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Sports medicine in a time of crisis

MARK FULCHER

I sit here writing and reflecting on what has been a remarkable few weeks for us all. The word 'unprecedented' has been used widely; however, it is hard for me to find a better adjective. Like many of you, my practicing life has been changed overnight. Working in a world where there is no organised sport and where we are unable to see our patients face to face has been a massive challenge.

At our clinic we have moved to a 100% telehealth solution. The speed at which this has happened would probably not surprise you, as I suspect that most of you will have experienced something similar. On Sunday, we decided that a change was urgently needed. We called our Monday patients and advised them that we would either not be available to see them in person or that we would conduct phone consultations. Our clinical and administrative teams collected everything they needed to work from home. We finalised systems that we felt would allow us to do this reliably and safely, and provided education for our staff on our new platform and processes. The following day, our entire clinical team conducted all of their consultations via our new telehealth platform. In a more normal world, the transition to an entirely new method of consulting would have no doubt involved dozens of meetings, extensive research into available technologies and lengthy discussions about how best to proceed. In reality, our change involved a relatively short internet search to identify available telehealth solutions, followed by a unilateral decision to implement what appeared to be the best available option. Despite this lack of 'process' and a ridiculously short timeframe, I believe that we have a solution that largely suits the needs of both our clinicians and patients.

It would be wrong to suggest that moving to a new method of consulting has been seamless. This has involved lots of hard work from both our clinical and administration team as well as a steep learning curve for all of us. Frequent reflection and adjustment of our processes have been necessary. I also think that it is important to acknowledge our patients as well. In general terms they have also shown great flexibility by adapting to a new way of seeing their clinician and have almost universally embraced the new technology. The overwhelming feedback that I have received from patients is that this telehealth is a medium that they enjoy and in many cases that they prefer over a face to face meeting.

One of the things that I have been reflecting on this week, now that the dust has settled somewhat, has been what the long-term impact of COVID-19 might be on our day to day working life in the future. As we have seen, innovation has been extremely rapid. It has been interesting to see how various different industries, not just sports medicine, have adapted to a new working environment. Those of us who continue to practice in the way that we did prior to COVID-19 will, I think, have missed an opportunity. I would challenge us all to think critically about what has gone well and what has not gone well during this difficult time. Where are the areas that we can look to improve the delivery of our services? I feel certain that there are going to be considerable changes to the way that we all practice sports medicine on a day-to-day basis. For example, it will now be hard for me to justify asking patients to take time

off work, to travel across the city and to wait in my waiting room for me just to review their MRI imaging. It will also be hard to justify asking patients to travel from out of Auckland for their first patient assessment when I have now performed dozens of new patient consultations via telehealth. At the very least, we should be offering them a choice when it comes to consultations. It will also be interesting to whether funders, like ACC, continue to offer clinicians the opportunity to provide funded consultations via telehealth after COVID-19.

Another area where my practice will certainly change more broadly relates to our use of technology and information systems. Our practice management software was designed in the year 2000 and functions and behaves as such. How many of us would accept a 20-year-old IT solution in our day-to-day life? Imagine using the computer that you had in the year 2000. While we have recently been actively considering changing to a new patient management software, I now think that this is the single most important change that our practice can make. Any solution needs to consider how we communicate with our patients, how we communicate with our referrers and how we incorporate basic functions like telehealth, secure digital communications and the delivery of treatment plans. They need to offer much more than a place to store clinical notes and to perform billing.

I have been surprised by how connected I can be from my home office (located in my garden shed). I have very much enjoyed connecting with colleagues from around the country, and in some cases around the world, via webinars, phone calls and online meetings. Our weekly clinical teaching has continued as normal and I have participated in my normal peer review meetings, all via online platforms. The value of these relationships, often fostered through organisations like Sports Medicine New Zealand, the Australasian College of Sport and Exercise Physicians or Physiotherapy in New Zealand has been clear to see. I have also reflected on how important these organisations are. They do important work advocating on our behalf; they ensure that we remain educated; and they facilitate these connections with our peers. I feel that, over the past few years, many of us have perhaps taken these types of organization for granted. It will be interesting to see how we interact with these groups and when we are able to, and all feel comfortable with, travelling and attending conferences again.

One of the next things we need to be thinking about is when and how we will be able to see patients face to face. I think that this is something that we should all be thinking carefully about now. Many sports medicine consultations require physical contact and we will all need to consider whether this is appropriate and how the risks associated with these consultations can be minimised.

Finally I hope that you are all feeling safe and are coping with the various pressures that this times bring. Remember that the sport and exercise medicine community is there to support you and remember to reach out to your friends and colleagues. I look forward to seeing you all, either online or in person, soon.

BEST OF BRITISH - HIGHLIGHTS FROM THE BJSM

CHRIS MILNE

Best of British January-April 2019

The January issue included an article on the cardiovascular risk profile in Olympic athletes.[1] A group of senior Italian authors including Antonio Pelliccia and colleagues evaluated the cardiovascular risk profiles of 1,058 Olympic athletes including 656 males and 402 females. The most common risk factor was dyslipidaemia, present in 32% followed by increased waist circumference present in 25%. Only 8% of athletes were smokers and 3.8% had hypertension and only 0.3% had hyperglycaemia. Not surprisingly, endurance athletes were the group with the lowest risks and aging was associated with an increase in the risk factors. Adductor longus injuries are the commonest cause of groin pain in football players. There was a useful infographic by Andreas Serner and colleague, describing the four predominant mechanisms.[2] These include change of direction, kicking, reaching and jumping.

Issue 2 could be subtitled 'The Exercise and Pregnancy' issue. All of the articles have relevance to those of us who are asked to advise pregnant women regarding exercise. Greg Davies and Raul Artal, two respected senior colleagues in the field put forward the view that exercise and pregnancy can be regarded as therapy.[3] Later in the same issue Margie Davenport and colleague, examined the relationship between prenatal exercise and low back plus pelvic girdle and lumbopelvic pain.[4] They examined 32 studies involving 52,000 pregnant women and found that prenatal exercise decreased the severity of such pain but did not decrease the risk of getting any of these conditions during pregnancy.

In the February issue there was a useful infographic by David Pope and colleagues with recommendations for running injuries.[5] They included data on load tolerance, load management and the underlying biomechanics. This is a useful one page summary of some important principles. Neck and low back pain are very common in the community. Miyamoto and colleagues looked at the cost effectiveness of exercise therapy in the treatment of nonspecific neck pain and low back pain.[6] They included 22 studies in their meta-analysis and concluded that exercise therapy seems to be cost effective compared with usual care for subacute and chronic low back pain but not for neck pain or acute low back pain. Plantar heel pain is a particularly tiresome condition for both the patient and their treating clinician. Babatunde and colleagues compared the effectiveness of various treatment options for this condition.[7] They evaluated 31 RCT's involving 2,450 patients. They found that corticosteroid injections either alone or in combination with exercise and shock wave therapy were as likely to be effective and exercise only appeared to be beneficial for long term pain or function.

The use of intravenous fluids in sports is a particularly contentious area and the practice is banned by WADA. Nevertheless, the practice is widespread in some American settings. Khodaee and colleague provide commentary on the commercialised, portable IV fluids in sports and conclude that these products are placing vulnerable athletes at risk.[8] I would agree and fortunately, the practice has not gained much traction outside of the USA. Bone stress injuries are common in distance runners. Michael Fredericson and colleagues used a modified female athlete triad cumulative risk assessment tool and found that this may be used to identify male runners at higher risk for bone stress injury.[9] This data is consistent with what we have found in rowing athletes in New Zealand with regard to their risk for rib stress fracture. Later in the same issue, Challoumas and colleagues evaluated the use of topical glyceryl trinitrate (GTN) for the treatment of tendinopathies.[10] They identified 83 studies of which 10 were found to be suitable for qualitative analysis. They found that topical GTN was useful for all chronic tendinopathies as an adjunct

to loading programmes that failed to produce satisfactory resolution of symptoms. GTN without a loading programme is essentially a waste of time. The main adverse effect is headaches which affect up to 20% of patients.

In the March issue there was a useful article entitled 'I Know What the Imaging Guidelines Say But……' by Kieran O'Sullivan and colleague.[11] High tech imaging has become widely available in the past two decades. Patients often expect this to be performed, even when the clinical indications are marginal at best. There is concern that in the 21st century, the MRI scan may become the de facto equivalent of the x-ray in the previous century. Managing patient expectations is a challenge for all clinicians. Patellofemoral pain is the commonest cause of musculoskeletal pain in most community settings. Bradley Neal and colleagues conducted a systematic review in meta-analysis of 18 studies involving 4,181 participants of whom 483 developed patellofemoral pain.[12] Subgroups studied included military recruits, adolescents and recreational runners, Quadriceps weakness in military recruits and high hip strengths in adolescents were the only consistently identified risk factors for patellofemoral pain. Mechanical knee symptoms are often cited as a reason for operating on a meniscal tear. Thorlund and colleagues evaluated 817 patients who underwent knee surgery.[13] They found that 55% of all patients reported symptoms of catching or locking but that these preoperative mechanical symptoms were equally prevalent in patients with or without a meniscal tear. They advised that clinicians should be cautious that patient reported mechanical symptoms are attributable to a meniscal tear even when this is confirmed by MRI scan. Following on from this same issue, there is an infographic describing the use of exercise therapy for meniscal tears. Pain relief after musculoskeletal trauma is an important area to consider. Gijs Helmerhorst found substantial variation in management of pain relief for patients after musculoskeletal trauma.[14] He found that opioid prescriptions were rapidly increasing in North America and Europe and this is a worrying trend. He recommends non opioid medication and providing the patient with effective coping strategies as an alternative. I would fully support this stance.

Does heading a football lead to dementia in later life? Rutherford and colleagues examined this issue and found no data on dementia risk in football.[15] The authors conclude that it remains premature, if not inappropriate to equate the neuropathological consequences of football to a lifetime of boxing based on a few isolated cases. In the second March issue was an article on concussion management in combat sports. This was a consensus statement from the Association of Ringside Physicians, i.e. those doctors covering boxing, kickboxing and mixed martial arts.[16] They include definitions of a knock out and technical knockout and the current minimal suspension periods applied in USA boxing. With greater public awareness of long term effects of repeated head injury it is getting increasingly harder to justify participation in a sport where the intention is to cause head injury. Falls prevention in older adults is an important area. Smirmaul and colleagues provide an infographic summarising the beneficial effects of exercise.[17] Some of the original data came from New Zealand where Tai Chi was found to be effective in falls prevention by John Campbell and colleagues from the University of Otago.

Does one concussion increase the risk of further concussions? Not according to Ian Shrier and colleagues who found that when the first concussion was managed appropriately, the risk of a second concussion was no higher.[18] Their data comes from management of Cirque du Soleil performers who had two or more concussions. Proximal hamstring injuries are potentially serious. Van der Made and colleagues provide a useful article summarising the important condition.[19] They mention a trauma mechanism of hip flexion and in the New Zealand setting, by far the commonest cause of high grade hamstring avulsion injuries is water skiing. People presenting with proximal hamstring pain after water skiing injuries should have an x-ray and ultrasound scan performed soon after the first presentation and if the ultrasound scan shows evidence of a high grade proximal hamstring injury, then referral on to a specialist who can arrange MRI scan is recommended. If there is more than 5cm of retraction, then early surgical management should be considered. We are all trying to build robustness in our athletes. Tim Gabbett who is well known for his research on training load has co-authored an interesting editorial entitled, 'In Pursuit of the Unbreakable Athlete: What is the Role of Moderating Factors and Circular Causation?'.[20] They ponder the question, 'What comes first; the robust athlete or the high training load?'. They recommend that a full understanding of the workload capacity relationship requires collaboration amongst all professionals involved in the training process. Athletes are increasingly being asked to perform in hot environments. Racinais and colleagues evaluated participants in the 2016 UCI Road World Championships.[21] They measured core temperatures via an ingestible capsule in cyclists competing in the team trial, individual time trial and road race. 85% of the cyclists reached a core temperature of at least 39°C with 25% exceeding 40°C. They note that in a given thermal environment, exercise intensity is a more potent determinant of body temperature than exercise duration. These findings have implications for those organisations which arrange competitions in situations of high heat stress.

Is early ACL reconstruction required to prevent additional knee injury? Stephanie Filbay, from the University of Oxford looked at the evidence.[22] She recommends education of patients regarding activity modification and optimising psychological readiness and physical function before returning to sport, irrespective of whether the ACL injury is managed operatively or non-operatively.

Do weekend warriors have a better life expectancy than their more sedentary contemporaries? Gary O'Donovan and colleagues found that one to two sessions per week of moderate intensity physical activity may be sufficient to reduce risks for all cause CHD and cancer mortality, regardless of adherence to prevailing physical activity guidelines.[23]

Are children less fit than the previous generation? Tomkinson and colleagues studied cardiorespiratory fitness of children and adolescents in 19 relatively high income countries between 1981 and 2014.[24] They found a decline in the O2 max of 3.3ml/kg/min over that time span which is an equivalent to a decline of 7.3%. This trend seems to have stabilised since the year 2000.

When should people return to drive after an episode of concussion? Lucas and colleagues surveyed members of the American Medical Society for Sports Medicine.[25] There was only a low response rate of 18% to their survey. Only those providers who managed at least one concussion per month were included in the study. Fewer than half of the doctors indicated that they almost always counsel patients regarding driving after concussion. Since road traffic accidents are a common cause of mortality and morbidity, particularly in adolescents and young adults, this is an important issue to be aware of for clinicians who manage patients who have experienced an episode of concussion.

That is all for this four month period. I will survey later issues of BJSM in a subsequent article.

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Injury incidence and prevalence in New Zealand high performance sports

JENNIFER L SCOTT, DUNCAN REID, BRUCE HAMILTON

ABSTRACT

Aim: To determine the injury incidence and prevalence in five New Zealand High Performance Sports

Study Design: Prospective longitudinal cohort study

Setting: High Performance Sport New Zealand (HPSNZ)

Participants: One hundred and fifteen New Zealand carded athletes across the five sporting disciplines of men's hockey, women's hockey, women's football, kayaking and sailing. The sample included 45 males (mean age 24.2 years SD. 3.9) and 70 females (mean age 22.9 years SD. 4.2).

Methods: A timeless injury definition was employed and both training and competition injuries were collected weekly using the HPSNZ injury surveillance survey. Demographic data was descriptively analysed for normal distribution. Descriptive analyses were used to determine injury incidence, prevalence and compliance. Chi squared analysis was used to determine injury frequency per body site in the three team sports.

Outcome measures: Injury incidence, injury prevalence and athlete compliance with survey completion

Results: The overall compliance rate was 61%. Injury incidence across the entire sample was 10.67/1000 hours of athlete training exposures (AE). The injury incidence for the five sports was as follows: men's hockey 14.15/1000 hours of AE; women's hockey 13.38/1000 hours of AE; women's football 8.18/1000 hours of AE, kayaking 4.35/1000 hours of AE and sailing 5.59/1000 hours of AE.

Injury prevalence taken as an average injury count for each sport was; 2.72 for men's hockey, 4.26 for women's hockey, 2.48 for women's football, 1.07 for kayaking and 1.33 for sailing.

Conclusion: Training injury incidence and prevalence was reported for athletes within five HPSNZ sports. The team sports had higher injury incidence and prevalence rates than both kayaking and sailing. This research has provided an injury incidence baseline for HPSNZ athletes involved in women's or men's hockey, women's football, flat water kayaking and sailing.

Keywords: Injury, Surveillance, Incidence, Prevalence, Compliance

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INTRODUCTION

High Performance Sport New Zealand (HPSNZ) is a government funded organisation that invests, supports and works in partnership with a number of National Sporting Organisations (NSOs). HPSNZ's fundamental goal is to see more elite New Zealand athletes competing and performing on the World stage, particularly at the Olympic, Paralympic and World championships. To achieve this goal, keeping athletes injury and illness free is paramount.

One of the biggest barriers to athletic performance is injury, which can result in time loss from sport and compromised performance.[27] Raysmith and Drew[30] have shown that successful athletes at the elite level must avoid injury and illness and achieve 80% of their training volumes. The HPSNZ performance health team has a model of care that is health and performance orientated and outlined below.

An important role of the HPSNZ performance health team (made up of doctors, physiotherapists, nurses and massage therapists) is to mitigate the occurrence and impact of injuries. However, without an understanding of the injury incidence in sports, interventions may not be targeted appropriately and their efficacy cannot be evaluated.[34,7]

Injury surveillance in New Zealand has typically been very limited in the high performance arena, with high methodological variability impeding inter-NSO comparison. In addition, there is sparse epidemiological data published on elite athletes in New Zealand. Greater knowledge of injury incidence and prevalence in each NSO may help to determine more efficient resource allocation, more effective injury prevention and enhance athlete performance. The ability to collect injury incidence data is in keeping with current injury prevention recommendations.[34,7]

The aim of this study was to provide baseline injury incidence and prevalence data for New Zealand athletes in specific sports.

METHOD

Study Design and Participants

This study was a 52-week longitudinal prospective cohort study beginning April 2015. Inclusion criterion for the study was any carded athlete involved with the four identified NSOs of women's football, men and women's hockey, kayaking and sailing. If, during the course of the study, the athlete became de-carded for any reason, or they did not have a phone or tablet, then they were excluded from the study.

Ethical approval was not required for this study as carded athletes provide consent for HPSNZ to use anonymised data for research purposes in their athlete contracts. Nevertheless, to ensure transparency, and to ensure that athletes were aware of the study, a separate consent form was issued to athletes who agreed to participate, informing them of their inclusion and to give athletes the option to opt out of the study.

A weekly web-based self-reported injury surveillance and training exposure questionnaire developed by HPSNZ was completed by the athletes over 52 consecutive weeks. It comprised of 19 questions including; number of trainings completed, number of trainings that were missed/

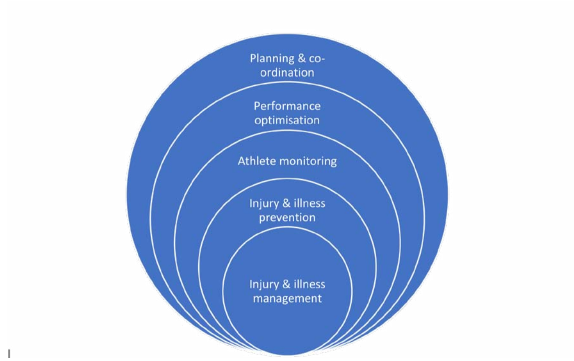

Figure 1: Performance Physiotherapy's Health and Performance Model (High Performance Sport New Zealand, 2016).

modified, the reason for any missed/ modified sessions and, if it was due to an injury, the injury details including the date it occurred, body site, diagnosis and interventions and investigations. The outcome measures recorded in this study were injury occurrence, nature of injury, number of training sessions completed, missed or modified, injury incidence and prevalence. For training exposure, average training session times were used directly from the strength and conditioning staff aligned with each NSO. Training exposure times estimated the minutes spent in the gym and at sport specific trainings each week but was not individualised for each athlete.

Definitions

Because of the limited consensus in methodology and definitions in the literature across the five sports, a pragmatic approach was undertaken in this study.

Injury definition

The definition for an injury was taken from Fuller et al's work,[11,10] "Any physical complaint, which was caused by a transfer of energy that exceeded the body's ability to maintain its structural and/ or functional integrity, sustained by an athlete during competition or training in their chosen sport resulting in one or more sessions being missed or modified." (p.329)

Injury classification

Injuries were classified as acute, chronic, recurrent or exacerbations. Acute injuries were new or index injuries that occurred during the study period.[8] Chronic injuries were injuries that pre-existed the start of the study and were of six or more weeks' duration. Recurrent injuries had occurred before but from which the athlete had returned back to full training prior to it becoming problematic again, and exacerbations were where athletes had returned to training but with modifications, before missing further trainings because of the same injury.[10,14]

Injury incidence

Injury incidence was defined as the number of injuries per 1000 hours of athlete training exposure as recommended by Junge et al.[22]

Injury prevalence

Injury prevalence was defined as the average number of injuries per player in each sport.[2]

Compliance

This was the number of surveys completed by each individual out of a possible 52. Even if response rates were low, all data was included for each individual athlete.

Injury frequency was investigated for specific body sites across the five sports. In addition, the broad categories of lower limb, upper limb and trunk and head were used to analyse the body regions most commonly injured in the sports. For the three sports with the larger populations (women's football, men's and women's hockey) Pearson's chi-square test was performed to examine a possible relationship with the broader injury categories.

RESULTS

All athletes consented to participate resulting in a sample of 124 eligible athletes. Over the 52-week study duration nine athletes were excluded. This left a final sample of 33 male hockey players, 34 female hockey players, 26 female footballers, 13 kayakers and 9 sailors totalling 115. The sample was made up of 39% male athletes and 61% female athletes with an age range of 16 to 39 years (mean 23.48, SD: 4.11). An independent t-test noted no significant difference for age between the male and female subjects ($p>0.05$). However, a significant difference was noted for height and weight between the male and female subjects ($p<0.05$). Male athletes had a mean height of 179.98 centimetres (SD 5.13) and mean weight of 77.34 kilograms (SD 6.32) and female athletes had a mean height of 168.81 centimetres (SD 6.32) and mean weight of 65.75kilograms (SD 6.49). A one-way ANOVA was run to determine between group differences between the five NSOs and this found significant differences ($p<0.05$) between age, height and weight between all of the NSOs.

The average compliance rate for survey completion across all five sports for the twelve months was 61%. The NSO with the highest average survey compliance rate was women's football at 84% (SD 19.66) and the lowest was kayak at 26% (SD 22.65).

Table 1: Time loss injury count per body site per sport

Sport	Ankle/ Foot	Lower Leg	Knee	Thigh	Hip	Low back	Mid back	Neck	Head/ Face	Shoulder	Upper arm	Elbow	Forearm	Wrist/ hand	Not Stated
Men's hockey	5	9	11	19	15	9	0	2	2	10	0	0	0	6	2
Women's hockey	14	10	17	25	24	27	0	2	7	6	0	0	0	6	7
Women's football	32	4	10	11	4	3	0	1	0	0	0	0	0	0	2
Kayaking	0	1	0	0	0	8	0	1	0	2	1	1	0	0	0
Sailing	4	0	4	2	0	0	0	0	1	0	0	0	0	1	0

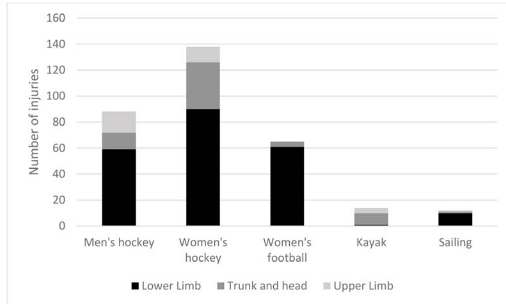

Figure 2 Injuries per sport per three body site groupings

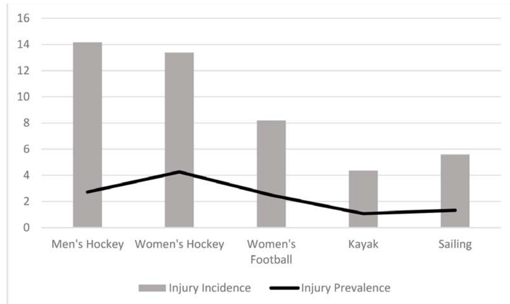

Figure 3 Injury incidence and prevalence for the five sports

An independent t-test demonstrated that female athletes had a significantly greater compliance rate than their male counterparts ($p<0.01$).

Over the 52 weeks of the study, 328 time-loss injuries were prospectively recorded across 87 athletes and 29 athletes reported no time loss injuries. From the 328 reported injuries, 245 were classified as acute, 14 chronic, 35 reoccurrences and 34 unknown classifications where further information was unavailable. Women's hockey had the highest total number of injuries at 145, men's hockey had 90, women's football had 67, kayaking had 14 and sailing had 12.

Injuries accounted for 1654 of a planned 30,090 trainings being missed or modified across the twelve months of this study over the five NSOs. This equates to 5.49% of trainings being missed or modified because of injury. This is not evenly spread with the range being 0.91% (sailing) to 9.81% (men's hockey) being missed or modified.

Table 1 shows the distribution of time-loss injuries across the various body sites for the five sports. The most commonly injured specific body sites were thighs in men's hockey, low backs in women's hockey and kayaking, ankles and feet in women's football and knees and ankles in sailing.

When the specific injury sites were collapsed together into the broader categories of injuries to the upper limb, injuries to the lower limb and injuries to the trunk or head, then the lower limb was the most frequently injured body site in women's football, men's and women's hockey (See Figure 2). Interestingly women's hockey athletes sustained significantly more trunk and head injuries than either men's hockey or women's football ($p=0.018$).

Figure 3 shows the lowest injury incidence was found in kayak at 4.35 injuries/ 1000 athlete training hours and the highest injury incidence was in men's hockey at 14.15 injuries/ 1000 athlete training hours. Women's hockey had the highest injury prevalence at 4.26 and kayak again had the lowest at 1.07.

DISCUSSION

This is one of the few studies in New Zealand elite sport to report injury incidence. While the study sample was 115 athletes, the majority of these athletes were involved in the team sports of hockey and football, with only 13 kayakers and nine sailors. Small study samples result in low powered studies however, elite sporting populations are limited by the nature of elite sport. Therefore baseline data on small populations of elite athletes remains important and falls within a medical team's duty of care.[9] The results from this study provide baseline injury data for five high performance sports which can aid in the development of sport-specific injury prevention programmes.

The overall compliance with the injury surveillance survey in this study was 61% over the 52 weeks. Female athletes were significantly more compliant than their male counterparts at 73% versus 48% ($p<0.01$). The female athletes' compliance rate is similar to Newlands et al[26] study in New Zealand rowing which had a compliance rate of 78%.

The compliance in this study is low compared to other studies. Nilstad et al,[28] had a compliance rate of 70% in their injury surveillance study in elite female football where text message surveillance was used. Other studies report compliance rates as high as 90-98% within community level sports[4] and even 100%.[15] Hammond et al[15] investigated elite football populations across three professional clubs and collected their data via separate investigators who attended all trainings and games for each club. For HPSNZ athletes in this study, it was impossible to have an investigator attend all trainings and competitions because a number of the athletes involved in this study were based overseas. In addition within the five sports a number of athletes have individual campaigns and coaches which prohibited consistent investigator attendance due to time and resource constraints.

The biggest influencing factor on compliance was how the NSOs promoted this injury surveillance survey to their respective athletes. Women's football had used weekly injury surveillance surveys since 2011, so it was second nature to them, whereas men's hockey had not used such a tool before. The use of a new system has previously been identified in epidemiological research as an obstacle to compliance.[5,9] Women's football and women's hockey were very keen to use the HPSNZ surveillance tool and their management team promoted it very positively to their athletes, another recognised facilitator to compliance.[5] By comparison, the majority of the male flat-water kayakers did not have a coach during the course of this study, and as a result did not have any external encouragement to complete the survey, a barrier to compliance.[5]

Consistent with previously published literature in elite sporting populations, the three team sports of men and women's hockey and women's football in this study had much higher injury numbers than both kayaking and sailing.[6,21] Previous literature also found that elite male hockey players experience a higher injury incidence than elite female hockey players[22,33] This was not the case in this study, with women's hockey having the highest injury incidence of any sport. Men's hockey had the second lowest compliance rate of this study which suggests that the true impact of injury on that sport may not have been captured. Future studies investigating men's hockey need to focus on improving compliance initially, to then obtain a representative injury data set for the sport.

The lower limb is the most commonly injured site in elite and professional hockey.[22,25,31] When this study's data for hockey was collapsed into three groupings for body sites injured (upper limb, lower limb, trunk or head) then this was also true for both men's and women's hockey. However, when individual sites are examined, there are differences between the genders. Indeed, in this study women's hockey were affected the most by injuries to the lower back compared with the male athletes who suffered most frequently from thigh injuries. A reason for this may be differences in movement

patterns between the sexes, and the speed at which the game is played. Faster paced activities are more associated with soft tissue injuries, which may explain why thigh injuries are more problematic in the men's game compared with the women.

In this study lower limb injuries also had the greatest impact in women's football which is consistent with findings in previous literature.[3,17,20,23] Specifically, ankle injuries were found to be the most common injury sustained in female football athletes at collegiate, professional and international level[3,20] as was the case in this study. The high-speed running demands and tackling, coupled with frequent changes of direction in both hockey and football inevitably contribute to the high volume of lower limb injuries.

Low back injuries had the biggest impact on kayaking. Previous literature investigating international kayakers have largely looked at the upper limb, or not mentioned the body site of injury.[6,18,21,29] It is therefore hard to draw conclusions on the cost that injury has in the sport. The one exception was a paper by Lovell and Lauder[24] which divided kayaking injuries into upper limb and trunk injuries, suggestive that the trunk is a common injury site for elite kayakers. Kayak has been identified as a sport with a low injury risk which may partially explain why there is so little published literature regarding its injury incidence.[6,21] Our data may be impacted by the low compliance from this sport. Conversely, the low compliance may be directly linked to the fact that acute injuries do not have a significant impact on the sport, therefore the benefits from injury surveillance may not be appreciated. Nevertheless, with the high training exposures and repetitive nature of the sport, kayaking is likely to be impacted by overuse injuries. Many of these injuries do not immediately result in time loss from sport so may not have been captured in this study. To fully understand the impact that all injuries have on kayaking, further research that captures overuse non-time-loss complaints in this sport should be undertaken. This would also be beneficial within sailing, where previous research into elite sailors found that the majority of training injuries were overuse in nature.[32] This study found injuries to ankles, feet and knees accounted for 66% of all of sailing injuries. This corroborates findings from previous literature where the lower extremity was found to be the most commonly injured site in elite level and club level sailors.[1] Given the large amount of upper body work that occurs during sailing, this seems a surprising result. However, it may be due to rough conditions and lower limbs getting caught and twisted in equipment. It could also be hypothesised that maybe off-water programmes focus more on core and upper body and neglect lower limb. This would be an example where injury surveillance results can then be used to guide practice to have maximum impact on athletes' performance.

Ideally, load measures would be collected from each individual athlete on a daily basis for each training session that they completed. Additionally, any modifications would be recorded in "real time" and therefore reduce any recall bias. These load measures, coupled with perceived exertion scores would then provide more meaningful load data and more accurate exposures for each individual athlete, rather than using an average for each athlete.[13] Unfortunately, this was not possible for this study.

Limitations

The small sample sizes across the five sports was a big limitation to this study. However, the domain of high performance sport is a limited population by the fact that it is elite in nature. It is therefore hard to increase the sample size when only a finite amount of athletes compete at the elite level in any country. Nevertheless, this research has bearing as findings in elite sporting populations are not always comparable to non-elite level.[1]

This study only used a time loss injury definition. This means that it is likely that overuse injuries, through which athletes could train, would not have been recorded. This means that the burden on injury on these high performance athletes could be underestimated. Future studies should also look to record overuse injuries.

The capturing of exposure measures through the HPSNZ questionnaire alone is insufficient to determine an individual athlete's exposure accurately. There is also wide variety between each NSO on how exposure measures are collected outside of the questionnaire. Therefore, it is recommended that NSOs work in conjunction with HPSNZ to determine more effective and consistent measures to record daily exposures for each athlete, regardless of what discipline they compete in. Additionally, training and match/ competition exposures need to be collected across all sports to enable the calculation of precise exposure-related incidence.[19] This is something which this study was unable to achieve. Ideally, future studies would include injury incidence for trainings, injury incidence for games/ competition and overall injury incidence measures based on individualised exposure measures.[11,19]

The greatest limitations of this study, are those which affect all injury surveillance methodologies reliant on self-reporting systems. Accurate reporting and recall are required to provide accurate data, and when this does not occur, the data is susceptible to bias. In this study, reporting inconsistencies were noted from some athletes who were having treatment and on modified training loads, yet they would deny the presence of injury on the questionnaire. This was attributed to it taking more time to detail an injury on the injury survey rather than deny the presence of one. Compliance is paramount to establish quality injury data, not only at an individual athlete level but also from an NSO level. The NSOs who actively encouraged injury surveillance had much better compliance than the other NSOs. Without the active engagement of coaching and management, the compliance levels were low, undermining the quality of the injury data collected. There was no minimum compliance level for this study, therefore, where compliance was low e.g. in kayak, the injury burden to that sport may be underestimated by this study.

CONCLUSION

This study's purpose was to determine injury incidence and prevalence across the five HPSNZ sports of men's hockey, women's hockey, women's football, kayaking and sailing using the HPSNZ injury surveillance tool. It was only possible to determine training injury incidence and prevalence using this tool. In addition to calculating competition injury incidence rates, improvements in exposure and load measures would help to achieve more accurate injury surveillance data. This reinforces how important it is to have a surveillance tool that is fit for purpose. Compliance was the biggest barrier to this study and the enthusiasm with which this system was adopted by the NSOs seems to have predicted how compliant the sport would be with this system.

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The acute effects of two eccentric thigh exercises on indicators of muscle damage

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ABSTRACT

Objective: To compare the acute effects of Nordic hamstring (NH) and Drop lunge (DL) exercises on indicators of muscle damage.

Design: Experimental.

Setting: Laboratory.

Participants: Sixteen females (NH group n=8, DL group n=8).

Main Outcomes Measures: Ultrasound echo intensity (EI) peak torque (PT), angle of peak torque (APT), limb circumference, soreness.

Results: There were clear changes in hamstrings (HS) and quadriceps (Q) APT post the DL (ES = -0.22 to -0.53) but not the NH exercise with no clear difference between exercises. Knee flexion and extension PT decreased immediately post the DL (ES = -0.50 to -0.32) and the NH exercise (ES = -0.83 to -0.29). There was a small change in girth following the DL (ES = 0.30 to 0.43). Both exercises increased HS soreness (DL ES = 1.7 to 3.0, NH ES = 1.8 to 2.0) and Q soreness (DL ES = 1.4 to 2.5, NH ES = 0.8 to 1.4), with greater change post the DL (ES = -0.7 to -1.8). Similar, small to moderate changes in echo intensity were seen for both exercises.

Conclusion: The DL and the NH exercises both induced changes indicative of muscle damage and there were few clear differences in the changes produced by each exercise.

Keywords: Hamstrings, Eccentric, Muscle damage

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INTRODUCTION

One of the most common injuries in team sports is the hamstring strain (HS),[1,2] with injury rates reported to range from 22% in professional football[3] to 9.7% in rugby sevens players.[4] Individual studies utilising eccentric hamstring training have reported reductions in the incidence of HS,[5-7] however the overall rate has not decreased.[8] This may in part be because the majority of eccentric hamstring training studies have used the Nordic hamstring (NH) exercise despite criticism that it is does not reproduce the biomechanics of the common mechanism of HS injury. Hamstring strain is commonly thought to occur during the late swing phase of sprinting when the hamstring is lengthened and contracting eccentrically.[9] The NH exercise involves bilateral eccentric knee extension with the hips held in neutral and places demands on the hamstring muscles that differ from this mechanism of HS.[10,11] Previous authors have suggested a unilateral closed chain exercise (eg, the drop lunge [DL]) that involves greater hip flexion could confer superior training stimulus by better reproducing the mechanism that endangers the hamstrings.[12,13] Additionally while the Biceps Femoris long head (BFL) is the most commonly strained muscle of the hamstrings group,[14] the NH exercise has

To date it is however unknown whether the DL provides sufficient eccentric stimulus when compared to the NH exercise. In order to establish this, measures of muscle damage, in response to these different eccentric exercises, could be quantified to allow this comparison to be made. Several markers of muscle damage exist to assess the acute effects of eccentric exercise. For example, a change in the echo-intensity of B-mode ultrasound images is thought to be an indicator of damage in a muscle post eccentric exercise.[17-19] It is also widely reported that following eccentric exercise there is a significant decrease in peak torque (PT) and/or a shift in the optimal angle of peak torque (APT) towards longer muscle lengths.[19-21] Finally, muscle soreness (based on changes in visual analogue score) and limb circumference have been used as indirect markers of muscle damage in numerous studies of eccentric muscle damage.[19,20] Thus the aim of this study was to investigate the acute effects of the DL compared to the NH exercise on these indicators of muscle damage.

METHODS

Participants

Sixteen healthy female students (mean ±SD; age = 23 ±4yrs, height = 165 ±5cm, mass = 72 ±9kg) volunteered to participate in the study.[22,23] All participants provided informed consent to participate and ethical approval was granted by the Auckland University of Technology Ethics committee (application 13/124). Participants were randomly assigned to either the DL or NH exercise group. Participants were instructed not to perform resistance, aerobic or flexibility training, avoid excessive stair climbing or unfamiliar exercise one week before and for the duration of the study.

Experimental design and eccentric exercise protocols

After a standardised warm up of five minutes of easy cycling at a self-selected pace, participants performed eight sets of eight repetitions of the DL or NH exercise (depending on their group allocation) with a 30 second rest between sets.

The DL was performed off a 30cm high box. The participant stepped off the box and landed with their dominant leg in front. They were instructed to drop straight down, bending at the hips and knees, stopping in a lunge position at approximately 90 degrees knee flexion before standing up.[24]

The NH exercise followed well established protocols[25] and was completed with a separate researcher to blind the lead researcher to group allocation.

Data Collection

In both groups the following measures were taken immediately before, immediately after and at 1, 2 and 3 days following the exercise protocols; (i) knee flexion/extension and hip extension concentric isokinetic PT and APT at 60 degrees per second (Humac Norm isokinetic dynamometer, Lumex, Ronkonkoma, NY, USA), (ii) limb circumference measured by tape measure, 1/3 and 2/3 of the distance between the gluteal crease and the popliteal crease and (iii) muscle soreness using a visual analogue scale. Additional echo intensity (EI) of B-mode ultrasound images of the hamstrings (at two locations; see below for detail) were measured the day before exercise and at day 3 post exercise;

A specialist musculoskeletal sonographer with 21 years of experience (blinded to the measurements), performed all the ultrasound scans using an iU22 Philips ultrasound machine with a 9-4 MHz curvilinear probe. The EI of semimembranosus (SM), semitendinosus (ST), BFS and BFL were measured. Manually changing the gain and system pre-set levels will influence the EI of the ultrasound image.[26] Therefore, to ensure consistency, the gain and system pre-set levels were kept constant during all measurements and for all participants to ensure all features influencing grey scale were standardised. Measurements were taken with the participant prone. To allow a standardised set of scanning locations relative to each participant, the distance between gluteal crease and popliteal crease

was measured. This distance was then divided into thirds and a mark was placed at the superior third intersection (1/3) and the distal third intersection (2/3) using a permanent marker.

Ultrasound scanning began at the ischial tuberosity and followed the ST distally until the tendinous inscription of this muscle was visualised to confirm its location. Ultrasound images were taken at ST 1/3 (ST1) and 2/3 (ST2) distal to the gluteal crease. SM was then visualised medial to ST. Ultrasound images were taken of SM 1/3 (SM1) and 2/3 (SM2) distal to the gluteal crease. BFL was then visualised laterally from ST. Ultrasound images were taken of BFL 1/3 (BFL1) and 2/3 (BFL2) distal to the gluteal crease. Finally the BFS was visualised, with ultrasound images taken 2/3 distal to the gluteal crease (BFS). At each of the scanning locations (ST1, ST2, SM1, SM2, BFL1, BFL2, BFS) one ultrasound image was captured. The protocol was then repeated in order to capture a second image for each location.

To enable off-line assessment of EI, a clear region-of-interest (ROI) was required to be established at each of the scanning locations. The sonographer provided the ROI at the time of capturing each ultrasound image and ensured as much muscle without bone or fascia was marked. EI was defined as the mean pixel intensity in the ROI[27] and determined, off-line, by grayscale analysis using the standard histogram function in Adobe Photoshop (Adobe Systems Inc, San Jose, CA, USA, version 14.1.2 x32).[26,27] The EI of the ROI was expressed as a measurement between 0 and 255 units. Zero indicated a pure black image and 255 indicated a pure white image. The mean of the two values for EI for each scanning location was used for analysis. The between-session reliability for the assessment of EI at each location ranged from moderate to very high (ICC = 0.67-0.93) for all areas except BFS which was low (ICC = 0.45).

Data Analysis

Means and standard deviations of PT values are reported to further describe the two groups. Mean changes in the dependent variables (PT, APT, limb circumference, muscle soreness, EI of B-mode ultrasound images) post each exercise were calculated. Differences in these changes between the DL and NH exercises were also calculated. An Excel spreadsheet[28] was used to derive magnitude based inferences as to the true effect of each exercise on all dependent variables. A further spreadsheet for comparing the means of two groups was used to derive magnitude based inferences,[29] as to the true difference between the effect of the DL and the NH exercise. A standardised Cohen effect size (ES) of 0.20 was used as the threshold for substantial change.[30] Where the effect had a >5% probability of being substantially positive and a >5% probability of being substantially negative the inference was stated as 'unclear'.[31] Otherwise the outcome was clear and the inference was based on the likelihood the true value of the ES was greater than 0.20 using the following scale: 25-75%, possibly; >75%, likely; >95%, very likely; >99.5%, most likely (30, 32). Magnitudes of observed ES's were interpreted based on the following scale: 0.20-0.59 (small), 0.60-1.19 (moderate), 1.20-1.99 (large), 2.00-3.99 (very large), ≥4.00 (extremely large) and their inverse.[30]

RESULTS

Changes in peak torque (PT) and angle of peak torque (APT)

The group mean and standard deviation for baseline PT and APT are shown in Table 1. Immediately following the DL there was a small decrease in knee flexion PT (ES=0.36) and a shift in the APT to longer muscle lengths at all time points (ES=0.28 to 0.53) (Table 2). There was also a small reduction in knee extension PT immediately post (ES=0.50) and up to day 2 (ES=0.35). Following the NH exercise there was a moderate decrease in knee flexion PT immediately (ES=0.83) and at day 1 (ES=0.82) and a small decrease at day 2 (ES=0.43) and 3 (ES=0.59). Additionally there was a small decrease in knee extension PT immediately (ES=0.48) and at day 1 (ES=0.29). The only change in APT following the NH exercise was a small decrease in hip extension APT immediately (ES=0.38).Changes in hip extension PT were trivial or unclear for both exercises.

Table 1: Baseline torque measures for each group.

Variable	Drop lunge	Nordic hamstrings
	Mean; (SD)	Mean; (SD)
Knee flexion PT (Nm)	103.70 (15.26)	105.3 (17.71)
Knee extension PT (Nm)	152.74 (30.37)	140.37 (24.03)
Hip extension PT (Nm)	230.31 (51.70)	218.00 (49.09)
Knee flexion APT (°)	28.52 (4.82)	28.30 (3.84)
Knee extension APT (°)	68.46 (9.60)	67.20 (6.36)
Hip extension APT (°)	76.72 (10.19)	78.96 (9.18)

PT = peak torque; APT = angle of peak torque

Table 2: Changes (standardised Cohen effects) in peak torque and angle of peak torque and magnitude based inferences for the changes following the drop lunge and Nordic hamstrings exercise

	Immediate post		Day 1		Day 2		Day 3	
	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]
Drop Lunge (n=8)								
KF PT	-0.36 (-0.81-0.09)	Small ↓*	-0.18 (-0.75-0.39)	Unclear	-0.44 (-0.75-0.39)	Unclear	-0.28 (-0.90-0.33)	Unclear
KF APT	-0.28 (-0.60-0.03)	Small ↓*	-0.44 (-0.89-0.01)	Small ↓**	-0.41 (-0.77--0.05)	Small ↓**	-0.53 (-0.94--0.12)	Small ↓**
KE PT	-0.50 (-0.86--0.15)	Small ↓**	-0.32 (-0.61--0.02)	Small ↓**	-0.35 (-0.84-0.15)	Small ↓*	-0.08 (-0.41-0.24)	Unclear
KE APT	-0.22 (-0.37--0.08)	Small ↓*	-0.37 (-0.90-0.16)	Small ↓*	-0.28 (-0.64-0.08)	Unclear	-0.22 (-0.62-0.18)	Unclear
HE PT	-0.21 (-0.65-0.23)	Unclear	-0.19 (-0.44-0.07)	Unclear	-0.37 (-1-08-0.35)	Unclear	-0.36 (-0.91-0.19)	Unclear
HE APT	0.10 (-0.17-0.38)	Trivial ↑*	-0.10 (-0.41-0.21)	Unclear	-0.28 (-0.89-0.32)	Unclear	-0.21 (-0.67-0.26)	Unclear
Nordic Hamstrings (n=8)								
KF PT	-0.83 (-1.31--0.35)	Moderate ↓***	-0.82 (-1.38--0.26)	Moderate ↓***	-0.43 (-0.91-0.05)	Small ↓**	-0.59 (-1.19-0.00)	Small ↓**
KF APT	-0.04 (-0.54-0.45)	Unclear	0.08 (-0.94-1.10)	Unclear	-0.43 (-1.11-0.26)	Unclear	-0.52 (-1.14-0.09)	Unclear
KE PT	-0.48 (-0.93--0.03)	Small ↓**	-0.29 (-0.62-0.05)	Small ↓*	0.04 (-0.29-0.37)	Unclear	0.04 (-0.29-0.37)	Unclear
KE APT	0.26 (-0.56-1.07)	Unclear	-0.05 (-0.48-0.39)	Unclear	0.08 (-0.46-0.63)	Unclear	0.24 (-0.30-0.78)	Unclear
HE PT	-0.15 (-0.45-0.15)	Trivial ↓*	-0.11 (-0.39-0.16)	Unclear	-0.19 (-0.34--0.04)	Unclear	-0.28 (-0.65-0.08)	Unclear
HE APT	-0.38 (-0.81-0.05)	Small ↓**	0.18 (-0.18-0.54)	Trivial ↑*	0.15 (-0.13-0.43)	Unclear	0.03 (-0.29-0.34)	Unclear

[a]Magnitude thresholds: <0.20, trivial; 0.20-0.59, small; 0.60-1.19, moderate; 1.2-1.99 (large), 2.0-3.99 (very large), ≥4.0 (extremely large) and their inverse. Asterisks indicate effects clear at the 90% level and likelihood that the true effect is substantial, as follows: *possible, **likely, ***very likely, ****most likely. KF=knee flexion; KE=knee extension; HE=hip extension; PT = peak torque; APT = angle of peak torque.

The immediate reductions in knee flexion PT were greater following the NH exercise than the DL (ES=0.53) as were the changes at day 1 (ES=0.69). There was no clear difference in knee flexion APT changes (Table 3). There were also no clear differences between exercises in changes in knee extension PT or hip extension PT. There were small to moderate differences between exercises in knee extension APT changes but none of these changes were clear in the within group analysis.

Changes in girth and pain scores

There were no clear changes in thigh girth 1 following either exercise but there was a small increase in girth 2 at all-time points after the DL (ES=0.27 to 0.43). There were large to very large increases in hamstrings VAS scores following the

Table 3: Mean difference (standardised Cohen units) between the change in peak torque and angle of peak torque and magnitude-based inferences for the difference in the changes following the drop lunge and the Nordic hamstrings exercise

	Immediate post		Day 1		Day 2		Day 3	
	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]
KF PT	-0.53 (-1.15-0.09)	Small** ↓	-0.69 (-1.44-0.06)	Moderate** ↓	-0.01 (-0.77-0.75)	Unclear	-0.35 (-1.15-0.46)	Unclear
KF APT	0.30 (-0.28-0.88)	Unclear	0.60 (-0.49-1.69)	Unclear	0.06 (-0.70-0.81)	Unclear	0.10 (-0.51-0.83)	Unclear
KE PT	0.11 (-0.42-0.63)	Unclear	0.06 (-0.35-0.47)	Unclear	0.35 (-0.22-0.92)	Unclear	0.03 (-0.40-0.46)	Unclear
KE APT	0.47 (-0.20-1.13)	Small** ↑	0.32 (-0.35-1.00)	Unclear	0.36 (-0.20-0.91)	Unclear	0.42 (-0.17-1.00)	Unclear
HE PT	0.06 (-0.48-0.60)	Unclear	0.05 (-0.32-0.42)	Unclear	0.13 (-0.68-0.94)	Unclear	0.05 (-0.63-0.72)	Unclear
HE APT	-0.47 (-1.01-0.07)	Small**↓	0.39 (-0.11-0.90)	Small**↑	0.60 (-0.17-1.37)	Moderate**↑	0.33 (-0.31-0.96)	Unclear

[a]Magnitude thresholds: <0.20, trivial; 0.20-0.59, small; 0.60-1.19, moderate; 1.2-1.99 (large), 2.0-3.99 (very large), ≥4.0 (extremely large) and their inverse. Asterisks indicate effects clear at the 90% level and likelihood that the true effect is substantial, as follows: *possible, **likely, ***very likely, ****most likely. KF=knee flexion; KE=knee extension; HE=hip extension; PT = peak torque; APT = angle of peak torque.

Table 4: Changes in girth and pain and magnitude based inferences for the changes following the drop lunge and Nordic hamstrings exercise

	Immediate post		Day 1		Day 2		Day 3	
	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]
Drop Lunge (n=8)								
Girth 1 (cm)	0.13 (0.07-0.20)	Trivial***	0.16 (0.12-0.21)	Unclear	0.18 (0.12-0.23)	Unclear	0.18 (0.13-0.24)	Unclear
Girth 2 (cm)	0.30 (0.23-0.36)	Small ↑***	0.27 (0.19-0.35)	Small ↑**	0.30 (0.18-0.41)	Small ↑**	0.43 (0.32-0.54	Small ↑****
H VAS	1.7 (0.9-2.6)	Large ↑**	3.0 (2.3-3.7)	Very large ↑****	2.8 (2.0-3.7)	Very large ↑****	1.9 (0.7-3.1)	Large ↑**
Q VAS	1.6 (1.0-2.2)	Moderate ↑**	2.4 (1.0-3.8)	Very large ↑***	2.5 (1.3-3.6)	Very large ↑***	1.4 (0.3-2.5)	Large ↑*
Nordic Hamstrings (n=8)								
Girth 1 (cm)	0.13 (0.07-0.20)	Trivial***	0.16 (0.12-0.21)	Unclear	0.18 (0.12-0.23)	Unclear	0.18 (0.13-0.24)	Unclear
Girth 2 (cm)	0.15 (0.09-0.21)	Trivial**	0.16 (0.09-0.24)	Unclear	0.24 (0.18-0.29)	Unclear	0.25 (0.14-0.36)	Unclear
H VAS	2.0 (0.6 3.4)	Very large ↑**	1.8 (0.9 2.6)	Large ↑**	2.0 (0.8 3.3)	Very large ↑**	0.7 (0.2 1.2)	Trivial**
Q VAS	0.7 (0.0-1.3)	Trivial**	1.4 (0.3-2.4)	Large↑*	0.8 (0.1-1.6)	Moderate ↑*	0.3 (0.0-0.6)	Trivial****

[a]Magnitude thresholds: <0.20, trivial; 0.20-0.59, small; 0.60-1.19, moderate; 1.2-1.99 (large), 2.0-3.99 (very large), >4.0 (extremely large) and their inverse. Asterisks indicate effects clear at the 90% level and likelihood that the true effect is substantial, as follows: *possible, **likely, ***very likely, ****most likely. H=hamstrings; Q=quadriceps; VAS=visual analogue scale.

DL (ES=1.7 to 3.0) and the NH exercise (ES=1.8 to 2.0). A moderate to very large increase in quadriceps VAS score that persisted at all time points was also observed following the DL (ES=1.4 to 2.5). There was also a moderate to large increase in quadriceps VAS score on day 1 (ES=1.4) and day 2 (ES=0.8) post the NH exercise but these differences were trivial immediately post exercise and by day 3.

There was a trivial difference in the effect of the two exercises on the girth measures at all time points (Table 5). The DL participants showed a moderately greater increase in hamstrings VAS on day 1 (ES=0.7) and day 3 post exercise (ES=1.0) however there was no clear difference observed at the other time points. There were moderate to large differences in quadriceps VAS scores between the exercises at all time points (ES=1.0 to 1.8) with the DL group reporting greater soreness.

Changes in echo intensity

Three days following the DL, moderate increases in EI were observed at BFL1 (ES=0.76) and ST1 (ES=0.92), and small increases were seen at SM1 (ES=0.52) and SM2 (ES=0.52) (Table 6). There were no clear changes at BFL2, BFS and ST2. In contrast, there were small increases 3 days post exercise following the NH exercise at BFL1 (ES=0.41), SM1 (ES=0.38), SM2 (ES=0.50), ST1 (ES=0.56), and ST2

Table 5: Mean difference between the change in girth and VAS and magnitude based inferences for the difference in the changes following the drop lunge and the Nordic hamstrings exercise

		Immediate post		Day 1		Day 2		Day 3	
		Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]
Girth (cm)	1	0.03 (-0.05-0.11)	Trivial***	0.07 (0.01-0.16)	Trivial***	0.09 (-0.01-0.19)	Trivial***	0.03 (-0.06-0.13)	Trivial***
Girth (cm)	2	-0.06 (-0.15-0.04)	Trivial***	-0.01 (-0.13-0.10)	Trivial***	0.06 (-0.06-0.17)	Trivial***	-0.04 (-0.20-0.12)	Trivial**
H VAS		0.6 (-1.1-2.2)	Unclear	-0.7 (-1.8-0.4)	Moderate ↓*	-0.1 (-1.7-1.5)	Unclear	-1.0 (-2.2-0.3)	Moderate ↓*
Q VAS		-1.0 (-1.9--0.2	Moderate ↓*	-1.2 (-2.8-0.4)	Large ↓*	-1.8 (-3.0--0.5)	Large ↓**	-1.2 (-2.4-0.0)	Large ↓*

[a]Magnitude thresholds: <0.20, trivial; 0.20-0.59, small; 0.60-1.19, moderate; 1.2-1.99 (large), 2.0-3.99 (very large), ≥4.0 (extremely large) and their inverse. Asterisks indicate effects clear at the 90% level and likelihood that the true effect is substantial, as follows: *possible, **likely, ***very likely, ****most likely. H=hamstrings; Q=quadriceps; VAS=visual analogue scale.

Table 6: Changes (standardised Cohen units) in echo intensity between pre exercise and day 3 post exercise and magnitude-based inferences for the changes following the drop lunge and Nordic hamstrings exercise

Hamstring location	Drop Lunge (n=8)		Nordic Hamstrings (n=8)	
	Mean; ±90%CL	Inference[a]	Mean; ±90%CL	Inference[a]
Echo intensity				
BFL1	0.76 (0.30-1.23)	Moderate ↑***	0.41 (-0.10-0.92)	Small ↑**
BFL2	0.20 (-0.43-0.82)	Unclear	0.19 (-0.20-0.59)	Unclear
BFS	0.17 (-0.42-0.76)	Unclear	0.28 (-0.29-0.86)	Unclear
SM1	0.52 (0.10-0.94)	Small ↑**	0.38 (-0.07-0.82)	Small ↑**
SM2	0.45 (-0.13-1.02)	Small ↑**	0.50 (0.11-0.90)	Small ↑**
ST1	0.92 (0.46-1.37)	Moderate ↑***	0.56 (-0.06-1.17)	Small ↑**
ST2	-0.57 (-1.56-0.42)	Unclear	0.58 (0.05-1.11)	Small ↑**

[a]Magnitude thresholds: <0.20, trivial; 0.20-0.59, small; 0.60-1.19, moderate; 1.2-1.99 (large), 2.0-3.99 (very large), ≥4.0 (extremely large) and their inverse. Asterisks indicate effects clear at the 90% level and likelihood that the true effect is substantial, as follows: *possible, **likely, ***very likely, ****most likely. BFL=Biceps femoris longhead, BFS=Biceps femoris shorthead, SM=Semimembranosus, ST=Semitendinosus.

(ES=0.58) and no clear changes at BFL2 and BFS.

A moderate difference in mean change in EI between exercises was observed at ST2 (ES=0.96) indicating greater damage following the NH exercise (Table 7). There were trivial or no clear differences between the changes in mean EI at the other measured sites.

DISCUSSION

Changes in peak torque (PT) and angle of peak torque (APT)

Findings from this study provide some evidence of hamstring muscle damage following both the DL and NH exercises as shown by small to moderate immediate decreases in knee flexion PT of 6% and 14.6% respectively. The greater effect of the NH exercise is likely due to the more specific isolation of the hamstring during this exercise compared to the DL. As expected due to the eccentric quadriceps contraction small decreases in knee extension PT were also seen following the DL (7.3% to 10.5%). Previous studies using a stepping down exercise have found greater decreases in quadriceps PT (25-29%).[33,34] However, these studies used a greater volume of eccentric exercise (200-240 repetitions). The exercise prescription in the current study was chosen based on replicating a realistic training load.

Table 7: Mean difference (standardised Cohen units) between the change in echo intensity and magnitude-based inferences for the difference in the changes following the drop lunge and the Nordic hamstrings exercise

	Echo intensity	
	Mean; ±90%CL	Inference[a]
BFL1	-0.16 (-0.63-0.96)	Unclear
BFL2	0.29 (-0.18-0.77)	Trivial* ↑
BFS	0.11 (-0.77-0.99)	Unclear
SM1	-0.21 (-0.50-0.93)	Unclear
SM2	0.36 (-0.34-1.07)	Unclear
ST1	-0.06 (-0.78-0.89)	Unclear
ST2	0.96 (0.11-1.80)	Moderate*** ↑

[a]Magnitude thresholds: <0.20, trivial; 0.20-0.59, small; 0.60-1.19, moderate; 1.2-1.99 (large), 2.0-3.99 (very large), ≥4.0 (extremely large) and their inverse. Asterisks indicate effects clear at the 90% level and likelihood that the true effect is substantial, as follows: *possible, **likely, ***very likely, ****most likely. BFL=Biceps femoris longhead, BFS=Biceps femoris shorthead, SM=Semimembranosus, ST=Semitendinosus.

Surprisingly, the participants who completed the NH exercise also showed decreased knee extension PT (5.4% to 8.8%), however this didn't last as long as following the DL. This was unexpected because there wouldn't likely be any eccentric loading of the quadriceps during the NH exercise. The decrease in PT may have been due to excessive co-contraction during an unfamiliar exercise. To increase the loading on the hamstrings the intensity of the DL could be increased by elevating the height of the drop or adding weight. There were no clear changes in hip extension PT following either exercise and to our knowledge this is the first time this has been reported. This suggests neither exercise caused significant damage to the gluteal musculature because there was insufficient volume, the exercise wasn't performed at a long enough muscle length, and/or the intensity of loading was insufficient.

In contrast to the PT changes there was a lengthening of the APT for knee flexion following the DL but no clear changes following the NH exercise (this difference was however unclear in our between exercise analysis). The NH exercise is performed at relatively short to moderate muscle lengths for the hamstrings. Greater shifts in APT are observed when eccentrics are performed at longer muscle lengths (ie, beyond optimal length).[35] Potentially, the DL may have caused greater lengthening of the hamstrings during hip flexion since the hamstrings have a longer muscle moment arm at the hip joint than the knee joint.[36] In a previous study, a 7.7 degree shift was observed immediately in the optimal angle of torque generation for the hamstrings following 12 sets of 6 repetitions of the NH exercise in a male cohort.[23] Potentially the lower volume of repetitions that were used in our study and the female cohort could explain the lack of change in the NH exercise group.

Additionally there were no clear changes in APT for knee extension or hip extension following either exercise. This contrasts with a 15.6 degree lengthening of knee extension APT reported previously following a step down exercise.[33] This may be because we didn't expose the quadriceps or hip extensors to sufficient load and/or far enough into the descending limb of their length-tension relationship to increase the series compliance of the myofibrils that has been associated with shifts in APT.[37] There were differences in the effect of each exercise on knee extension and hip extension APT, however these are of little practical relevance due to the lack of an effect of each exercise separately.

Decreases in PT and lengthening of the APT commonly occur together as markers of muscle damage.[38] Interestingly, the knee flexion PT decreases observed following the NH exercise did not correspond to a clear change in APT. This was the opposite following the DL where a small lengthening of APT was observed at all time points but only a small decrease in PT occurred immediately. Thus it appears these changes can occur independently and as both are considered risk factors for injury this adds weight to the idea that both exercises have merit. Peak torque and APT may in fact be separate markers of damage. Additionally athletes with limb strength asymmetry may benefit from a unilateral dominant exercise such as the DL as opposed to the bilateral NH exercise.

Changes in girth and soreness

The increase in girth 2 following the DL but not the NH exercise may be because both the hamstrings and quadriceps contract eccentrically during the DL. Additionally previous studies have also demonstrated greater increases in girth at the distal sites[39] due to gravitational drainage of fluid resulting from the inflammatory response noted post eccentric exercise.[23,33] The increases in girth post the DL were similar to those reported by Bowers et al[33] (mean increase 0.6cm) following 12 sets of 20 eccentric step downs even though our volume of exercises was less. Similarly the DL caused more quadriceps and hamstring soreness than the NH exercise suggesting greater muscle damage. Our VAS scores were lower than those reported previously for the quadriceps and hamstrings[23,33,37,40,41] which is again likely due to the lower volume of eccentric exercises we used.

Echo intensity

The changes observed in EI were found at similar sites for both exercises. If EI is an indicator of where the eccentric load is applied through the muscle and thus where there may be muscle growth then both exercises showed potential to address the atrophy of BFL reported post injury[14] with a moderate increase in EI at BFL1 following the DL and a small increase following the NH exercise. The moderate increase in EI observed at the proximal aspect of BFL1 following the DL agrees with a previous MRI study that reported the lunge exercise loads the proximal regions of the BFL.[16] There was a lack of clear changes in BFS EI following either exercise. Changes in EI at a single site have been reported previously.[19] The potential advantage of measuring ultrasound changes of EI at numerus sites is the ability to tailor prevention and rehabilitation exercises to common injury sites. Unfortunately our results show no clear differences between exercises in this regard.

Limitations

There are number of limitations in the current study that need to be considered. There were small baseline differences in absolute PT between groups which may have influenced the propensity for muscle damage. However, measures of baseline APT were well matched and this was probably the most important factor when considering the effect of eccentric exercise. A lack of clarity in some results may be due to the small sample size and the error of measurement in a number of the ultrasound measures. Furthermore the participants were all healthy female recreationally trained tertiary students.

CONCLUSION

Changes in markers of muscle damage were observed following both exercises and there were few clear differences in the magnitude of these changes between the exercises. This suggests the DL provides a similar eccentric stimulus to the NH exercise and should be considered as an alternate unilateral eccentric hamstring exercise for hamstring strain injury prevention and rehabilitation. The DL may be especially beneficial for addressing limb asymmetries. Future studies are needed to investigate if the DL can reduce the risk of HS injury and to investigate other forms of eccentric hamstring training that may place greater stress on the BFL.

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Changes in the stress and recovery of injured versus non-injured amateur domestic women's rugby union team players over a competition season in New Zealand

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ABSTRACT

Objective: To investigate changes in stress and recovery over a season of training and match participation for injured and non-injured female amateur rugby union players.

Methods: Thirty two female rugby union club level players completed the Recovery-Stress Sport 52 (RESTQ-Sport) item at the 2019 pre-season training session, at the end of each month following match activity and two days following the final match. Recovery and stress metrics were determined for each month and for the season. The team medic recorded injury numbers.

Results: During 54 training sessions and 12 competition matches over five months there were 79 match related injuries (equating to 330 per 1,000 match hrs (95% CI: 264.7 to 411.4) injury incidence). Players recorded a higher score in the Physical Recovery scale at the end of the competition season (Month 6) compared with pre-competition (1.12 ±0.40 vs. 2.17 ±1.25; F(6,8)=4.1; p=0.0345; t(14)=-2.8; p=0.0147), and Month 2 was significantly higher than Month 1 (1.76 ±1.32 vs. 2.58 ±1.32; F(9,15)=2.7; p=0.0416; t(24)=-3.1; p=0.0053). For Month 1 there was a significantly lower Total Stress score compared with the Total Recovery score (1.33 ±0.41 vs. 2.51 ±0.45; F(19,6)=52.8; p<0.0001; t(25)=-4.2; p=0.0003). Non-injured players recorded a higher General Well-being scale score in Month 2 (3.32 ±1.53 vs. 3.06 1.18; F(4,4)=13.2; p=0.0142; t(8)=-3.5; p=0.0081) compared with Month 6 than non-injured players. Injured players recorded a significantly higher Injury scale score in Month 6 (3.79 ±0.99 vs. 3.36 ±0.66; F(2,3)=16.0; p=0.0251; t(2)=-2.6; p=0.0483) compared with pre-competition than non-injured players.

Discussion: Like previous studies in other sports, when the scores for all aspects of the RESTQ-Sport were retrospectively reviewed, the injured female rugby players had lower recovery-related scores and higher stress-related scores than the non-injured female rugby players.

Conclusion: The RESTQ-Sport appears to be efficacious for detecting differences in individual rugby players for injury recovery.

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INTRODUCTION

Played in over 200 countries, rugby union is a field based full contact intermittent collision sport played by men, women, boys and girls from six years of age.[1] The game of rugby union requires participants to undertake repeated bouts of high-intensity activity (running, sprinting, tackling, scrummaging, rucking and mauling) interspersed with periods of low-to moderate-intensity exercise (standing, walking and jogging) throughout a match.[2] There are two formats of the game with the traditional rugby-15s played over two 30-40 minute halves interspersed by a 10-minute rest period whereas rugby7-s is a shortened version of the game with seven players competing on a full size rugby field over two seven-minute halves.[3] For players to compete in these match activities there is a need to undertake rugby specific training to develop physical, technical and tactical abilities.[4] As a result, these activities, combined with match participation, can have both positive and negative physiological and psychological effects and require effective management of the training loads and recovery strategies.[5]

Balancing the effects of the stress of training and match participation with the recovery from these activities is important in improving player performance.[6,7] Optimising performance and decreasing the risk of injury requires balancing the appropriate training stimulus with an adequate recovery programme.[4] Previously, both the stress-injury,[8] and overtraining and recovery models[9] have been utilised to describe the balance between physical and/or psychosocial stress and recovery. Changes, or disturbances, in these physical and/or psychosocial aspects of the individual, such as increased muscle tension, may result in a disturbance of motor coordination, reduced flexibility and narrowing of the visual field.[8] As such, the relationship between stress and sports performance has previously been reported in competitive rowing[10,11] and rugby league.[12,13] However, other aspects, outside of the sporting environment, may impact the stress-recovery process and these factors may also have an impact on training and match performance and vice-versa.[14]

A tool that has been developed for coaches to systematically monitor the complexities of stress and recovery states in players over a period of training or matches is the multidimensional Recovery-Stress Questionnaire for Athletes (RESTQ-Sport).[15] Comprising of 76, 52 and 36 question versions, the RESTQ-Sport has been utilised for individual players as part of a recovery program,[16] and in the training environment.[10,17,18] More recently the RESTQ-Sport has been used to monitor team sport athletes overall stress and recovery during competition in basketball,[19] rugby league,[12,13] rugby union[20,21] and soccer.[22,23] The study in rugby union[20] on adolescent male players in Australia reported that, as the weekly volumes of intensity increased across the competition season, the participants' stress and under recovery also increased. As a result of this finding, it was recommended[20,21] that the use of the RESTQ-Sport to serially monitor players over a competition period was valuable. In addition to studies on male rugby players,[20,21] the RESTQ-Sport has also been utilised on female soccer[19] and basketball[23] players. To date, no study has reported the stress and recovery of amateur domestic female rugby union players over a season, nor any differences between injured and non-injured players.

AIM

To investigate changes in stress and recovery over a season of training and match participation for injured and non-injured female amateur rugby union players.

METHODS

Participants and Ethical Approval

A prospective observational study was undertaken following a women's rugby union club-based team (32 players; 26.3 ±7.9 yr.; 1.64 ±6.1 m; 86.9±12.5 kg) in domestic competition (nine teams playing in a home and away format from April to July). All players were offered the opportunity to participate in the study and gave their informed consent. No player withdrew throughout the duration of the study. All players were amateur and did not receive match payments. Ethics approval was provided by the Health and Disability Ethics Committee (18/STH/224).

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.[10,17,24] The questionnaire uses a self-report approach of a player's physical, subjective, behavioural and social aspects of stress and recovery (see Table 1), through examination of the following scales; 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).[15,18] 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 across the previous three days and nights. The stem of each item is "In the past 3 days/nights…" Examples of these are "I felt anxious or inhibited" (emotional stress), "I was tired from work" (fatigue), and "I was convinced that I performed well" (self-efficacy). The internal consistency and reliability of the RESTQ-Sport have been previously reported via Cronbach's α (0.67 to 0.88) and test-retest reliability (r=0.51 to 0.81) (see Table 1).[10,15] The internal consistency reportedly[15] 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.

Injury Management

The team medic recorded and reported all the injuries over the duration of the season. The team medic was a registered comprehensive nurse with tertiary sports medicine qualifications and accredited in injury prevention, assessment, and management. Injury data were collected from all training and match activities the teams participated in, which included preseason fixtures and all competition matches including the final series. All injuries were recorded on a standardised injury reporting form regardless of severity.[25] All matches were 80 minutes in duration. The injury definition has been previously defined.[26]

Testing Schedule for RESTQ-Sport

Similar to previous studies,[12,13] the RESTQ-Sport was undertaken at the commencement of the pre-season training sessions. As pre-season commenced at the beginning of the year (January), another assessment was completed approximately one month prior to the competition starting in April. The RESTQ-Sport was then completed at the end of each month following a match activity through to the last match (semi-final) where assessment was completed approximately two days following the match. The questionnaire was administered monthly as the coaching staff did not want this done any more frequently. The questionnaire took approximately 10 minutes to complete and players typically completed this prior to the training session commencing. Internal consistency was checked at the completion of each testing utilising Cronbach's alpha (α). Only those questionnaires that were completed were included in the study; over the duration of the study there were eight incomplete questionnaires not included in the analysis.

Table 1: Number of scales, scale of orientations (o), number of items per scale (n), example sample item of scale, Cronbach's α, and test-retest reliabilities15 and scale values for the results for the RESTQ-Sport.

No.	RESTQ-Sport Scale	o	n	Example	α	Test-Retest	Scale Summary
1	General Stress	S	4	…I felt down	0.76	0.71	High values = frequently mentally stressed, depressed, unbalanced and listless
2	Emotional Stress	S	4	…I was in a bad mood	0.71	0.72	High values = frequent irritation, aggression, anxiety and inhibition
3	Social Stress	S	4	…I was angry with someone	0.85	0.77	High values = frequent arguments, fights, irritation concerning others, general upset, lack of humour
4	Conflicts/Pressure	S	4	…I felt under pressure	0.68	0.73	High values = conflicts unsettled, unpleasant things done, goals not reached, certain thoughts could not be dismissed
5	Fatigue	S	4	…I was overtired	0.78	0.81	High values = time pressure in job, training, school, life; constantly disturbed during important work, over-fatigue, lack of sleep characterize this are of fatigue
6	Lack of Energy	S	4	…I was unable to concentrate well	0.72	0.68	High scores = ineffective work behaviour, inability to concentrate, lack of energy and decision making.
7	Physical Complaints	S	4	…I felt uncomfortable	0.71	0.76	Physical indisposition and physical complaints related to the whole body characterized by this scale.
8	Success	R	4	…I finished important tasks	0.67	0.70	High scores = success, pleasure at work, creativity during past few days.
9	Social Recovery	R	4	…I had a good time with my friends	0.80	0.74	High values = frequent pleasurable social contacts and change combined with relaxation and amusement.
10	Physical Recovery	R	4	…I felt at ease	0.85	0.79	High values = physical recovery, physical well-being, and fitness.
11	General Wellbeing	R	4	…I was in a good mood	0.84	0.61	High values = frequent good moods, high well-being, general relaxation, contentment
12	Sleep Quality	R	4	…I had a satisfying sleep	0.83	0.70	High values = enough recovering sleep, absence of sleep disorders when falling asleep, sleeping through the night = recovery sleep
13	Disturbed Breaks	S	4	…my coach demanded too much of me during the breaks	0.79	0.64	High values = recovery deficits, interrupted recovery, situational aspects that get in the way during periods of rest
14	Emotional Exhaustion	S	4	…I felt I wanted to quit my sport	0.71	0.72	High values = burnt out, wanting to quit
15	Injury	S	4	…my performance drained me physically	0.78	0.59	High values = acute injury / vulnerability to injuries
16	Being in Shape	R	4	…I was in good condition physically	0.88	0.71	High values = perception as fit, physically efficient, vital
17	Personal Accomplishment	R	4	…I dealt very effectively with my team-mate's problems	0.80	0.81	High values = feel integrated into team, communicate well with team-mates, enjoy sport
18	Self-Efficacy	R	4	…I was convinced that I had trained well	0.89	0.82	High values = how convinced player is that they trained well and optimally prepared.
19	Self-Regulation	R	4	…I prepared myself mentally for performance	0.83	0.77	High values = use of mental skills to prepare, push motivate, set goals for themselves.

Statistical Analysis

Data were entered into a Microsoft Excel spreadsheet enabling assessment scores to be graphed automatically. Match and training exposure rates were calculated as previously reported.[25] Data were analysed with the Statistical Package for Social Sciences for Windows (SPSS; V25.0.0). Following tests for normal distribution (Shapiro-Wilk test: p=0.1555), descriptive data were presented as means and standard deviations. To check for internal consistency a Cronbach's α test was conducted after each testing session.[27] One-way analysis of variance (ANOVA) tests were used for the mean of the individual scales and the total stress and recovery scores and for differences between injured and non-injured players. When differences were detected a post-hoc two-tailed paired t-test was utilised to determine the location of those differences. A Bonferroni-type adjustment was applied to maintain the Type-1 error probability at the 0.05 alpha level. A t-test was used to determine the differences in the individual scale scores across the recovery duration. Total recovery and stress scores were obtained by calculating the mean of all recovery and stress scales as previously described.[24] Overall monthly recovery and stress scores were obtained by calculating the mean of all recovery and stress scales.[24] The statistical significance was set at p<0.05.

RESULTS

Training and Match Exposure

Over the competition season there were 54 training sessions with an average of 19 ± 5 players per training session and 12 competition matches completed for the 32 players in the study. There were a further two matches scheduled that were not fulfilled due to defaults. There were 54 training sessions resulting in a training exposure of 1,691 hrs.

There were 23 training related injuries recorded resulting in a training injury incidence of 14.1 (95% CI: 9.4 to21.2) per 1,000 training hrs. There were 12 competitive matches resulting in a match exposure of 239.4 match hrs. There were 79 match-related injuries recorded resulting in a match injury incidence of 330.0 (95% CI: 264.7 to 411.4) per 1,000 match hrs.

RESTQ-Sport Scores

Table 2 provides the scores of the different scales of the RESTQ-Sport for General Stress, General Recovery, Sports-Specific Stress and Sport-Specific Recovery for the players as a group for the seven assessments completed over the season. The internal consistency of test items varied between testing periods with a range in Cronbach's α=0.80 to 0.95 and an overall Cronbach's α=0.84.

As a group, the players recorded a significantly higher score in the Physical Recovery scale at the end of the competition season (Month 6) compared with the pre-competition period (2.17 ±1.25 vs. 1.12 ±0.40; F(6,8)=4.1; p=0.0345; t(14)=-2.8; p=0.0147: see Table 2). This was similar when comparing Month 1 with Month 2 of the competition season (1.76 ±1.32 vs. 2.58 ±1.32; F(9,15)=2.7; p=0.0416; t(24)=-3.1; p=0.0053). Players recorded a significantly higher score in Month 5 in the Being in Shape scale compared with Month 2 (3.08 ±1.02 vs. 3.02 ±1.30; F(7,5)=5.3; p=0.0430; t(12)=-2.6; p=0.0249). Players recorded a significantly higher Total Recovery in Month 4 when compared with Month 1 of the season (2.59 ±0.92 vs. 2.51 ±0.45 ; F(19,6)=5.6; p=0.0209; t(25)=-5.9; p<0.0001). Month 1 also recorded a significantly lower

Table 2: Scores (means ±standard deviations) of the different scales of the RESTQ-Sport(52) for General Stress, General Recovery, Sports-Specific Stress and Sport-Specific Recovery for 32 amateur domestic women's rugby union players in New Zealand over the 2019 domestic competition season.

Scale		Pre-Comp Mean ±SD	Month 1 Mean ±SD	Month 2 Mean ±SD	Month 3 Mean ±SD	Month 4 Mean ±SD	Month 5 Mean ±SD	Month 6 Mean ±SD
General Stress								
1	General stress	0.97 ±0.59	1.03 ±0.65	0.64 ±0.47	1.17 ±1.11	0.90 ±0.84	0.67 ±0.53	0.83 ±0.56
2	Emotional stress	1.21 ±0.56	1.25 ±0.53	1.22 ±0.51	1.52 ±1.13	1.32 ±1.08	1.15 ±0.85	1.20 ±0.46
3	Social stress	1.07 ±0.41	1.11 ±0.43	1.06 ±0.57	1.32 ±1.12	1.15 ±0.95	1.10 ±1.02	1.08 ±0.65
4	Conflicts/pressure	1.29 ±0.65	1.19 ±0.69	1.12 ±0.54	1.62 ±1.01	1.34 ±0.95	1.19 ±0.81	1.40 ±1.20
5	Fatigue	1.57 ±0.81	1.50 ±0.77	1.27 ±0.59	1.74 ±0.94	1.27 ±0.93	1.29 ±1.35	1.47 ±0.80
6	Lack of energy	0.96 ±0.39	1.06 ±0.44	1.34 ±0.61	1.44 ±0.95	1.29 ±0.91	1.21 ±0.71	1.00 ±0.52
7	Physical complaints	1.00 ±0.64	0.90 ±0.58	0.81 ±0.54	1.17 ±0.64	0.94 ±0.68	0.92 ±0.82	1.18 ±1.04
General Recovery								
8	Success	1.41 ±0.37	2.08 ±1.42	2.56 ±1.22	2.50 ±1.29	2.25 ±1.19	1.98 ±1.00	2.00 ±1.28
9	Social recovery	1.89 ±0.64	2.47 ±1.23	3.04 ±1.37	3.56 ±1.54	2.42 ±1.40	2.50 ±1.13	3.05 ±1.32
10	Physical recovery	1.12 ±0.40[f]	1.76 ±1.32[c]	2.58 ±1.32[b]	2.35 ±1.04	2.04 ±1.25	1.92 ±0.95	2.17 ±1.25[a]
11	General well-being	1.66 ±0.58	2.27 ±1.40	3.02 ±1.50	3.11 ±1.44	2.56 ±1.27	2.40 ±0.86	2.82 ±1.11
12	Sleep quality	1.43 ±0.61	1.99 ±1.44	3.18 ±1.42	2.82 ±1.41	2.67 ±1.08	2.92 ±1.21	2.62 ±1.19
Sport Stress								
13	Disturbed breaks	1.25 ±0.53	1.29 ±0.57	1.28 ±0.69	1.54 ±0.84	1.18 ±0.70	0.96 ±0.45	1.25 ±0.65
14	Emotional exhaustion	1.75 ±0.88	1.50 ±0.91	1.47 ±1.27	1.89 ±1.31	1.14 ±0.69	1.21 ±0.47	1.55 ±0.97
15	Injury	2.51 ±1.04	2.46 ±0.89	2.11 ±1.16	2.46 ±1.02	2.07 ±1.05	1.67 ±0.77	2.33 ±1.48
Sport Recovery								
16	Being in shape	2.32 ±0.85	2.76 ±1.23	3.02 ±1.30[e]	3.12 ±1.17	2.75 ±1.05	3.08 ±1.02[c]	3.00 ±1.40
17	Personal accomplishment	2.93 ±0.94	3.08 ±0.94	2.86 ±0.91	2.63 ±0.95	2.69 ±0.95	3.02 ±1.31	3.05 ±1.03
18	Self-efficacy	2.62 ±1.03	2.93 ±1.13	3.33 ±1.09	2.83 ±1.17	2.83 ±0.97	2.98 ±1.12	2.87 ±1.27
19	Self-regulation	2.95 ±0.87	3.25 ±1.12	3.22 ±0.77	3.48 ±1.18	3.11 ±1.24	3.73 ±1.32	3.87 ±1.36
Total Stress		1.36 ±0.42	1.33 ±0.41[h]	1.23 ±0.46	1.59 ±0.70	1.26 ±0.65	1.14 ±0.58	1.33 ±0.50
Total Recovery		2.04 ±0.46	2.51 ±0.45[dg]	2.98 ±1.02	2.93 ±1.01	2.59 ±0.92[b]	2.73 ±0.84	2.83 ±0.97

SD = Standard Deviation; Significant Difference (*p*<0.05) than (a) = Pre-Competition; (b) = Month 1; (c) = Month 2; (d) = Month 4; (e) = Month 5; (f) = Month 6; (g) = Total Stress; (h) = Total Recovery

Table 3: Scores (means ±standard deviations) of the different scales of the RESTQ-Sport(52) by non-injured and injured players for General Stress, General Recovery, Sports-Specific Stress and Sport-Specific Recovery for 32 amateur domestic women's rugby union players in New Zealand over the 2019 domestic competition season.

Scale		Pre-Competition		Month 1		Month 2		Month 3		Month 4		Month 5		Month 6	
		23 Non-Injured Mean ±SD	9 Injured Mean ±SD	22 Non-Injured Mean ±SD	10 Injured Mean ±SD	24 Non-Injured Mean ±SD	8 Injured Mean ±SD	26 Non-Injured Mean ±SD	6 Injured Mean ±SD	27 Non-Injured Mean ±SD	5 Injured Mean ±SD	24 Non-Injured Mean ±SD	8 Injured Mean ±SD	20 Non-Injured Mean ±SD	12 Injured Mean ±SD
General Stress															
1	General stress	1.00 ±0.53	0.94 ±0.69	1.00 ±0.58	1.08 ±0.77	0.60 ±0.49	0.72 ±0.45	1.02 ±0.90	1.65 ±1.66	0.95 ±0.92	0.65 ±0.22	0.63 ±0.59	0.83 ±0.29	0.69 ±0.39	1.04 ±0.75
2	Emotional stress	1.30 ±0.48	1.11 ±0.65	1.28 ±0.45	1.20 ±0.67	1.10 ±0.43	1.47 ±0.59	1.50 ±1.08	1.60 ±1.42	1.35 ±1.18	1.20 ±0.54	1.13 ±0.93	1.25 ±0.66	1.25 ±0.56	1.13 ±0.26
3	Social stress	1.10 ±0.43	1.03 ±0.40	1.09 ±0.40	1.13 ±0.49	1.00 ±0.55	1.19 ±0.64	1.22 ±0.92	1.65 ±1.71	1.16 ±1.03	1.10 ±0.55	1.08 ±1.12	1.17 ±0.76	1.19 ±0.75	0.92 ±0.47
4	Conflicts/pressure	1.20 ±0.56	1.39 ±0.75	1.13 ±0.66	1.30 ±0.76	1.04 ±0.54	1.28 ±0.53	1.64 ±0.90	1.55 ±1.41	1.33 ±1.02	1.40 ±0.58	1.15 ±0.92	1.33 ±0.29	1.06 ±0.65	1.92 ±1.68
5	Fatigue	1.45 ±0.81	1.69 ±0.83	1.34 ±0.74	1.75 ±0.80	1.13 ±0.54	1.56 ±0.61	1.58 ±0.94	2.25 ±0.81	1.26 ±1.02	1.30 ±0.27	0.98 ±1.07	2.33 ±1.89	1.39 ±0.81	1.58 ±0.85
6	Lack of energy	1.00 ±0.24	0.92 ±0.53	1.13 ±0.39	0.95 ±0.51	1.22 ±0.46	1.59 ±0.82	1.45 ±0.78	1.40 ±1.51	1.26 ±0.99	1.40 ±0.55	1.13 ±0.68	1.50 ±0.87	0.89 ±0.50	1.17 ±0.54
7	Physical complaints	0.88 ±0.56	1.14 ±0.73	0.80 ±0.47	1.08 ±0.72	0.69 ±0.30	1.06 ±0.83	1.23 ±0.71	0.95 ±0.27	0.97 ±0.69	0.85 ±0.68	0.93 ±0.90	0.92 ±0.63	1.19 ±1.01	1.17 ±1.17
General Recovery															
8	Success	1.28 ±0.18	1.56 ±0.46	2.42 ±1.71	1.53 ±0.45	2.68 ±1.28	2.31 ±1.12	2.78 ±1.25	1.60 ±1.08	2.24 ±1.21	2.30 ±1.24	1.70 ±0.69	2.92 ±1.46	2.08 ±1.32	1.88 ±1.34
9	Social recovery	1.78 ±0.59	2.03 ±0.70	2.73 ±1.44	2.05 ±0.66	3.26 ±1.52	2.56 ±0.87	3.70 ±1.65	3.10 ±1.18	2.35 ±1.42	2.70 ±1.40	2.25 ±1.05	3.33 ±1.15	3.19 ±1.21	2.83 ±1.56
10	Physical recovery	1.03 ±0.32	1.22 ±0.48	2.11 ±1.56	1.20 ±0.45	2.78 ±1.42	2.16 ±1.04	2.55 ±0.98	1.70 ±1.08	2.14 ±1.34	1.60 ±0.68	1.65 ±0.74	2.83 ±1.15	2.67 ±1.06	1.42 ±1.21
11	General well-being	1.38 ±0.44	1.97 ±0.58	2.52 ±1.69	1.88 ±0.63	3.32 ±1.53[c]	2.38 ±1.30	3.36 ±1.34	2.30 ±1.59	2.55 ±1.36	2.60 ±0.82	2.18 ±0.70	3.17 ±1.04	3.06 ±1.18[b]	2.46 ±0.98
12	Sleep quality	1.45 ±0.54	1.42 ±0.72	2.38 ±1.67	1.38 ±0.69	3.65 ±1.41	2.19 ±0.83	3.25 ±1.31	1.45 ±0.65	2.60 ±1.07	2.95 ±1.23	2.88 ±1.14	3.08 ±1.70	2.83 ±1.34	2.29 ±0.95
Sport Stress															
13	Disturbed breaks	0.98 ±0.32	1.56 ±0.56	1.16 ±0.56	1.50 ±0.55	1.06 ±0.67	1.75 ±0.48	1.39 ±0.75	2.00 ±1.03	1.15 ±0.75	1.30 ±0.48	0.88 ±0.44	1.25 ±0.43	0.83 ±0.35	1.88 ±0.47
14	Emotional exhaustion	1.55 ±0.83	1.97 ±0.93	1.28 ±0.83	1.85 ±0.96	0.97 ±0.89	2.53 ±1.34	1.47 ±0.86	3.25 ±1.67	1.01 ±0.68	1.70 ±0.51	1.28 ±0.51	1.00 ±0.25	1.08 ±0.61	2.25 ±1.04
15	Injury	1.75 ±0.63	3.36 ±0.66[c]	1.94 ±0.56	3.30 ±0.65	1.46 ±0.64	3.50 ±0.65	2.00 ±0.60	3.95 ±0.48	1.67 ±0.59	3.80 ±0.89	1.38 ±0.58	2.67 ±0.29	1.36 ±0.74	3.79 ±0.99[a]
Sport Recovery															
16	Being in shape	2.28 ±0.85	2.36 ±0.89	3.02 ±1.39	2.35 ±0.84	3.32 ±1.33	2.38 ±1.01	3.23 ±1.23	2.75 ±0.95	2.93 ±1.05	1.95 ±0.67	3.13 ±1.08	2.92 ±1.01	3.39 ±1.39	2.42 ±1.30
17	Personal accomplishment	2.73 ±0.89	3.17 ±1.00	2.98 ±0.95	3.23 ±0.96	2.99 ±0.80	2.59 ±1.12	2.64 ±0.88	2.60 ±1.27	2.72 ±1.03	2.55 ±0.54	2.98 ±1.44	3.17 ±0.95	3.08 ±1.33	3.00 ±0.39
18	Self-efficacy	2.25 ±0.78	3.03 ±1.16	2.89 ±1.18	3.00 ±1.10	3.43 ±0.89	3.13 ±1.48	2.95 ±1.17	2.45 ±1.22	2.92 ±1.05	2.40 ±0.22	2.95 ±1.26	3.08 ±0.63	3.11 ±1.28	2.50 ±1.28
19	Self-regulation	2.60 ±0.81	3.33 ±0.81	3.30 ±1.27	3.18 ±0.91	3.41 ±0.75	2.81 ±0.68	3.59 ±1.11	3.10 ±1.43	3.09 ±1.37	3.20 ±0.37	3.70 ±1.31	3.83 ±1.66	3.53 ±1.60	4.38 ±0.74
Total Stress		**1.22 ±0.29**	**1.51 ±0.50**	**1.21 ±0.29**	**1.51 ±0.47**	**1.03 ±0.35**	**1.67 ±0.37**	**1.45 ±0.58**	**2.03 ±0.94**	**1.21 ±0.70**	**1.47 ±0.33**	**1.05 ±0.59**	**1.43 ±0.53**	**1.09 ±0.38**	**1.68 ±0.48**
Total Recovery		**1.86 ±0.34**	**2.23 ±0.51**	**2.70 ±0.34**	**2.20 ±0.50**	**3.20 ±1.04**	**2.50 ±0.84**	**3.12 ±0.96**	**2.34 ±1.05**	**2.62 ±1.01**	**2.47 ±0.46**	**2.60 ±0.81**	**3.15 ±1.01**	**2.99 ±1.07**	**2.57 ±0.84**

SD = Standard Deviation; Significant Difference (*p*<0.05) than (a) = Month 1; (b) = Month 2; (c) = Month 6

Total Stress score when compared with Total Recovery (1.33 ±0.41 vs. 2.51 ±0.45; F(19,6)=52.8; p<0.0001; t(25)=-4.2; p=0.0003).

Injured vs Non-Injured

When RESTQ-Sport data were analysed by injured versus non-injured (Table 3), there were significant differences with non-injured players recording a higher General Well-being scale score in Month 2 (3.32 ±1.53 vs. 3.06 1.18; F(4,4)=13.2; p=0.0142; t(8)=-3.5; p=0.0081) when compared with Month 6. Injured players recorded a significantly higher Injury scale score in Month 6 (3.79 ±0.99 vs. 3.36 ±0.66; F(2,3)=16.0; p=0.0251; t(2)=-2.6; p=0.0483) when compared with pre-competition.

Discussion

As shown by this study players recorded a higher score in the Physical Recovery scale at the end of the competition season (Month 6) compared with pre-competition, and Month 2 was significantly higher than Month 1. There was a significantly lower Total Stress score compared with the Total Recovery score for Month 1. Non-injured players recorded a higher General Well-being scale score Month 2 compared with Month 6 than non-injured players. Injured players recorded a significantly higher Injury scale score in Month 6 compared with pre-competition than non-injured players.This study utilised the RESTQ-Sport to monitor the stress and recovery of amateur domestic female rugby players over a competition season. Although there are other monitoring tools available for monitoring of sports participants (Total Quality Recovery (TQR) scale,[9] the Daily Analysis of Life Demands for Athletes (DALDA) scale[28] and the Recovery-Cue[29]) these were reviewed and the RESTQ-Sport appeared to be more suited to this type of study environment as it has been reported to be able to be utilised as a guide for intervention strategies as it provides comprehensive insights about possible sources of stress and lapses in recovery.[30,31]

When analysed on an individual basis there were more observable differences in RESTQ-Sport scale scores than in the group analysis. These results were similar to a previous study in rugby union where it was identified that the RESTQ-Sport was more beneficial for use on an individual basis than on a group level.[20,21] This trend was also reported by the authors of the RESTQ-Sport.[15] The RESTQ-Sport has been reported to be useful for a review of lowered performance and for the identification of current stress and recovery but not for the prediction of future performance and injury.[21] However, unlike previous studies reporting on the RESTQ-Sport in team sports, our study was conducted monthly and not weekly in order to identify if there was an overall trend as well as differences in individual players stress and recovery.

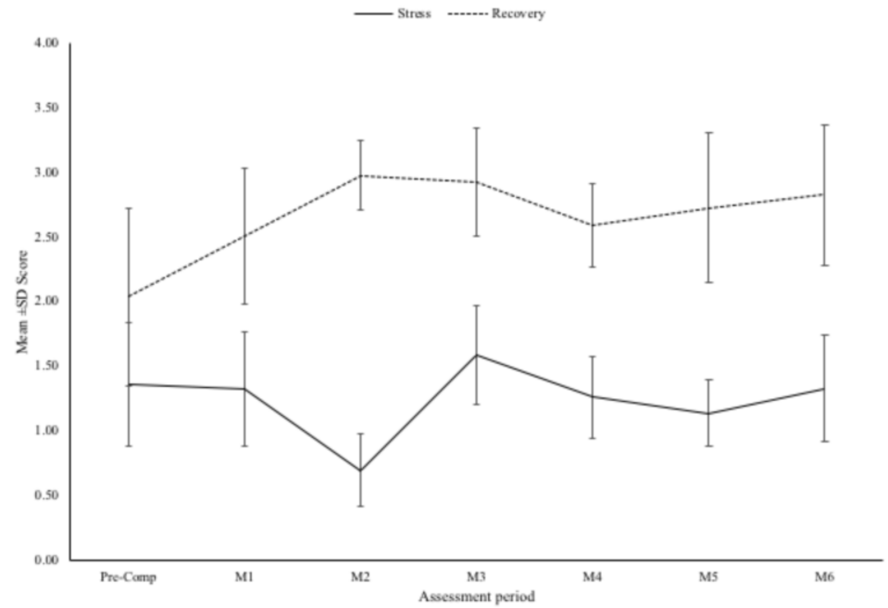
When the RESTQ-Sport was utilised across all players as a group there were small differences observed in most of the scales. However, when the RESTQ-Sport was utilised for the assessment of injury recovery, differences were more evident for individual players.

The analysis of injured versus non-injured players (Table 3) showed that overall, injured players reported higher scale scores in the Total Stress aspect for Conflicts/Pressure, Fatigue, Physical Complaints (General Stress), Disturbed Breaks, Emotional Exhaustion, and Injury (Sport Specific Stress) when compared with the non-injured players. When comparing the Total Recovery aspects, it can be seen that the players recorded lower scores when the competition started for Being in Shape, Personal Accomplishment, Self -Efficacy and Self-Regulation (Sport-Specific Recovery). This is similar to previous studies[12,32] where injured players recorded high scores in the Fatigue, Emotional Exhaustion and Injury scales and low scores in the Self-Efficacy scales when compared with non-injured players. It has been suggested[12,32] that changes in these scales may be predictive of an injury but further longitudinal studies are warranted on a larger cohort.

As can be seen in Figure 1, the stress level decreased at Month 1 then increased again. This testing period was programmed to occur after the first match of the competition to examine whether there were any effects on stress and recovery at the start of the competition season and then again, each month after a match. Unfortunately, on two occasions the opposition team defaulted the day before a match was scheduled to occur and therefore the testing was undertaken the day after. The effects of an unscheduled no-match weekend resulted in some of the team members undertaking other social activities which corresponded with a decrease in the reported stress levels. This is similar to a previous study[13] where unscheduled changes in the competition resulted in individual players having to adjust activities outside of the game that resulted in observable changes in players stress-recovery scores. Further research is warranted on a more regular basis to see if there are meaningful changes in individual and groups recovery-stress scores due to changes in the competition season.

Whilst the RESTQ-Sport has been utilised for the monitoring of players in rugby league,[12,13] rugby union[20] and soccer,[22] it has been reported[12] to be able to identify amateur players at risk of injury. Similar to previous studies,[12,13,32] when the scores for all aspects of the RESTQ-Sport were retrospectively reviewed, injured players had lower recovery-related scores and higher stress-related scores than non-injured players. Of note, current

Figure 1: Total stress and total recovery scores of the RESTQ-Sport(52) of amateur domestic women's rugby union players over a competition season in New Zealand.



players in this study who exhibited such a profile and had a high injury score, were identified retrospectively to have been injured during rugby union activities over the duration of the study. It has been recommended[12,32] that a shorter version of the RESTQ-Sport specifically for injury risk assessment may be useful for sports participants. As previously identified,[12,32] this would mean a shortened version of the current questionnaire enabling less disruption to the individual participants.

Limitations

Although the players completed the RESTQ-Sport prior to a training session, the results were not able to be reviewed until later due to the time requirements for the analysis of the results. Despite this, the attained results were useful for future follow-up and provided the individual players with a visual representation of their results compared to the average group results.

Players were not asked to report prior injury history, menstrual cycle phase, nor use of contraception. The authors acknowledge that hormonal concentrations might affect RESTQ-Sport responses however we are not aware of any studies that have addressed this.

CONCLUSION

This study utilised the RESTQ-Sport to monitor the stress and recovery of amateur domestic female rugby players over a competition season. Although there were some noticeable differences in the group analysis this did not occur on all aspects of the RESTQ-Sport, but when analysed on an individual basis there were more observable differences identified. Changes in these scales may be predictive of an injury when comparing injured with non-injured players, but further longitudinal studies are warranted on a larger cohort

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Goals not roles

REBECCA LONGHURST, BRUCE HAMILTON

INTRODUCTION

It takes many hands to make light work, but too many cooks spoil the broth. In the field of elite sport how do we work together, as multiple disciplines, to ensure that this delicate balance is achieved and performance goals are met? As Ebonie Rio[11] and David Opar[8] so eloquently put it in their 2015 editorial; "can we all play nice together?".

In the high-performance sporting environment, the ability for all member of the inter-disciplinary team (IDT) to communicate well and work together towards a common goal is integral. Having goals rather than the traditional disciplinary roles can help streamline this process. Often the complexity within a case may not be in the diagnosis and management of the injury. Instead the complexity may lie with how the case is managed across multiple disciplines.

As a discipline, Sports Physiotherapy continues to evolve the ability to interact with all members of the health and wider performance team to ensure optimal patient outcomes. Working together to establish common goals and speaking a common language of performance can help to foster this process. Understanding and respecting when each discipline should lead and when they should defer to others and follow is integral to being part of a successful IDT, which can lead to streamlined successful outcomes for athletes.

PRESENTATION

Athlete X is a 24-year-old Paralympic Bronze Medal swimmer who races the; 50m 100m and 400m freestyle and 100m backstroke events. Athlete X was born with L1 sacral agenesis, which presents as; normal anatomy from L1 up, incomplete bony formation below L1, no sacral formation and incomplete pelvis and lower limb formation with limited hip, knee and ankle movement. Athlete X mobilises primarily in a wheelchair and is not able to actively propel through the water with the lower body.

Athlete X presented with a history of chronic left shoulder pain that had slowly and steadily become increasingly problematic over the preceding few months. A constant low level ache was present and was exacerbated by; more demanding speed or power based sessions in the water, transferring in and out of the pool, transferring in and out of the wheelchair and overhead activities. Night pain was present and significant enough to require medication. No intervention or modification to training utilised over the past few months had been able to change the shoulder pain.

There were several changes within activities of daily living (ADLs) that were increasing demand on the shoulders. Due to changes in living situation additional load was added to the shoulders with having to navigate a flight of stairs in and out of the house. Prior to the Rio Paralympic Games Athlete X was fitted with a new wheelchair. This custom-built chair had a lower backrest height than the incumbent chair to allow more movement in the gym. The trade-off for more freedom of movement was that it removed the passive stability offered by the chair and therefore more active postural control was required, that potentially was not attainable. Due to the pain in Athlete X's shoulder, swimming at higher speeds or longer duration was not possible resulting in a decrease in cardiovascular training and subsequent increase in skinfolds over the preceding year.

Pain was experienced across most of the shoulder complex rather than an exact location. A habitual posture of protracted shoulders with mild scapula abduction, upward rotation and slight elevation of the left was adopted. Range of motion testing showed a loss of 5 degrees of external rotation both at 0 and 90 degrees of abduction and a 5 degree increase of internal rotation on the left side when compared to the right. Thoracic rotation was restricted bilaterally and although this had been a continual work on, this had remained unchanged over the past 4 years. This reduced thoracic mobility may be attributed to the thoracic spine locking down to attain some stability to compensate for the inability for core musculature to do this, bearing in mind the function below the L1 level is affected by the sacral agenesis. With swimming the ability to rotate through the thoracic spine is critical to be sure that the shoulders are able to work efficiently. All resisted testing of the shoulder, reproduced a low level of pain in the lateral shoulder region. Hand-held Dynamometry testing showed an 12% decrease in the power of the left shoulder (external rotation in neutral) compared with the right. Jobes relocation test was negative and pain was reproduced with; Hawkins, Empty Can, Biceps Tendon Loading and O'Briens. Multiple areas throughout the surrounding shoulder musculature were tender on palpation, particularly the biceps tendon and anterior joint line. Tenderness on palpation was also present in the left sternoclavicular joint and bilateral acromioclavicular joints with right being more tender than the left.

Previous bilateral surgical intervention for Osteochondritis Dissecans (OCD) in the elbows was another factor that could be increasing the load on the shoulder complex. Of interest, a revision to the OCD surgery on the left elbow was required two months into the rehabilitation process for this shoulder issue, lending further weigh to the argument that movement patterns may have been changing because of what was happening anatomically at the elbow joint.

MRI showed a mild tendinopathy of both the supraspinatus and subscapularis tendon, with mild disruption to the continuity of the supraspinatus tendon on the bursal side. The acromioclavicular (AC) joint showed moderately increased signal on T2 images, but no overt degenerative changes were noted with only a small amount of sub-acromial inflammation. The Glenohumeral joint itself, appeared within normal limits. There was no significant change between the MRI results from 2015 to the present scan two years later.

The diagnosis of an acute flare of chronic rotator cuff tendinopathy was made. Consultation with the coach did not flag any technical considerations that could be earmarked as causing shoulder issues. The current escalation of Athlete X's recurrent rotator cuff issues was attributed to; increase in load (swimming, ambulating in wheelchair and activities of daily living), posture and scapula dyskinesis.

MANAGEMENT

The complexity in this case does not lie in the diagnosis of the shoulder pathology, but in the multi-factorial and inter-disciplinary team (IDT) approach to long term management of Athlete X's shoulder. Central to this was the Athlete's potentially conflicting goal of both swimming fast at the 2020 Tokyo Paralympic Games and maintaining the long-term health of the shoulder. Rather than focussing on how the IDT could expedite the return to training, decisions were also framed around how the shoulder health could be optimised post their athletic career. Work from Raysmith et al[10] shows that athletes are 7 times more likely to achieve their performance goals if they are able to complete more than 80% of their planned training, therefore the first step for the IDT was to establish what normal/planned training into a pinnacle event would look like, and what input the IDT, as a whole and parts thereof, would play in this.

A meeting was held with the Sports Physician, Physiotherapist, Strength and Conditioning Coach, Coach and Athlete to discuss the shoulder and the long-term planning around the shoulder. The 'Swim Fast Tokyo 2020' framework was discussed and developed from this meeting (see Figure 1). The IDT approach to managing the barrier to optimal training was then established. Four broad areas in which the IDT could help overcome the restriction that the recurrent rotator cuff

Optimal Training	Swim 40kms per week	Full S&C programme 3 x 75 minute sessions per week	Power and Speed based sessions 2-3 times a week

Barriers to Optimal Training	Recurrent Rotator Cuff issues

Strategies to overcome present barriers	Reduce pain in shoulder	Attain and maintain race weight	Manage load in shoulder	Optimise scapula function, strength and dynamic stability	Optimise athlete wellness

Interdisciplinary Team Intervention	Analgesia management plan	↑ rotator cuff strength and function	Manage load of shoulders in the pool	Psychology consult	↑ cardiovascular fitness	Nutritional strategies	Postural correction	Manage load outside the pool	Prioritise university degree completion
Interdisciplinary Team involved	-Sports Physician	-Physio -S&C	-Coach -Biomech. -Athlete -Physio	-Psych -Coach -Physio -Sports Physician	-S&C -Physio	-Nutrition -Athlete Life Advisor	-Physio -S&C	-Physio -Athlete Life Advisor -Team Manager	-Athlete -Athlete Life Advisor

Figure 1. Framework for Swim Fast Tokyo 2020

issues were placing on the ability to optimally train and therefore swim fast in Tokyo 2020 were identified namely; reduce pain, manage load in the shoulder, attain and maintain race weight and optimise scapula function. The athlete wellness piece was added in at this juncture to reflect the importance of ensuring the IDT was looking at the whole athlete. In consultation with the athlete the athlete's life goal of finishing university in that current calendar year was brought into the Swim Fast Framework. It was then identified where each member of the IDT could help with each of these areas.

Firstly, an analgesia management plan was formulated and led by the medical team with the optimal outcome being a weaning off pain medications so that medications could be used for flare ups rather than a standard daily dose. Concurrent to this to help reduce pain and therefore the need for high doses of regular analgesia, rotator cuff strength and function and load in the shoulder were targeted.

Rotator cuff muscle function and strength were addressed with the inclusion of isometrics in the pre-swim routine, to target tendon pain and strength.[11] Rotator cuff pain free isotonic and eccentric strengthening throughout range along with isometrics were included in the gym programme. Posture was also targeted by physiotherapy with the addition of bite-sized pilates reformer sessions targeting scapula strength, proprioception and positioning along with verbal cueing and home based exercises. Hands on physiotherapy focussed on maintaining thoracic spine mobility and function and targeted associated musculature that required soft tissue intervention. The issue of load in a wheelchair athlete's shoulder requires a multifactorial approach and several types of load need to be considered (wheelchair load, activities of daily living load, swimming load, gym load and atypical load because of sacral agenesis and no core). A plan was established and led by the athlete's coach to slowly reduce Athlete X's swimming load down to a point where pain stayed stable throughout and between sessions, with no

analgesia on board. Once this non-symptomatic level had been found, a base was to be built and then load systemically increased over time. Due to the alien weightless environment of the pool,

Table 1. Daily loading affecting the shoulder outside of the pool environment

Activity	Daily Frequency
Transfers in and out of wheelchair	30-40 times
Time in wheelchair	10+ hours
Time spent pushing wheelchair	300 minutes
Lifting chair (X kg with SmartDrive Xkg without SmartDrive) in and out of car	10-16 times
Daily uphill pushing	200-300m

swimmers tend to have poor outcomes in relation to return to sport if they spend prolonged time out of the water therefore maintaining some swim training was of high priority for Athlete X.

Load outside of the pool was then monitored over the week by the athlete and averaged (Table 1). Attempts to manage this where possible were made so that extra loading for the shoulder could be saved for essential tasks and swimming.

The SmartDrive® is a device that ataches the axel of a wheelchair and assits in propelling the chair, thereby decreasing the effort required to propel the chair and potentially decreasing the load on the rotator cuff tendons. Unfortunately the benefits of first generation version of the SmartDrive, were negated by the additional 9kg weight of the unit added to the chair when the unit was not in operation and when lifting the chair in and out of the car. Issues with the battery also made the unit unsuitable for airline travel. The second generation SmartDrive ® is lighter, less bulky, significantly easier to travel with and includes a PushTracker, a device that measures total time and percentage effort of propelling the chair. Applications through multiple channels were intiated to update the SmartDrive ® to the newer model. Ramps were installed by the athlete and a power opening door at the Training Centre was installed to assist easy access.

Rolling resistance, or the force opposing the movement of the tires rolling on a surface, is an important factor when considering load on wheelchair users shoulder.[7] Reduced rolling resistance aides in propulsion by keeping the wheels rolling for a longer distance before another push is required. Under-inflation results in high rolling resistance and therefore more load on the shoulders. Inspection of tires showed they were often under-inflated and signs of extreme wear on the tires was present. The idea of switching from pneumatic tires to solid tires was investigated, as solid tires require less maintenance, however the decision to stay with pneumatic tires was made due to a) pneumatic tires have been shown to significantly reduce rolling resistance when compares to solid tires b) less shock absorption qualities from the solids and c) decreased performance outdoors and higher rolling resistance when pushing outside with solid tires.[5,13] Ultimately this means that the time and effort it takes to check and maintain adequate tire pressure is off set by the performance advantages and decreased loading on the shoulders that pneumatic tires offer when compared to solid tires. Regular tire maintenance and appropriate intervention when required was advocated by the IDT.

Performance nutrition input consisted of regular reviews and advice regarding attaining and maintaining race weight, support for meal planning for Athlete X and shopping on a budget that allowed maximal nutritional value.

Inability to train optimally in the pool resulted in loss of cardiovascular fitness. Subsequently cardiovascular components (utilising medicine balls, ropes and the grinder) were added to strength sessions in the gym with increases in speed and variations in rest periods and total weight lifted. Each addition to the gym programme was weighed up with careful consideration in respect to the loading of the shoulder. In an able-bodied athlete, the options for cross training whilst injured are higher and relative rest of the shoulder would be more easily attained. Changes to the strength and conditioning programme, and hence total load, were made taking into consideration both the short and long term benefits of the health and function of the shoulder and ultimately quality of life.

The presence and role of scapula dyskinesis in shoulder issues is well documented.[4] In a Paralympic athlete, the focus on ways to treat scapula dyskinesis needs to include posture (and therefore scapula function) whilst in the wheelchair. The ability to influence scapula dyskinesis for an athlete in a wheelchair is not as straight forward as it might be in the able-bodied athlete and is not always modifiable. Thus, posture correction and maintenance were approached from several different angles. Posture in the wheelchair can be driven by extrinsic factors such as seat back height and seat ergonomics.[7,5] In a study carried out by Cherubini and Melchiorri,[1] the authors found that 68% of prescribed wheelchairs were not suitable for their users. Due to concerns around posture, recurrence of their shoulder pain and the decrease in back height in the current wheelchair, a review of the wheelchair as arranged

The role of psychosocial factors in rehabilitation and rehabilitation outcomes cannot be ignored,[2] especially for athletes who spend longer periods of time in the 'rehabilitation' or 'injured athlete' space. As physical and psychosocial recovery rarely happen within the same timeframe, input from, and correspondence with, the Sports Psychologist that worked with Athlete X was sought. Rehabilitation was woven into the matrix of Athlete X's normal training routine to help with the feeling of being perpetually in the rehabilitation space and physiotherapy clinic.

CONCLUSION

As a Sports Physiotherapist focusing solely on what physiotherapy can do to help runs the risk of working in a silo and likely will not result in best outcome for an athlete. Understanding where each discipline may have input and accepting that often it is not physiotherapy that should take the lead in certain areas, is often a hallmark of a good Sports Physiotherapist. The complexity in this case was not in the diagnosis and physiotherapy management of the athlete, but instead in the ability to communicate and work efficiently as an IDT keeping the long-term goals and health of the athlete at the forefront of all thinking. As an IDT spending the time at the front end of a rehabilitation journey to ensure everyone is on the same page can aid in; a more holistic approach to recovery, consistent messaging, consensus around return to play (RTP) decisions, streamlining of necessary interventions and optimal outcomes for athletes.

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Junior doctor perspectives on exercise prescription in New Zealand

CARMEN Y CHAN

Summary

This article contains a discussion surrounding the perspectives and behaviours of junior doctors on exercise prescription in New Zealand. It explores the international research on exercise prescription, the exercise vital sign and also discusses how exercise prescription and screening can be incorporated into the clinical consult, and tertiary hospital setting.

Key words: exercise prescription, junior doctor, exercise vital sign, primary prevention, New Zealand.

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I am a junior doctor . Earlier this year, I undertook an exercise prescription paper, and while I knew generally that 'exercise is important for health', being shown the evidence based research on sedentary behaviour and physical inactivity makes me ponder if we need a radical paradigm shift in the medical sector to screen for physical activity in hospitals as much as we do in screening for smoking, alcohol and recreational drug use.

Increased amounts of physical activity has direct association with mitigating the severity of non communicable diseases, and increasing one's VO2max has direct correlation with mortality and morbidity.[1] Yet worryingly, 49% of New Zealanders do not meet the minimum national guidelines for the recommended 150 minutes of moderate physical activity per week.[2] On a daily basis, people present to hospitals with non-communicable diseases, it is often a critical moment in a person's life, and as healthcare professionals it can be a pivotal opportunity for influencing change behaviours.

For two years, I have worked with the inpatient hospital services in the medical, surgical and emergency departments. Along with reviewing medications, and facilitating the patient-team interface, I also discharge patients when they are well enough to go home. While I'd often ask about smoking habits or alcohol use on admission, I had rarely enquired about physical activity (PA). Why? Well, I could offer nicotine replacement therapy for the smoker, and the CAGE questions[3] for the drinker, but until studying exercise prescription, I wouldn't have known how to structure exercise screening and intervention. Now that I do, I want to share what I've learnt with you and the healthcare sector: exercise is important.

I conducted a survey of my colleagues to enquire about our exercise prescribing behaviour, personal physical activity and perspectives. A survey utilising the Likert scale was delivered to PGY1-PGY3 junior doctors via the private graduated cohort Facebook 'class pages' of 2016 2018 of both Otago and Auckland medical schools, and to the PGY1-PG2 cohort in the Wellington region. A total of 58 doctors responded with the majority practising in their first or second year, of which 60% had trained at the University of Otago, 36% from the University of Auckland and 4% from overseas.

The survey showed that 69% of these junior doctors perceived that exercise prescription was 'important' or 'very important' in a clinical management plan, but that 59% 'rarely' or 'never' discussed exercise with their patients. I wasn't alone in being sparse with discussing physical activity with my patients: only 9% of my colleagues identified that they did this on a regular basis.

Most of these doctors (93%) undertook some form of exercise on a weekly basis themselves, and 70% of those who perceived that exercise was 'very important' exercised more than five times a week. However, despite these values, there was little correlation with physically active doctors discussing exercise any more with their patients than in comparison with their peers. Looking further into the international literature on this subject, a large cohort study performed by Solmundson[4] demonstrates similar findings - despite the commonly perceived perception than 'active doctor' equals a more 'active patient', no evidence of this was found in these junior doctor cohorts(5). While medical students perceived that physical activity counselling was relevant to their practice, research has similarly yet to identify how this translates into clinical practice with newly qualified clinicians.[4,6-8]

When comments were sought from the 58 junior doctors who responded to the survey regarding exercise prescription, the most commonly identified barriers included clinical time pressures, perceptions that exercise prescription was beyond scope of practice, not knowing the available exercise prescription programmes and resources for referral, and that discussion of physical activity was not a priority in the acute setting. As commented by a junior doctor colleague, "there shows a real cognitive gap here!"

This 'cognitive gap' identifies an opportunity for creating positive change. Junior doctors are well positioned to screen for physical activity and have significant potential for influencing intervention.[9] It's our responsibility. The New Zealand Curriculum framework details that we have a mandate to 'advocate for healthy lifestyles and discuss environmental and lifestyle risks to patient health'.[10] We know that clinicians can play a role in influencing behaviour change,[9] and we need to do this more often – especially as we know that providing counselling on physical activity has more of an impact when it is applied in the context of a specific health problem.[11]

The world is catching up to this. In 2007, the Exercise Is Medicine (EIM) global health initiative was launched in the United States by the American College of Sports Medicine to promote physical activity assessment in clinical care.[12] Recognising the benefit of physical activity in treatment plans, this initiative had three aims:

1 To encourage that clinicians screen for a patient's level of physical activity.

2 That a patient's physical activity is compared with national guidelines.

3 That patients are given physical activity counselling or referred onwards if they do not meet national guidelines.[13]

So, what can we do? A validated tool known as the 'Exercise Vital sign'(EVS)[14] is a simple screen for PA that one may use at admission to offer exercise prescription to mitigate or improve chronic conditions or non-communicable diseases. The key components in this tool involve two questions that can be conducted in less than a minute:

1 "On average, how many days per week do you participate in moderate to vigorous PA (eg, a brisk walk)?"

2 "On average, how many minutes per day do you perform PA at this level?"

This exercise prescription tool is now incorporated into the education curriculum of both New Zealand medical schools. At the University of Otago, it is taught through clinical skills tutorials in the 'Early Learning in Medicine' phase, and also during the presurgical exercise intervention education during the Advanced Learning in Medicine phase.[15] At the University of Auckland, the value of exercise has been recognised through the Health and Wellbeing domain, and the university prescribed pocket clinical handbook[16] now includes a component which teaches a student to 'ask about amount and type of exercise over a typical week'. Education surrounding the use of the 'green prescription' – a referral to the government initiative is also provided.[17]

As stated by sports medicine guru Dr Robert Sallis "clinicians have a duty to assess the exercise habits of every patient and make sure the patient understands the health risks associated with inactivity". As healthcare professionals, we all have role and ethical obligation in primary prevention in discussing alterations in health detrimental behaviours.

Imagine working in a hospital setting where a patient's exercise vital sign is noted in every admission history. With each consultation, we ask about physical activity, and track the amounts that have been done over time. We regularly refer a patient to a fitness professional as much as we do to the outpatient cardiology services or endocrinologists, and with follow up we notice out patients getting better. Kaiser Permanente, a healthcare system in California has started doing this, and has demonstrated that patient populations who have had their EVS reviewed have greater relative weight loss, and for those with diabetes, a greater relative HbA1c decline compared to cohorts that do not have a EVS review.[18]

We are here to improve lives, mitigate the detriments of disease and ailment. We can do this through encouraging a simple intervention as natural as walking. For creating healthier lives, and populations, clinicians need to screen for physical activity, and offer an avenue for exercise prescription at every consultation. We need to familiarise ourselves with national standards and recommendations for physical activity and get ourselves, our patients, and our communities moving.

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Graeme Campbell

General and Soft Tissue Surgeon, Sports Medicine Pioneer in the Waikato

CHRIS MILNE

Graeme Campbell, one of the trail blazers in early sports medicine in New Zealand, died recently. He was my first mentor in sports medicine and was hugely influential in sports medicine both in the Waikato and nationally.

His professional background was as a general and pediatric surgeon and he had a long-standing public hospital appointment at Waikato Hospital. In addition, he ran a successful private practice. One of his career highlights as a surgeon would have been a successful separation of Siamese twins that was performed with Stuart Brown, fellow pediatric surgeon, and multiple other colleagues in the 1990's. This made national news headlines.

His sports surgery practice was particularly helpful for those athletes with chronic compartment syndrome and recalcitrant Achilles tendon problems. At the time he was most active in the field, not many orthopedic surgeons had much of an interest in those pathologies, so he got plenty of referrals from far and wide.

He had a longstanding involvement with the then New Zealand Federation of Sports Medicine both at a local branch level and nationally. Before the national office moved to Dunedin, it was pretty much Noel Roydhouse, Mayne Smeeton and Graeme who ran things. Graeme would drive up from Hamilton to meet with the others, and from early anecdotes it would appear that a good portion of the intellectual property and records of the organisation resided in his briefcase. He was SMNZ's President from 1977 until 1981, awarded Fellowship in 1990 and Life Membership in 1996.

He was also a chapter author in the first definitive sports medicine textbook co-authored by John Williams, a surgeon, and Peter Sperryn, a physician. Graeme wrote the chapter on abdominal injuries. I quote directly from the introduction to his chapter on thoracic, abdominal and perineal injuries. "Injuries to the thorax, abdomen and perineum occur usually in the contact sports as a result of direct trauma. Fortunately, on most occasions the injury is only a minor one and can be dealt with easily. In some instances, however, it may be of greater significance – Aristotle himself describing how 'even the slightest blow could rupture an intestine without sign of injury to skin'. Sports injuries can therefore lead to serious problems and they can even be fatal. All attending physicians should be aware of these possibilities and they must be on guard constantly for the detection, early diagnosis and subsequent treatment."

Graeme also had appointments as team doctor. His most prominent role was as team doctor for the 1974 Commonwealth Games team in Christchurch. He was also team doctor at the 1976 Montreal Olympics and appointed again for the 1980 Moscow Games, and of course because of the Soviet invasion of Afghanistan, only four NZ athletes went to those games.

He was very encouraging of any young clinicians who took an interest in sports medicine. My first meeting with him was in Auckland at the conference of the Australian and New Zealand Association for the Advancement of Science. Graeme had given a lecture and then spent a good half hour with me explaining what the field involved. I would regard him as my first mentor in sports medicine.

He will be remembered by many who were present at the SMNZ conference in Wellington in 2010. He gave an 'off the cuff' talk at short notice about how things were in the early days and had the audience spellbound with some classic anecdotes. I seem to recall one where he had difficulty moving heavy furniture, possibly a piano. He managed to get a good few of the Waikato rugby players to help with the task!

Graeme set up the first medical cover for the Waikato rugby team for home games in the late 1960's. He chaired a panel of 4 doctors showing his passion for rugby and the Waikato with his regular support.

He was Christian in belief and in action and volunteered his time especially later in his career when he went to Pakistan for several months.

I visited him at his home in Woburn, Lower Hutt, a few years ago and we had a good catch up over tea and biscuits. His house exuded the old-world atmosphere that I so much enjoy, and he showed me his office which was crammed full of memorabilia including some of the early Sports Medicine New Zealand records.

All in all, a wonderful man and I feel privileged to have known him and been influenced by him.

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