)	44 (22.6)
Finger	10 (9.7)	22 (11.3)
Head	7 (6.8)	11 (5.6)
Low back	7 (6.8)	9 (4.6)
Shoulder	4 (3.9)	11 (5.6)
Acute injuries:		
Sprains	48 (56.5)	75 (48.1)
Contusions	15 (17.6)	30 (19.2)
Fractures	8 (9.4)	18 (11.5)
Strains	6 (7.1)	11 (7.1)
Overuse injuries:		
Anterior lower leg pain (periostitis)	5 (27.8)	20 (51.3)
Knee pain	5 (27.8)	6 (15.4)
Low back pain	3 (16.7)	5 (12.8)
Mean (SD) age of injured players in years*	17.3 (0.7)	17.1 (0.7)

*Range 15-18 years in both groups.

Table 3 Intention to treat analysis. Values are numbers (percentages) of injured players

	Intervention group (n=958)	Control group (n=879)	Intracluster correlation coefficient	Inflation factor	Number needed to treat	Relative risk (95% CI)*	P value (Wald's test)
All injuries	95 (9.9)	167 (19.0)	0.043	1.6	11	0.49 (0.36 to 0.68)	<0.0001
Lower limb injuries	66 (6.9)	115 (13.1)	0.050	1.7	16	0.51 (0.36 to 0.73)	<0.001
Acute knee or ankle injuries:	46 (4.8)	76 (8.6)	0.057	1.8	26	0.53 (0.35 to 0.81)	0.004
Acute knee injuries	19 (2.0)	38 (4.3)	0.071	2.0	43	0.45 (0.25 to 0.81)	0.007
Acute ankle injuries	28 (2.9)	40 (4.6)	0.071	2.0	59	0.63 (0.36 to 1.09)	0.097
Upper limb injuries	17 (1.8)	39 (4.4)	0.071	2.0	38	0.37 (0.20 to 0.69)	0.002

*Cox model calculated according to method of Lin and Wei,[17] which takes cluster randomisation into account.

76 700 hours in training). Table 4 shows the severity of injury for different types of injury. Injuries overall, acute injuries, and acute knee or ankle injuries differed significantly, whereas reductions in 7-53% for slight injuries and 18-59% in minor injuries did not reach significance. The overall difference in the incidence of match and training injuries was also significant, whereas acute injuries and acute knee or ankle injuries differed only for matches (table 5). The 13 control clubs using training exercises to prevent injuries had a significantly lower incidence of injuries than the clubs in the control group doing no prevention training (rate ratio: all injuries 0.48, 95% confidence interval 0.31 to 0.73, $P<0.001$; lower limb injuries 0.35, 0.19 to 0.63; $P=0.001$; acute injuries 0.47, 0.29 to 0.76; $P=0.002$; acute knee or ankle injuries 0.22, 0.09 to 0.55; $P=0.001$). No category of injury differed by sex.

Discussion

The rate of injuries in adolescent athletes using a structured warm-up programme as a part of their training improved clinically and statistically, especially the rate of severe injuries to the knee and ankle. The reduction in the relative risk is highly significant and has been adjusted for the cluster sampling, which takes into account the analytical limitations of a cluster randomised study. As far as we are aware, our study is the first randomised controlled trial among adolescents with a sufficient sample size to show that acute knee or ankle injuries can be reduced by 50% and severe injuries even more.

Data validation

The trial took place in the divisions comprising 16 year and 17 year olds from large geographical regions of Norway and

Table 4 Numbers and severity of injuries

	Intervention group (n=958)	Control group (n=879)	Rate ratio (95% CI)*	P value (z test)
All injuries:	103	195	0.49 (0.39 to 0.63)	<0.0001
Match	56	112	0.48 (0.35 to 0.66)	<0.0001
Training	47	83	0.53 (0.37 to 0.75)	<0.001
Slight	4	8	0.47 (0.14 to 1.55)	0.21
Minor	47	62	0.71 (0.48 to 1.03)	0.07
Moderate	20	56	0.33 (0.20 to 0.55)	<0.0001
Major	32	69	0.43 (0.28 to 0.66)	<0.0001
Overuse injuries:	18	39	0.43 (0.25 to 0.75)	0.003
Slight	0	3	—	—
Minor	4	9	0.41 (0.13 to 1.35)	0.14
Moderate	7	12	0.54 (0.21 to 1.38)	0.2
Major	7	15	0.44 (0.18 to 1.07)	0.07
Acute injuries:	85	156	0.51 (0.39 to 0.66)	<0.0001
Slight	4	5	0.76 (0.20 to 2.78)	0.66
Minor	43	53	0.75 (0.51 to 1.13)	0.17
Moderate	13	44	0.28 (0.15 to 0.51)	<0.0001
Major	25	54	0.43 (0.27 to 0.69)	0.001
Contact	51	82	0.58 (0.41 to 0.82)	0.002
Non-contact	34	74	0.43 (0.29 to 0.64)	<0.0001
Acute knee or ankle injuries:	48	81	0.55 (0.39 to 0.79)	0.001
Slight	3	3	0.93 (0.19 to 4.62)	0.93
Minor	22	25	0.82 (0.46 to 1.46)	0.5
Moderate	8	25	0.30 (0.13 to 0.66)	0.003
Major	15	28	0.50 (0.27 to 0.94)	0.03
Knee ligament injuries	3†‡	14‡§	0.20 (0.06 to 0.70)	0.01
Meniscus injuries	2	7	0.27 (0.06 to 1.28)	0.1
Players with two or more injuries	8	19	0.39 (0.17 to 0.90)	0.03
Re-injury¶	0	3	—	—

*Rate ratio obtained from Poisson model.
†Anterior cruciate ligament: n=3.
‡Anterior cruciate ligament (n=10), posterior cruciate ligament (n=3), medial collateral ligament (n=1).
§10 of the 16 ligament injuries to the cruciate ligament also included concomitant injuries to the medial collateral ligament, lateral collateral ligament, bone bruise, or meniscus injuries, or a combination of these.
¶Same type and location of injury.

Table 5 Number of acute injuries, acute knee or ankle injuries, and incidence of injuries during matches and training. Incidence is reported as the number of injuries per 1000 player hours, with standard errors

	Intervention group (n=958)		Control group (n=879)		Rate ratio (95% CI)*	P value (z test)
	Injuries	Incidence	Injuries	Incidence		
No of acute injuries:	85	0.9 (0.08)	156	1.8 (0.06)	0.51 (0.39 to 0.66)	<0.0001
Match	53	4.7 (0.06)	111	10.3 (0.04)	0.46 (0.33 to 0.64)	<0.0001
Training	32	0.4 (0.14)	45	0.6 (0.12)	0.66 (0.42 to 1.04)	0.07
No of acute knee or ankle injuries:	48	0.5 (0.11)	81	0.9 (0.09)	0.55 (0.39 to 0.79)	0.001
Match	28	2.5 (0.06)	57	5.3 (0.06)	0.47 (0.30 to 0.74)	0.001
Training	20	0.2 (0.18)	24	0.3 (0.17)	0.78 (0.43 to 1.41)	0.41

*Rate ratio obtained from Poisson model.

recruited 85% of eligible players organised by the Norwegian Handball Federation in these areas.

The external validity of the trial should therefore be high. As we found no differences between the two groups at baseline, in dropout rates, and in exposure during the study, the internal validity should also be high. We discussed the reliability and validity of injury and exposure registration in detail in an earlier study, and our method should ensure good reliability and validity of the injury and exposure data and also good reliability for comparing the data between the intervention and the control groups.

Compliance

On comparison with a previous study that investigated the prevention of injuries to the anterior cruciate ligament at the senior level,[10] we found a considerably higher compliance (87%) among the youth clubs. In view of the media attention focusing on the problem of injuries to the anterior cruciate ligament in women's team handball, we were surprised to find that only 29% of the clubs participating in a similar non-randomised study of adult players fulfilled the compliance criteria.[10] However, this study, and our intervention study, may have motivated some of the youth clubs to include exercises to prevent injuries as a regular part of their training programme, as evidenced by the crossover observed in 22% of the control clubs. In support of the study findings, these clubs had a significantly lower incidence of injuries than the other control clubs. Also, not all clubs continued to use the programme of warm-up exercises used to prevent injuries after the initial intensive introduction period. However, we included all the clubs in an intention to treat analysis, which means that the effect of the programme may be even higher than we have reported.

Structured programme of warm-up exercises to prevent injuries

The exercises used in the programme were developed on the basis of previous intervention studies in team handball[10 11] and other sports,[8-9 12] and had been feasibility tested and modified to be suitable for team handball. The focus on alignment of the hip, knee, and ankle—especially the knee over toe position—was supported by data from Ebstrup and Boysen-Moller[17] and Olsen et al.[18] Their video analyses of the mechanisms for injuries of the anterior cruciate ligament in team handball indicate that players could benefit from not allowing the knee to sag medially during plant and cut movements or when suddenly changing speed. The programme therefore focused on the proper technique for planting and cutting movements, aiming at a narrower stance as well as a knee over toe position. Recent data from a study investigating the prevention of injuries to the anterior cruciate ligament among adult women's team handball players indicate that a programme of balance and cutting exercises focusing on knee control not only prevents injuries[10] but also improves dynamic balance and that this effect is maintained for at least 12 months.[19] One randomised study from senior men's elite soccer also showed a substantial decrease in the rate of injuries to the anterior cruciate ligament as a result of a static balance training programme using a balance board.[8]

The prevention programme that we tested is multifaceted and considers many aspects that could be related to the risk for injury (agility, balance, strength, awareness of vulnerable positions of the knee and ankle, playing technique), and it is not possible to determine exactly which part of the programme may be effective in preventing injuries to the knee and ankle. Based on data from volleyball,[20] our programme also focused on landing on both legs after jumps rather than just one leg, and with an emphasis on increased hip and knee flexion to attenuate the landing. The programme also included a strength exercise, the "Nordic hamstring lower" exercise, which has been shown to be effective in improving eccentric hamstring muscle strength among adult male soccer players.[21] Since the hamstrings can act as agonists to the anterior cruciate ligament during stop and jump tasks,[20 22 23] it is possible that stronger hamstring muscles can prevent injuries to the ligament, but this theory has never been tested. Further studies are needed to determine what the key component(s) of the programme are in reducing risk of injury, and it seems warranted to examine the physiological effects of each programme component, as well as the effect on injury risk. In this way it may be possible to develop even more specific programmes that require less time and effort and may be suitable for "weekend recreational" athletes too.

Although injuries to the anterior cruciate ligament are a particular concern, especially in women's pivoting sports, it was not possible to plan this investigation on young players to determine the effect of the intervention programme on rates of injury to the anterior cruciate ligament alone. Our power calculations indicated that a study looking at ruptures of the anterior cruciate ligament would have needed 12 000 players in each group to detect a 50% reduction in such injuries. Even so, we found an 80% reduction in ruptures of knee ligaments (anterior cruciate ligament, posterior cruciate ligament, and medial collateral ligament) in the intervention group, which reached significance.

Generalisability

We used youth team handball (age 15-17) as a case of youth sports in our trial. Since the intervention was implemented for both sexes and at different levels, the result indicates that the youth elite as well as the intermediate and recreational players would benefit from using the warm-up programme to prevent injuries. We do not know if the results can be generalised to other age groups or to other youth sports such as football, basketball, or volleyball. However, these sports have a high incidence and similar pattern of knee and ankle injuries, and the injury mechanisms are also comparable (most injuries resulting from pivoting and landing movements). Therefore it seems reasonable to

What is already known on this topic

Sports injuries constitute 10-19% of all acute injuries treated in emergency departments, with injuries to the knee and ankle the most common types

The risk of serious knee injuries, such as injuries to the anterior cruciate ligament, is high among adolescents playing pivoting sports such as football, basketball, or team handball

It may be possible to reduce the incidence of knee and ankle injuries among young people, but studies showing this have been small and mainly non-randomised, with significant methodological limitations

What this study adds

A structured warm-up programme designed to improve awareness and knee and ankle control during landing and pivoting movements prevents knee and ankle injuries among youth athletes

The incidence of knee and ankle injuries can be reduced by at least 50%

Preventive training should be routine in training programmes for adolescents in pivoting sports

assume that the prevention programme used in the present study also could be modified to be used in other similar sports. Moreover, if the goal is to develop movement patterns that are more resistant to injury, it may be easier to work with even younger players who have not yet established their motion patterns. Therefore, we suggest that programmes focusing on technique (cutting and landing movements) and balance training (on wobble boards, mats or similar equipments) are implemented in players as young as 10-12 years.

Conclusion

A structured warm-up programme designed to improve awareness and control of knees and ankles during landing and pivoting movements reduces injuries to the lower limb in youth team handball. Preventive training should therefore be introduced as a natural part of youth sports training programmes in similar pivoting sports.

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We like to be critical of the Chinese - but how much better are we?

Dr J

Watching the recent Beijing Olympics, I was reminded about one of my all-time favourite sports medicine patients. I can't remember her name but I clearly recall the history and diagnosis. We doctors get fairly accused of thinking like this, although in this situation it means that, fortunately, I won't be breaking patient confidentiality. I saw this Chinese woman as a patient in the mid 1990s. She was working cash-in-hand as a waitress in Sydney but was a retired elite volleyballer. So elite, in fact, that she had previously played in the Chinese team for many years and was an Olympic medallist.

She came to see me about a knee injury. It occurred when she landed awkwardly during a volleyball match, playing for China, in the1980s. She knew that something was badly wrong with her knee. However, her coach and whatever passed for medical care in charge of training the team didn't believe her. They told her she just had to forget about the injury and keep playing. She tried to keep playing but found the knee kept collapsing on her. The next match for the Chinese volleyball team was in Australia and, whilst here, she made the decision to run away from her team and illegally settle in Sydney. She told me that if she hadn't performed in that tour, that she would have been sacked from the team. This would have meant that she would have also been kicked out of her apartment, which was provided for her by the Chinese government solely because she was on the volleyball team.

As many of you would have diagnosed from the history alone, my examination confirmed that she had torn her anterior cruciate ligament in that landing ten years earlier while playing for China. I then started to tell her that the injury could be fixed but it would require surgery. Unfortunately it would cost her many thousands of dollars. I wasn't actually sure whether she was an illegal immigrant and whether she was eligible to join a public hospital waiting list, so I started to outline the costs of getting the operation done privately.

At this point she started crying. I started to feel bad too, thinking that I was in the exalted company of an Olympic medallist but one who was so poor, through no fault of her own, that she couldn't afford to get a knee reconstruction. However, on seeing my sad expression she stopped me. She said I didn't understand her tears. She was no longer worried about fixing the knee. She was crying tears of joy because I was the first doctor she had seen that explained to her that the injury to her knee was genuine. My opinion meant that she realised she had made the right decision to run away from China. A small part of her had worried that maybe the coaches were right and there wasn't anything wrong with knee and she should have kept playing. Because I told her that she couldn't have returned to sport without surgery, she now knew there was no chance she would have had a better life had she remained in China. The knee injury meant that her destiny was that she had to move to Australia.

This is a somewhat heart-warming story that most Australians will love, and it might confirm prejudices that we live in the best country in the world. One of the reasons we believe that we do, amongst many others, is because we yet again have finished as a top nation on the Olympic medal count. Australia is such a terrific sports-loving nation and we are proud that we punch above our weight at the Olympics every time. We note that we would easily beat countries like China and the USA on the "per-capita" medal table. And popular opinion has it that the Chinese treat their elite athletes like caged animals. Their gymnasts are rumoured to be all 13 years old and start training at the age of 4 to deliberately stunt their growth so they are more likely to win Olympic medals. Then it is claimed that they falsify their birth certificates to get them competing at an illegal age. Their injured athletes are supposedly cast aside and replaced by clones who managed to survive the ridiculously-arduous training programs. Regardless of the accuracy of these assertions, we are so lucky that we can do so well on the Olympic medal tally without treating our athletes like the Chinese.

I don't want to defend China at all for how they treat their athletes, but would argue that in many ways Australia walks on the same side of the street.

Like the Chinese government, Australia's primary government investment in sports and exercise has been devoted to achieving Olympic success. It has not been a stated goal of the Australian government that a certain percentage of the population should be exercising. By contrast, it has been a clearly stated goal of our government that we want to finish high on the medal count at the Olympics as possible. Our Federal governments of the last 30 years have clearly held the view that the public wants the taxpayer to fund elite sport to achieve international success, but that the public does not want to taxpayer to fund exercise programs as a form of preventive medicine. The Rudd government has been talking the talk (a la 2020 Summit) about needing to devote more resources to preventive health, but it has yet to walk the walk. There are some positive signs that this might be about to change but I will keep the champagne corked until it actually does. It has been said that Kevin Rudd has "hit the ground reviewing" which is an apt descriptive of the first nine months of his government. If they really do start spending big on preventive and participation programs then they will be worthy of accolades. At the moment most of the Howard money for elite athletes is still there, but the money for encouraging sports participation and preventing injury is still only 'under consideration'.

Therefore, we still don't have a national goal for physical activity, or even the pronouncement from our government that it is completely unacceptable that only half the population is adequately physically active for health benefit. This government has not yet seemed to have strayed from the well beaten track that they will only support initiatives that will win them more votes. Olympic medals are an opiate for the masses, but preventive health apparently isn't. Hence our government will continue to pay to import Chinese gymnastic coaches to teach our gymnasts how to train like Chinese gymnasts.

However, will it fund programs to try to turn around the recent increases in Type II diabetes and obesity in the general population? Public hospitals will be forced to continue to treat the cardiovascular disease, mental illnesses and cancers caused by the inactivity epidemic. Will the Federal Health Ministry set a concrete goal of, say, 80% of the population meeting physical activity guidelines and vow to keep increasing programs until we have met that goal? Although the Rudd government apparently doesn't want to increase overall government spending, this is an area akin to smoking cessation in that every dollar you put in to it would pay itself back tenfold in savings over future years.

And what of the Chinese Olympic volleyballer - how would she have been treated if she was an Australian at the time? Of course if she was in the national team, she would have had access to high quality physiotherapists, sports physicians and orthopaedic surgeons. The ACL tear would have been diagnosed and surgically managed, paid for by the elite athlete program. She would have been given every chance to return to the national team. We would have given her this type of management in the 1980s, even if China is struggling to provide it today.

However, what about a girl from one of Kevin's 'working families' in country or outer suburban Australia in 2008?

What happens if she tears her ACL playing volleyball or netball? She will probably attend a bulk-billing GP and an emergency department, both of which are still most likely to miss the diagnosis. She would have an X-ray ordered which would probably be normal. Like the Chinese volleyballer she may get told "there's nothing badly wrong with your knee" if she complains that it doesn't feel right. Perhaps a physiotherapist would suspect the diagnosis, but what if she doesn't get to a physiotherapist because she has no private health insurance and can't afford the fees? It is unlikely she'll see a sports physician because according to our government (who refuses to fund the training of sports physicians), these doctors are a luxury item who aren't required in the outer suburbs and country. Her family might get understandably frustrated with the mainstream medical system and suggest she go to see an alternative practitioner of some sort because the regular doctors haven't been helping her. If she is very lucky she might end up on a public hospital waiting list for 12 months and be told "not to play any sport in this time". There she might have this difficult surgery done by a fully-qualified orthopaedic surgeon, but equally she might have a registrar working unsupervised and using her knee as practice for the real world of private medicine.

You might say that this girl's biggest mistake was not choosing a stockbroker father or lawyer mother so her family could have afforded to pay for private health insurance and to see a top knee surgeon. Equally you could say that her biggest mistake was not to have been born in New Zealand, Switzerland or one of the Scandinavian countries. In these countries everyone is properly insured for the consequence of this sort of injury. In New Zealand, she would have had free physiotherapy, sports medicine, MRI and private orthopaedic surgery consultations paid for by the ACC. She would receive compensation for the time that she was off work and hence her surgery would have been done promptly.

New Zealand doesn't have the mining riches of Western Australia or Queensland, hence their government is running on a much tighter budget than ours. But they can afford to make sure that all of their citizens who suffer a serious sporting injury get properly looked after. We obviously could afford it in Australia, but we choose not to. We pump the money into elite athlete programs ahead of sport for the community. And it shows. We smoked New Zealand in the Beijing medal tally. Now all we have to do is catch China. And if we beat China in the medal tally, would this prove how much we really love sport in Australia? Or should we be trying to look after injured athletes in the community better than our poor neighbour New Zealand does?