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NZ JOURNAL OF SPORTS MEDICINE

Instructions to Authors

GENERAL

The New Zealand Journal of Sports Medicine is the official journal of Sports Medicine New Zealand, publishing material relevant to sports medicine and related disciplines. The New Zealand Journal of Sports Medicine welcomes submissions of original manuscripts from both members and non-members of Sports Medicine New Zealand in the following areas: sports medicine, sports physiotherapy, clinically relevant sports science, rehabilitation, coaching issues as they relate to sports medicine, exercise prescription and training, sports chiropractic, sports podiatry, and sports psychology. Manuscripts must not have been published elsewhere except in abstract form. Manuscripts will be reviewed by the editorial board and/or experts in the field of interest. Submissions are in the following categories:

a) Original Research b) Case Reports c) Review Articles d) Editorials e) Letters to the Editor f) Sports Medicine Tips g) Policy Statements

SUBMISSION DETAILS

Manuscripts are to be submitted to The Editor, New Zealand Journal of Sports Medicine, Sports Medicine New Zealand, PO Box 6398, Dunedin, New Zealand. Telephone +64 3 477 7887, facsimile +64 3 477 4459, email smnznat@xtra.co.nz. The manuscript text should be submitted in Microsoft Word format. If using Vista, please save the file as Office 2003 compatible, ie, .doc. Please do not use styles for headings, etc, ensure your manuscript is in the style 'Normal'. (For submission of graphics, please see Tables, Illustrations, Figures, Photos below). The manuscript may be sent via email. Manuscripts should be double-spaced with wide margins. Each page should be numbered. The manuscript should include the following: title page; structured abstract (followed by five key words); introduction; methods; results; discussions; conclusion; acknowledgements; references; tables; figures. Case reports are to have no more than two figures and are not to include an abstract. There should be no more than 12 references for a case report. The structure of a case report is as follows: introduction; case report; discussion. Structured abstracts are to be no longer than 300 words and should use the following subheadings: aim; study design; setting; participants/subjects; interventions; outcome measures; results; conclusions. Abstracts for review articles should use the following headings: aim; data sources; study selection; data extraction; data symphysis; conclusions. The title page should include the title of the article and a running title not exceeding 45 letters and spaces, authors' names (first name, middle initials, last name), degrees, affiliations with institutes, contact details for the corresponding author (to include name, address, telephone, fax, and email). The standard for spelling is to be in accordance with the Oxford Dictionary.

TABLES, ILLUSTRATIONS, FIGURES, PHOTOS

Tables, illustrations, figures, photos, etc, should be included on a separate sheet rather than in the body of the text. Please identify all illustrations with the manuscript title, name of author, figure number, and, if necessary, identification of the top of the image. All markings should be removed from x-rays before photographing. Please do not produce graphics in Microsoft Word. Graphics should be supplied in TIF, EPS or PDF format, preferably at a resolution of no less than 300 dpi.

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Drug names: generic only are to be used. Abbreviations: the American Medical Association Manual of Style (9th edition 1998) (published by the American Medical Association, 535 North Dearborn St, Chicago, IL 60610, USA) is to be used for abbreviation style. The List of Journals Indexed in Index Medicus (Superintendent of Documents, US Government Printing Office, Washington, DC 20402, USA, DHEW Publication No. (NIH) 83-267;ISSN0093-3821) is to be used for abbreviations for journal titles.

REFERENCES

References are to be numbered in alphabetical order. Names of journals should be abbreviated according to the format approved by Index Medicus. All references listed must be sited in the text. Journal titles that are single words only should be spelt out in full. All authors must be listed. Pagination should be inclusive. Examples of the appropriate formatting of references are given below:

Journal Article:

Speedy D B, Kelly M, O'Brien M. The effect of pre-exercise feeding on endurance exercise performance. *NZ J Sports Med* 1998; **26**:34-37.

Book: McRae R. Practical fracture treatment. Edinburgh; Churchill Livingstone, 1989.

Chapter in Book: Figoni S F. Spinal cord injury. In, Wikgren S (ed.): ACSM's exercise management for persons with chronic diseases and disabilities. Champaign: Human Kinetics, 1997; 175:179.

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Mythridates VI and the impact of viruses on performance

BRUCE HAMILTON

Sitting on the plane to Rio watching Eddie the Eagle sore (couldn't resist that one) in the 1988 Winter Olympics led me to reflect on the amazing opportunity that the 2016 Olympics presents for New Zealand athletes. However, in order to realise that opportunity, it is critical that athletes stay healthy in both the preparation period and during the games. Hence the crucial role of the NZOC health team is to prevent health related issues impacting upon the chances of athletes achieving their goals. It's fair to say that this is a big ask, as there are a myriad of ways that health issues may undo the best laid plans. Contracting a virus of any type can be a disaster for athletes preparing for pinnacle events; they occur frequently, often at the most unforgiving times, and can negatively impact on results.[1,2] Perhaps reflecting the associated virus anxiety, a frequently asked question of me by athletes (and staff) in the lead up to the games was, "It's ok, if I get a cold now, at least I won't get one during the Olympics?!" Whether it's actually a question, a statement of fact, or whether it's just an overly-optimistic, overly-simplified, deterministic self-fulfilling belief (OODS - I think it's this one), remains unclear to me, but I have always felt obliged to provide some form of semi-academic, semi-lucid, non-confrontational response – here goes.

The overly-optimistic, overly-simplified, deterministic self-fulfilling belief described above, appears based on both an innate need to behave positivity in the lead up to a major event, and the principle of developing resistance, immunity or something else to infectious agents, by getting "sick" with a virus . At least intuitively, the latter principle would seem to make sense, since many of the vaccinations that we gave athletes in the lead up to Rio are based on the principle of using an attenuated or small dose of virus, in order to stimulate an immune response and thereby mitigate any subsequent infection. Indeed the process of gradual exposure to small doses of harmful materials in order to develop resistance has been recognised in some form or other for Millennia, and so it is perhaps inevitable that an athlete will see the positive from an infection prior to the games. Given that it is possible to trace this principle back almost 3,000 years, perhaps it's unavoidable that we think in this way?

Mythridates VI ruled the region of Pontus in the eastern black sea region of modern Turkey, around the time of the 7th – 8th century BC (as an aside this is the same region where the legendary Amazonian athletes/warriors are believed to originate). It was a time where death could come by both fast and slow means, but for rulers death by poisoning was a "popular" outcome. After his father's death by poisoning (Mythridates suspected his mother – times were tough 27 centuries ago), Mythridates took himself off to the wilds of Pontus in order to safely build his immunity to all of the then known poisons – allegedly by ingesting small, but progressively larger non-lethal doses of various poisons. Remarkably, he was successful in his approach, avoided death by poisoning, and the rest is, as they say, history! The process that he popularised remains known as mithridatism. While mithridatism is not something recommended to try at home, it has allegedly been used successfully by individuals who insist on putting themselves in the way of highly venomous animals such as cobras and vipers.

Perhaps the most famous example of mithridatism is from the 1987 re-telling of the true life love story "The Princess Bride" (for those of you who may not have seen this movie, I strongly recommend viewing at least one scene before reading on: https://www.youtube.com/watch?v=9s0UURBihH8). "The Princess Bride" provides many valuable learning opportunities for athletes, coaches and health practitioners alike, but in the scene relevant to this dialogue, the story's hero (the "man in black", AKA "The Dreaded Pirate Roberts" AKA "Westley") engages in a dramatic battle of wits with the Sicilian Vizzini ("Never go in against a Sicilian when death is on the line!"). In a complex battle ultimately involving the consumption of the odourless, tasteless but totally deadly Iocaine powder (Iocaine powder, like many similarly deadly things, is, of course, found in Australia) by both men, the man in black ultimately prevails. Applying the historical principles of mithridatism, the man in black survived instant death having spent years building up "immunity" to Iocaine, thereby avoiding being a victim of Sicilian skulduggery (for a full understanding of the complexity of this scene, see the movie or refer to http://c2.com/cgi/wiki?BattleOfWits) and for a broader understanding of the science behind this story line, I recommend: http://nerdist.com/what-kind-of-poison-is-the-princess-brides-iocane-powder/).

So, has mythridatism, popularised by the epic re-telling of the great love story subtly influenced our athletes and staff thinking, and do we need to correct this thought process? Does getting a "cold" help prevent you getting another or a worse cold in the future, and does mythridatism work for our athletes? I suspect not.

One of the reasons for this could be that our (that's a royal our, I'm not sure how well I really understand this complex area) understanding of immunology and virology has moved on in the last 27 centuries, while perhaps our persistent reversion to overly-optimistic, overly-simplified, deterministic self-fulfilling beliefs remains firmly entrenched in the thought processes of the middle ages. We now have a pretty good but incomplete understanding of how our bodies respond to viruses, and while much of it is too complex for me to grasp, some basic principles quickly seem to dispel the concepts alluded to with the aforementioned belief pattern. Firstly, the common cold is not caused by a single entity, but may be the result of exposure to any one of a large number of viruses. Hence in order to build up one's immunity, you would theoretically need sequential exposure to each of the different viruses. To add even more complexity, if you take only the most common cause of the common cold, the rhinovirus, there are at least 100 known serotypes, all inducing an individualised immune response. It's this range of serotypes that accounts for why there remains no vaccine for the most common cause of the common cold.

Unfortunately then, while the desire of an athlete to put a positive spin on any infection is understandable (and to be fair, probably in the best interests of any ultimate performance outcomes), I suspect that the technically correct response to the athlete who presents with a viral infection prior to the games, is that "… if you get a cold now, you won't be able to train properly while you have the infection, and it's unlikely to have any impact on your susceptibility to infection during the games….". Not great news, sorry. It's fair to say that in my standard consultation I would not necessarily frame my answer that way. However, all is not lost. Within the high performance environment, there is increasing integration of health systems into the training world of high performance athletes, and this has elevated the level of awareness of the risks incumbent in immune system compromise during training and competition. Similarly, engagement of health systems in the training world of athletes has allowed the clear messaging of healthy life, training and competition practices to minimise viral exposure both before and during the competition periods, with the goal of minimising the risk of infectious disease impacting on performance.

The latter approach of encouraging healthy practice, combined with a clear operational hygiene strategy for all team members to follow, was the single most reinforced tactic the NZ health team established to assist performance in Rio. Themed around "It Starts Here", all athletes and staff were educated and regularly nudged towards good hygiene practice.

As I sit on the plane heading back from the games some 40 days after starting this piece, it's possible to reflect on the impact infectious disease may have had on Olympic results. The Zika virus (I had to mention it once), gastroenteritis and respiratory infections were all felt to be potential confounders to success in Rio, and were high on the radar for all countries' respective health teams. Albeit anecdotally, there is little doubt that many countries were negatively impacted by infections during the games, while the overall impression of the NZ health team was that the strategic approach to hygiene taken by the NZ team appears to have been effective in minimising infectious disease in the team. A complete analysis of the team's illness data will shed more light on this.

New Zealand athletes provided many inspirational moments during the games, and returned with more medals than any previous NZ Olympic team. Whether we could have achieved even greater heights had infection mitigation been even more effective is mere speculation. What we do know is that despite the tendency for athletes and staff to formulate overly-optimistic, overly-simplified, deterministic self-fulfilling beliefs to the contrary, it is unlikely that infections in athletes at any time are performance enhancing.

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What's the rush to move athletes from the playground to the podium?

Too much, too serious, too organised, too many injuries is how Chris Whatman describes modern youth sport in his editorial for the NZJSM 2015.[1] Dietitians agree with him and are particularly concerned at the lack of early sports nutrition education to support the growth of young athletes and their extra training loads.

While the NZ High Performance Pathway to Podium Programme(P2P)currently offers extensive training guidance including sports nutrition education to 350 talented athletes and 150 coaches, it is aimed at 17-23 year olds (13-14 year old paralypmpians) but for many athletes this help may be too late.[2]

In 2011 The Young Peoples Sports Survey series looked at participation in sport of over 17,000 children (5-18 years) from over 500 schools in New Zealand.[3] They found 80% of children participated in organised sports at least 3 hours per week and many spent long hours with additional training in more than one sporting code. While the time spent diminished for 15-18 year old girls and boys, the level of commitment of 7-14 year-olds in both genders increased with age.

The survey also found that almost as many 10-14 year old children were involved in regional and national levels of competition as older children.

The International Olympic Committee (IOC) has reported that performance of many developing athletes is being thwarted because their nutrient and energy intakes are not keeping pace with their training regimes.[4]

While nutrition surveys of athletes are lacking the 2002 Children's Nutrition Survey in NZ have identified 11-18 year-old children have low intakes of energy (at the higher end of requirements), dietary fibre, calcium, selenium and iodine while the sodium levels were 125% of needs. Iron levels were low for 15-18year old girls.[5,6]

These factors are important to growing athletes if they are keen to remain healthy and reduce training time lost due to colds, flu, illnesses such as glandular fever, fractures and other injuries.

Basic nutrition education in NZ schools and the community to correct these nutritional shortfalls is lacking.

NZ schools focus on children developing holistic concepts of health and well-being, attitudes and values and socio-ecological perspective of their environment. Formal cooking lessons are available in years 7 and 8 (11-12 year olds) in schools with kitchen access.[7] However there are no Ministry of Education cooking manuals and concern has been expressed about the lack of training and supply of home economics teachers in NZ and Australia.[8]

		Year Group	Age	Formal Nutrition Education	Resources
Boys	Girls				Puberty
		13	17	Home Econ L3	NZQA
		12	16	Home Econ L2	NZQA
		11	15	Home Econ L1	NZQA
		10	14		Nestlé
		9	13		Millineum Institute
		8	12	Cooking	Nutrition Foundation, HETTANZ
		7	11	Cooking	Heart Foundation Cookbook
		6	10		Food for thought
		5	9		Heart Foundation canteen guidelines
		4	8		
		3	7		
		2	6	Life Education	Life Education Trust
		1	5	Life Education	Curriculum in Action 1999
		Pre-school		Well Child Checks 1-5yrs	5+ A Day recipes
					Fuelled4life Heart Fdn food service guidelines

Figure 1: The level of nutrition education available in NZ schools from pre-school to year group 13 portrayed alongside puberty for girls and boys, actual age and resources available from MOE and outside organisations.

Groups such as the Heart Foundation, Vegetable Producers and Millennium Institute have stepped into the void to provide nutrition resources and teaching guides for year groups 6-10. Home economics teachers have also produced resources. (HETTANZ ref Figure 1).

Nutrition education resources are better for children who take Home Economics at NCEA level because this is an examinable subject. See Figure 1.

Another concern is the sponsorship of resources in school and sports stadiums by multi-national food and beverage companies such as Coca Cola, Nestlé and McDonald's as the intake of confectionery, drinks and processed products are contributing to problems of obesity and diabetes in New Zealand.

Young athletes are vulnerable to pressure from coaches, parents and friends to perform better. With dietary supplements now readily available online, these athletes are at risk of inadvertently consuming banned substances that could affect their future sporting careers.[10]

If we genuinely want to help athletes to develop stronger, fitter bodies then sports nutrition education needs to be emphasised from primary school.

This may require the P2P programme to develop sports nutrition resources for parents and children at school and sports clubs level.

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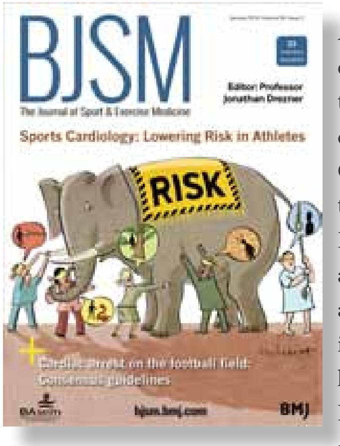
BEST OF BRITISH - HIGHLIGHTS FROM THE BJSM

CHRIS MILNE

This covers 12 issues of BJSM from January to June 2016, so coverage is by necessity highly selective.

The January 2016 issue was published in conjunction with the IOC and concentrated on preventive measures in alpine skiing. Equipment design has been progressively refined in an effort to reduce the risk of injury. An example of this was a paper by Kroll et al entitled "Side cut radius and kinetic energy: equipment designed to reduce the risk of severe traumatic knee injuries in alpine giant slalom ski racing".[1] These authors found that using skis with greater side cut radius potentially provided additional injury protection. However, they cautioned against over-estimating the gains to be made.

We all know that regulations can influence injury, and Haaland and co-authors looked at the injury rate and injury patterns in FIS World Cup alpine ski races between 2006 and 2015.[2] They asked the question 'have these new regulations made an impact?' The answer is yes. They found a reduction in the absolute injury rate in the three seasons after new regulations were introduced in 2012/2013 season. These changes were evident for male skiers but not female skiers and were confined to upper body injuries.



Issue 2 addressed issues in sports cardiology. Matthew Wilson from Aspetar, who has lectured at SMNZ Conference, provided a guide to clinical interpretation of T-wave inversion in athletes' ECGs. Sports Medicine Practitioners are at the centre of the decision making process and are aware of the complexity of unresolved issues relating to pre-participation cardiac screening. In addition, they are often the first to respond when an athlete collapses in the field of play. T-wave inversion may be an indicator of cardiac disease, specifically cardiomyopathy, andforty-five percent of athletes with T-wave inversion ultimately having various cardiac pathology; the authors recommend detailed initial evaluation and close monitoring throughout the athlete's sporting career with an annual cardiac evaluation to ascertain possible disease expression.[3]

One of the most provocative articles I have read in recent years was entitled "Labelling people as 'high risk': a tyranny of eminence".[4] Written by Teppo Jarvinen from the University of Helsinki, he points out that labelling a person as being at high risk of having a disease has become a disease in and of itself. Risk is a relative concept and, as with all interventions, the major gains are made with the most basic interventions and the marginal impact decreases as one goes up the chain. He poses the question 'does the Hippocratic Oath oblige us to intervene', and argues that in many disciplines involving the health and wellbeing of humans we usually make decisions based on cost. Treating 'high risk' can make a mockery of shared decision making.

An increasing number of athletes are being treated with implantable cardioverter defibrillators. Can these athletes return to competitive sports? Prutkin and co-authors answered this question and generally the answer is positive, provided there has been no need for an ICD shock in the last three months.[5]

Marfans syndrome is an autosomal dominant condition that is associated with an increased risk of sudden death, usually via aortic rupture and catastrophic bleeding from the aorta. Cheng and Owens from Seattle examine the problems confronting an athlete with Marfans in an attempt to provide rational guidelines for these individuals.[6] They advise as to be cautious but not overly restrictive, and comment that individuals with Marfans and other genetic aortic conditions should feel comfortable performing ordinary activities of daily living and other exercise such that a conversation can be maintained.

Issue 3 examined the mental health of athletes, which is a topic receiving increasing media attention. James Bauman from Seattle wrote a provocative editorial entitled "The stigma of mental health in athletes: are mental toughness and mental health seen as contradictory in elite sport?" He comments that from personal and professional experience, he sees a need for growing organisational support for addressing athlete mental health and performance psychology.[7] Certainly in New Zealand we owe a huge debt of gratitude to All Black great Sir John Kirwan for bringing these issues to public attention.

Later in the same issue, Trojian from Philadelphia commented that it is time for primary care sports medicine to be proactive and screen widely for depressive symptoms.[8] He advocates having patience, expressing interest and understanding plus giving support. All of these actions need to take place in an atmosphere of trust and confidentiality. The doctor needs to be aware of associated medical issues such as iron deficiency, hypothyroidism or Vitamin D deficiency.

Wolanin and colleagues examined the prevalence of clinically elevated depressive symptoms in college athletes.[9] They found the prevalence, as measured on the Centre for Epidemiological Studies Depression Scale (CES-D), was 23.7%. A moderate to severe level of depressive symptoms was reported at 6.3%, with female athletes exhibiting nearly twice the risk of male athletes for endorsing clinically relevant symptoms. Clearly, these are important issues that we clinicians need to be cognisance of.

Depression may be associated with an eating disorder, and Elizabeth Joy and colleagues provide a 2016 update on eating disorders in athletes.[10] This was a comprehensive eight page report and could be considered state of the art; all clinicians dealing with athletes with eating disorders should have access to this article.

Back pain is one of the commonest conditions seen in clinical practice, and clinicians dealing with athletes see a fair bit of it. Jorgen Jevene from Norway wrote a challenging editorial entitled "Stabbed in the back: catalysts for a paradigm shift in back pain care".[11] He argues that we need to reconceptualise people's notion of pain and inform people that its relation to tissue injury is not a linear one. We need to battle the perception of quick fixes and magic bullets, and he also argues that the frontline care for back pain should be provided by practitioners who primarily deal with musculoskeletal conditions, in order to minimise unnecessary confusion and frustration among patients. I suspect this would be hard to do with the primary care model we have in New Zealand. Furthermore, he sees a need to confront the 'guruism' within back pain care, identifying that there are many self-proclaimed experts who create hypotheses but do not go on and scientifically test them. He further comments that the number of gurus by outweighs the number of serious academics, which should act as an alarm bell for the whole musculoskeletal community.

Most people with back pain can be treated non-operatively, but when surgery is required there is debate regarding open versus microdiscectomy. Reiman and colleagues from Duke University, USA, found 14 articles comparing the two surgical approaches.[12] They found no significant difference in the outcomes between the two different types of surgery, but comment that not all athletes returned to the level of participation they performed at prior to surgery. In other words, your preferred surgeon should stick to his or her preferred treatment option for the condition.

Individualised physiotherapy can be helpful as an adjunct to guideline-based advice for low back disorders and primary care. Jon Ford and colleagues from La Trobe University in Australia found that ten sessions of individualised physiotherapy is more effective then two sessions of advice alone in participants with low back disorders of between six weeks' and six months' duration.[13] This would be the accepted standard of care within most practices in New Zealand.

Peter Brukner, sports physician, and David Connell, radiologist, are two Australians well-known to New Zealanders. They contributed an article entitled "Serious thigh muscle strains: beware the intramuscular tendon which plays an important role in distal hamstring and quadriceps muscle strains".[14] They comment that in thigh muscles the attached tendon extends for a significant distance within the muscle belly, and can itself be injured from time to time. These injuries have a variety of appearances on MRI scanning. There is some evidence that these require a more prolonged rehabilitation time and may have a higher recurrence rate.

Patellofemoral pain is one of the commonest conditions seen in most sports medicine clinics, accounting for between 11-17% of all knee presentations to general practice. The clinical picture is pretty typical, with pain relating to bent knee activity and it is worth noting that this pain can cause reflex inhibition of the quadriceps muscles leading to symptoms of instability, which may be mistaken for a meniscal tear or ACL rupture. Most people have noticeable improvement 6 12 weeks after starting physiotherapy. Patella taping and quadriceps plus gluteal strengthening exercises are the mainstay of treatment. Imaging is rarely required. Kay Crossley, an Australian physiotherapist who is well-known to Kiwis, and her colleagues from the UK and Qatar have written a comprehensive four page article in this issue that was originally published in the British Medical Journal. They also sought patient feedback and altered a couple of items without the article in response to this. This is a positive development amongst academics.[15]

The fifth issue was published in conjunction with Sports Physiotherapy New Zealand, with Hamish Ashton acting as guest editor. In his editorial he comments on the need for good sideline communication and mutual respect between coach, player and clinician.[16] This is highly relevant and exemplified by an article in this article entitled "No way, Jose": "Clinicians must have authority over patient care, their manager's scope of practice does not cover medical decisions."[17] This article was written in response to the outburst by Chelsea manager Jose Mourinho, who publicly attacked his medical team after they were beckoned on twice by the referee to tend to player Eden Hazard. Mourinho reportedly commented, "I was not happy with my medical call because, even if you are a medical doctor or secretary on the bench, you have to understand the game … I was sure that Eden didn't have a serious problem. He had a knock and was very tired." Even for a coach as gifted as Mourinho, who rates himself as 'the Chosen One', it is a fair stretch of imagination – plus an inflated ego – that would have led to this conclusion. Team doctor Eva Carneiro and physiotherapist John Fearn were executing the referee's instruction and their duty of care. This issue was huge in the media at the time and exemplifies that it is best when coaches stick to coaching and allow doctors and physiotherapists to get on with providing clinical care.

Culvenor and Crossley examine the issue of accelerated return to sport after ACL injury and wonder if this is a risk factor for early knee osteoarthritis.[18] They conclude that the impact of returning to sport at any time post-ACL reconstruction on the development of later arthritis has not been evaluated. They call for the research and clinical focus to include more specific elements of maintaining long term joint health, particularly in trials addressing early return to sport. I would comment that, whilst it is not my usual practice to correct academics, the correct term is posttraumatic arthritis. Most experts agree that the force required to rupture an anterior cruciate ligament sets in train a variety of other pathologies within the knee. It could be argued that posttraumatic arthritis after ACL reconstruction is virtually inevitable, and it is just the degree of this and its rate of progression that we need to study in more detail.

Femoroacetabular impingement are two of the buzzwords in sports medicine. What causes this is still up for debate. Rintje, Agricola and Weinans comment that the presence of cam deformity seems especially high in weight-bearing sports that require high flexion plus rotational movements of the hip.[19,20] Importantly, these are most of the team sports our children play. This article was written from a European perspective so includes soccer, basketball and ice hockey. In New Zealand such sports would include rugby union, rugby league, hockey and netball. The authors comment that around the age of 12-13 years there is an adolescent growth spurt and the skeleton is especially responsive to mechanical loading. They further argue that this might be a critical period where subtle mechanical triggers might interact with molecular stimuli and easily lead to bone formation and potentially development of a cam deformity. This issue is up for debate, but it is certainly a thoughtful article.

Rowing is our most successful Olympic sport in recent years and rowing injuries tend to be under researched. Therefore, the development of a guideline for diagnosis and management of a rib stress injury is welcome. Co-authors Dr Ann Redgrave, Chief Medical Officer for GB rowing team, and Dr Guy Evans, Lead Doctor for the U23s and new seniors in the squad, have provided a new clinical guideline for the management of rib stress injuries. This has helped in accurate diagnosis and provision of effective management. The guideline itself is reproduced on pages 271 and 272 of Issue 5 of BJSM Vol 50. It should be regarded as the gold standard in this area.[21,22]

Current dogma suggests that higher training loads should cause higher injury rates, however Tim Gabbett has challenged this.[23] He proposes that athletes accustomed to high training loads have fewer injuries than athletes training at lower workloads. He further comments that excessive and rapid increases in training loads are likely responsible for a large proportion of non-contact soft tissue injury. He describes the critical variable as being the acute:chronic workload ratio and believes this is the best practical predictor of training related injury. In the New Zealand rowing squad we use this data, in combination with heart rate variability, to determine appropriate training loads.

Later in the same issue, Anna Soar and colleagues challenge this view and comment that subjective self-reported measures trump commonly used objective measures. In other words, we clinicians should be talking with our athletes and taking note of issues such as sleep, enthusiasm for training and irritability or contentment as key factors in assessing whether or not they are overtraining.

Issue 6 concentrated on the issue of physical activity, with the front cover having an interesting graphic emphasising four points:

1 Be active for a healthy heart and mind
2 Sit less
3 Build strength to keep your muscles, bones and joints strong
4 Improve balance to reduce your chance of falls

Exercise is Medicine has been a major initiative in the last two decades. Various articles in this issue analyse its effectiveness. A rather sanguine analysis entitled “Death by effectiveness: exercise as medicine caught in the efficacy trap!” was written by Chris Beedie, Greg Whyte and colleagues from the UK and Spain.[24] For a while it was thought that exercise was a potential public health panacea. As these authors comment, sadly the early promise waned. There are numerous reviews extolling the efficacy of exercise but, equally, there is an apparent dearth of evidence regarding its effectiveness. These authors challenge SEM researchers to conduct rigorous effectiveness studies to avoid the inexorable decline of SEM into an early grave.

On a more positive note, later in the journal is an article on the effect of physical activity and cancer mortality. Tingting Li and colleagues from Wuhan, China, analysed the findings from 71 prospective cohort studies. In essence, the findings were of a 27% lower risk of cancer mortality in cancer survivors who completed 15 metabolic equivalents of task hours per week of physical activity.[25]

Hypertension is a common affliction in Western societies. Mats Borjesson and colleagues from Sweden evaluated the effect of physical and exercise on hypertension. They looked at 27 randomised controlled trials and found that regular medium to high intensity aerobic exercise reduced the blood pressure by a mean of 11mm systolic and 5mm diastolic. This indicates that physical activity has a great role to play a single or additive treatment for hypertension.[26]

COPD (chronic obstructive pulmonary disease) is another common condition in our society. Emtner and Wadell from Uppsala, Sweden, looked at six systematic reviews of the effect of exercise training on COPD.[27] They found that there was improved health-related quality of life and decreased dyspnoea, anxiety and depression. Therefore, they recommended that patients with COPD should be recommended to take part in exercise training.

Issue 7 carried the subtitle “High Performance on the Pacific Rim”. There were excellent articles on the role of sleep. The editorial was entitled “Stealing sleep: is sport or society to blame”.[28] I learned a new term ‘social jetlag’ which represents a discrepancy between circadian and social clocks. Often our obligations do not correspond with when we would like to be asleep. For athletes this may be due to training, travel and/or competition times. In addition, the editorial highlights the use of smartphones and electronic devices. Educational initiatives involving coaches and team management are recommended.

Another article in this issue that caught my eye was entitled “Dinosaurs among us causing chaos and confusion".[29] Written by Adam Meakins of Spire Bushey Hospital in the UK, it is directed at many iconic, influential and idolised clinicians and researchers who continue to promote and teach outdated methods of assessment and treatment. He comments that these so-called dinosaurs may have vested interests in peddling snake oil treatments and selling their courses and books that promise simple assessments and quick fixes, from realigning subluxed sacroiliac joints or twisted thoracic rings, to releasing psoas muscles or immobile kidneys. He comments that disagreement is not disrespectful. In essence, this is an article in support of questioning old Shibboleths and maintaining a certain cynicism with regard to established beliefs. It is only by questioning the current dogma that we will ever make progress.

Later in the same issue Samuels, Meeuwisse and colleagues introduce the Athlete Sleep Screening Questionnaire.[30] This is a 15-item tool that they promote for assessing sleep in elite athletes. The next phase of their research is to conduct a series of studies comparing results from this new questionnaire to blinded clinical reviews and to data from objective sleep monitoring. This will go some way to establishing the validity of this questionnaire as a reliable sleep screening tool for elite athletes.

Athletic groin pain is a clinical conundrum. Falvy and colleagues from Dublin analysed 382 patients, comparing their clinical findings, MRI findings and patient reported outcome measures; 91% of their patients played field-based ball sports, i.e. similar to that in New Zealand. They found the adductor squeeze test in 90° of hip flexion was 85% sensitive but not specific for pubic aponeurosis and adductor pathology.[31] Analysed in series, positive MRI findings and tenderness of the pubic aponeurosis had a 93% post-test probability. Interestingly, no hernia or incipient hernia was diagnosed. This would be news to Mr Gilmore from the UK.

Issue 8 concentrated on training load and injury. Some parts appear to be a re-run of material in Issue 5. The editorial by Tim Gabbett, Peter Blanch (who is well-known to New Zealanders) and co-authors comment that high training workloads alone do not cause sports injuries – how you get there is the real issue. They stress the importance of the acute:chronic workload ratio; in other words, if the chronic workload is high, i.e. the athlete is fit, and the acute workload is low, then the athlete is considered well-prepared.[32] In essence, this is what Arthur Lydiard found way back in the 1950s and goes some way to proving that there is very little new under the sun.

Busy clinicians struggle with a tidal wave of data. Clare Ardern from Aspetar provides what she describes as systematic review hacks for the sports and exercise clinician.[33] She identifies five essential methodological elements:

1 A clearly stated aim in the clinical research question
2 Unambiguous eligibility criteria that addresses the research question
3 A thorough literature search to avoid missing key articles
4 Analysis of the risk of bias within and between individual articles
5 Clearly described and predetermined plans of how the results of each article in the systemic review will be combined

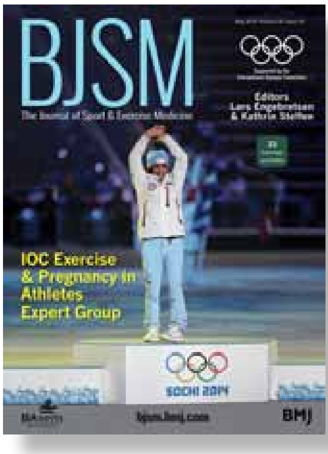
As a clinician who was privileged to hear David Sackett, the High Priest of evidence-based medicine, back as a registrar in Waikato Hospital in the 1980s, I think this article is an excellent piece of advice for the clinician wanting to interpret the literature.

Sugar is a major scourge in modern society. Republished research from the BMJ by Inamura and colleagues compared the consumption of beverages sweetened with sugar, artificial sweeteners or fruit juice on their effects on consumers and their risk of getting type 2 diabetes.[34] They found that habitual consumption of sugar-sweetened beverages was associated with a higher incidence of type 2 diabetes, independently of adiposity. They comment that artificially sweetened beverages and fruit juices were unlikely to be healthy alternatives to sugar-sweetened beverages for the prevention of diabetes. Let's hear it for water, as was drunk by children in my day.

Issue 9 looked at ACL rupture and the risk of posttraumatic arthritis; its subtitle was "The old knee in the young athlete". The major article was co-authored by Bob McCormack of Vancouver and Mark Hutchinson of Chicago, both highly respected senior orthopaedic surgeons.[35] In particular, they analysed the results from the work of Thomson et al, who published their 20-year follow up of 90 patients who underwent single incision ACL reconstruction using the same technique. Their selection criteria excluded patients with chondral injuries, previous meniscectomies and large meniscectomies. Therefore, any long term degenerative findings and outcomes were primarily related to the ACL injury itself. Females had fewer re-ruptures but, overall, inferior subjective and functional outcomes compared with their male counterparts; pain with kneeling persisted in 63% of patients over time; 56% of patients and their cohort eventually tore the ACL in the opposite knee and, surprisingly, this risk persisted even past 10 years. Given that a lot of the patients we see with ACL ruptures have associated other pathology, either meniscal tears or chondral injuries, results in those patients would be expected to be less favourable. The bottom line is, we cannot guarantee that somebody who we see in our rooms with an ACL rupture in their 20s is going to have a perfectly functioning knee in their 40s, and this news needs to be broken to them by their treating clinician.

Femoroacetabular impingement is much in the news. Casartelli and colleagues look at the rationale for non-surgical treatment for this condition.[36] They emphasise the importance of good dynamic hip joint stability, and this can be achieved through neuromuscular training. I would add that provision of mechanical support down the medial side of the foot to reduce excess subtalar joint pronation probably has an additional role to play, although the hardcore trial-based evidence for this is yet to be published.

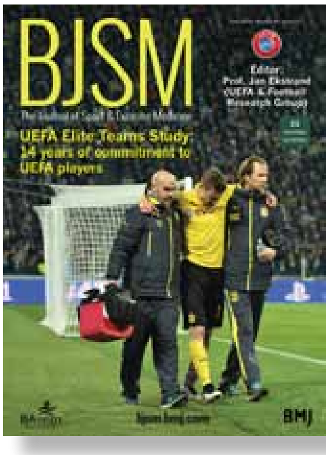
The issue closes with an article entitled "The evidence base for orthopaedics and sports medicine: scandalously poor in parts".[37] Only 20% of orthopaedic procedures are estimated to be supported by at least one low risk of bias RCT showing that surgery is superior to a non-operative alternative. A similar paucity of evidence exists in sports medicine. The authors, Lohmander and Rouse, introduced me to an important law termed Buxton's Law: "It is always too early for rigorous evaluation until unfortunately it is suddenly too late." How often has this been seen, particularly when dealing with elite athletes? We need to be mindful of our role as scientific clinicians, and not jump on every bandwagon just because the athlete sitting in front of us is operating at a high level, or has an important sporting event coming up in the near future. In essence, that athlete should be managed as we would want our own family to be managed, i.e. with care and consideration of all of the alternatives.



Issue 10 contained the Exercise in Pregnancy Consensus Statement. This was a summary of evidence from the IOC expert group meeting held in Lausanne in September 2015. Readers familiar with the previous literature will note the name of Raul Artal from St Louis, Missouri, lead author of the previous definitive guidelines. This article contained 321 references and should be required reading for anyone advising pregnant women with regard to exercise.[38]

Alonso and colleagues analysed the injury data from top level international athletics championships between 2007 and 2015. Not surprisingly, they found that muscle injury was the most common injury type, and the hamstring was the most commonly affected muscle. Male athletes were at double the risk of female athletes, particularly athletes in explosive power events. They comment that injury prevention strategies should be sex-specific.[39]

Issue 11 was entitled "Injury prevention and health promotion in Olympic sports". Golf and Rugby Sevens made their debut in Rio and each of these sports has articles devoted to it. Golf is a form of moderate aerobic activity and counts towards the recommended 150 minutes of physical activity per week. The authors comment that golfers can expect to live five years longer than non golfers and that golf is good for all ages and abilities.[40,41] I really should take Tony Edwards' advice and start playing.



There was also an article entitled "It's not the destination, it's the road to load that matters: a tennis injury prevention perspective".[42] Written by Babette Pluim, Deputy Editor of BJSM, and Michael Drew, it applies load principles to tennis and comes to similar conclusions with regard to establishing a basic fitness level and minimising the week-to-week changes, trying to avoid peaks in load. This seems to be the best recipe for a long career.

Concussion is a hot topic these days. Martin Raftery and colleagues outline a 4-step process to diagnose or rule out concussion within 48 hours of injury.[43-45] They propose the following:

1 The pitchside presence of symptoms or signs of concussion
2 An abnormal postgame same-day assessment
3 An abnormal 36-48 hour assessment
4 The presence of clinical suspicion by the treatment doctor at any time

This article was a collaboration between respected doctors from around the rugby world, including our own Deb Robinson, and should be read by anyone treating rugby players, i.e. most of us.

Meldonium has been much in the news following Maria Sharapova's use of it and her subsequent ban. Klaus Steinbach and colleagues analysed meldonium use by athletes at the Baku 2015 European Games.[46] They comment that meldonium was declared as imported into the host country of Azerbaijan by 2 of 50 participating teams, but athletes from 6 countries declared the use of meldonium; 66 of the total 762 athlete urine samples analysed during the Games and during pre competition tested positive for meldonium. Meldonium use was widespread, being detected in athletes competing in 15 of the 21 sports during the Games. This drug seems to be widely used in Eastern Europe in particular, and is mostly used for people with cerebral circulatory disorders in a clinical setting. However, it was also reported to be of benefit for the improvement of reduced work capacity and for physical and psychoemotional overexertion. Therefore, you can see its appeal for athletes. It could hardly be regarded as a core part of preparation for elite sport in 2016.

Issue 12 provided summary data from the UAFA elite teams study. Football is huge in Europe and UAFA collects good quality data. They found that hamstring injuries have increased by 4% annually in men's professional football since 2001. This data was reported by Ekstrand and colleagues.[47]

Another article in the series looked at injury prevention strategies, coach compliance and player adherence of 33 of the UAFA elite club injury Study team. They comment that medical officers place importance on workload-related variables as risk factors for injury in elite European football players. However, a lack of consistently high player adherence may limit the effects of contemporary injury prevention programmes in elite European footballers. I suspect the same applies to rugby players in New Zealand.

The football calendar is becoming increasingly congested. Carling and colleagues analysed the impact of short periods of match congestion on injury risk in an elite football club.[48] They comment that there was a higher risk of injury in the final 15 minutes of play in the second match played three days or less after a previous match. This is what one would expect from first principles and is no surprise to me, however it is good to have one's intuition confirmed.

My pick for most influential article in the last six months is a dead heat between that in Issue 2 entitled "Labelling people as 'high risk': a tyranny of eminence" and "Dinosaurs among us causing chaos and confusion" in issue 7. We need to maintain our intellectual curiosity and critical faculties throughout our professional careers, and these two articles exemplify that very well.

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Migraine with aura: Atypical clinical presentation of concussion in three professional rugby players

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INTRODUCTION

Concussion results in an immediate and transitory change in higher brain functions which may range from simple confusion to loss of consciousness. Headache is the most frequent post-concussion sign, but there are different types of headache; migraine or tension headache.

In the classification of the Sport Concussion Assessment Score (SCAT II), migraine with aura or isolated aura, is not reported. We think that this sign should be known by physicians. After a head trauma, the occurrence of an aura, followed with or without headaches, should be considered as a sign of concussion.

We report three cases of professional rugby players, out of a population of 168 concussed rugby players, who were assessed in our specialised "Concussion Consultation Clinic", between 2010 and 2015.

CASE 1

A full time professional rugby player aged 23, had a history from school age of four concussions while playing rugby, however, none of these concussions had caused a loss of consciousness or been followed by a headache. The symptoms had been limited to dizziness and loss of balance, and he had only once needed to leave the field. He never stopped playing rugby after a concussion. He had no personal or family history of migraine.

In March 2013 he was struck on the head during a match and had a brief (less than one minute) loss of consciousness. Afterwards, he was immediately fully alert and had no loss of memory. Fifteen minutes later, he developed pins and needles, followed by numbness in the left hand, and then in the whole left upper limb. He could not move his arm and had to use the other arm to lift it. He then felt numbness and paraesthesia on the left side of his face, followed by a severe pulsatile headache. The weakness in the arm disappeared after 15 minutes but the numbness persisted for three hours and the headache until the following morning. During this time, a brain MRI and a cervical Doppler examination were performed and found normal: excluding carotid dissection or hematoma.

He did not suffer any further post-concussion manifestations and resumed practicing after a week when he was vetted by a neurologist according to the protocol for stage 3 (Cantu or AAN) concussion. He was cleared to return to play after two weeks.

The final diagnosis was of post-traumatic migraine with aura.

CASE 2

A player, aged 29, consulted a neurologist in 2003 with a history of migraine attacks precipitated by playing rugby.

From the age of 14 he had suffered identical episodes, beginning with scintillating scotoma followed by hemianopsia and headache with nausea, always during or after rugby. Although he practiced other sports (running, tennis, body building), he had never suffered any migraine following other exertion. He never had a migraine attack, with or without aura, in any other circumstances.

In 1999, he had suffered a concussion during a rugby match and developed an episode of migraine with aura lasting 24 hours. He played another match the following day and had a similar attack Despite feeling fatigue the next day, he decided to go on playing and, as a result, he experienced his third migraine attack in the same week. From this time, he felt unwell, complaining of fatigue and depression and gradually he stopped playing rugby. He thinks that, after the three consecutive episodes of migraine, that he never recovered his initial performance level on the field and he abandoned professional rugby to become an orthopaedic surgeon. Since stopping rugby he has not experienced any further migraine with aura.

CASE 3

A full time professional Irish rugby player, aged 29, was referred to our clinic in November 2014. He had had three concussions playing rugby in 2014.

In 2008, he had a severe concussion with an anterograde amnesia which lasted 15 hours. He returned to play three weeks later. In 2014, he had his second concussion with a black out followed by blurred vision, scotoma and hemianopsia lasting about 15 minutes. After this he had pulsatile headaches with nausea and photophobia lasting a few hours. Six months later, during warm up, he got hit on the head by a ball and developed the same signs but not followed by headache. He decided to play the match and near the end of it he was injured by a teammate while both of them were tackling the same opponent. He left the pitch with headache and grogginess.

He had no previous history of migraine. However, a brother and his mother did have a history of migraine with aura.

DISCUSSION

There is a complex interaction between sport and migraine. Several recent studies have found a positive effect of aerobic exercise on migraine prevention, leading to the realisation of therapeutic programmes including the regular practice of sport, for severe headache.[1,2]

On the other hand, it is well known that migraine and especially migraine with aura may occur in sport related circumstances. Williams and Nukada[3] in 1994 have described a total of 129 subjects experiencing sports headache. Effort migraine was diagnosed in 11 subjects. Several sports were implicated. Some subjects reported migraine triggered by unusually intense exertion, especially in hot weather. In the same study, the diagnosis of trauma-triggered migraine was made in eight subjects, two women and six men. All had aura, visual and or sensory, followed by severe headache. Contact sports were usually those involved.

The overall prevalence of migraine in athletes is still debated, some studies have found a greater frequency of migraine in elite players,[4] while others have found that migraine was actually less frequent in this population.[5]

In our first case, a unique episode of migraine with visual and sensory aura occurred, immediately after a head trauma during a match of rugby, in a young player without any personal or family history of migraine. The association of motor weakness with visual and sensory disturbance leads to the diagnosis of hemiplegic migraine according to the criteria of the HIS classification IHCD-II. However, as the headache developed in close temporal relation with a head trauma, it should probably be qualified as a secondary headache, since it is admitted that secondary headaches can take the characteristics of migraine with aura [Headache Classification Subcommittee of the International Headache Society, 2004].

The second case presents a young man who suffered from recurrent attacks of migraine with visual aura in the context of rugby, leading to the diagnosis of primary migraine with aura according to the HIS classification IHCD-II. However, after a concussion, the patient suffered a dramatic worsening of the course if his migraine, leading to the end of his playing career

The third case of a rugby player who developed migraine with aura after two concussions without any spontaneous episodes. We should follow him to see if he will develop a typical migraine with aura appearing without any traumatic causation, as his mother and brother both have – or if it will only happen after a concussion, or like the second case, after a head impact.

When visual and/or sensory disturbance follow a head trauma, several serious conditions like carotid dissection or brain hematoma must be considered. But, after proper investigations have been conducted, the diagnosis of sport related migraine with aura can be accepted as it is supported by a good number of published examples. Mathews in 1972[6] described five young men who suffered from migraine with visual aura immediately after a blow to the head while playing football. None of these players had migraine in other circumstances. In the same year, Espir[7] presented a young football player who had a first attack of migraine with visual aura after a head trauma and then had recurrent similar attacks precipitated by playing football – mostly after heading the ball. These publications introduced the concept of "footballer's migraine". Afterwards several papers have described similar cases in athletes, mostly after minor head trauma.[8,9,10] More recently in 2011, Corbelli[11] described cases of three young men who had attacks of migraine with aura after a football match.

"Footballers migraine" must be differentiated from the triggering of an attack by exertion.[12] Exertion is a known trigger of migraine with aura (and it has been suggested that the attacks triggered by exertion could differ from other forms of attacks in a patient.[13] However, this has limited consequences on sports practice beyond recommendations of gradual training and avoidance of heat for the athlete with a history of migraine.

On the other hand, the occurrence of migraine following a minor trauma may be related to brain dysfunction and should have a prognostic value as a predictor of post-concussion syndrome. In a group of student athletes who had sustained concussions, a post traumatic migraine at J1 predicted a prolonged symptom recovery compared with athletes with non-migrainous headache and without head injury.[14] Similarly, in 108 male high school football athletes, migraine was one of the cut-offs predicting protracted recovery.[15]

1 Moreover, in a group of high school football players, the post traumatic migraine [PTM] group performed worse 8-14 days after injury. The PTM group performed worse on visual memory, reaction time, and symptoms, than did the other groups at 1–7 days and 8–14 days after injury. The PTM group was 7.3 times [95% confidence interval. 1.80-29.91] more likely to have protracted recovery (>20days) than the no headache group and 2.6 times (95% confidence interval, 1.80-29.91) more likely than the headache group (16}. In our first case, neuropsychological and balance testing had been performed pre-season and was repeated 10 days after symptom recovery. All tests were found similar in both situations. Contrary to the previous results, our subject had no protracted recovery and the RTP occurred at two weeks.

2 We have so far followed in our "Concussion Consultation" Clinic, 168 high level rugby players and found 13 who suffered from migraine with aura. Nine had typical migraine with aura as defined by HIS criteria and had suffered a migraine with aura following a concussion. Four had post-concussion migraine with aura (without a history of migraine or migraine with aura before that trauma) not followed by new episodes for at least six months after. RTP for Case 1 was two weeks. Case 2 decided to stop rugby because he noticed that tackles and contact triggered migraine with aura. Since he stopped rugby in 2003, he has never developed an episode of migraine with aura. Case 3 had two episodes of concussion with migraine with aura. He had a further episode of migraine with aura during warm up and suffered a new concussion at the end of the match. We stopped him playing for three months

because he had suffered four concussions in one year. He had pulsatile headaches for a month. Six months after the RTP he didn't suffer any further concussions or migraine.

The mechanisms of post-traumatic migraine with aura are not fully understood[17] but are believed to be related to Leao's cortical depression.[18] As the understanding of post-traumatic encephalopathy develops, and as better rules for managing concussed athletes are in the process of being established, it is of particular importance to collect information on cases of authentic post-traumatic migraine with aura and to learn more about its mechanisms.

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COMMENT

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As the authors of this paper rightly point out the most common single reported symptom following a concussion is a headache. It is very important for clinicians to recognise that there are many different 'types' of headaches which can occur. An accurate diagnosis can significantly speed up a players' recovery.

Some points which should be considered when faced with a player complaining of a headache after a concussion include:

- A player with a severe headache, or headache which is increasing in intensity, should be referred acutely for cross sectional imaging. Similarly neurological symptoms should also prompt further assessment.
- Migraine-like and tension-like headaches are reported to be two main types of headache which are associated with sport-related concussion. Both can mainly be treated effectively with the short-term use of analgesic drugs like paracetamol or oral NSAID's like ibuprofen.
- Headaches which are accompanied by photophobia, have been shown to be more likely to be associated with a prolonged recovery period.
- In my experience, Cervicogenic headaches are also a very common cause of ongoing symptoms following a concussion. These headaches can often be effectively treated with physiotherapy modalities.
- It is important to remember though that analgesics, like paracetamol and ibuprofen, are not designed to be used for prolonged periods and can cause headaches themselves if taken over a longer period of time.

Stress and recovery changes of injured and non-injured amateur representative rugby league players over a competition season

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ABSTRACT

Objective To monitor amateur representative rugby league players stress and recovery utilising the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) and the Recovery-Cue to identify which tool could differentiate which players were at a higher risk of an injury occurring during rugby league match and training activities.

Methods Thirty male rugby league players in a premier division representative rugby league team participated in this study. The multidimensional RESTQ-Sport with 52 items (10-12 minutes completion) and the Recovery-Cue tool were used to measure the complexities of stress and recovery states in players at the selection of the team and following every scheduled match.

Results During the 9 week study period (25 training sessions and 9 matches) 13 training injuries (13 per 1,000 training hours) and 39 match injuries (188 per 1,000 match hours) occurred for 30 amateur players. Over the matches, players who were subsequently injured in a match or training activity had significantly higher general- and sport-specific stress scale scores and lower general and sport-specific recovery scale scores of the RESTQ-Sport than non-injured players.

Discussion The development of a shortened version of the RESTQ-Sport specifically related to the scales of Social Stress, Success, Personal Accomplishment, Fatigue, Emotional Exhaustion, Injury and Self-Efficacy may be beneficial in the identification of players at risk of injury and would be quicker to complete, limiting time away from the training environment. The study results support sports medicine practitioners utilising the RESTQ-Sport to systematically monitor stress and recovery of players.

INTRODUCTION

Overload adaptation requires adequate recovery to enable the body to both adapt to the increased demand and then to recuperate from the increased stimulus.[1,2] Failure to provide adequate recovery periods between increasing the training stimuli before adequate rest exposes the player to overtraining and performance decline.[3] Unfortunately it is difficult to quantify the exact amount required and imbalances may result in over-reaching of the player who may burnout, suffer over-training syndrome and be at an increased risk of injury.[4]

The stress-injury model[5] and the overtraining and recovery model[6] are used to describe the balance between physical and psychosocial stress and recovery. Changes, or disturbances, in the physical and/or psychosocial aspects, such as increased muscle tension resulting in disturbed motor coordination and reduced flexibility and narrowing of the visual field,[5] can contribute to the development of attentional changes that may result in overload of the body increasing the risk of an injury occurring.[5] The response to the attentional changes is moderated by individual coping resources, personality and history of stressors but may physically result in increases in muscle tension and distractibility, placing the player at increased risk of injury.[5] Previous authors[5,6] have only investigated the use of these models for evaluating training frequency and life event stress at the commencement of a playing season.

A tool developed for coaches to systematically monitor over a period of training or matches the complexities of stress and recovery states in players is the multidimensional Recovery-Stress Questionnaire for Athletes (RESTQ-Sport).[7] There are three versions of the RESTQ-Sport, consisting of a 76, a 52 and a recently published 36 question version. The main differences are the number of questions in each of the scales with the RESTQ-Sport-52 having fewer in the general stress and recovery scale sections of the questionnaire when compared with the 76 question version, whereas the RESTQ-Sport-36 also contains a reduced number of scales. Previous studies have utilised the RESTQ-Sport on individual players in the training environment[3,8,9] and as part of a recovery programme.[10] More recently the RESTQ-Sport has been used to monitor sports team members overall stress and recovery during competition in rugby union,[11] rugby league[12] and soccer.[13] In rugby league[12] the RESTQ-Sport results allowed identification of players with an undisclosed injury and was utilised to monitor injured player's rehabilitation progress as they returned to competition participation. Although this study[12] used the RESTQ-Sport-52 (52 items) it did not assess the players for a risk of injury prior to matches or training activities.

As the RESTQ-Sport takes ten to twelve minutes to complete a monitoring tool that is quicker to complete is desirable as it could provide more timely feedback to both the player and the coach. Similar to the RESTQ-Sport, the Recovery-Cue has been developed to monitor for warning signs of possible overtraining but on a more continual basis.[14] The seven-item tool takes only 30 s to complete. Designed to provide visual feedback on the players' current stress and recovery states, the Recovery-Cue can also be used as a visual tool for improving the player's knowledge and awareness of their own stress and recovery by allowing the results to be plotted over a timeline for each of the seven items utilised.[14] The Recovery-Cue has been previously used in the monitoring of sports players in basketball,[15] rowing and cycling[16] but no published studies have reported the use of both the RESTQ-Sport and the Recovery-Cue for monitoring individual players or team sports players. Therefore the purpose of this study was to monitor amateur representative rugby league players' stress and recovery utilising the RESTQ-Sport and the Recovery-Cue to identify which tool could differentiate whether players were at a higher risk of an injury occurring from rugby league match and training activities.

METHODS

Participants and Ethical Approval

A prospective observational study was undertaken following one premier division rugby league team (30 male players; mean ±SD 23.3 ±4.3 yr., 1.80 ±0.05 m, 93.6 ±14.4 kg) in the 2010 New Zealand regional representative competition season (six teams from around New Zealand playing in a home and away competition format over seven weeks from August to October). This team was utilised as the lead researcher was involved in the management of these players directly. The team consisted of players selected from their region as part of the national representative completion in New Zealand. All players were amateur as they derived their main source of income from other means and did not receive match payments. Ethics approval was provided (AUTEC 09/282).

The Recovery-Stress Questionnaire for Athletes (RESTQ-Sport)

The RESTQ-Sport-52 version is a psychometrically paper based questionnaire that assesses a player's recovery-stress state.[3,8,17] Consisting of twelve basic scales (seven stress scales: General Stress, Emotional Stress, Social Stress, Conflicts/Pressure, Fatigue, Lack of Energy, Physical Complaints; and five recovery scales: Success, Social Recovery, Physical Recovery, General Well-Being, Sleep Quality) with seven additional sport-specific scales (three sport-specific stress scales: Disturbed Breaks, Emotional Exhaustion, Injury; and four sport-specific recovery scales: Being in Shape, Personal Accomplishment, Self-Efficacy, Self-Regulation) the questionnaire uses a self-report approach of players physical, subjective, behavioural, and social aspects of stress and recovery (see table 1).[7,9,18] Each of these scales consist of items that require the player's response using a seven-point Likert scale ranging from 0 (never) to 6 (always). Each item response indicates how often the player participated in stress- or recovery-associated activities during the previous three days.

The mean of each scale indicates the player's stress-associated subjective strain for the stress-associated scales. This is similar for the player's recovery process for the recovery-orientated scales. As such, the results of these scores indicates the player's stress-associated subjective strain and recovery process for the recovery scales. To compensate high states of stress equivalent recovery processes need to be initiated.[7] Chronic imbalances, such as high stress and low recovery, may place the participant at a high risk of chronic stress, burnout, performance decrements and possible health problems.[7]

The internal consistency and reliability of the RESTQ-Sport have been previously reported with Cronbach's α (0.67 to 0.88) and test-retest reliability (r=0.51 to 0.81) (see Table 1).[7,8] The internal consistency reportedly[7] increases with the participant's familiarity with the RESTQ-Sport as occurs with any other questionnaire. The RESTQ-Sport scores were provided to players as individual and grouped theme scale scores: General Stress (mean of the seven general stress scales); Sport-specific Stress (mean of the three sport-specific stress scales); General Recovery (mean of the five general recovery scales) and Sport-specific Recovery (mean of the four sport-specific recovery scales). An Overall Stress score (mean of the ten general stress and sport-specific stress areas) and an Overall Recovery score (mean of the nine general recovery and sport-specific recovery) were calculated.

Table 1: RESTQ-Sport scales, scale orientation (o), number of items (n) and sample item, Cronbach's α, and test-retest reliabilities[7]

No	RESTQ-Sport scale	o	n	Example: "In the last 3 days…"	α	Test-Retest
1	General Stress	S	2	…I felt down	0.76	0.71
2	Emotional Stress	S	2	…I was in a bad mood	0.71	0.72
3	Social Stress	S	2	…I was angry with someone	0.85	0.77
4	Conflicts/pressure	S	2	…I felt under pressure	0.68	0.73
5	Fatigue	S	2	…I was overtired	0.78	0.81
6	Lack of Energy	S	2	…I was unable to concentrate well	0.72	0.68
7	Physical Complaints	S	2	…I felt uncomfortable	0.71	0.76
8	Success	R	2	…I finished important tasks	0.67	0.70
9	Social Recovery	R	2	…I had a good time with my friends	0.80	0.74
10	Physical Recovery	R	2	…I felt at ease	0.85	0.79
11	General Well-Being	R	2	…I was in a good mood	0.84	0.61
12	Sleep Quality	R	2	…I had a satisfying sleep	0.83	0.70
13	Disturbed Breaks	S	4	…my coach demanded too much of me during the breaks	0.79	0.64
14	Emotional Exhaustion	S	4	…I felt I wanted to quit my sport	0.71	0.72
15	Injury	S	4	…my performance drained me physically	0.78	0.59
16	Being in Shape	R	4	…I was in good condition physically	0.88	0.71
17	Personal Accomplishment	R	4	…I dealt very effectively with my team-mates' problems	0.80	0.81
18	Self-Efficacy	R	4	…I was convinced that I had trained well	0.89	0.82
19	Self-Regulation	R	4	…I prepared myself mentally for performance	0.83	0.77

S = Stress; R = Recovery

The Recovery-Cue

The Recovery-Cue14 is a seven item paper based questionnaire that can provide immediate feedback regarding current stress and recovery states to the reviewer. Players who report low score (0) can be easily identified from those reporting high scores (6). Each of the seven items (questions) in the self-monitoring tool is related to how the player felt about their recovery in the last week and required the player to respond using a seven-point Likert scale.

For example, the item for Rest asked the question "How successful were you at rest and recovery activities last week?" and the player rated their response from 6 (successful) to 0 (not successful at all). Three items (Perceived Exertion, Perceived Recovery and Recovery Effort) monitor for early warning signs of possible overtraining effects[6] while the other four items (Physical Recovery, Sleep Quality, Social Recovery and Self-Regulation) represent scales in the RESTQ-Sport important for the recovery process.6 The Recovery-Cue utilised in this study was adapted from the original design14 to ensure players could not duplicate the previous weeks score (see Appendix I).

Testing Schedule for RESTQ-Sport and Recovery-Cue

The study period of nine weeks included 25 training sessions, and nine matches. Similar to a previous study,[12] the RESTQ-Sport was undertaken prior to the competition starting (baseline establishment) and then on the first training session (a recovery pool session) following each match and the Recovery-Cue was included in the recovery assessments. Baseline assessment using the RESTQ-Sport and the Recovery-Cue was conducted on weeks 1 and 2 to enable capture of all players. This assessment also assisted in identification of injured players and provided a baseline to gauge the recovery against. Subsequent assessments (T1-T6) were conducted on the first Monday of each week of the competition irrespective of whether the player participated in the previous match and was injured or not. This was a planned recovery session from the previous weekend match. The RESTQ-Sport took approximately 10 to 12 minutes to complete while the Recovery-Cue took approximately 30 s to complete. This assessment time was programmed into the recovery programme and did not prolong the player's from undergoing their planned session. The team coach did request to see the Recovery-Cue immediately after completion and implemented changes to the recovery session for players with lowered Recovery-Cue scores such as low intensity activities and non-contact activities for the training session.

Injury definitions, data collection, match and training exposure and injury rate calculations

Over the competition, all training and match injuries were recorded by the team medic on a standardised injury reporting form regardless of severity.[19] All 25 training sessions were 90 minutes in duration and all matches were 80 minutes in duration. The injury definition utilised for this study was "any physical complaint or disability that occurs during participation in rugby league match or training activities that is sustained by a player, irrespective of the need for match or training time loss or for first aid or medical attention."[20]

Injury rates were expressed as the number of injuries sustained per 1,000 hours.[20-22] Match injury rates were calculated on the premise that there were 13 player positions on the field, regardless of any substitutions for 80 minutes (1.33 hours) per game. Training injury rates were reported as a function of total training exposure time.

STATISTICAL ANALYSES

Data was entered into a Microsoft Excel spreadsheet enabling weekly assessment scores to be graphed automatically. Data were analysed with the Statistical Package for Social Sciences for Windows (SPSS; V23.0.0). Comparisons of the data between injured and non-injured players were undertaken in two-ways; (1) For the non-injured players, the RESTQ-Sport and Recovery-Cue scores were taken as a mean across all of the assessment weeks; (2) For the injured players their scores were taken from the assessment prior to the match in which they were injured.

A Generalised Linear Model was utilised for all the scales of the RESTQ-Sport and the Recovery-Cue, for the mean of the individual scales and the total stress and recovery scores utilising the injured player as the dependent variable. If differences were detected a post-hoc two-tailed paired t-test was utilised to determine if any significant differences existed. A Bonferroni-type adjustment was applied to maintain the Type-1 error probability at the 0.05 alpha level. Total recovery and stress scores were obtained by calculating the mean of all recovery and stress scales as previously described.[17] Overall weekly recovery and stress scores were obtained by calculating the mean of all recovery and stress scales.[17] The risk ratio (RR) of injury (injured players: non-injured players) was calculated with the Generalised Linear Model for all the scales of the RESTQ-Sport and the Recovery-Cue, for the mean of the individual scales and the total stress and recovery scores utilising the injured player as the dependent variable. Changes in match and training injuries were compared using a one sample Chi-squared (χ^2) test.

RESULTS

Match, training exposure and injury rates

Over the duration of the representative competition there were 25 training sessions resulting in 1004 hours of training exposure. Not all players were present at every training session resulting in a mean (±SD) of 23 ±3 players present at trainings over the study period. Thirteen training injuries were recorded over the study period giving a training injury rate of 13 (95% CI: 8 to 22) per 1,000 training hours. The team participated in nine matches (three trial matches and six representative matches) resulting in 207.5 match exposure hours. There were 39 match injuries recorded over the study period giving a match injury rate of 188 (137 to 257) per 1,000 match hours.

RESTQ-Sport and Recovery-Cue over the Competition

Injured players recorded a significantly higher pre-injury stress-score over the duration of the study when compared with the non-injured amateur rugby league players (see Table 2). Injured players recorded a significantly higher overall stress score than non-injured players at baseline ($\chi2(1)=33.25$, $p<0.0001$; $t(19)=-3.69$, $p=0.0016$), T1 ($\chi2(1)=17.44$, $p<0.0001$; $t(12)=-6.45$, $p<0.0001$) and T4 ($\chi2(1)=65.33$; $p<0.0001$; $t(12)=-5.88$, $p=0.0011$) assessments.

Injured players recorded higher scores in the general ($\chi2(1)=117.8$, $p<0.0001$; $t(72)=-10.63$, $p<0.0001$) and sport-specific ($\chi2(1)=92.2$, $p<0.0001$; $t(72)=-9.86$, $p<0.0001$) stress scales and lower scores in the general ($\chi2(1)=59.57$, $p=<0.0001$; $t(72)=5.45$, $p<0.0001$) and sport-specific ($\chi2(1)=62.36$, $p<0.0001$; $t(72)=5.35$, $p<0.0001$) recovery scales before an injury was recorded (see Table 3). As a result, injured players recorded higher total stress scores ($\chi2(1)=117.67$, $p<0.0001$; $t(72)=-12.85$, $p<0.0001$) and lower total recovery scores ($\chi2(1)=65.97$, $p<0.0001$; $t(72)=5.95$, $p<0.0001$) than non-injured players over the duration of the study. Of the 17 players that

Table 2: Mean and standard deviations for scores in the different scales of the RESTQ-Sport-52 and the Recovery-Cue for players who recorded an injury and non-injured players in the week following the assessment corresponding to the seven measurements during the study period, players present at training, training injuries, total match injuries and match results of the 2010 regional representative amateur rugby league team.

RESTQ-Sport	Baseline Injured	Baseline Non-Injured	T1 Injured	T1 Non-Injured	T2 Injured	T2 Non-Injured	T3 Injured	T3 Non-Injured	T4 Injured	T4 Non-Injured	T5 Injured	T5 Non-Injured	T6 Injured	T6 Non-Injured
Overall stress score	1.87 ±0.48a	1.15 ±0.44	1.94 ±0.41a	0.95 ±0.37	1.92 ±0.53	0.90 ±0.41	1.78 ±0.38a	0.95 ±0.15	1.64 ±0.47a	0.83 ±0.38	1.61 ±0.30	0.67 ±0.28	1.54 ±0.38a	0.82 ±0.31
General stress	1.73 ±0.57a	1.07 ±0.52	2.03 ±0.73a	0.85 ±0.37	1.74 ±0.61	0.83 ±0.60	1.67 ±0.44a	1.07 ±0.26	1.56 ±0.44a	0.79 ±0.43	1.54 ±0.32a	0.61 ±0.34	1.60 ±0.59a	0.74 ±0.33
General Stress	1.05 ±0.56	0.82 ±0.84	1.55 ±1.00a	0.50 ±0.50	1.43 ±0.83	0.33 ±0.58	1.14 ±0.50	0.86 ±0.90	1.04 ±0.57a	0.36 ±0.48	1.10 ±0.57a	0.19 ±0.37	1.11 ±0.93	0.38 ±0.46
Emotional Stress	1.68 ±0.59a	1.11 ±0.58	2.23 ±1.25a	0.92 ±0.49	1.79 ±0.73	0.67 ±0.76	1.18 ±0.51	1.07 ±0.67	1.54 ±0.50a	1.00 ±0.41	1.35 ±0.34a	0.50 ±0.53	1.56 ±0.63a	0.62 ±0.42
Social Stress	1.55 ±0.71a	0.86 ±0.66	1.55 ±0.87a	0.73 ±0.48	1.50 ±0.92	0.83 ±0.29	1.36 ±0.55	0.71 ±0.70	1.25 ±0.64a	0.57 ±0.61	1.15 ±0.63a	0.25 ±0.38	1.28 ±0.57a	0.42 ±0.49
Conflicts/Pressure	2.15 ±0.92a	1.34 ±0.68	2.56 ±0.88a	1.23 ±0.63	2.07 ±0.68	0.67 ±0.58	1.86 ±0.55	1.57 ±0.61	1.75 ±0.55	1.07 ±0.89	1.45 ±0.72	1.00 ±1.13	1.61 ±0.82	0.96 ±0.69
Fatigue	2.43 ±1.16a	1.23 ±1.03	2.31 ±1.15a	1.12 ±0.77	2.07 ±1.02	1.00 ±0.50	2.36 ±1.00a	1.50 ±1.04	2.36 ±1.35a	1.00 ±0.82	2.25 ±1.27a	1.00 ±0.93	2.11 ±1.69	1.23 ±0.97
Lack of Energy	1.88 ±0.78a	1.34 ±0.76	2.37 ±0.71a	1.00 ±0.58	1.79 ±0.61	1.00 ±1.00	1.86 ±0.64a	0.93 ±0.79	1.57 ±0.55a	0.79 ±0.49	1.60 ±0.46a	0.56 ±0.42	1.67 ±0.56a	0.96 ±0.32
Physical Complaints	1.40 ±0.88a	0.80 ±0.78	1.63 ±0.86a	0.46 ±0.48	1.54 ±0.82	1.33 ±1.53	1.91 ±1.04	0.86 ±0.48	1.43 ±0.87	0.71 ±0.81	1.90 ±0.94	0.75 ±0.80	1.89 ±1.47a	0.58 ±0.57
Sport-specific stress	2.17 ±0.47a	1.32 ±0.40	1.72 ±0.56a	1.18 ±0.54	1.78 ±0.76	1.06 ±0.13	2.05 ±0.55a	0.65 ±0.37	1.80 ±0.76a	0.92 ±0.37	1.76 ±0.44a	0.80 ±0.32	1.38 ±0.40	1.01 ±0.41
Disturbed Breaks	1.88 ±0.77a	1.45 ±0.85	1.65 ±0.66	1.13 ±0.71	1.64 ±0.95	0.92 ±0.14	1.82 ±0.60a	0.68 ±0.61	1.63 ±0.78	1.18 ±0.95	1.63 ±0.44a	0.53 ±0.49	1.31 ±0.74	0.94 ±0.66
Emotional Exhaustion	1.60 ±0.71a	0.80 ±0.54	1.46 ±0.78a	0.73 ±0.57	1.27 ±1.10	0.50 ±0.25	1.48 ±0.95	0.32 ±0.19	1.18 ±0.81a	0.32 ±0.31	0.98 ±0.32a	0.44 ±0.68	0.72 ±0.44	0.50 ±0.48
Injury	3.03 ±0.94a	1.69 ±0.56	2.04 ±0.56	1.67 ±0.78	2.45 ±0.63	1.75 ±0.66	2.84 ±1.06a	0.96 ±0.70	2.61 ±1.10a	1.25 ±0.99	2.68 ±0.84a	1.44 ±0.50	2.11 ±0.67	1.60 ±0.91
Overall recovery score	3.64 ±0.40a	4.16 ±0.77	3.35 ±0.32a	4.20 ±0.45	3.70 ±0.43	4.14 ±0.10	3.80 ±0.69	4.28 ±0.66	3.53 ±0.67	4.43 ±0.61	3.89 ±0.70	4.21 ±0.68	4.02 ±0.76	4.29 ±0.79
General recovery	3.75 ±0.43	4.16 ±0.84	3.33 ±0.81	4.28 ±0.39	3.55 ±0.75	4.10 ±0.20	3.83 ±0.73	4.17 ±0.75	3.66 ±0.69	4.41 ±0.53	4.16 ±0.61	4.29 ±0.20	3.81 ±1.09	4.38 ±0.79
Success	3.35 ±0.78	3.82 ±1.17	2.96 ±1.16	3.65 ±0.80	3.29 ±1.20	3.17 ±1.26	3.41 ±1.18	3.64 ±0.99	3.07 ±1.16	3.71 ±0.70	3.35 ±1.18	3.19 ±1.07	3.28 ±1.48	3.54 ±1.45
Social Recovery	4.58 ±0.86	4.36 ±1.03	3.76 ±1.04a	4.58 ±0.64	3.89 ±1.04	3.83 ±0.76	4.68 ±0.46	4.21 ±0.86	4.04 ±1.34	4.71 ±0.57	4.65 ±0.75	4.75 ±1.20	4.39 ±0.96	4.85 ±1.05
Physical Recovery	3.03 ±0.77	3.68 ±1.21	2.92 ±0.57a	3.77 ±0.83	3.07 ±0.85	3.83 ±1.26	3.14 ±0.84	4.29 ±0.91	3.25 ±0.94	3.93 ±1.59	3.60 ±0.74	4.13 ±0.99	3.33 ±1.27	4.38 ±0.94
General Well-Being	4.10 ±0.85	4.52 ±1.05	3.38 ±1.00a	4.77 ±0.53	3.68 ±1.07	4.50 ±0.50	4.32 ±0.75	4.43 ±0.93	3.96 ±0.60	5.00 ±0.50	4.70 ±0.71	4.94 ±0.90	4.17 ±1.03	4.85 ±0.77
Sleep Quality	3.68 ±0.82a	4.43 ±1.17	3.63 ±1.23a	4.65 ±0.88	3.82 ±0.91	5.17 ±1.04	3.59 ±1.45	4.29 ±1.35	3.96 ±1.01	4.71 ±1.22	4.50 ±1.11	4.44 ±1.27	3.89 ±1.75	4.31 ±1.11
Sport-specific recovery	3.51 ±0.54a	4.15 ±0.89	3.38 ±0.69	4.09 ±0.78	3.75 ±0.79	4.19 ±0.44	3.76 ±0.76	4.42 ±0.64	3.36 ±0.75a	4.44 ±0.82	3.55 ±0.88	4.12 ±0.92	4.28 ±0.93	4.18 ±0.87
Being in Shape	3.23 ±0.91a	4.50 ±0.97	3.65 ±0.89	4.37 ±0.75	3.79 ±1.00	4.67 ±0.14	3.64 ±1.17	4.54 ±0.76	3.52 ±0.85	4.54 ±1.51	3.83 ±1.01	4.38 ±1.02	4.33 ±0.90	4.56 ±0.87
Personal Accomplishment	3.35 ±0.61	3.73 ±0.98	3.04 ±0.63a	3.65 ±0.77	3.32 ±0.80	3.42 ±1.15	3.27 ±0.88	3.79 ±0.62	3.05 ±0.74	4.04 ±0.82	2.93 ±0.96	3.44 ±1.08	3.19 ±1.22	3.83 ±1.11
Self-Efficacy	3.43 ±0.77a	4.02 ±1.02	3.29 ±0.78a	3.92 ±0.85	3.89 ±0.79	3.67 ±0.29	3.86 ±0.98	4.43 ±0.72	3.23 ±1.02	4.04 ±0.68	3.48 ±0.98	3.97 ±0.91	4.69 ±1.00	3.98 ±1.06
Self-Regulation	4.04 ±1.01	4.36 ±1.21	3.54 ±0.92a	4.40 ±1.19	4.00 ±0.89	5.00 ±0.66	4.27 ±0.68	4.93 ±1.01	3.64 ±0.82a	5.14 ±0.79	3.95 ±0.86	4.69 ±1.15	4.89 ±0.99	4.35 ±1.23
Recovery-Cue														
Effort	2.94 ±1.34	2.94 ±1.09	3.31 ±0.95	3.69 ±1.18	2.93 ±1.00	3.33 ±1.15	3.18 ±1.60	2.43 ±0.79	3.42 ±0.90	2.71 ±0.95	3.10 ±0.88	2.63 ±1.41	3.67 ±1.32	2.62 ±1.26
Recovery	3.82 ±1.59	4.00 ±1.00	3.69 ±0.95a	4.92 ±0.86	4.21 ±0.70	4.33 ±0.58	4.36 ±0.50	4.71 ±0.95	3.83 ±0.58	3.71 ±1.98	4.00 ±0.94	4.00 ±1.41	4.33 ±1.50a	5.31 ±0.75
Rest	3.94 ±1.14	3.76 ±1.09	3.62 ±0.87a	5.15 ±1.07	4.14 ±0.95	5.00 ±1.00	3.82 ±0.40a	5.00 ±1.00	4.08 ±0.67	4.71 ±1.25	4.20 ±0.92	4.13 ±1.81	4.89 ±1.36	5.00 ±0.91
Physical	3.88 ±1.41	4.18 ±1.01	4.00 ±0.82a	5.31 ±0.75	4.29 ±1.20	4.33 ±0.58	4.00 ±1.26	5.14 ±0.90	4.25 ±0.87	4.86 ±1.35	4.30 ±1.16	4.13 ±1.36	4.56 ±1.42	5.46 ±0.66
Sleep	3.76 ±1.71	4.53 ±1.07	4.31 ±1.18	4.92 ±1.04	4.50 ±1.16	4.67 ±1.15	4.09 ±1.22	5.14 ±1.07	4.33 ±1.23	5.00 ±1.41	4.70 ±1.16	4.50 ±1.51	4.78 ±1.30	4.85 ±1.41
Fun	4.76 ±0.66	4.76 ±1.30	4.00 ±0.91a	5.46 ±0.52	4.93 ±1.07	4.33 ±1.53	4.82 ±0.75	5.14 ±1.07	4.33 ±0.78	5.57 ±0.53	4.90 ±0.74	5.13 ±0.99	4.56 ±1.24	5.31 ±1.03
Achievement	4.12 ±1.05	4.41 ±1.18	4.08 ±0.76	4.62 ±0.96	4.79 ±0.70	4.33 ±0.58	4.36 ±0.92	5.29 ±0.76	3.83 ±1.19	5.00 ±0.82	4.70 ±0.67	5.00 ±1.20	5.11 ±1.05	5.00 ±1.15
Mean ±SD players at trainings		20.8 ±2.8	28.8 ±5.8		25.3 ±7.4		20.0 ±7.0		20.3 ±4.0		20.3 ±4.2		23.3 ±2.8	
Training Injuries (No.) 1,000 training hrs		(2) 25.0	(8) 23.2		(0) 0.0		(0) 0.0		(0) 0.0		(0) 0.0		(2) 29.0	
Total match injures (No) 1,000 match hrs		-	(0) 0.0		(4) 231.3		(8) 404.9		(4) 231.3		(9) 520.5		-	
Results (W=Win ;L=Loss; H=Home; A=Away		-	22-8 (W; H)		24-18 (W; A)		74-0 (W; H)		18-10 (W; A)		30-34 (L; A)		Bye	

T=Testing; SD: Standard deviation; Significant difference (p<0.05) with (a)=Non-Injured

recorded an injury, there was an observable increase in the test scores for the RESTQ-Sport scales Conflict/Pressure (RR: 1.9 [95% CI: 1.3 to 2.9]; p=0.0009), Social Recovery (RR: 3.6 [95% CI: 1.8 to 7.1]; p=0.0004), Disturbed Breaks (RR: 2.0 [95% CI: 1.1 to 14.1]; p=0.0188) and Injury (RR: 2.4 [95% CI: 1.1 to 5.5]; p=0.0342) scales (see Table 3) before the following match when they recorded the injury.

There were differences observed in scores for the Recovery ($\chi 2(1)=78.52$, p=<0.0001; t(72)=2.74; p=0.0080) and Physical ($\chi 2(1)=70.25$, p<0.0001; t(72)=3.54, p=0.0008) items of the Recovery-Cue for all players over the duration of the study (see Table 3). Significant differences (p<0.0001) occurred between all the scales of the Recovery-Cue between the injured and non-injured players over the duration of the study (see Table 3). Although injured players recorded a similar mean Effort score ($\chi 2(1)=68.36$, p=<0.0001; t(72)=-0.70, p=0.4839) prior to recording an injury, they had a lower mean score in all other areas of the Recovery-Cue when compared with non-injured players.

An example of injury risk potential can be seen in the RESTQ-Sport and Recovery-Cue profile of player A (see Table 4) who had a shoulder injury from club participation prior to baseline assessment and was stood down from training and match activities until rehabilitated. He was monitored and following rehabilitation his RESTQ-Sport profile scores altered (baseline). At T1 his general (1.29 vs. 2.14; $\chi 2(1)=10.33$, p<0.0013; t(9)=-2.30, p=0.0615) and total (1.50 vs. 1.80; $\chi 2(1)=6.80$; p=0.0091; t(9)=-0.77, p=0.4600) stress scale score had risen, while his general (3.90 vs. 2.60; $\chi 2(1)=33.75$; p<0.0001; t(9)=3.47, p=0.0255) and total (3.72 vs. 2.36; $\chi 2(1)=9.20$; p=0.0024; t(9)=5.29; p0.0007) recovery scores had lowered when compared with his baseline. He self-recorded a high level of Recovery, Rest, Physical, Sleep,

Table 3: Mean and standard deviation (±SD) of the RESTQ-Sport-52 scale and Recovery-Cue scale scores and Risk Ratio's with 95% confidence intervals of injured (n=17) and non-injured (n=13) amateur representative rugby league players.

Variable	Injured Mean ±SD	Non-Injured Mean ±SD	RR (95%CI)
General Stress	**1.71 ±0.56**	**0.88 ±0.43**	**1.8 (1.2 to 2.7)***
General Stress	1.20 ±0.72	0.55 ±0.67	1.3 (0.9 to 1.8)
Emotional Stress	1.64 ±0.75	0.89 ±0.56	1.5 (0.9 to 2.4)
Social Stress	1.40 ±0.72	0.65 ±0.58	1.2 (0.8 to 1.9)
Conflicts/Pressure	1.97 ±0.81	1.18 ±0.75	1.9 (1.3 to 2.9)*
Fatigue	2.29 ±1.19	1.18 ±0.91	2.3 (1.6 to 3.2)*
Lack of Energy	1.83 ±0.67	1.02 ±0.65	1.8 (1.2 to 2.7)*
Physical Complaints	1.62 ±0.96	0.71 ±0.71	1.3 (0.9 to 2.0)
General Recovery	**3.70 ±0.73**	**4.26 ±0.67**	**1.3 (0.9 to 2.0)**
Success	3.24 ±1.11	3.62 ±1.09	3.1 (1.7 to 5.8)*
Social Recovery	4.27 ±1.00	4.53 ±0.93	3.6 (1.8 to 7.1)*
Physical Recovery	3.16 ±0.85	3.96 ±1.09	3.1 (1.7 to 5.8)*
General Well-Being	4.01 ±0.92	4.71 ±0.83	4.1 (1.7 to 10.1)*
Sleep Quality	3.84 ±1.14	4.49 ±1.11	4.0 (2.1 to 7.6)*
Sport Specific Stress	**1.85 ±0.61**	**1.07 ±0.45**	**2.0 (1.1 to 3.7)***
Disturbed Breaks	1.68 ±0.73	1.08 ±0.77	2.0 (1.1 to 3.7)*
Emotional Exhaustion	1.29 ±0.81	0.59 ±0.52	1.3 (0.7 to 2.6)
Injury	2.58 ±0.91	1.53 ±0.74	2.4 (1.1 to 5.5)*
Sports Specific Recovery	**3.62 ±0.76**	**4.20 ±0.81**	**1.3 (0.7 to 2.6)**
Being in Shape	3.64 ±0.98	4.49 ±0.92	2.8 (0.5 to 14.1)
Personal Accomplishment	3.18 ±0.80	3.72 ±0.92	3.6 (0.8 to 15.6)
Self-Efficacy	3.63 ±0.96	4.02 ±0.89	2.5 (1.1 to 6.0)*
Self-Regulation	4.00 ±0.94	4.56 ±1.13	3.1 (1.2 to 7.9)*
Total Stress	**1.75 ±0.47**	**0.94 ±0.38**	**1.3 (0.9 to 1.8)**
Total Recovery	**3.66 ±0.64**	**4.23 ±0.66**	**1.5 (0.9 to 2.4)**
Recovery-Cue			
Effort	3.19 ±1.15	2.93 ±1.18	3.4 (2.6 to 4.6)*
Recovery	4.01 ±1.06	4.49 ±1.20	4.2 (3.1 to 5.8)*
Rest	4.06 ±0.97	4.59 ±1.25	3.8 (2.7 to 5.2)*
Physical	4.15 ±1.16	4.81 ±1.08	4.2 (3.0 to 5.9)*
Sleep	4.30 ±1.32	4.78 ±1.20	4.0 (2.9 to 5.5)*
Fun	4.62 ±0.91	5.15 ±1.03	4.8 (3.4 to 6.6)*
Achievement	4.38 ±0.98	4.78 ±1.05	4.8 (3.5 to 6.6)*

RR = Risk Ratio; CI = Confidence Interval; (*)=Significant difference (p<0.05); Non-injured players RESTQ-Sport and Recovery-Cue scores were taken as a mean across all of the assessment weeks; Injured players RESTQ-Sport and Recovery-Cue scores were taken from the assessment prior to the match in which they were injured

Fun and Accomplishment in the Recovery-Cue at T1. He played in the next game despite the observed changes in the RESTQ-Sport scales and his self-reported Recovery-Cue scores but subsequently re-injured his shoulder. The subsequent RESTQ-Sport and Recovery-Cue profile (T2) again changed reflecting the effects of the injury with an increase in total stress (2.35 vs. 1.50; $\chi2(1)=4.34$; $p=0.0.0372$; $t(9)=-2.13$, $p=0.0625$) and a slight increase in total recovery (3.78 vs. 3.72; $\chi2(1)=3.96$, $p=0.0467$; $t(9)=-0.11$, $p=0.9120$) scores when compared with his baseline. As a result of the injury he subsequently withdrew from the team and did not participate in any other match or training activities in the representative competition.

DISCUSSION

In undertaking this study the RESTQ-Sport-52 and Recovery-Cue were utilised to monitor the stress and recovery of amateur rugby league team players. The Recovery-Cue was also selected to provide immediate visual feedback. The visual feedback was obtained by reviewing the scores to see where they were in relationship to the scale provided and did not require being calculated. While monitoring players it was identified that there were specific characteristics recorded for players who subsequently recorded an injury compared with non-injured players.

The training cycle for the rugby league competition consisted of activities involving aerobic and anaerobic endurance activities, skills, and drills, undertaken in an intermittent fashion mimicking match activities.[23,24] As the season progressed, the intensity increased to reflect the ensuing matches. Increases in training requirements and harder matches may lead to higher fatigue, stress, physical complaints, injuries and lower recovery scores. A surprising result was that following the bye (no match played), players (n=8) who recorded injuries in the subsequent match had a greater increase in the general stress and decrease in the general recovery scores than the mean of the non-injured players. Further research is warranted to identify if byes in the middle of competitions do place higher stress and decrease the recovery process.

Team management were keen to utilise the RESTQ-Sport questionnaire to assist with monitoring the players, even though immediate feedback was not possible. Alternative recovery monitoring tools may be more appropriate for feedback (i.e. Total Quality Recovery (TQR) scale,[6] or the Daily Analysis of Life Demands for Athletes (DALDA) scale25). The immediate visual identification of where the players were at in their recovery from the previous week's activities, via the Recovery-Cue, allowed

Table 4: Mean and standard deviation (SD) of scales of RESTQ-Sport scores and score of Recovery-Cue of player A pre injury and following a competition ending injury for amateur representative rugby league.representative amateur rugby league team.

	RESTQ-Sport						Recovery Cue						
	Stress			Recovery									
	GS	SSS	TS	GR	SSR	TR	Effort	Rec	Rest	Phy	Sleep	Fun	Accom
Baseline	1.29 ±0.86e	2.00 ±1.32	1.50 ±1.00	3.90 ±0.74ce	3.50 ±0.54c	3.72 ±0.65c	2	3	2	2	0	4	3
T1	2.14 ±0.85	1.00 ±1.00	1.80 ±1.01	2.60 ±0.22bf	2.06 ±0.52b	2.36 ±0.45bdef	3	5	5	6	6	6	6
T2 a	2.29 ±1.65	2.50 ±0.25	2.35 ±1.36	3.90 ±1.47	3.63 ±1.03	3.78 ±1.23c	3	5	5	4	4	4	4
T3	2.36 ±0.69b	1.58 ±0.58	2.13 ±0.73	4.70 ±0.76b	3.81 ±1.39	4.31 ±1.11c	3	4	3	2	2	5	2
T4	2.14 ±1.60	1.92 ±0.63	2.08 ±1.34	4.40 ±1.24c	3.13 ±0.75	3.83 ±1.20c	5	3	3	3	3	4	2

(a)= Injury occurred in next match following this assessment; GS = General Stress; SSS = Sport Specific Stress; TS = Total stress; GR = General Recovery; SSR = Sports Specific Recovery; TR = Total Recovery; Rec = Recovery; Phys = Physical; Accom = Accomplishment; Significant difference (p<0.05) than (b) = Baseline; (c) = T1; (d) = T2; (e) = T3; (f) = T4 adjustment of training intensity when required or to exclude players from certain activities if the coaching staff considered it necessary. The decision to review the Recovery-Cue once they were completed was undertaken in conjunction with the team medic as the competition rules allowed for the naming of a squad of 25 players to be named prior to the representative competition started. It was decided to add in an additional five players to be on 'active reserve' in case of injury where players were unable to further compete in the competition. If the scores, in conjunction with the injury status, indicated that the player may not be able to continue (as in the situation of player A) then there were procedures required to replace the player and the more notice to do this ensured the replacement player was available to be included in the main and travelling team squad for the next game.

In a previous study[11] the RESTQ-Sport did reflect how the players were dealing with the effects of amateur participation and other requirements in their own life (e.g., work, relationships). Although the RESTQ-Sport was able to identify current stress levels and lowered performance it may not be able to predict future performance and injury.[26] However, when the scores for all aspects of the RESTQ-Sport for the current study were retrospectively reviewed, injured players had higher stress related scores and lower recovery related scores than non-injured players in the assessment prior to the injury occurring.

Shier and Hall27 utilised the RESTQ-Sport-76 (76-items) questionnaire at baseline before two weeks of injury data collection for circus performers', and found low levels of Self-Efficacy and high levels of Fatigue, Emotional Exhaustion and Injury were associated with a two to three-fold increase in the risk for injury.[27] The current study had methodological differences in that it utilised the RESTQ-Sport-52 (52-items) completed each week by all members of the representative team and had high scores in the scales Fatigue, Emotional Exhaustion and Injury and low scores for the scale Self-Efficacy. A suggestion Shier and Hall's[27] study reported was that a high score for scale Social Stress and low score for either the scale Success or Personal Accomplishment may be predictive of injury.[27] This was a similar finding for the current study. Despite these findings not all injured players had similar changes in their RESTQ-Sports scale scores. Further longitudinal research is warranted to identify if any the changes in the scale scores are able to assist in prediction of an injury.

Further studies that prospectively monitor stress, recovery and injury over one or more rugby league competition seasons are required to develop a system that can indicate the risk of an injury occurring from rugby league participation. In addition, the Recovery-Cue could be utilised for the recovery monitoring of injured players. The goal would be to develop a system able to visually report on how players are coping with life outside of rugby league, recovery progress from an injury that has occurred and project modification requirements in regards to rugby league training activities that can assist in the reduction of the incidence of injuries in rugby league. The development of a shortened version of the RESTQ-Sport specifically related to the scales of Social Stress, Success, Personal Accomplishment, Fatigue, Emotional Exhaustion, Injury and Self-Efficacy may be beneficial in the identification of players at risk of injury and would be quicker to complete, limiting time away from the training environment. Further research with a shortened version of the RESTQ-Sport for rugby league is warranted.

A limitation to this study was there was only one team monitored for a short duration competition season. There were only 25 players in the competition team and they were not allowed to be substituted unless they were medically excluded from the rest of the competition. Future studies utilising the RESTQ-Sport and Recovery-Cue for player monitoring should be undertaken over more seasons with a larger player base enabling better confidence for injury prediction and injury rehabilitation monitoring.

In this study we monitored measures of stress and recovery as a result of participating in rugby league activities. We identified that there were certain characteristics of players who subsequently recorded an injury and developed a monitoring strategy for injury identification. From this point forward research is warranted to evaluate if this form of monitoring (RESTQ-Sport and Recovery-Cue) and any subsequent interventions utilised will lead to a reduction in injuries in rugby league.

What are the new findings?

- There was a two to three-fold increase in the risk of an injury occurring with increases in the psychological factors of Physical Complaints, Emotional Exhaustion, General and Social Stress.
- Use of the Recovery-Cue can assist in the monitoring of the recovery of an injured player.
- The Social Stress, Success and Personal Accomplishment scales are most useful for predicting injury.

Competing Interests Statement

None of the authors have any competing interests with regard to this manuscript.

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The use of additional laboratory based performance testing in the return-to-play decision; a case study in elite football

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INTRODUCTION

Identifying readiness for return-to-play is a complex process, particularly at the elite level and when an athlete has a history of multiple injuries. In this case study we report on an elite female football player where laboratory based performance testing guided rehabilitation and assisted the return-to-play decision making.

Case Description

Approximately one year prior to the 2016 Rio Olympics a 25-year-old female elite football player (height = 1.67 m, mass = 62.0 kg) underwent movement and strength assessment in the AUT Sports Performance Research Institute New Zealand (SPRINZ) laboratories. The aim of testing was to assist with return-to-play decision making following a series of lower limb injuries. At the time of testing she was suffering from a left Achilles reactive tendinopathy and as a result running load was being managed and she was not participating in all on-field training sessions.

The athlete was a left leg dominant defender who had sustained two significant knee injuries and a series of other leg injuries on the left side over the previous two years (Table 1). Pre-injury sprint and isokinetic data were available for the athlete from 2012, along with average data for the entire New Zealand Football Squad (n = 50) from the same year. The primary goal for the athlete in performing this process was to be at full fitness during the lead up to, and participation in, the Rio Olympic Games.

Table 1: Injury history, injury timeline with respect to testing and rehabilitation duration

Event	Months Prior to Testing	Rehabilitation
L Achilles tendinopathy	0	4 weeks
L Soleus strain	4	3 weeks
L Rectus femoris strain	6	6 weeks
L Quadriceps strain	7	3 weeks
L Knee ACL rupture	15	9 months
L Achilles partial thickness tear	19	12 weeks
L Lateral femoral condyle impaction fracture	25	8 weeks
L Ankle sprain	52	4 weeks

L=left

Laboratory Testing Protocol

The movement and strength assessment included; i) three-dimensional (3D) motion analysis with force in all three planes, ii) sprint assessment on a non-motorised force treadmill (for assessment of functional leg strength and symmetry), and iii) isokinetic dynamometry of the hip and knee.

Three-Dimensional Motion Analysis

A 9-camera Vicon motion analysis system (Oxford Metrics Ltd., Oxford, UK) combined with a Bertec instrumented treadmill (Bertec Corp., Worthington, OH, USA) were used for kinematic and kinetic collection. Joint angles and moments were calculated via inverse dynamics using Visual3D software (C-motion Inc., Germantown, MD, USA). Three-dimensional motion analysis consisted of running for 2 minutes each at 3.3 and 3.8 m/s with recording of data in the final 20 seconds. The athlete then performed up to five bilateral and unilateral drop landings and drop jumps from a height of 35 cm. Additionally, two trials per leg of a series of three unilateral hops for maximal height, and five cutting movements per leg, with a self-selected run up of approximately 2.5 m. The athlete was instructed to cut at approximately 45 degrees.

Sprint Assessment

Bilateral sprint kinetics were assessed on a non-motorised treadmill (Woodway Force 2.0, Woodway USA, Inc., Waukesha, WI, USA). A horizontal strain gauge was attached to the athlete's waist via a non-elastic tether. Two trials at 100% of maximum speed were collected and ten steps were analysed during the maximal velocity phase to determine peak horizontal and vertical force.

Isokinetic Assessment

The athlete lay supine on a HumacNorm dynamometer (Lumex, Ronkonkoma, NY, USA) for hip isokinetic strength assessment, and was seated for the knee assessment to allow for full range of flexion and extension. Five concentric repetitions were recorded for the hip and knee at 60°/s, and five eccentric repetitions for the knee at 30°/s. The asymmetry index was calculated as the difference between the two legs divided by the average strength of the two legs.

RESULTS

This case study represents a rare occurrence where measurements were available for the athlete prior to the two major knee injuries along with normative values specific to the athlete's population. Strength testing results showed the athlete's concentric hip and knee extension strength was weaker on the left compared to the right (39% and 19% respectively) (Table 2). In contrast, prior to injury (testing from 2012) the athlete had a larger 70% strength deficiency in left hip extension, but symmetrical knee extensor strength. By comparison the 2012 squad data indicated that on average, differences between left and right leg strength were less than 10%. As a result of the continued left hip extension weakness the athlete's left hip flexion/extension ratio (0.85) remained notably different to the squad mean (0.39).

Table 2: Athlete strength measures pre and post injury compared to the New Zealand Football Ferns (NZF)

	NZF					Athlete 2012			Athlete 2015		
	Left		Right		% diff	Left	Right	% diff	Left	Right	% diff
	Mean	SD	Mean	SD		Mean	Mean		Mean	Mean	
						Peak Concentric Torque (60°/s)					
Hip Flexion (Nm/°)	69.2	16.2	71.5	17.9	-3.3	56.9	164.0	-97.0	98.3	86.1	13.3
Hip Extension (Nm/°)	175.5	37.3	185.9	48.9	-5.8	52.7	108.4	-69.1	115.4	171.7	-39.2
Knee Flexion (Nm/°)	95.8	16.8	98.6	18.1	-2.9	79.7	90.2	-12.4	72.6	77.0	-5.9
Knee Extension (Nm/°)	131.7	27.9	127.6	28.2	3.2	129.2	129.7	-0.4	137.9	167.4	-19.3
Hip Flex: Ext ratio	0.39		0.38			1.08	1.51		0.85	0.50	
Knee Flex: Ext ratio	0.73		0.77			0.62	0.70		0.52	0.46	
Posterior chain ratio	0.55		0.53			1.51	0.83		0.63	0.45	
Mixed Ratio (Knee)	0.94		0.94			1.01	0.94		0.74	0.55	
						Peak Eccentric Torque (30°/s)					
Knee Flexion (Nm/°)	123.3	27.4	119.9	32.1	2.8	129.9	121.5	1.2	101.7	92.5	9.4
Knee Extension (Nm/°)	153.0	36.7	153.6	38.7	-0.4	187.2	184.4	1.5	221.4	225.2	-1.7

Table 3: Horizontal tethered force production during sprinting pre and post injury compared to the New Zealand Football Ferns (NZF).

	NZF		Athlete 2012			Athlete 2015		
			Left	Right	% diff	Left	Right	% diff
	Mean	SD	Mean	Mean		Mean	Mean	
Peak Velocity (m/s)	5.0	0.5	4.9			4.9		
Contact Time (ms)	181.3	23.6	161.9	160.2	1.1	148.9	143.3	3.8
Flight Time (ms)	77.1	16.3	82.7	90.0	-8.5	103	106	-2.9
Peak Horizontal Force (Nm/kg)	3.9	1.1	4.7	3.5	29.3	3.2	4.2	-27.5

Table 4: Temporal and impulse differences (%) between left and right leg for a variety of running, landing and cutting movements.

			Impulse			
	tc (ms)	tf (ms)	Vertical Acceptance	Vertical Impact	Braking	Propulsive
Run 3.3 m/s	0.2	4.0	2.2		2.9	13.5 (R)
Run 3.8 m/s	0.9	1.9	2.4		8.7	14.7 (R)
DropJump2	2.8	1.2	12.2 (R)	8.2		
DropJump1	14.9 (R)	4.2	12.2 (R)	3.0		
Cut	2.6		15.6 (R)	7.2	36.5 (R)	5.7

(R) = right leg has the greater force or time, tc = contact time, tf = flight time.

Table 5: Percentage difference between left and right leg for key lower limb peak joint movements during running and drop jumps.

	Flexion Moment			Abduction Moment		Rotation Moment	
	Hip	Knee	Ankle PF	Hip	Knee	Hip (Ext)	Knee (Int)
Run 3.3 m/s	30.6(R)	19.1 (L)	6.5	29.3 (R)	2.6	112.5 (L)	42.9 (R)
Run 3.8 m/s	31.8 (R)	16.4 (L)	7.3	30.0 (R)	14.7 (R)	69.4 (L)	77.8 (R)
DropJump2	20.1 (R)	21.2 (R)	8.4	32.4 (R)	8.3	17.7 (R)	27.0 (L)
DropJump1	12.5 (R)	61.6 (R)	9.8	10.4 (R)	36.7 (L)	24.7 (L)	15.8 (L)

(R) = right leg has the greater force or time; (L) = left leg has the greater moment.

During the non-motorised treadmill sprint the right leg produced 28% more horizontal propulsive force than the left leg which was opposite to the 2012 results where the left leg produced greater force. This higher force production on the right, post the left leg injuries, was due to a drop in absolute left leg force production rather than an increase on the right.

From the 3D motion analysis a number of differences between the left and right leg were apparent. Propulsive impulse (running), vertical impulse during weight acceptance (jumps and cutting), and braking impulse (cutting) were all greater on the right leg (Table 3). Hip and knee flexion and hip abduction moments were generally higher for the right leg (Table 5). Differences in knee abduction moment were generally less than 10%. Differences between sides in hip and knee rotational moments varied depending on the movement.

DISCUSSION

Asymmetries in sport may be beneficial for specific skilled performance, however from an injury perspective any differences in strength and movement control could increase the risk of injury to the athlete.[1,2] This athlete was evaluated following a series of major left leg injuries. Moving into the build up to the Rio Olympic Games, the athlete's physiotherapist was concerned that a premature return to play would progress this injury pattern further and limit the athlete's ability to compete in this key event.

Prior to injury, left hip weakness combined with the higher than average hip flexion/extension ratio may in part explain the series of left leg injuries the athlete sustained. Although the athlete's major injuries were at the knee these hip strength deficits highlight the importance of examining the entire kinetic chain. Following injury and rehabilitation left hip and knee extension strength improved but remained weak compared to the right side, and this coincided with reduced horizontal force production on the left side during running. Not only does reduced horizontal force production have important performance implications for the rapid accelerations required in football, the asymmetry between the two legs may increase the risk of the athlete sustaining further injuries. Hip and knee extension weakness combined with reduced horizontal force production has previously been reported in a rugby union player on the injured leg following a similar series of two major and multiple minor injuries.[3] The athlete's movement profile suggested reduced control of knee internal rotation and abduction, particularly when landing on a single leg. This reduced knee control may have been placing the athlete at increased risk of sustaining a further knee injury.

The combined test results confirmed the observations of the treating physiotherapist and were used to demonstrate to the athlete, strength and conditioner and coaching staff the need for further rehabilitation. Rather than returning to full play, as had been proposed by the athlete and her coach, the athlete underwent a ten week reconditioning programme focused on normalising the unilateral hip/knee imbalances and building overall lower limb strength and plyometric power. Unfortunately the athlete was not available for retesting in the laboratory post the ten week programme. However she took up a short term professional contract and then returned to play for the Football Ferns in their tour to Brazil in December 2015. At the time of reporting she has not had any time loss from injury since this profile/programme was formulated. Subjectively she reported feeling fitter and more capable than she has been at any stage over the last two seasons including being able to complete full, successive training sessions which she has been unable to do prior to the most recent injury. On review by the rehabilitation team approximately six months post testing there were still some concerns around total power output (based on observations of the physiotherapist) and the focus on plyometric exercises and landing strategies was increased. This case study highlights how additional laboratory based testing of strength and movement ability can assist in confirming appropriate decision making around return to play in an elite athlete.

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Go Beyond, Create Tomorrow
Lillehammer Winter Youth Olympics 2016

SARAH GILLESPIE

Being a physiotherapist at the 2016 winter Youth Olympic games tasked with looking after the wellbeing of elite junior athletes may seem like an apparent oxymoron. These young athletes are at the top of their sport for their age, happy, healthy and driven with a competitive spirit. It was an absolute honour to support them on their journey for success on the international stage.

The Winter Youth Olympic games were held in Lillehammer, Norway , February 12-21 2016. New Zealand sent a team of 11 athletes (aged 14-17 years) to compete in snowboarding, freeskiing, alpine skiing, ice hockey and curling. While some of these athletes had multiple previous opportunities to compete on the international stage, for some it was their first trip out of New Zealand. It was rapidly apparent that my role of supporting athlete wellbeing extended far beyond that of physical wellbeing, but included being part of the four person performance team there to help each athlete achieve their goals. From day one at the Olympic village the NZ team was cohesive and motivated, with the united goal being successful team performance. Ultimately we were rewarded with 2 shiny Olympic medals thanks to Freeskier Finn Bilous.

My goal as physiotherapist for this team was to introduce the young athletes to the high performance environment and educate on good habits when accessing medical support available as an elite athlete. For many of the athletes having readily accessible medical support was a new and novel experience. For some athletes it was the first time they had been concussion tested (an important tool in this high impact sport), had a musculoskeletal screen or been subjected to drug testing, "what do you mean I have to pee into a cup with someone watching?" A highlight was watching the entire team, myself included, develop a rosy cheeked blush as I gave the sexual health talk at our first team meeting. The Games were also an opportunity to develop their time management and organisational skills - both which tend to be lacking in this age demographic of athletes. With an environment as stimulating as the Olympic games we focussed on getting good rest, hygiene, eating well, not over indulging on Norwegian brown cheese in the food hall, and making sure we were the loudest cheering team in the curling hall! The Olympic village was designed to encourage meeting other athletes and learning. The expo area on the way into the dining hall focussed on "learn and share" with numerous freebees and prizes with stalls ranging from drug free sport, to first aid skills, social media and sponsorship. However, the best spot in my opinion was the coaches corner, it had the best coffee of the village and the chance to sit and engage with other coaches and medical professionals from across the world.

There were injuries and illness. Many of the winter events such as half pipe, slopestyle and alpine skiing are very high risk sports. Not having a team doctor at the games meant I was relying on the medical team in New Zealand for support via Skype who were fantastic, and we even called on their Norwegian colleagues for assistance at times. Each event had very comprehensive medical staffing, good access to medical facilities and Norwegian medical professionals all speak a very high level of English so I felt very supported. The word got out quickly that team New Zealand didn't have a doctor with them, and I had offers of support from Canada, Great Britain and Australia medical staff should I have needed it. This "Team Queen" bond also meant we could distribute our available medical staff across the different venues of the games.

The games weren't all Norwegian brown cheese, Vikings, and sunny days on the slopes. The days were long, with the therapy sessions crammed into a small space between the bunk beds in our room. Most days started at 5.30am on the alpine skiing hill, helping on the course and with carrying gear for the athletes, then returning to the village for curling, ice hockey and physiotherapy sessions. Daily medical meetings and writing up media reports from the days action, before returning to the bunk room late for a quick sleep and repeat. Working with the athletes on their time management and organisational skills was very important. With a small performance team of four people our Chef de Mission Jesse Teat quickly showed the way to get things done. With one media pass for the entire team we quickly adapted a "jump the fence, blend in, they won't notice, they have really big cameras, I have an iPhone, we really need this photo" attitude. The performance team and the coaches all picked up roles well outside of their official role at the games, ensuring the athletes enjoy a relaxed, humorous and stress free environment, which ultimately leads to less demand on the medical team and better performance.

The winter sports future in New Zealand is very promising, but injuries to young athletes remains its biggest threat. I hope that these athletes have taken away the skills they need to integrate into a high performance, drug free sport, and an injury prevention focussed environment. The opportunity to work with young elite athletes and contribute to their development is rewarding. Keep your eyes out for some of these young superstars at the next Winter Olympics, Korea 2018.

Sarah Gillespie

Physiotherapist

2016 Youth Winter Olympics

'Return to Play' Conference, Isokinetic, London

9-11 April 2016

TONY EDWARDS

I attended the Isokinetic Conference in London this year as the theme of 'Return to Play' [RTP] had a huge relevance to our every day work in high performance sports medicine. I have recounted here some of the themes from the conference.

The decision over the timing of return to play [RTP] for an athlete is critical, as we know that the risk of re-injury is up to four times as high as the risk of initial injury. Making a decision regarding return to play is multi-factorial but fundamentally needs to take into account what is in the athlete's best interests. Factors to be considered are included in Table 1.

Table 1: Considerations in RTP decision making.

The age of the athlete
The stage in their career
The time since injury
Mechanism of injury
Previous treatment
The player's commitment and motivation
The athlete's perception of readiness
The risks involved in return to play

The risks involved in RTP include the risk of re-injury, but also the risk of incurring long-term damage such as arthritis, the risk of head or spinal cord injury or death. The seriousness of the injury is a critical element in the RTP decision as there are potentially very different consequences for a concussion versus an ankle sprain. As practitioners, we need to better quantify these risks through well designed prognostic studies and systematic reviews.

Many of the RTP presentations utilised the work of Creighton et al,[1] published in 2010 in which they proposed a 3 step approach. In step 1, the health status of the athlete is assessed through the evaluation of medical factors related to tissue healing status. In step 2, the clinician evaluates the participation risk associated with participation, taking into account the current health status of the athlete but also the sport risk modifiers (eg, ability to protect the injury with padding, athlete position). Different individuals are expected to have different thresholds of an "acceptable level of risk," and these thresholds will vary based on the context. In step 3, decision modifiers are considered and the decision to RTP or not, is made.

Basic science plays a role in determining return to play. Considering the issue of RTP after ACL reconstruction, we need to consider the physiology of surgical repair. It is known that the risk of graft rupture after RTP post surgery, reduces after 7 months, as compared to an earlier return.[2] This, with other studies, has helped change the way many centres are returning athletes to play, with a progressive increase in change of direction from about 5 months, and not returning to full contact play until the 9 month mark. This contrasts with the RTP goal of 6 months post surgery, more common in the past. So essentially we are delaying our RTP programme until the tissue has adapted enough to tolerate the rehabilitation load and the player has regained sufficient strength, proprioception and neuromuscular control. Despite this of course, only 48-65% of athletes return to their prior level of competition, but this is up to 90% in elite professional athletes. The latter group have a financial incentive to return to their previous level of sport and often access to personalised intensive rehabilitation. As part of the RTP plan we also need to include a secondary prevention component. In the setting of an ACL reconstruction we still need to establish an adequate injury prevention programme, given that there remains an increased risk of graft rupture and a 12% chance of ACL rupture on the contralateral side.

So how do we decide when an athlete is ready to RTP?

There is mixed evidence on predictive tests to judge ability to return to sport. Each individual test within the battery should mimic the forces and stresses that will be experienced by that athlete in a competitive situation. Typically, there are 'criteria based' and 'time based' assessments. A criteria based 'traffic light' process seems to be most accepted worldwide. This takes into account factors such as achieving functional milestones, regaining aerobic and neuromuscular fitness and especially a return of player confidence and mental readiness to RTP. The psychological state of the athlete is so important, as anxiety, apprehension, and fear are associated with a higher risk of re-injury (as well as their detrimental effects on performance). Other considerations include the restoration of flexibility, pain free range of motion and the elasticity of the tissue involved. The assessment of sports specific function is also important. As an example of functional performance testing for the RTP-decision after hamstring injury in the footballer, repeated Sprint Ability Tests, deceleration drills, the single leg bridge, and position specific GPS targeted match specific rehabilitation, along with explosive movements to mimic the actual football performance, may be used. Strength is also an issue some experts were using as criteria such that the injured limb returns to within 10% of other leg or to pre-season isokinetic values, if known, but there is significant controversy over its use, as it is not a functional test.[3]

It is important to decide who is best

positioned to make the informed decision regarding RTP. There is often a multi disciplinary team that supports an athlete and each discipline brings a certain perspective. Does the final decision rest with the team physician, the physiotherapist, the strength and conditioning trainer, the psychologist, the athlete, or the coach? In reality it comes down to discussion among the team and an agreement in advance as to who has the casting vote if there is an impasse. Free open communication within the support team is essential, as is understanding the athlete's expectations and concerns. It is also critical to consider where the athlete's opinion sits in this decision making process. As Creighton points out, "it is often difficult to determine if the athlete is in a position to provide informed consent because of the nature of the injury (eg, concussion) or if she/he is being coerced by "handlers" or "superiors" (eg, coach or family members). In this context, the clinician's assessment of what constitutes an acceptable risk may contradict the athlete's assessment".[1] In the end, the decision of return to play often rests with the coach, while the "support team" makes the decision on return to training at whatever level is deemed appropriate (eg. drills vs practice game play).

As practitioners, it is important to consider our role as clinicians in the decision making process and be cognisant of outside influences that may affect our decisions. We need to be aware of influence of individuals who, while they are not trained or experienced in medical decision making (eg, coach, family, team mates , media, player agents), they may influence the RTP process. Furthermore, while it shouldn't influence our process, conflict with any coach's view of RTP may also influence our future in that role, given the autocratic nature of sport. While our role is to be an advocate for the athlete, clinicians also have obligations to the team if they are paid employees, and this needs to be made clear to the athlete so everyone understands this unique environment. It is important as clinicians that we acknowledge these influences and be aware of how they may affect our decision-making.

Regardless of the RTP decision, health care providers need to fully inform athletes about the risks associated with RTP and appropriately document all instructions and restrictions given to the athlete.

There exists in sport, a conflict between health, wellness, functionality, disease protection, elitism, entertainment, competiveness, and winning. In the high performance environment it is our job as clinicians to get that balance right and act in the athletes' short and long term interests.

I would like to thank HPSNZ and the Prime Minister's Scholarship fund which supported my attendance at this conference.

Tony Edwards

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American College of Sports Medicine Annual Meeting, Boston

31 May to 4 June 2016

JUDITH MAY

I attended the 63rd Annual meeting of the American College of Sports Medicine, which was held in conjunction with the World Congress on Exercise is Medicine and the World Congress on the Basic Science of Energy Balance. This year there was record registration with over 7000 attendees from a diverse range of disciplines. Each day there could be up to 20 concurrent sessions scheduled ranging from poster presentations, hands on workshops, tutorials and symposium on a wide range of topics including public health, clinical medicine, exercise physiology and nutrition. As a result, each day requires careful planning, but there is generally something for everyone.

With Boston being home to the longest running annual marathon in the world, there was a symposium on the Scientific, Medical and Social history of the Boston Marathon. Amby Barfoot presented on the history of Boston Marathon, and he noted that the first recorded injury in the Boston marathon occurred during the first running in 1897 when an ambulance corps fell off his bike. The sports medicine doctor and cardiologist who provide the medical care for the marathon presented on the unique challenges of Boston, including co-ordinating 1700 medical volunteers. They noted that over the past few decades the demographics of marathon runners have changed with today's runners being less experienced, older and slower; all of which carry an increased risk of medical complications. The numbers of females participating has also increased from 18.5% in 1990 to 45.5% in 2015 which is relevant to medical coverage as they have an increased risk of postural hypotension. While there has been a media and scientific focus on cardiac arrest and screening in young elite athletes, there is little consideration on the risk and prevention of severe medical complications in the recreational athlete. South African physician Martin Schwellnus presented on the implementation of a pre-race medical screening and intervention system that has reduced medical risks for recreational runners in the Two Oceans marathon. With a changing world and the risk of terrorism highlighted by the Boston bombings in 2013, large marathons now also have to consider the unexpected factors involving mass gatherings with plans in place in case of mass casualties.

I attended the Female Athlete Triad Coalition meeting which involved discussion on current research activities which include the effects of low energy availability in male athletes, development of new measurements of bone strength and the effects of the triad on tendinopathies. There was an interesting session on stress and reproductive dysfunction in exercising females. Psychological stress can lead to menstrual disruption by its effect on the hypothalamic/pituitary/adrenal axis and the locus coeruleus which is the noradrenergic nucleus in the brain. Amenorrhoeic runners have been shown to have higher levels of emotional distress, anxiety and obsessive-compulsive behaviours.[1] The combination of metabolic stressors such as low energy availability and psychogenic stress can have a synergetic effect on the menstrual cycle. Judy Cameron presented her studies on macaque monkeys who have similar menstrual cycles and stress responses to humans.[2] The monkeys were stressed by constantly moving rooms but were controlled for diet and exercise. They found there were highly stress resistant monkey who continued to ovulate and stress sensitive (SS) monkeys who didn't ovulate. The SS monkeys had lower levels of gene expression involved in serotonin neural function. Interestingly serotonin reuptake inhibitors e.g citalopram did not restore the menstrual cycle in SS monkeys but serotonin and noradrenaline reuptake inhibitors e.g reboxetine did restore menstruation, suggesting a role for the noradrenaline neurons.[3] This goes some way to explain my observation that there are athletes who seem particularly prone to menstrual cycle disruption, despite apparently adequate energy availability.

Not surprisingly, there was a symposium on tendinopathy in athletes. This seemed to bypass the role of mechanical loading on the tendon, and concentrated on the role of biologics. Though the evidence on the role of PRP and stem cells in tendinopathies is still equivocal, there is recent evidence to suggest the combination of fenestration with PRP may improve outcomes.[4]

A symposium on the hypermobile athlete suggested that Ehlers-Danlos syndrome (EDS) is underdiagnosed. Benign Hypermobility Syndrome and EDS have the same diagnostic criteria for joint laxity and are essentially the same condition. Previous classifications systems for EDS have been confusing, so a new system is being considered that divides patients into a "common" form who just have hypermobility and joint laxity, and an "uncommon" form who also have skin manifestations and vascular complications . It is recommended that all with either forms of EDS have regular echocardiogram to exclude aortic root and mitral valve pathology.

Internationally recognised cardiologist Dr Paul Thompson gave a lecture on the clinical cardiac complications in lifelong endurance athletes. Though studies have shown an increase in cardiac biomarkers with exercise, he felt these were a physiological rather than pathological response to exercise. However atrial fibrillation, myocardial fibrosis and coronary artery calcification have all been found in a percentage of lifelong exercisers.[5] The right ventricle seems particularly vulnerable due to the effects of increased pulmonary artery pressures during exercise. It has been shown that physically active individuals with a genetic defect in desmosomal proteins develop right ventricle cardiomyopathy earlier and with more severity than individuals who do not exercise. He suggests that there are likely a number of other cardiac conditions where there may be a genetic susceptibility, which has variable penetrance due to environmental factors such as exercise. Most studies show that endurance athletes live longer, but there are likely to be some individuals whose genetics puts them at more risk of cardiac complications with extreme exercise.

A symposium on exercise associated muscle cramps (EAMC) outlined new theories and treatment options in the prevention and treatment of muscle cramping. The traditional views that EAMC is due to either dehydration, lactic acid or electrolyte changes has largely been discredited. Recent evidence suggests that cramps are due to altered neuromuscular control and related to hyper excitability of alpha motor neurons in the spinal cord that innervate muscle. Interestingly, a number of popular remedies such as pickle juice and mustard which were aligned to the electrolyte loss theory, do appear to have scientific evidence to support their effect. However, it was noted the beneficial effect occurred within 90 seconds, so gastric emptying would be too slow for serum changes in electrolytes or fluid to be the explanation for the effect. Researcher Kevin Miller suggests that the acetic acid in pickle juice is likely stimulating sensory neurons in the mouth and oesophagus via activation of TRP (Transient receptor potential) channels.[7] This then stimulates a neural pathway that reduces the hyper excitability of the motor neurons. A number of other natural products can also activate TRP channels such as capsaicin, mustard and wasabi. The researchers have formulated and are marketing their own product called "Hot shots" with a combination of substances that affect the channels that is used 15 to 30 minutes prior to exercise to prevent the onset of cramps. Future research will help determine whether there could also be benefits to reduce post exercise muscle soreness and muscle fatigue, or even help muscle spasm in diseases that affect the alpha motor neurons such as amyotrophic lateral sclerosis and multiple sclerosis.

I would like to thank HPSNZ and the Prime Ministers Scholarship fund for supporting my attendance at this conference.

Judith May

HPSNZ Medical Director Triathlon NZ

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RESTQ: The Recovery-Stress Questionnaires User Manual

Kallus, KW & Kellmann, M. 2016.

Pearson Assessment & Information GmbH, Germany. €97.00

Having utilised the Recovery-Stress Questionnaire for Sports (RESTQ-Sport) before I was looking forward to reading the updated manual on this questionnaire. What a surprise I had when I first opened the manual and saw the chapter headings and how far the RESTQ has developed. For a sports related recovery and stress questionnaire, this has now been developed to encapsulate other domains alongside with the variety of sizes of the questionnaires. What did get my attention was the questionnaire for clinical settings and how this could be utilised within a variety of environments opening up a whole domain of research for health professionals on patient perspectives.

The chapters report on the different questionnaires scope, application, and related theory of the different environmental stress. The scale item construction, reliability, validity and construct validity is also reported for each questionnaire. The chapters are then rounded off with some of the published results of the questionnaires providing case studies for the different questionnaire types and these are useful resources for referring back to when conducting reviews of the data obtained or for possible future research to be conducted. A bonus to each chapter is a section on the application of the RESTQ prompting a perspective of where the questionnaire may be utilised. The individual chapters are a one-stop resource of the questionnaires having summarised the 24 pages of references of research into an easily accessed information platform of these aspects of the questionnaires. Having these aspects of the questionnaires readily available means that you can quickly reach for the required information if publishing your research findings, or being able to know what these are for future use. The final chapter of the manual provides the readers with an overview of the questionnaires and hints for the application of these questionnaires to different environments.

Of interest within the new manual is the application of the RESTQ enabling this to be utilised outside of the traditional sporting environment from just the sports participants to a basic version with 7, 24 and 48 items, a new 36 item sport questionnaire, a work version, a child and adolescent version, and the clinical setting version. The number of items also varies from the basic 7-item version to the 92-item more complex version and there are a variety of different number-item versions for all of these settings. The possible research opportunities that are available with the variety of the questionnaires presented in the manual is limited to only what the reader can perceive. The manual is therefore not just for the researcher within the sporting environment but can be broadened to the clinical environment and to the children and adolescent perspective as well.

With the increasing awareness of work related stress and the need for increased productivity, the RESTQ-Work questionnaires would provide the employer with a snapshot of how the workforce is coping with the demands of the workplace and what trends are occurring. I can see how the use of this questionnaire within the healthcare hospital and clinical workplace would be beneficial for the environment providers to see what resources are required where enabling workplace resource distribution to be utilised over time. Combine this with the clinical application of the questionnaire and there is the potential for research to be undertaken within the healthcare system enabling awareness of the issues pertinent to healthcare providers directly.

The only downside to the manual is you have to dig around in the appendices for the questionnaire components and this requires reading through the information. Once the relevant questionnaire is identified, the items are grouped within the different domains and it is quite easy to shape the structure of the individual questionnaire together. I found it best to write the question items on an Excel Spreadsheet and then auto-sort to enable the questionnaire to fall into shape for what I wanted. Once this was done the questionnaires are readily available for use. Mind you, this may have been constructed this way to ensure people do read the manual to get the information necessary for the conducting of the questionnaires and how to assess them. A disappointing find for me was that the clinical setting was only available in German and correspondence with the authors to date has been unsuccessful in getting the clinical setting version in English, but with a little Kiwi ingenuity I am sure this can be overcome.

Despite these downsides to the manual I am enjoying having this at my deskside so I can start to implement these questionnaires into future research and the possibilities of what can be undertaken is limited to the development of the different research concepts of the individual researcher. So if you're a healthcare or sporting researcher, workplace manager, or have an interest in stress and recovery this manual is a useful resource for you and is worth getting hold of. For more information visit the website or download the flyer for the manual at http://www.pearsonassessment.de/out/pictures/wysiwigpro/RESTQEBF_2016_eng.pdf

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Selected Abstracts from the 2016 Sports Medicine NZ Conference

Auckland • 17-19 November *(in Order of Presentation)*

THE DR MATT MARSHALL LECTURE
RETURN-TO-PLAY MEDICAL DECISIONS

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Return-to-play decisions are often difficult for the clinician providing care to highly competitive athletes. "Cleared" or "Not Cleared" for participation is a binary decision that belies the complexity of the actual decision making progress. Moreover, each decision is individualised, making it difficult to use standardised protocols.

Given the environment of competitive sport, return-to-play decisions are a high-stakes endeavor. In order to improve understanding of the factors that go into the decision and to provide a standardised approach for an individualised decision, we developed a framework for return-to-play decision making.

The process uses three groups of factors for consideration. The first group is related to the health status of a given injury or body tissue and is called Evaluation of Health Risk. The second group relates to the factors that create risk for participation in sport and is called Evaluation of Activity Risk. The third are the factors that go into the consideration of risk tolerance following the assessment of the first two groups of factors. This third step is known as Evaluation of Risk Tolerance.

This three-step process provides the clinician with a standardised method for considering return-to-play medical decisions while, at the same time, permitting individualised decisions to be made.

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EXERCISE PRESCRIPTION IN CHRONIC DISEASE

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Abstract from

Physical activity prescription: a critical opportunity to address a modifiable risk factor for the prevention and management of chronic disease: A position statement by the Canadian Academy of Sport and Exercise Medicine

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Abstract
Non-communicable disease is a leading threat to global health. Physical inactivity is a large contributor to this problem; in fact, the WHO ranks it as the fourth leading risk factor for overall morbidity and mortality worldwide. In Canada, at least 4 of 5 adults do not meet the Canadian Physical Activity Guidelines of 150 min of moderate-to-vigorous physical activity per week. Physicians play an important role in the dissemination of physical activity (PA) recommendations to a broad segment of the population, as over 80% of Canadians visit their doctors every year and prefer to get health information directly from them. Unfortunately, most physicians do not regularly assess or prescribe PA as part of routine care, and even when discussed, few provide specific recommendations. PA prescription has the potential to be an important therapeutic agent for all ages in primary, secondary and tertiary prevention of chronic disease. Sport and exercise medicine (SEM) physicians are particularly well suited for this role and should collaborate with their primary care colleagues for optimal patient care. The purpose of this Canadian Academy and Sport and Exercise Medicine position statement is to provide an evidence-based, best practices summary to better equip SEM and primary care physicians to prescribe PA and exercise, specifically for the prevention and management of non-communicable disease. This will be achieved by addressing common questions and perceived barriers in the field.

ANTI-DOPING AND THE ATHLETE BIOLOGICAL PASSPORT FROM THE OBVIOUS TO THE ELUSIVE

Bridget Leonard
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Sports Medicine practioners can often be treating elite athletes who are part of Drug Free Sport New Zealand's (DFSNZ) or an international federation's anti-doping testing pool. These athletes are required to provide out-of-competition urine and/or blood samples for the purpose of detecting the use of substances or methods which are prohibited under the World Anti-Doping Code.

In recent years anti-doping testing has evolved from testing solely for the presence or absence of prohibited substances to also monitoring the physiological effects of these substances by measurement of markers in urine and blood. This strategy has seen the development of the Athlete Biological Passport (ABP), formally introduced by the World Anti-Doping Agency (WADA) in 2009.

This longitudinal profiling of markers in blood, and more recently urine, intends to establish whether an athlete is manipulating their physiological variables. It involves collating results of multiple tests from an athlete to establish a longitudinal profile or 'biological passport' for that athlete indicating their individual norms. A significant variation from that individual's norm (an atypical passport finding) may indicate use of prohibited substances or methods. This biological data can be used to direct further testing and allows an anti-doping rule violation to be pursued.

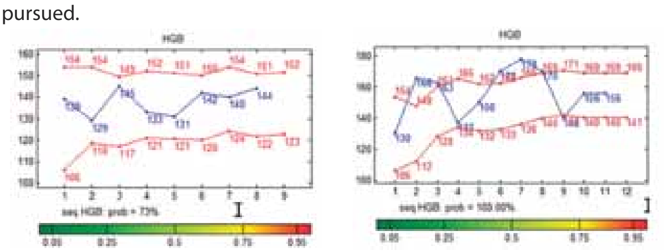

Figure 1. Snapshot of the hemoglobin (HGB) parameter of the haematological module of the ABP from two female endurance athletes. Vertical axis: hemoglobin (g/l), horizontal axis: sequential test number. Blue lines: actual test results, red lines: individual limits as found for the Athlete Hematological Passport. Modified from Sottas et al, 2011.

International experience indicates athletes have modified their behaviours in response to the introduction of the passport. For example, the shift to microdosing with erythropoietin and the use of transdermal testosterone patches. Passport data can be further confounded by use of multiple performance enhancing drugs for which the effects on haematological and steroidal parameters may not be well described. This, along with the physiological effects of training as an elite athlete makes interpretation of the ABP increasingly complex.

DFSNZ's testing programme continues to evolve to meet both changing WADA requirements, evolving analytical science and changing behaviours of athletes. This talk provides an overview of the Athlete Biological Passport and its role in detecting and deterring doping.

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FEMALE PUBERTAL DEVELOPMENT INCREASES ABERRANT NON-DOMINANT KNEE BIOMECHANICS: IMPLICATIONS FOR ANTERIOR CRUCIATE LIGAMENT INJURY

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Background: Non-contact anterior cruciate ligament (ACL) injury is 4-6 times higher in females than males during pubertal development.[1,4] Evidence is emerging that higher ACL rupture rates occur in girls during multi-planar knee motion, where the knee buckles into flexion, abduction and rotation.[3] Furthermore, the non-dominant limb appears to be injured more often in females,[2] yet no studies have investigated whether differences in multi-planar knee biomechanics of the non-dominant limb exist across stages of pubertal development. The purpose of this study was to examine whether biomechanical differences exist across pre-pubertal, pubertal and post-pubertal development during a single-limb landing task.

Methods: Lower limb biomechanics of 94 healthy physically active females was analysed during a single-limb drop lateral jump (DLJ) on the non-dominant leg. To standardise the test, the height of the box and the distance of the lateral jump were scaled proportionally to the leg length of each girl. Girls were classified according to their developmental stage as either pre-pubertal (Tanner stage I), early/mid-pubertal (Tanner stage II-III) or late/post-pubertal (Tanner stage IV-V). Girls who had commenced their menstrual cycle were tested within the first 7 days of their new cycle. To control for fluctuations in estrogen during pubertal development, and the potential influence on biomechanics, all participants provided a 5 ml saliva estradiol (E2) sample. Marker trajectories (120 Hz) and ground reaction force data (2400 Hz) were collected via a 12 camera Vicon motion analysis system (Oxford, UK), synchronised with a concealed force plate (AMTI, Inc., Watertown, MA, USA). Biomechanical outcomes of interest, calculated via inverse dynamics in Vicon Nexus software, were the peak knee abduction moment (KAM), peak knee flexion moment (KFM) and peak knee internal rotation moment (KIRM) during the first 25% of stance. A one-way ANOVA ($p < 0.05$) was used to test for differences with post-hoc analysis carried out via Fisher's Least Significant Difference (LSD) tests.

Findings: There were no significant differences in E2 concentrations between developmental groups ($p > 0.05$). Girls in the late/post-pubertal group exhibited a 22% higher peak KAM (mean difference (MD)= 0.09, 95% CI [-0.02, -0.16] Nm/kg, d = 0.63) compared to the pre-pubertal group. The peak KFM was 16% higher in the late/post-pubertal group (MD = 0.45, 95% CI [0.22, 0.66] Nm/kg, d = 1.07) and 11% higher in the early-mid-pubertal group (MD = 0.28, 95% CI [0.05, 0.51] Nm/kg, d = 0.59) compared to the pre-pubertal group. The peak KIRM was 33% higher (MD = 0.07, 95% CI [-0.11 to -0.03] Nm/kg, d = 0.79) in the late/post-pubertal group than in the pre-pubertal group.

Conclusion: These findings demonstrate that multi-planar differences in knee biomechanics during single-limb landing exist across pubertal development in girls. Specifically, our results support the notion of increased non-contact ACL injury risk in the late/post-pubertal phase. Future studies integrating musculoskeletal modelling are needed, to look at the effect caused by this aberrant loading pattern on lower limbs muscle function and knee-spanning ligaments, with particular focus on the ACL.

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EFFECTS OF ATHLETIC PERFORMANCE AND INJURY REDUCTION OF A NETBALL SPECIFIC PRE-SEASON PROGRAMME: A PILOT STUDY

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Netball is a dynamic sport requiring strength, speed and power to perform jumping and agility based movements. With adolescent female players susceptible to lower limb injuries more so than their male counterparts, in particular ankle sprains and anterior cruciate ligament (ACL) rupture, Netball injury statistics are continuing to rise. Therefore prevention strategies and programmes are of priority to reduce these injury rates. A six week preseason Netball conditioning programme was piloted to investigate the effects on athletic performance and injury prevention against a control group.

Baseline data indicates a relationship between high Netball hours per season and current injury status particularly a history of knee and ankle injury. Athletic performance measures of strength and jumping were well below the standards set by Netball New Zealand and Functional Movement Screening (FMS) for both groups was less than 14 proposing a higher rate of injury risk.

Statistically significant improvements were found in strength (p<0.05) and agility (p<0.001) following the preseason programme, with significant gains in strength (p<0.05) compared to the control group. Functional Movement Screening improved at the end of the programme with statistically significant differences between the intervention and control groups (p<0.001). The intervention group showed a much greater change suggesting that the preseason programme enhanced the players' injury prevention over and above normal preseason activities.

There is evidence to suggest that a preseason Netball specific programme can improve athlete performance and decrease the risk of injury however further investigation is required to determine the extent of these effects.

RETURN TO PLAY IN THE MODERN ERA WE'RE GOING BEYOND 'SHE'LL BE BACK IN SIX WEEKS' BUT TO WHERE?

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There have been some important shifts in clinical practice and opinion regarding the return to play process. This lecture will attempt to synthesise these thoughts in a clinically relevant manner for the practicing clinician. Two separate, but related threads will be discussed: considering time-based versus criteria-based progression of rehabilitation and return to play, and shared decision making within a risk mitigation framework.

Historically, pronouncements were made regarding the time a particular pathology would take to return to sport, and it can be seen that this became a self-fulfilling prophecy: the athlete returned after 6 weeks because the doctor/surgeon/physio/ said that they would be ready after 6 weeks, irrespective of any influencing factors. Underpinning this approach was the notion that with the passage of time, adequate healing of injured tissue would occur, and the athlete would therefore be restored to normal function. Unfortunately our results have been patchy using this approach with every team having at least one "chronic rehabber" on their staff, and the medical team left scratching their heads. Better understanding of the (often poor) association between identified pathology and performance or disability have forced a rethink of this approach. Increasingly there has been a push to attempt to identify certain criteria through which the athlete's readiness to perform a durable return to sport can be measured – the trick is identifying those criteria for the given athlete that truly reflect this readiness. Examples will be given here of our experience with hamstring, ACL, and throwing-related pathology.

The concept of "Shared decision making" is one where all relevant parties (eg, athlete, coaching staff, medical and physical preparation teams) have to arrive at a mutually agreeable decision regarding an athlete's readiness to return to play. While this seems sensible in theory, the difficulty arises in quantifying a given individual's risk associated with return to play. It's obviously impossible to have a truly shared decision without informed consent, and when there is poor information to inform this consent, we need to admit that we're simply paying lip service to a cliché, and not actually advancing athlete welfare. Embracing the idea of making decisions under uncertainty involves quantifying risk, and there are a few pitfalls the team needs to navigate here including taking group level risks (eg, knee valgus for ACL injury) and applying this to a given individual ("how much chance is there that the athlete in front of me will rupture his ACL now that I know he falls into valgus on a drop jump?").

Once this minefield is navigated, the risk then needs to be understood and interpreted in a risk acceptance model: the same level of absolute risk will be tolerated differently, for example, in the context of a young athlete in the pre-season versus a veteran athlete seeking clearance for a grand final. During this discussion the notion of the predictive (versus associative) probability of workload ratios will be discussed, and it will be suggested that we are a long way from truly fully understanding this "hot topic" area.

AN INNOVATIVE APPROACH TO PREVENTING CHRONIC DISEASE: PREVENTING BY DESIGN

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The morbidity and mortality from preventable chronic disease has not improved substantially over the last four decades. Moreover, mortality rates in developing countries now outstrip infectious disease mortality rates by more than 10:1. While other healthcare sectors have witnessed phenomenal advances in diagnostics and therapeutics, the prevention of chronic disease seems as though it's frozen in time.

Central to disease prevention is behavioral change. If we've learned anything about behavioral change it's that top-down approaches using research data, consensus reports, and recommendations have been, by and large, ineffective. To cross the "Knowing-Doing Gap" requires that we move from what we know to be efficacious toward outcomes that are also effective. In order for disease prevention to become a reality, we must use new thinking and new tools that are focused on behavioral change.

This requires that we work directly with patients to assist them with behavioral change. Fortunately, there is a science from outside of healthcare that helps us do this. Human-centered design uses tools and methods to meet people where they are and design programs to help them get where they want to be. It is ideally suited for disease prevention because it addresses human limitations through insights gained through the empirical study of the people who will actually use the programs. Human-centered design is a science that has been used for decades in other industries and that can be easily taught and distributed to large numbers of people in the same way that basic life support has been taught. When large numbers of people are equipped with the tools and methods of behavioral design, our mindset toward chronic disease will change.

Disease prevention is overdue. It is time we make it a reality.

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WORKSHOP
HAMSTRINGS: SO MANY PAPERS, SO LITTLE EVIDENCE I CAN ACTUALLY USE IN PRACTICE

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Over the last 8 years, Aspetar's rehabilitation department have attempted to standardise their care of acute hamstring injury, and document their clinical outcomes. By revisiting the data associated with over 200 acute first-time hamstring injuries, some light can be shed on what subjective and objective factors are useful to assess the first time you see the injured athlete, what you should assess on any given day, and how accurately you can take the components of this information and predict when the athlete will return to sport.

Spoiler alert: you don't need that fancy MRI for the great majority of your athletes, and you should be using your clinical skills. You will need to learn how to use a hand held dynamometer, an inclinometer, and your palpation skills need to be dusted off. The workshop will cover each of the items of assessment that have been found to be useful, while ignoring the (many many) other dead ends we pursued.

Equally importantly, the individual elements of a 6-stage, criteria-based rehabilitation protocol will be presented that has shown a return to play in a median of 21 days, with a 7% recurrence rate in these athletes. Finally, some intriguing preliminary findings will be presented regarding indicators of re-injury that may force a fundamental rethink of some of our practice.

INJURY SURVEILLANCE IN NEW ZEALAND RUGBY

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Rugby is one of the world's most popular team sports. As physical contact between players is inherent to the nature of this sport, the likelihood of an injury occurring during play is high.[1,2] Previous work has indicated that it is "essential that national governing bodies for rugby together with the team doctors have a complete understanding of the incidence, nature, severity and causes of injuries in order to review the adequacy of their injury prevention, treatment and rehabilitation strategies."[1] A review of the match injuries statistics collected from 2006 to 2013 for the New Zealand Super Rugby teams revealed that injury rates over this time period ranged from 79 to 42 injuries per 1000 match hrs (See Figure 1). These injury rates were captured using RugbyMed, a claims management system utilised by NZR on behalf of ACC under the Accredited Employer Scheme.

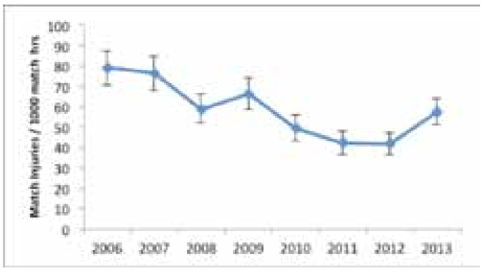

Figure 1: Total match injuries per 1000 player hours per year from 2006-2013.

While these differences between years may be explained by seasonal variation, rules changes or changes to the game schedule, they are within range of what has been reported by other unions.[1,3] Concerns were identified when further examination of the number of days missed as a result of injury revealed that only 260 injuries resulting in less than 7 days of missed play were reported between 2006-13. In contrast, over the same time period 402 injuries where the incapacity date exceeded 7 days were documented. This suggests that the injury surveillance system did not accurately capture injuries that result in less than a week of missed play and/or training. Additionally, very few training injuries were captured, with the vast majority that were reported were sustained during match play.

In response to these concerns NZR reviewed their injury surveillance practices. The first step was the development of clear and concise definitions for documenting and capturing injuries. Information was gathered regarding the current consensus on injury definitions and data collection procedures in rugby. These definitions and protocols were then examined and piloted with key stake holders involved in rugby at the NPC level. At the completion of the 2014 season, focus groups were held to review the process and highlight any potential weaknesses, or areas of confusion.

A revised version of the surveillance program was then rolled out to all Super 15 NZ doctors in 2015. As part of this program doctors were asked to document all 'medical attention' and 'time loss' injuries that were sustained during match play or training. These injuries were captured using a custom excel document and RugbyMed. This process allowed doctors to easily enter injuries in a weekly format. The results suggested a much more robust and comprehensive understanding of injuries and their occurrence over the season (see Table 1 & 2).

Table 1: Total Injury count for time loss and medical attention injuries by phase of season

Phase of Season	Injury Type			
	Time Loss	Medical Attention		Total by Phase
Pre-Season	177	324		501
Wk 1-9	187	330		517
Wk 10-18	190	314		504
Play offs	24	66		90
Total by Injury	578	1034		
Avg (Pre-season to Wk 18)	116	207		

Table 2: Team injuries by the session in which they occurred.

Session Type	Pre-Season	Regular Season		Play Offs		Total
		Wk 1-9	Wk 10-18			
Game	0	238	312	50		600
Non-competition Game	118	97	33	6		254
Rugby Training Contact	108	72	60	4		244
Rugby Training Non-contact	66	17	20	17		120
Rugby Units	39	33	19	5		96
Field Based Fitness Training	69	10	5	3		87
Team Training	30	9	13	1		53
Other	12	9	14	0		35
Upper Body Weights	11	8	6	1		26
Rugby Skills	12	5	7	1		25
High Intensity Cross Training	17	1	1	0		19
Lower Body Weights	11	3	2	0		16
Rehab/ Recovery	5	5	3	1		14
Training Gym/Individual	0	4	6	0		10
Full Body Weights	2	3	2	1		8

Following the completion of the 2015 season a review of the injury surveillance system was conducted. Based on the feedback from the medical teams an App was developed that would enable teams to quickly and accurately enter both 'time loss' and 'medical attention' injuries. Additionally issues were highlighted about the variation in injury documentation between teams. To address these concerns revisions and clarifications were made to the injury definitions and protocols in an attempt to reduce inter-team variation.

Changes over the last two seasons have highlighted the importance of feedback and continual examination of definitions and protocols to enhance the quality of the injury surveillance program by both stakeholders and providers. It has also emphasised the importance of including the entire medical team to enhance compliance and support for injury surveillance.

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GPS DERIVED METRICS STRONGLY ASSOCIATE TO OVERUSE RELATED INJURY RISK IN SOCCER

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Introduction: Overuse-related injuries (OVR) are a consistent issue within soccer due to increases in professional training loads at clubs.[1] These injuries are defined as repetitive submaximal loading of the musculoskeletal system when rest is not adequate. Player worn Global Positioning Systems (GPS) offers insight into causes of this type of injury. The aim of this research was to examine the association between GPS derived metrics have to OVR risk.

Methods: Over the 2012-13 season, data were collected from 18 male English Premier League academy soccer players (Age 18.7 ± 1.2y). Each season consisted of 42-weeks, with ~6 x 1-hour training sessions plus 1-fixture per week, giving a squad total of 3894 hours on-legs exposure. GPS were worn in all training sessions and matches across the season (Viper Pod, V1.0, StatSports, Belfast, UK). The units recorded: total distance (TD), meters per minute (MPM), high speed running meters (HSR), number of sprints (NOS), accelerations (ACC), decelerations (DCC), average metabolic power (AMP) and energy expenditure (EE). Injuries were diagnosed by a qualified physiotherapist. A binary logistics regression with a Hosmer and Lemeshow test was used on the GPS metrics to assess association to OVR risk. Results are displayed as significance value, effect size and ± 90% confidence interval (P, ES ± CI). ES scores between -0.2 – 0.2 were considered trivial, while those above 0.2 were considered likely positive.

Results and Discussion: Of the 26 injuries (excludes 2 illnesses), 24 (92%) were to the lower limbs, 15 (58%) were contact injuries, 11 (42%) were non-contact injuries. During the season, 19 OVR were sustained at an injury incidence rate of 4.88 per 1000 hours of training and matches. Six GPS variables had a strong association with a player sustaining an OVR: TD ($P = 0.00$, $ES = 1.02 \pm 0.76$), MPM ($P = 0.02$, $ES = 0.72 \pm 0.76$), HSR ($P = 0.05$, $ES = 0.76 \pm 0.76$), NOS ($P = 0.01$, $ES = 0.60 \pm 0.76$), DCC ($P = 0.01$, $ES = 0.15 \pm 0.76$) and AMP ($P = 0.01$, $ES = 0.72 \pm 0.76$). The Hosmer and Lemeshow test gave a strong statistical power of the regression model ($X2 = 14.18$, $df = 8$, $P = 0.08$).

Conclusion: Using specific GPS variables, coaches can potentially modify individual's training schedules to reduce OVR risk. Further research is required on the development of prudent guidelines for use in professional soccer clubs.

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MEDIA BASED INJURY SURVEILLANCE FROM THE 2015 CRICKET WORLD CUP

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Introduction: Effective injury prevention strategies rely on quality data from injury surveillance programmes. These programmes require strict compliance and are time consuming for medical staff. Cricket World Cup One-Day Tournament 2015 (CWC) hosted across Australia and New Zealand had no official injury surveillance undertaken. Therefore, our aim was to quantify the number and type of media reported injuries from all CWC competing teams.

Method: Data was collected two weeks prior to the tournament until its 49th and final match 57 days later. A member of the study group monitored the tournament website, the homepage of each team and media news websites to track availability and injury status of each of the 15 members of all 14 teams. Injury diagnosis was documented in detail and included injury type, body part and activity at injury onset. Injuries were also classified as being either time loss or non-time loss.

Results: Through injury, players were unavailable for selection for a total of 69 matches and 316 days. Media reported a total of 31 injuries, of which 17, 8 and 6 occurred in the lower limb, trunk and upper limb respectively. The majority (27 or 87%) of injuries were time-loss injuries, and of these fast bowlers (12) and batsmen (11) had a similar injury incidence. Despite this fast bowlers missed a greater number (31 or 45%) of total matches compared to batsmen (23 or 33%). Hamstrings accounted for the most tournament matches missed (17) followed closely by side strains (14), hands (9), shoulder (6) and foot injuries (6). The most common activity being performed at injury onset was bowling in matches (32%), followed by general training (29%), match batting (23%) and match fielding (16%).

Discussion: Despite its popularity, Cricket has a paucity of published injury surveillance data, with data often gathered only from a single team. The first injury surveillance of the CWC with multiple teams (5/14) still involved only 36% of the competing teams (Ranson et al., 2011). This study included all teams, but was conducted using media reports which may under-report injuries with teams possibly not wanting to disclose their likely playing team, too far in advance. Nevertheless even prospective injury surveillance by team medical staff (in football) has been shown to underestimate time loss injury incidence by at least one fifth (Bjørneboe et al., 2011). This report of the 2015 CWC data provides a useful addition to previous injury surveillance and demonstrates the need for more formal and rigorous injury surveillance programmes. The high numbers of matches players were unavailable for highlights that reducing injury incidence and severity may increase teams' competitive strength, and possibly their tournament placing.

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ROWING INJURIES

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Rowing, one of the founding Olympic sports, is increasingly enjoyed by people of all ages and abilities. There has been significant growth in masters (age 27 years and above) and para-rowing populations, along with coastal and indoor rowing events. Rowing-specific injury research has similarly increased, revealing areas of improved understanding in preparticipation screening, training load, emerging concepts surrounding back and rib injury, and relative energy deficiency in sport.

This lecture will cover these areas and other classic injuries to better equip physicians and other healthcare practitioners to provide care for their rowing athletes.

ENERGY AVAILABILITY OF FEMALE ADOLESCENT TEAM SPORT ATHLETES

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Background: Low energy availability (EA) is known to be an underlying factor in a broad syndrome of health and performance related problems (1). It is well recognised that athletes participating in endurance, aesthetic or weight class sports are at increased risk of low EA (1). However, few studies have documented the risk of low EA in female adolescent team sport athletes.

Purpose: To determine the energy availability of female adolescent team sport athletes.

Methods: Twenty-two secondary school female athletes (14.8±0.9 y) were recruited for the 3-day study period. Participants played in one or more team sports and all sports were in their mid-season phase. Energy availability was the primary outcome measurement and defined as:

Energy Availability (kJ/kg FFM/day) = (Energy intake - Exercise energy expenditure)/Fat Free Mass (2). Energy intake (EI) was calculated from participants keeping a 3-day food record diary (2 training days and one rest day). Exercise energy expenditure (EEE) was recorded for a three-day period concurrent to the food record diaries. EEE was assessed using data collected from accelerometers and physical activity logs. Net EEE was calculated for estimating EA. Fat free mass (FFM) was estimated using a skin fold model developed specifically for female athletes (3). Energy availability was calculated as the mean over the three-day recording period. Low EA was defined as < 125kJ/kg FFM, suboptimal EA 125-188kJ/kg FFM or optimal EA ≥ 188kJ/kg FFM.

Results: Twenty of the 22 participants completed the study. Of these 25% (n= 5) displayed low EA, 60% (n = 12) had suboptimal EA, and 15% (n = 3) had optimal EA. The correlation between energy availability and energy intake was r(20)=0.967, p=<0.01. Mean values were EA = 150.9±37.0 kJ/kg/day, EI = 8772.1±2052.0 kJ/day, EEE = 1341.4±568.3 kJ/day.

Conclusion: This study adds to the limited body of knowledge on the EA of female adolescent team sport athletes. It identified that the majority of athletes were in an energy deficient state, with a quarter of participants below the threshold established for low EA. Education regarding nutrition and increased energy intake for female adolescent athletes is warranted.

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ACHILLES TENDON INJURY RELATED INCIDENCE AND COSTS IN NEW ZEALAND

Nikhilesh Todkari, Doug King

Introduction: Achilles tendon injuries are a common condition among both athletes and the general population. There is, however, a paucity of information on the total costs of Achilles tendon injuries in the literature. This study provides an overview of the epidemiology of Achilles tendon injuries and associated costs over a nine year period.

Method: New Zealand national Accident Compensation Corporation (ACC) injury data for the period 2005 to 2014 were searched for Achilles tendon injury cases. Data was analysed by demographics, activity prior to injury, cause of injury, number of claims and total costs by region.

Results: There were an average (±SD) of 13,392 (±856) injury claims per year costing NZD$15,506,115 (±$1,735,209) per year. NZ European Males (5,207 ±258) and females (4,491 ±259) recorded the highest average number of injury claims per year. The most common cause of Achilles injury recorded was "loss of balance" with an average number of 6,455 ±722 per year over the duration of the study. The 40-44 yr. age group recorded the highest average number of ACC claims per year (1,689 ±76) over the duration of the study.

Discussion: The optimal management of Achilles tendon injures remains in debate for operative vs. non-operative management. The associated economic differences between these treatment modalities have not yet been reported. The socio-economic cost of Achilles tendon injuries to the patient and society have yet to be determined. Further detailed studies are required to identify the different treatment modality related costs and the longitudinal socioeconomic effects of these injuries to society and how these costs can be reduced.

Conclusion: Achilles tendon injury remains a common condition that has significant social and economic related costs.