THE UNIVERSITY OF SYDNEY

NSW SPORTING INJURIES COMMITTEE GRANT 2012

FINAL REPORT

13 May 2013

Injury Prevalence and Characteristics in Elite Junior Rugby League Players

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EXECUTIVE SUMMARY

Background

Rugby league is physically demanding contact sport and associated with higher injury rates than most other collision sports. The majority of injuries occur in a tackle, to the ball-carrier in the match environment. Few studies, though, report training injury rates which are less than match injuries. Only five studies, comprising players aged 6 to 19 years, describe injuries at the junior level. Injuries increased with playing standard and age which can be attributed to increased speed, body mass and greater collision forces. Injury incidence has increased over the past decade due to increased numbers of competitors, more matches within a season, higher match and training intensity, higher collision forces and changing physique of players. These findings underscore the importance of careful injury surveillance and management in the junior competition to reduce the risk of injury at a time when their bodies are still maturing biologically. The development of a standardised, operational sports injury surveillance paradigm in rugby league has lagged behind other contact sports.

With rugby league being such a physically demanding sport, many age, skill and physique-based factors are considered to be critical for optimal performance. Tackling proficiency, in particular, is a key requisite skill. The negative association between skinfold thickness and defensive performance reflected in fewer tackle attempts, completed and dominant tackles and lower tackling efficiency, highlight the importance of physique for success in rugby league. The physical attributes of Polynesians such as greater height and muscularity suggest they are suited for rugby league play, although no research has confirmed this. Junior male rugby league players are a unique population as adolescents at this age are still undergoing growth and maturation of muscle mass, strength and power which are all substantial contributors to performance. No studies have comprehensively documented the physique characteristics of junior rugby league players by using somatotype and internationally standardised guidelines.

This project **aims** to investigate the incidence and nature of injuries sustained by elite junior rugby league players, and to develop a systematic injury surveillance system that can be implemented in junior rugby league. The specific objectives are to:

1. systematically develop evidence-based measurement instruments;
2. establish an injury profile of players, describing the incidence and causes of injuries over a season in junior elite rugby league;
3. investigate the relationship between injuries and positional play; and
4. comprehensively describe the physique of junior representative rugby league players and examine differences between playing position and ethnicity.

Methodology

Participants were recruited from the NSWRL Junior Representative Competitions. Data collection involved the completion of five developed documents. The Players' Baseline Information Form was completed on recruitment by parents or players, and recorded demographic information and player characteristics. The Physical Activity Diary was completed by players to record the amount of time players spent in sporting endeavours and training outside of the current competition The Player Injury Notification Form was completed by the team medical trainer or other personnel to whom players reported for training and/or match injuries, and provided information about the mechanism, type and site of injury. The Injury Follow-up Form was completed by the team doctor, physiotherapist or medical/rehabilitation trainer who diagnosed the injury or determined the treatment of the injury and return to training and/or match play. The Match Exposure Form was used by the team managers or trainers to record players' game time as exact number of minutes spent in play, or to the nearest quarter of on-field play.

Each team was consulted to identify the staff members who would be responsible for co-ordinating the study and for completing each of the four latter forms. Implementation of the surveillance system was tailored for each team following discussion on feasible procedures for each team's operation. We conducted familiarisation of key staff by way of individual presentations on the objectives of the study, identifying members' roles and the main elements for the successful completion of the forms. A written explanation of the purpose of each form and how each was to be completed was also provided to all teams. All the paperwork was packaged and supplied to each team, and Reply Paid envelopes were provided for the return of the forms.

In the anthropometric profiling sub-study of the main project, players from the Under 18s Competition were invited to participate. Anthropometric characteristics were measured by accredited anthropometrists in accordance to the approved protocol. Measurement of: body mass; height (stretch stature); eight skinfold sites; five girths; and two bone breadths were made. Body fat was calculated from these data. Somatotyping was performed so that player position and performance could be related to adiposity (endomorphy), muscularity (mesomorphy) and linearity (ectomorphy).

Injury Results

A total of 385 players with mean age of 15.8 years were recruited. However, only 114 full data sets (5 teams of Under 16s: and 2 teams of Under 18s) were available for analysis due to poor compliance from clubs with respect to form completion and data collection. There were 109 recorded injuries; 92% were match-related and occurred mostly in forwards (66%) compared to backs (34%). Three-quarters of injuries were tackle-related (43% from being tackled, 32% from making the tackle). Injuries were classified as transient (no matches missed following the injury), mild (1 match missed), moderate (2-4 matches missed) and major (5 or more matches missed). Of the 109 injuries, 65% were transient, 18% mild, 15% moderate and 2% major. There were 38 non-transient injuries (ie missing one or more matches) which resulted in a total of 70 missed matches giving an injury incidence of 0.10/1000 playing hours compared to 0.15/1000 playing hours when all 109 injuries were considered. Examination of these 38 injuries showed that forwards now sustained 53% of injuries compared to 47% by backs

The most prevalent injured sites were the ankle, head/face, shoulder and sternum in the 109 reported injuries, accounting for almost half of all injuries. Ankle injuries produced the greatest match losses per player (3-5 games). Knee injuries caused 3-4 lost matches. We observed a differential pattern of injury between playing positions, where forwards sustained more shoulder, knee and sternum injuries, whereas backs suffered more quadriceps injuries. Training injuries (albeit small in number) followed a similar pattern to match-related injuries. The major injury types included bruise/cork/haematoma; sprain/ligament injury; concussion; and muscle tear/strain. Injuries predominantly occurred to ankle; head/face; shoulder/clavicle; sternum and quadriceps.

Injury Conclusions

For the first time, an injury surveillance mechanism was trialled in the elite junior representative competition. Most reported injuries are consistent with previous studies. Injuries are mainly transient with apparently inconsequential results. The findings suggest that rugby league is a safe participation sport for adolescent athletes.

No studies have previously position-specific injury types or sites in junior rugby league .Forwards sustain the majority of injuries, which reflects their higher game involvement in tackles and collisions. The injury patterns of players appear to be consistent with positional play where forwards are predominantly involved in tackling, and injuries more related to sprinting occur in backs. Injuries were more often sustained during the second half of matches. These findings suggest that fatigue or accumulative microtrauma, or both, may contribute to injuries in elite junior rugby league players. No studies have previously examined in junior rugby league.

The low injury rate likely reflects the poor compliance in reporting and underestimation of injuries. There was limited adherence to documentation by teams. Whilst club personnel agreed that routine injury surveillance and supervision is important, only a minority persevered with recording throughout the season.

Anthropometry Results

A total of 116 players (26% of the U18s competition) participated in the sub-study. Compared to age-matched boys in the general population, rugby league players were taller and heavier. All players were classified as endomorphic-mesomorphs (round and muscular). Compared to backs, forwards had significantly greater body mass index (BMI), girths, bone breadths and body fat. Forwards were also more endomorphic (round) and mesomorphic (muscular), but less ectomorphic (lean and tall) than backs. Polynesian juniors exhibited greater height, body mass, BMI, girths, bone breadths and mesomorphy (muscularity) than their non-Polynesian peers.

Anthropometry Conclusions

To our knowledge, this is the first study to comprehensively describe the physical characteristics of Australian junior elite rugby league players. Results indicate clear body composition differences between players and adolescents of the same age in the general community, between forwards and backs and between Polynesian and non-Polynesian players. Physique is a determinant of performance in rugby league. Greater body mass, muscularity, adiposity and bone size in forwards is desirable for tackling and attacking and may protect against high impact forces sustained in this position. The advantageous physical attributes of Polynesian players may influence selection into junior representative rugby league.

The **significance** of the study is that it has developed a standardised methodology for injury reporting and surveillance for implementation in junior elite rugby league. The study provides pilot data for a larger study to explore the identification and aetiology of risk factors for injuries; as well as the subsequent reduction in the likelihood of re-injury; the development of safe return to training and play guidelines, and recommendations for training volume and total game exposure to minimise injury from rugby league. The results provide a baseline for the longitudinal assessment of injuries and physique in junior rugby league players. Thus, the study will assist the code to develop a functional process for injury reduction/prevention programs and on-going athlete monitoring in order to achieve sustainable health in elite junior players for their long-term progression in rugby league.

2. BACKGROUND

Rugby league (RL) is an international collision sport where players participate in physically demanding high intensity activities such as running, tackling, passing and sprinting and interspersed with low intensity activities (walking, jogging). Musculoskeletal injuries are common to RL and injury incidence has been reported in 35 studies across all participants from elite to junior levels (1). Most injuries occur in the match environment, with rates typically increasing as the playing level increases. However, professional level injury rates (58-211 per 1000 playing hours[1]) are reportedly less than semi-professional participation (115-825 per 1000 playing hours) (1). Only seven studies have reported training injury rates (12-89 per 1000 training hours) which are less than match injuries (1).

Although the nature and incidence of injuries are well documented in senior RL players, only five studies conducted in Australian and New Zealand, describe injuries at the junior level (2-6). Three studies comprised players aged 16 to 19 years (2,3,6) while the cohort of two studies ranged from 6 to 15 years (4,5). Pringle et al.(4) also recruited from two additional sports (rugby union and netball) and rugby league players comprised 33% of the total sample (n=1730). Two studies recruited elite players (2,3). Compared with elite professionals, junior RL match injury rates range from 1 (5) to 197 (6) per 1000 playing hours (Table 1). Injury incidence in these age groups was similar to other football codes (5), although Pringle observed higher rates in RL compared with rugby union players (24.5 vs 15.5 per 1000 playing hours respectively) (4). The higher rates in King's study (6) was suggested to be the result of higher playing intensity during the shorter season. Injuries increased with playing standard (5) and age which can be attributed to increased speed, body mass (7) and greater collision forces (5). Raftery and colleagues noted that the largest rise in injury, observed from age 12 to 13, was due to the increase in players in a team (5). Furthermore, current injury incidence in elite junior RL is comparable to that of elite professional players because the relative playing intensity, speed and impact forces are similar (3).

Table 1: Injury Rate in Junior Rugby League Players

Study	Duration	Age (yr)	No Teams (No Players)	Average Injury Rate (per 1000 playing hours)
Estell et al. 1995 (2)	1 season	17-19	6	17.8 – 28.0
Pringle et al. (1998) (4)	4 weeks	6-15	(1730)	24.5 (RL players only)
Raftery et al. (1999) (5)	1 season	6-12	253	5.3 (range 1.4 – 13.0)
		13-15		14.9 (range 11.4-17.1)
		16-17		13.6 (range 13.5-15.6)
King et al. (2006) (6)	7 weeks	16-18	4	129.2
Gabbett (2008) (3)	4 seasons	17-19	1 (80)	56.8

[1] Injury incidence is reported as per 1000 playing/training hours and is calculated as:
(Number of injuries in the period / Number of Players x hours x matches) x 1000 (1)

The tackle is the main cause of injury in both junior and senior RL players. Injuries are greater to the ball carrier (51% (5); 19.2 per 1000 playing hours (3)) than to the tackler (40% (5); 10.1 per 1000 playing hours (3)). Fatigue may contribute to match injury by reducing tackling proficiency (3). The most common injury sites in juniors are shoulder (28%), knee (14%), ankle (13%) and head/neck (11%) (1,3-5). Ten percent of injuries were considered to be recurrent (5). Interestingly, shoulder injuries have surpassed knee injuries (in both juniors and seniors) which may be attributed to the changes in match rules of the 10m defensive line and ball stripping in the tackle. The main types of injuries seen in junior RL are sprains, fractures, predominantly in the peri-pubertal age group, and soft tissue bruising (5). Only Raftery (5) reported training injuries (18%) compared with match injuries (66%). Although the incidence and nature of injuries in junior RL have been documented, there are no reports evaluating injury severity, training injuries (with one exception (5)), and injuries relating to positional play, time of injury and seasonal variations.

A notable feature of the two recent studies (3,6) is the higher injury incidence compared with studies from the previous decade (2,4,5). Methodological differences may provide one explanation but other reasons could include: increased numbers of competitors, more matches within a season, higher intensity of play and training, and changing physique of players. Furthermore, for the first time, a study has empirically demonstrated that a history of hip/groin injury sustained during elite junior Australian Football (AFL) participation can predict missed game time through hip/groin injury in the elite senior competition (8). This result highlights the significance of injury in junior years that may negatively impact injury incidence during an elite senior career. Although this relationship has not been tested in RL, the findings underscore the importance of careful injury surveillance and management during junior years to reduce the risk of injuries during the elite senior competition.

Currently in RL, there is no standardised procedure in use for monitoring or recording injures from elite to junior competitions. The development of an operational sports injury surveillance paradigm in RL has lagged behind other contact sports such as rugby union, AFL, cricket and football (soccer), which have used the Orchard Sports Injury Classification (9,10). Rugby union (11) and football (12) have also developed Consensus Statements on injury definitions and data collection procedures, thus enabling comparisons between the sports (1) and consistent reporting. Although an injury reporting form has been developed for sports and used in RL (13), and most NRL clubs are using their own developed methodology, no systematic injury surveillance scheme has been adopted for the code. Two drawbacks to developing a standardised approach have been the inconsistencies in injury definitions and methodologies used, thus leading to difficulties in comparing injury data between studies (1). Variations in reporting injury incidence have been ascribed to small sample size, small numbers of teams, limited duration of study (1), different collection methods, different algorithms for estimating incidence and insufficient detail in reporting methodology (14). Studies using single clubs and short durations do not reflect the extent of player involvement and make generalisability of findings difficult. Whilst there is a trend to standardised reporting of injury, no set format has been agreed upon (1). However, a set of definitions and classifications for RL injuries, algorithms for calculating incidence and standardised methodology for data collection and reporting have been developed (15).

With rugby league being such a physically demanding sport, many age, skill and physique-based factors are considered to be critical for optimal performance. In professional players, attacking ability is associated with greater playing experience, faster speed and better perceptual skill qualities (16), while defensive performances are associated with tackling proficiency, greater age, experience, lower body muscle power and faster acceleration (16,17). The negative association between skinfold thickness and defensive performance reflected in fewer tackle attempts, completed and dominant tackles and lower tackling efficiency also highlight the importance of physique for success in this sport (16). At senior and junior levels, anthropometric measures such as body mass and adiposity have been reported as predictors of team selection (18,7), and have consistently been shown to discriminate between forwards and backs (19-12). Some ethnic populations may also have physical attributes suited for rugby league and/or certain positions. In particular, physical attributes of Polynesians such as greater height and muscularity are normally considered to be suitable for rugby sports (22), although no research has confirmed this in rugby league athletes.

Junior male rugby league players are a unique population as adolescents at this age are still undergoing growth and maturation of muscle mass, strength and power which are all substantial contributors to performance (23,24). Research in Australian junior elite players from one club observed that they were taller, heavier and leaner with greater maximal aerobic capacity, speed and acceleration than sub-elite juniors (25). Similarly, UK junior players were identified by greater age, height, maximal aerobic capacity and sprint speed, and lower body mass and skinfold thickness (21). Despite this research, no studies have comprehensively documented the physique characteristics of junior rugby league players by using somatotype and internationally standardised guidelines that include measurement of weight, height, skinfolds, girths and bone breadths (26,27). Use of wide-ranging and standardised anthropometric techniques allow for a more comprehensive and accurate comparison of players and teams, whereas somatotyping can be useful for relating player position and performance to adiposity (endomorphy), muscularity (mesomorphy) and linearity (ectomorphy) (27).

3. OBJECTIVES

This project aims to investigate the incidence and nature of injuries sustained by elite junior rugby league players, and to develop a systematic injury surveillance system that can be implemented in junior rugby league. The specific objectives are to:

1. systematically develop evidence-based measurement instruments (injury notification, injury follow-up and match exposure forms);
2. establish an injury profile of players, describing the incidence and causes of injuries over a season in junior elite rugby league;
3. investigate the relationship between injuries and positional play; and
4. comprehensively describe the physique of junior representative rugby league players and examine differences between playing position and ethnicity.

4. METHODS

Study Design

The study was a prospective cohort experimental design. The duration of the study was the 2012 season of the NSWRL Junior Representative Competitions. Participants were recruited from the Harold Matthews (under 16 years (U16)) and SG Ball (Under 18 (U18)) teams. All procedures involving human subjects in this study were approved by the Human Ethics Committee of the University of Sydney (protocol number 13933). Written informed consent was obtained from all participants and their parent or guardian.

Injury Definition

Sporting injuries have generally been classified as broad/complex, those that capture all injuries requiring first aid or medical attention (15) or narrow, those that result in missed games only (28). The broad definition results in increased volume of data to be recorded, a bias towards minor injuries, and increased potential for inconsistent and inaccurate reporting. The narrow definition results in a bias towards major injuries and may miss many soft-tissue injuries, but is simpler to use with less chance of error (29). Because there is scant data on injuries at junior level, we will examine injuries with respect to both definitions. Injury severity was categorised as transient (0 matches lost), mild (1 match lost), moderate (2-4 matches lost) or major (5 or more matches lost) (1).

Measurement Instruments

An athlete injury surveillance profile, standardised data collection methodology and reporting was developed. Measurement instruments were developed from injury information and forms used by rugby league (15), football (12), AFL, rugby union and cricket (9). Data collection involved the completion of five documents: Players' Baseline Information, Player Physical Activity Diary, Player Injury Notification, Injury Follow-up and Match Exposure Forms.

The Players' Baseline Information Form was completed on recruitment by parents or players and recorded:

1. Demographics (age, ethnicity);
2. Anthropometry and Physique (stature, body mass, body fat, bone breadths); and
3. Player Characteristics (position, participation level, play history, medical and injury history, use of headgear, involvement in other RL competitions and sports).

The Physical Activity Diary was completed by players to record the amount of time players spent in sporting endeavours and training outside of current competition (including rugby league played with other teams) in an average week. This form was completed at training. The training volume with the Junior Representative team was reported to researchers by the trainers.

The Player Injury Notification Form was completed by the team medical trainer or other personnel to whom players reported for injuries sustained at training and/or matches, and incorporated the following factors (primary outcome measures):

1. Characteristics (cause/mechanism, type, body region, severity, new/recurrent);
2. Onset (date, time, match/training, time period in match/training);
3. Diagnosing/treating person;
4. Initial treatment and referral;
5. Training time and match time lost

Definitions of injury, classification, severity, recurrence, training and match time lost were those determined by King and colleagues (1,15). Injury reporting should be completed as soon as possible after the injury is sustained for optimal accuracy. Where possible the injury should be recorded by the same individual for each team throughout the study.

The Injury Follow-up Form was completed by the team doctor, physiotherapist or medical/rehabilitation trainer who diagnosed the injury or determined the treatment of the injury and return to training and/or match play.

1. diagnosis of the injury
2. treating person
3. further referral for medical treatment and/or investigations
4. number of training sessions and/or matches missed
5. return to play with modified training

The Match Exposure Form was recorded by the team managers or trainers. players' game time recorded as the exact number of minutes spent in play, or to the nearest quarter of on-field play (15 min for U16s and 18 min for U18s). Definitions of training and match exposure were according to King et al. (2008) (15). Where possible the Exposure Report Form was recorded by the same individual for each team throughout the study.

Each team was consulted to identify the staff members who would be responsible for co-ordinating the study and for completing each of the four latter forms. Implementation of the surveillance system was tailored for each team following discussion on feasible procedures for each team's operation. We conducted familiarisation of key staff by way of individual presentations on the objectives of the study, identifying members' roles and the main elements for the successful completion of the forms. A short written explanation of what each form was for and how each was to be completed was also provided to all teams. All the paperwork was packaged and supplied to each team, and Reply Paid envelopes were provided for the return of the forms.

In the anthropometric profiling sub-study of the main project, players from the SG Ball Competition were invited to participate. For inclusion, players were required to be considered 'eligible to play'. Injured players who were unable to train or were ineligible for game selection were excluded.

Anthropometric characteristics were measured by International Society for the Advancement of Kinanthropometry (ISAK) accredited anthropometrists in accordance to the ISAK approved protocol for the restricted profile (26). This includes measurement of: body mass; height (stretch stature); eight skinfold sites (triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh and medial calf); five girths (arm relaxed, arm flexed and tensed, waist, gluteal and maximum calf); and two biepicondylar bone breadths (humerus and femur). All measurements were recorded in duplicate on the right side of the body (where appropriate). The mean of the first two measurements was reported if there was <5% difference between skinfolds or <1% for other measures. If the difference between the first two measures was outside these limits, a third measure was taken and the median of all three measures reported. Percent body fat was estimated using the equation of Withers et al (30), and somatotype determined using the Heath-Carter method (27).

5. RESULTS

A total of 385 players from 19 teams (10 Harold Matthews Under 16s and 8 SG Ball Under 18s) within 13 clubs were recruited. One team withdrew from the study. One club with two teams failed to provide any paperwork and is not included in the recruitment numbers.

Baseline information

The total number of 385 players comprised 201 Under 16 (U16) and 184 Under 18 (U18) players, with mean age 15.0 and 16.7 years respectively (an overall study mean age of 15.8 years) (Table 2). The major ethnic backgrounds were Caucasian Australian (67%) and more than one ethnic group could be selected. The participants reported an average of 8.5 years' experience in playing rugby league, and 65% of players participated in between one to six additional sports, some concurrently with the NSW Junior Representative Rugby League competition. Asthma was the most prevalent medical condition reported by players with 8% of players taking medications. With respect to supplementation, 36% of players reported administering 'supplements', protein powders in particular, and multivitamins. There was however a significant difference between U16 and U18 players' supplement use with U18s taking more than U16s (overall 44% vs 27% respectively). Only 7% of players (n=27) reported wearing headgear as protective equipment, however there was a poor (54%) response received.

Table 2 Player Demographics and Medical History

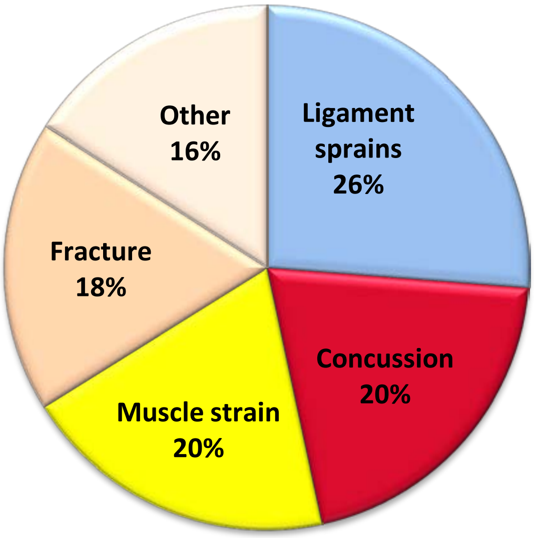
Variable	Total	Under 16	Under 18
Number of players recruited	385	201	184
Number of teams	20	11	9
Mean age (year)	15.8	15	16.7
Ethnic Background			
Caucasian Australian	67%		
Aboriginal or Torres Strait Islander	8%		
Polynesian	36%		
Rugby League participation (year)	8.5	8	9.1
Positions (n) Backs/Forwards/NR	168B 191F 26NR	89B 103F 9NR	79B 88F 17NR
Playing in other sports & competitions n (% reported responses), [NR]	242 (77%) [56]	135 (79%) [29]	107 (74%) [27]
Play in Headgear (n, % responses)	27 (13%)	16 (18%)	11 (10%)
All Supplementation n (% reported responses), [NR]	131 (36%) [24]	54 (28%) [7]	77 (46%)* [17]
Protein Powders	98 (29%) [48]	42 (42%) [23]	56 (35%)* [25]
Multivitamins	20 (6%), [57]	5 (3%) [41]	15 (9%)* [16]
Fish Oil / Omega 3 Fatty Acids	11 (3%) [26]	4 (2%) [11]	7 (4%)* [15]
Medical History			
Asthma n (%)	39 (10%)		
Allergies n (%)	18 (5%)		
Taking Medication n (%)	29 (8%)		

* Significant difference between U16 and U18 players (p<0.05), [NR] = Not reported ie, no response was

Injury History

Rugby league-related injuries sustained over the past 12 months (ie in the 2011 season) comprised ligament sprains (22.9%), concussion (17.8%), muscle strain (17.0%), broken bones (15.7%) and other injuries (13.9%) (Figure 1). The majority of ligament injuries were ankle (n=41, 48%), shoulder (n=12, 14%) and knee (n=10, 12%). Some players reported more than one ligament and muscle injury. Muscle strains occurred to the back (n= 15, 23%), hamstrings (n=12, 18%), calves, shoulders, quadriceps and ankles (n=10, 12% each). The most common broken bones reported were finger/thumb/hand (n=19) and wrist (n=12). Other injuries of note to be reported were shin splints, stress fractures, dislocated shoulders, osteopubitis and torn kidneys. Players also reported more serious injuries requiring surgical repair (total n=41) including reconstructions to shoulder (n=4), knee (n=3), ankle (n=3) and anterior cruciate ligament (n=2). The older U18 players primarily suffered these injuries. Of concern however, is the information that two U16 players required shoulder reconstructions.

Figure 1. Rugby League-Related Injury History for the 2011 Season



Injuries in 2012 Junior Representatives Season

Only 114 full data sets (U16: n=5 teams; U18: n=2 teams) were available due to poor compliance from clubs with respect to form completion and data collection. Of the 109 recorded injuries, 90% were (n=98) match-related and occurred mostly in forwards (66%) compared to backs (34%). However, using the definition of an injury as missing one or more matches, only 38 injuries were eligible for analyses. These resulted in 70 matches missed with an injury incidence of 0.10/1000 playing hours compared to 0.15/1000 playing hours when all 109 injuries were considered. There were only six mild to moderate training injuries recorded with a resultant loss of 8 matches. Table 3 shows the numbers and percentages of injuries related to match or training, and sustained by position play (ie backs and forwards). Table 4 illustrates the numbers and percentages of matches missed as a result of the injuries by match or training and positional play.

Table 3 Severity of injuries sustained during matches or training and by positional play

Injury Severity (Matches missed)	Major (5+)	Moderate (2-4)	Mild (1)	Transient (0)	Total Injuries
All injuries n (%)	2 (2%)	16 (15%)	20 (18%)	71 (65%)	109 (100%)
Injuries resulting in ≥1 match missed n (%)	2 (5%)	16 (42%)	20 (53%)		38 (100%)
Match-related n (%)	2 (2%)	15 (14%)	15 (14%)	68 (62%)	100 (92%)
Training-related n (%)	0 (0%)	1 (8%)	5 (1%)	3 (3%)	9 (8%)
By Backs n (%)	1 (1%)	7 (6%)	10 (9%)	19 (17%)	37 (34%)
By Forwards n (%)	1 (1%)	9 (8%)	10 (26%)	52 (48%)	72 (66%)

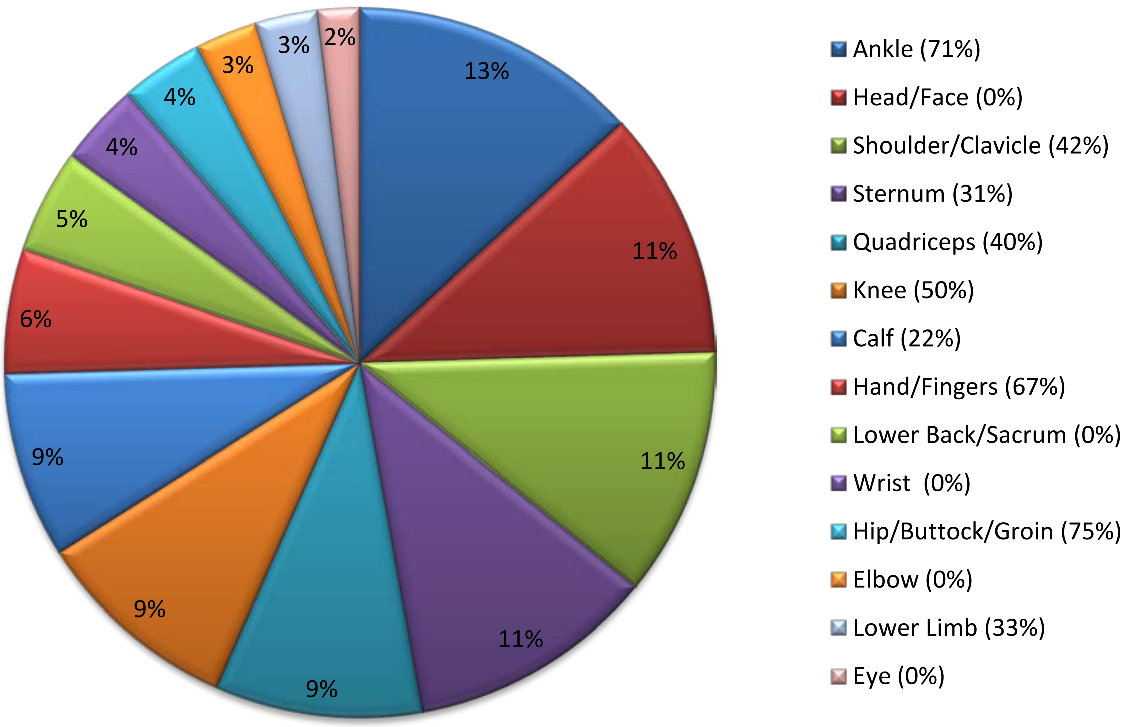
Table 4 Loss of matches as a result of injuries sustained during matches or training and by positional play

Injury Severity (Matches missed)	Major (5+)	Moderate (2-4)	Mild (1)	Total Matches Missed
All injuries n (%)	11 (16%)	39 (56%)	20 (29%)	70 (100%)
Match-related n (%)	11 (16%)	36 (44%)	15 (21%)	62 (89%)
Training-related n (%)	0 (0%)	3 (4%)	5 (7%)	8 (11%)
By Backs n (%)	6 (9%)	7 (10%)	10 (14%)	32 (46%)
By Forwards n (%)	5 (7%)	9 (13%)	10 (14%)	38 (54%)

Injury Site

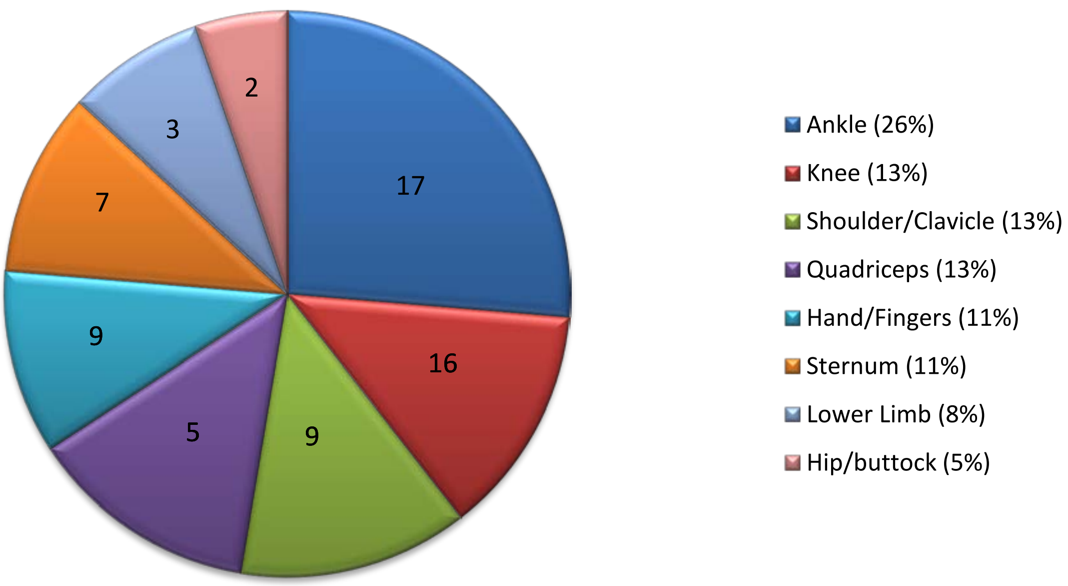
Ankle, head/face, shoulder and sternum injuries were the most prevalent of the 109 reported injuries, accounting for almost half of all injuries (Figure 2). Ankle injuries produced the greatest match losses per player (3-5 games). Knee injuries caused 3-4 lost matches; fractures and shoulder joint injuries resulted in 3 and 1-3 lost matches, respectively. Figure 3 depicts the sites of the 38 injuries that led to missed matches. Forwards sustained substantially more shoulder, knee, sternum and hand injuries and slightly more ankle injuries, than backs. Quadriceps, hip and buttocks injuries, however, were primarily experienced by backs. Training injuries occurred to the ankle (n=2), shoulder, hand/fingers and buttocks.

Figure 2 Sites of injury and per cent prevalence in junior rugby league players



Note: The per cent prevalence of injury is denoted within the chart. In the legend, the percentages with the body parts denote the per cent of that injured part which result in missed match(es).

Figure 3 Sites of injury and percent prevalence leading to missed match(es) in junior rugby league players

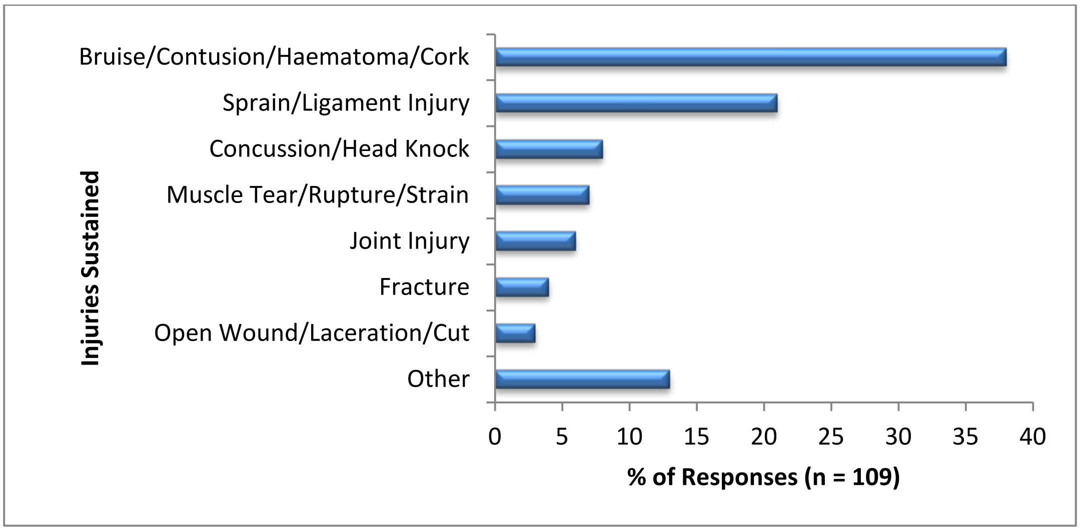


Note: the numbers displayed within each section denote the total number of matches lost as a result of injury at that site.

Injury Type

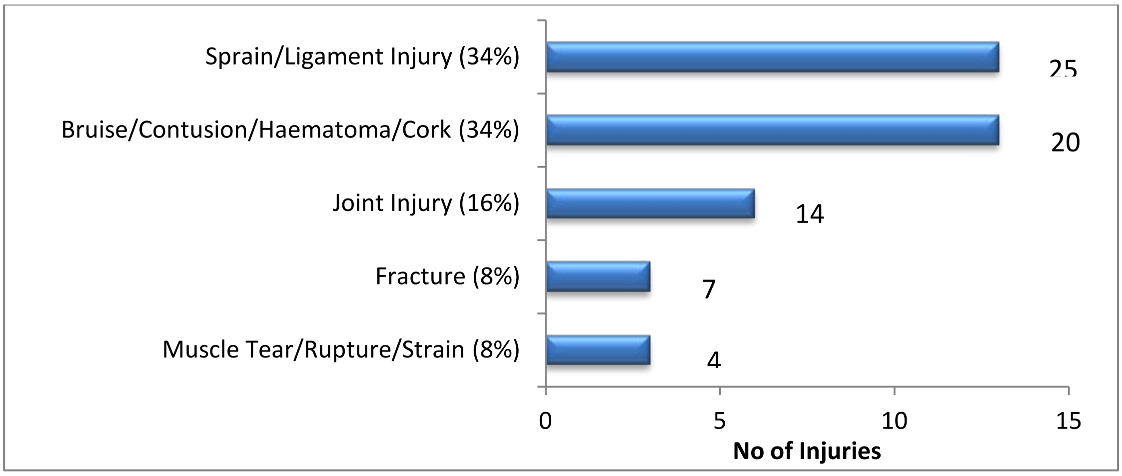
From all 109 injuries reported, the major injury types included bruise/cork/haematoma 48%; sprain/ligament injury 21%; concussion 7%; muscle tear/strain 7%. Injuries predominantly occurred to ankle 13%; head/face 12%; shoulder/clavicle 11%; sternum 11%; quadriceps 11% (Figure 4). Three-quarters of injuries were tackle-related: 43% from being tackled, 32% from effecting the tackle. Similarly, sternum injuries and corks/haematomas resulted in 1-2 lost matches. Training injuries resulting in loss of matches included a fracture, bruising, sprain/ ligament injury, muscle teat and joint injury.

Figure 4 Type of Injuries Sustained in all Recorded Injuries



The prevalence of injury types altered slightly when considering the 38 non-transient injuries only. (Figure 5). Although the prevalence of sprains and bruises are identical, more match time was lost from sprains and ligament injuries. Concussion was the third most recorded injuries and sustained by forwards (7 of 8 players). All injured players were able to play in the following match. Forwards also showed a higher incidence of contusions, joint injuries, muscle tears and ligament injuries, while fractures were equally distributed between backs and forwards.

Figure 5 Type and Prevalence of Non-transient Injuries Sustained



Note: the numbers displayed to the right of the bar denote the total number of matches lost as a result of the type of injury.

Mechanism of Injury

Three-quarters of injuries were tackle-related, approximately half of these from being tackled and one-quarter as a result of effecting the tackle (Figures 6 and 7). Injuries were more often sustained during the second half of matches (55%) compared with the first half (31%) and warm up (3%). However, 28% of injuries did not report when the injury occurred.

Figure 6 Mechanism of injury in all 109 recorded injuries

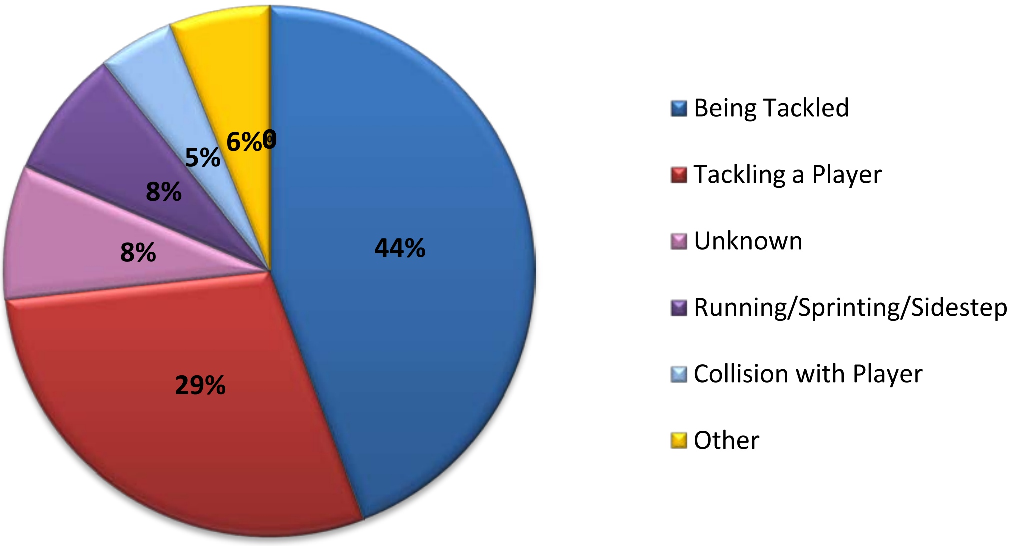
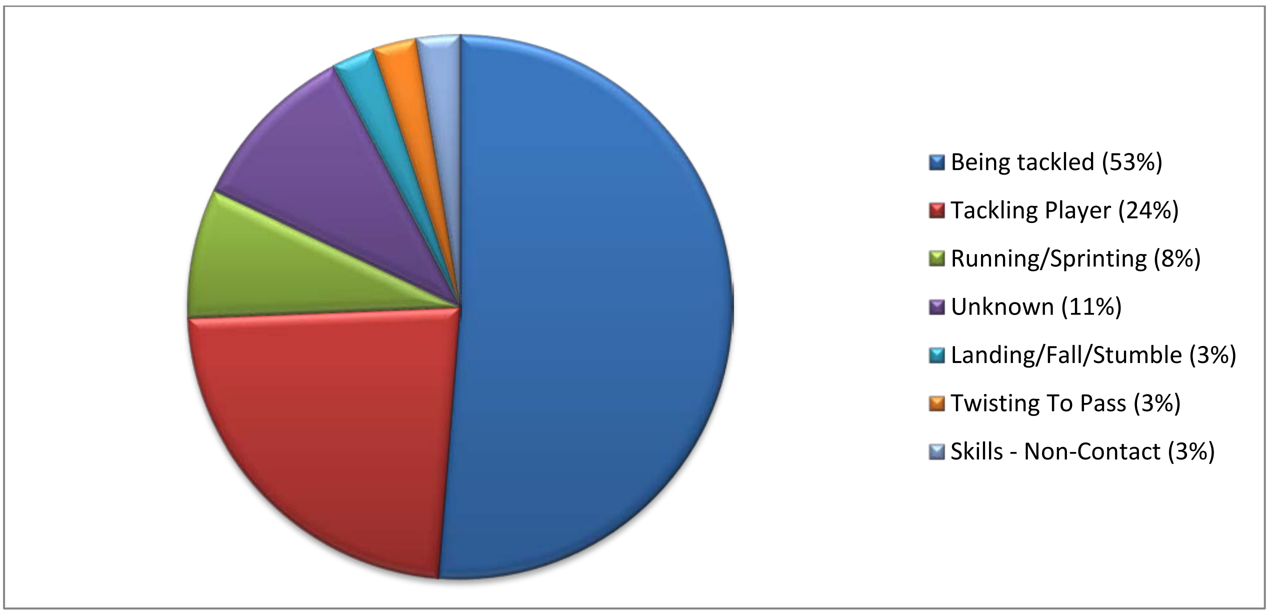


Figure 7 Mechanism of injury in non-transient injuries (n=38)



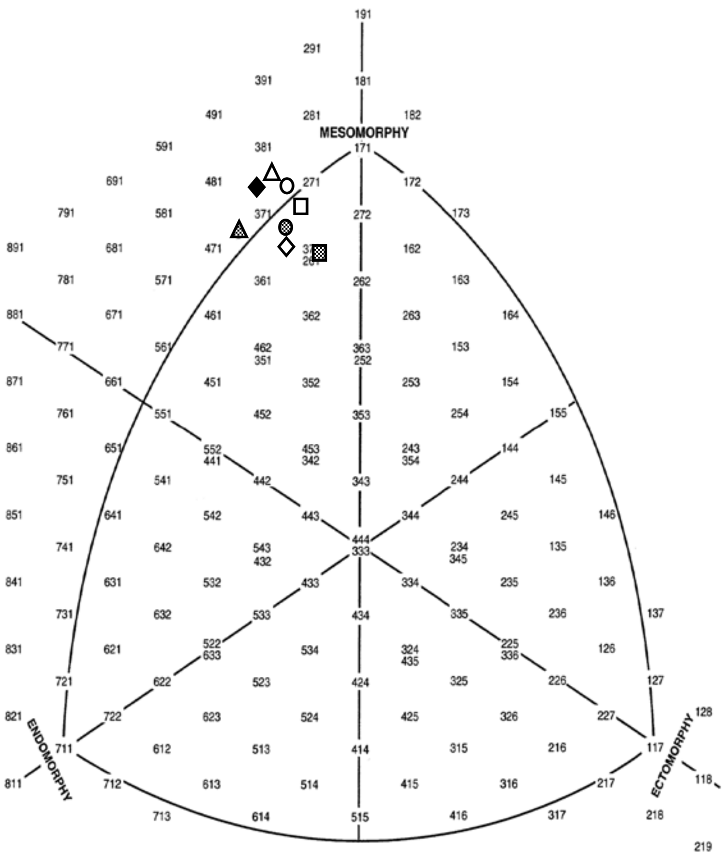
Anthropometry Results

A total of 116 players from five clubs in the SG Ball Competition participated in the study. This was 26% of all players competing at this level. Mean height (179.6 ± 6.1 cm) placed the players above the 50th percentile for height compared to age-matched boys in the general population, with 34% (forwards: n=28; backs n=12) also above the 85th and 3% (forwards n=4; backs: n=0) above the 97th percentiles[18]. Similarly, mean BMI (26.9 ± 2.9 kg/m^2) was above the 85th percentile, with 31% (forwards: n=34; backs: n=2) also having BMIs above the 97th percentile. As represented in the somatoplot (Figure 7), all players were classified as endomorphic-mesomorphs.

When anthropometric characteristics were assessed between forwards and backs, forwards had significantly larger skinfolds, girths and bone breadths for all sites measured, which consequently led to a greater percent body fat. Forwards and backs also differed significantly for all three somatotype components with forwards having greater endomorphy (adiposity, stock build) and mesomorphy (muscularity, strong build) but lower ectomorphy (linearity, tall and thin).

To examine the influence of Polynesian heritage on team and position selection, anthropometric and positional data were assessed between Polynesian (including those of mixed ethnicities) and non-Polynesian players. Compared to other players, Polynesians were statistically taller, had greater body mass, limb girths and bone breadths. Furthermore, they showed significantly greater mesomorphy than their non-Polynesian peers. Within the forwards and backs, Polynesians were still observed to have significantly greater bone breadths and mesomorphy than non-Polynesians in corresponding position. Overall, there was a high percentage (38%) of Polynesians in this sample with more than half (57%) assigned as forwards. However, this ethnic discordance between team positions was not found to be significant.

Figure 7 A visual comparison of somatotypes between junior and professional forwards and backs, as well as between junior players of Polynesian and non-Polynesian descen



6. CONCLUSIONS AND RECOMMENDATIONS

Injury

For the first time, a standardised injury surveillance mechanism was developed for junior rugby league. Most reported injuries are match-related which is consistent with previous studies (1,3,5). Just over one-third of reported injuries result in loss of match time, thus most injuries are transient with apparently inconsequential results. The findings suggest that rugby league is a safe participation sport for adolescent athletes. Non-time loss injuries can account for 72-95% of injuries (1). Forwards sustain the majority of injuries, which reflects their higher game involvement in tackles and collisions (31). However, when further examining non-transient injuries (those leading to match loss), there is little difference between forwards and backs in injury severity (53% vs 47% respectively). These findings are similar to all match injuries observed in New Zealand junior rugby league players and amateur rugby league players (32)

The most commonly injured regions are the ankle, head, shoulder and sternum injuries in contrast to King et al (1) who report the shoulder having surpassed knee and ankle injuries in junior rugby league. Ankle injuries in this study also produced the greatest match loss per player. We observe that forwards sustained substantially more shoulder, knee, sternum and hand injuries and slightly more ankle injuries, than backs. Quadriceps, hip and buttocks injuries, however, are primarily experienced by backs. These injury patterns appear to be consistent with positions where forwards are predominantly involved in tackling, and injuries more related to sprinting occur in backs. No studies have previously examined injured sites by positional play in junior rugby league.

The findings show that bruise/cork/contusions and sprains/ligament injury are the most commonly sustained injuries, however sprains and ligament injuries account for the greatest matches lost. Forwards show a higher incidence of contusions, joint injuries, muscle tears than backs. Furthermore, injuries are more often sustained during the second half of matches. These results suggest that fatigue or accumulative microtrauma, or both, may contribute to injuries in elite junior rugby league players (31). No studies have previously examined position-specific injury types in junior rugby league. Interestingly, concussive injuries were the third most recorded injuries, occurring in forwards (88% prevalence), yet all injured players were able to play in the following match. Collisions are the major cause of head injuries. Evaluation of these is variable at best, due to limited medical supervision at junior rugby league games. Head knocks without loss of consciousness are generally disregarded, increasing the risk of injuries and concussive events, given the frequency of tackling. Undiagnosed concussion is concerning as the developing brain is more vulnerable to injury. Concussion incidence in junior rugby league is largely unreported in the literature. This observation about concussion clearly indicates that on-field injury surveillance, immediate reporting and injury follow-up is warranted.

Our study is one of the few to report training injuries in junior rugby league (1,5). Our findings show that 8% of injuries are sustained at training but contribute to 11% of matches missed. It is likely that under-reporting of training injuries happened in this study.

The injury incidence of 0.15/1000 playing hours, much lower that reported in junior rugby league players (Table 1). The low injury rate likely reflects the poor compliance in reporting and underestimation of injuries. There was limited adherence to documentation by teams. Whilst club personnel agree that routine injury surveillance and supervision is important, only a minority persevered with recording throughout the season. Being time poor and the added burden of completing the documentation are the most cited reasons for non-compliance. Few relationships or conclusions can be drawn from the data due to the limited adherence to documentation by teams. A factor in the under-reporting of injuries and matches lost is due to the nine week (plus finals) season. Players who suffer an injury in their last match would record an injury but there is no reporting of matches lost, hence an indication of the severity of the injury. For example, anecdotally, in the last game of the season, a player suffers a ruptured anterior cruciate ligament requiring surgical repair and cannot train or play for 10 weeks. This major injury is recorded as transient (no matches lost) due to completion of data collection. Another explanation for the inconsistency in injury incidence is the use of the actual minutes played per player to calculate match exposure. Most reports of injury incidence are based on an estimation of match minutes (ie 60 minutes for U16 and 70 minutes for U18 games). This estimation does not take into account the fact that a player may not have played each match or played for the full game. There are 10 permitted interchanges per game and four to five players are named as bench players (reserves) to act as substitutions. Using actual match minutes would enhance the accuracy of reporting.

Anthropometry

To our knowledge, this is the first study to comprehensively describes the physical characteristics of Australian junior representative rugby league players. Results indicate clear anthropometric and body composition differences between forwards vs. backs and between Polynesian vs. non-Polynesian players.

As physique is an important determinant of rugby performance (33), standardised anthropometric characterisation can more accurately and consistently identify the favourable physical attributes associated with success. This is especially relevant for assessing positional differences as physical demands and exposure to collisions between players are different (34). Consistent with earlier research in junior rugby league, forwards in this study had significantly greater body mass and skinfold thickness than the backs (7,34). Additionally, they also had greater girths, bone breadths and mesomorphy which has not been reported previously. These attributes are advantageous for forwards who are frequently exposed to tackling and collisions. Higher body mass can also assist with generating greater momentum and impact forces (20), while larger skinfold thickness and muscularity may provide protection against injury, especially for hit-up forwards such as props and second rows (34). Having high body mass and adiposity however, is not without its disadvantages as speed (35), tackling ability (17), thermoregulation (36) and match exposure (16) have been reported to be compromised in heavier players.

Polynesians (including those of part-Polynesian heritage) were significantly taller and heavier compared to players of non-Polynesian descent (predominantly European). Furthermore, this study demonstrates that limb girths, bone size and muscularity are also greater in Polynesians. With larger body size shown to be strongly correlated with important rugby skills such as tackling ability (33), these natural physique advantages may bias Polynesian players toward selection for competitive rugby league teams. The over-representation of Polynesians in this sample (38%) compared to the Australian population (<1%) is suggestive of this (37).

Conclusion

Rugby league is a fast and physically demanding contact sport and linked with greater risk of injury. Adolescent players now participating at the elite junior level sport attain increased muscularity and physique to match the demands of playing positions within the sport. Given that the musculoskeletal system is still developing in adolescents, the intensity of play, training regimes and injury incidence warrants rigorous documentation and careful monitoring. A systematic and functional injury surveillance system should be implemented in junior rugby league to minimise injury risk and ensure the long-term health of players who are still maturing biologically.

Recommendations and Future Directions

As a result of this study, the following recommendations are suggested:

1. Evidence-based implementation strategies should be developed with working parties comprising researchers and appropriate rugby league clubs and teams personnel.
2. Junior rugby league at the organisational level should lead the initiative and provide support to assist both financially to increase staff and in education and training programs to promote a culture change within the clubs and teams.
3. Apply a minimum level of medical expertise to be present at all junior games such as a specialist medical trainer. Clubs could share the cost of a physiotherapist or resident doctor to be present at each competition venue on match days.
4. Paper-based injury reporting may be onerous. Development of an application (app) to be used on smartphones, iPhones and/or iPads could assist with faster, straightforward recording and help improve compliance
5. Accurate documentation of match exposure time (ie playing time on-field) is required for more precise injury incidence reporting.
6. Measurement of match and performance demands and collision forces may assist in better understanding of injury risks.

7. PROJECT LIMITATIONS

This study was not without its limitations. The major limitation of the study is the poor compliance from the majority of recruited clubs or teams leading to substantial under-reporting of injuries. The completion of the three major forms (Injury Notification, Injury Follow-up and Match Exposure), generally by different personnel, is reported to be an onerous task. At the junior level, many clubs rely heavily on volunteers to undertake the administrative duties, training and coaching and managing the team and other related tasks. These volunteers also have work and family responsibilities to balance with their sporting community commitments. Thus adding another level of paperwork is viewed as an additional burden. Some staff comment that they are accustomed to their established practices and it is difficult to change; some could not recognize the value of the study. Methods to address this limitation are offered in the recommendations above.

In the anthropometry sub-study, players from only five clubs were included. Firstly, it is possible that our sample may not be representative of all junior rugby league players in Australia. This is particularly relevant for certain player positions (e.g. five-eighths) and ethnic backgrounds (e.g. Indigenous Australian and Middle Eastern) where only a small number of participants were able to be recruited. Secondly, five accredited anthropometrists were involved in collecting physique data. Using multiple anthropometrists was logistically necessary for the data collection process but this may have increased measurement error. Strategies including restriction of all skinfolds to one anthropometrist and allocation of girths and bone breadths to two anthropometrists were employed to minimise error. Thirdly, due to participants time constraints (many still attending school), anthropometric measurements were sometimes performed after training. This could have influenced limb girths secondary to training-induced changes to muscle blood flow and hydration status. However, inclusion of training status as a covariate in statistical tests performed did not alter the significance of the results.

8. ACKNOWLEDGEMENTS

This study is supported by the NSW Sporting Injuries Committee. The authors would like to thank Mr Martin Meredith from NSWRL Academy and Mr Brian Canavan, Chairman Rugby League Research Board for their invaluable assistance in liaising with key team personnel, their advice and contributions to the study, The authors would also like to thank the players and Junior Rugby League teams' personnel for their participation and support of the study. We thank the students who assisted with data collection in the anthropometry sub-study and Miss Eka Peng Cox for her contribution to data entry and analysis.

9. SUPPORTING DOCUMENTATION

Manuscripts

One manuscript was submitted to Journal of Science and Medicine in Sport and is under review

1. *Anthropometric Characteristics of Australian Junior Representative Rugby League Players*

Abstracts or Oral Presentations

Two abstracts were accepted for the **be active 2012**, the 4th International Congress on Physical Activity and Public Health held in Sydney, Australia from 31 October to 3 November 2012. The abstracts (attached) are:

1. *Injury Surveillance in Rugby League Junior Development Competitions* (for poster presentation at the National Sports Injury Prevention Conference component of the Conference)
2. *Anthropometric Characteristics of Junior Representative Rugby League Players in Australia* (for oral presentation at the Australian Conference of Science and Medicine in Sport component of the Conference).

One abstract was accepted for short oral presentation at the 18th Annual Congress of the ECSS to be held in Barcelona 26-29 June 2013.

3. *Injuries in Australian Elite Junior Rugby League Players*

Abstract 1

Presented at the *be active* 2012 4th International Congress on Physical Activity and Public Health

Injury Surveillance in Rugby League Junior Development Competitions

Introduction Currently in junior rugby league (RL), there is no standardised procedure to record or monitor injures sustained at training or in competition matches. The development of an operational sports injury surveillance paradigm in RL has lagged behind other contact sports such as rugby union, AFL, cricket and football (soccer). This study aims to develop a systematic reporting structure for rugby league injuries suffered during match play and training as well as for injury follow-up. **Method** The study is a prospective cohort experimental design. Players from the 2012 NSW Junior Representative RL Competitions will be recruited and monitored during the pre-season through to the competition grand final. Three standardised measurement instruments have been developed. The Players' Baseline Information Form included demographics (age, ethnicity, medical history) and player characteristics (position, play history, injury history). The Player injury Notification Form will be completed by the team medical trainer or other personnel to whom players report for injuries sustained at training and matches. It consists of: the nature, characteristics and mechanism of the injury, onset, environmental conditions, diagnosing/treating person, initial treatment and referral. The Injury Follow-up Form will be completed by the team doctor, physiotherapist or medical/rehabilitation trainer who determines the treatment of the injury and return to training and/or match play. This form includes: diagnosis of the injury, treating person, further referral for medical treatment and/or investigations, number of training sessions and/or matches missed or date for return to play. The players' match and training exposure and compliance to completion of forms will also be recorded. Personnel completing the forms will be surveyed to determine the ease of completion, relevance to the team's requirements, preparedness to adopt, and reasons for not adopting the form. **Results** A total of 332 players from 22 teams (Under 16s and Under 18s) within13 clubs have been recruited. **Discussion** A standardised methodology for injury reporting and surveillance has been developed for the junior elite RL competition. The findings may enable the identification of risk factors for injuries as well as provide data for a larger study to explore the subsequent reduction in the likelihood of re-injury; the development of safe return to training and play guidelines, and recommendations for training volume and total game exposure to minimise injury from rugby league to achieve sustainable health in elite junior players for their long-term progression in rugby league.

This study was supported by the NSW Sporting Injuries Committee

Abstract 2

Presented at the ***be active* 2012 4th International Congress on Physical Activity and Public Health**

Anthropometric characteristics of junior representative rugby league players in Australia

Introduction Rugby league is a popular physically demanding collision sport. Although physique is reported to discriminate player position, tackling ability and team selection, few studies have described physique characteristics of players at the professional or development level. This study aimed to describe anthropometric characteristics of Australian rugby league players competing at junior representative level. Methods Players from a state-wide under 18's competition were recruited. Socio-demographic information collected included age, ethnicity (Polynesian or non-Polynesian) and player position (forward or back). Anthropometric information was collected using the International Society for the Advancement of Kinanthropometry (ISAK) restricted profile and included: stretch stature; body mass; body mass index (BMI); 8 skinfold sites (triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, medial calf); 5 girths (arm relaxed, arm flexed and tensed, waist, gluteal, calf); 2 biepicondylar bone breadths (humerus, femur). In addition to su m of 8 skinfolds, percent body fat and somatotype was calculated using published equations relevant to the population. Data:mean±SD. Results 116 players aged 16.8±0.6y participated. Mean body mass, sum of 8 skinfolds and percent body fat were 87.0±11.6kg, 95.7±31.9mm and 14.0±4.6% respectively. Compared with backs, forwards had significantly higher BMI (28.4±3.0 vs. 25.4±1.7kgm-2; p<0.001), skinfolds (110.4±32.0 vs. 79.8 ±23.0 mm; p<0.001); girths (all p<0.001); bone breadths (humerus:7.6±0.4 vs. 7.5±0.4 cm; *p*=0.033; femur:10.8±0.6 vs. 10.3±0.5 cm; *p*<0.001); and percent body fat (16.1±4.8% vs. 11.8 ±3.2%; p<0.001). Players of Polynesian descent exhibited significantly higher stature (181.0±5.7 vs. 178.7±6.3cm; p=0.047); body mass (90.6 ±11.7 vs. 84.7±11.1 kg; p=0.008); BMI (27.6±3.1 vs. 26.5±2.7kgm-2; p=0.039); girths (arm and calf; all p<0.05); and bone breadths (humerus:7.8±0.4 vs. 7.5 ±0.4; p<0.001; femur:10.9 ±0.5 vs. 10.3±0.6; p<0.001) than non-Polynesians. Assessment of somatotype against player position and ethnicity revealed significantly higher endomorphy (3.6±1.0 vs. 2.6 ±0.7; p<0.001), mesomorphy (7.5±1.3 vs. 6.5±0.8 ; p<0.001) and lower ectomorphy (1.0±0.9 vs. 1.7±0.7; p<0.001) in forwards compared with backs. Mesomorphy (7.6 ±1.2 vs. 6.7 ±1.1; p<0.001) was also significantly higher in the Polynesian players. Discussion Junior representative rugby league forwards had significantly greater body mass, muscularity, adiposity and larger bone size compared to backs. These anthropometric characteristics are reported as desirable for performance in forwards and are likely also protective of the higher impact nature of this position. Polynesian players were significantly taller, heavier and more muscular with larger bone size than those from other ethnic backgrounds. This may bias toward selection of Polynesians in junior rugby league, particularly for forward positions.

This study is supported by the NSW Sporting Injuries Committee

Abstract 3

Accepted for the 18th Annual Congress of the ECSS to be held in Barcelona 26-29 June 2013.

INJURIES IN AUSTRALIAN ELITE JUNIOR RUGBY LEAGUE PLAYERS

Orr, R and O'Connor H. The University of Sydney, Australia

Introduction

Rugby league (RL) is a collision sport where players participate in physically demanding activities and musculoskeletal injuries are common. Few studies describe injuries at the junior level (1-5). Currently no injury surveillance paradigm in the Junior RL Competition has been established, although Clubs record player injuries asystematically. Thus, the aim of this study was to characterise the injuries sustained by junior players within the elite competition.

Methods

The study was a prospective cohort experimental design. We developed and implemented an injury surveillance mechanism in the 2012 NSW Junior (Under 16 (U16) and Under 18 (U18)) Representative RL Competitions. Players' match and training injuries were recorded for nine rounds and five finals rounds.

Results

We recruited 385 players (201 U18, 184 U16; mean age 15.8 y). Only 113 full data sets (5 U16, 2 U18 teams) were available due to poor compliance from clubs with respect to completion of forms. There were 109 injuries (97 match, 12 training); 32 injuries (29%) resulted in 72 missed matches. The major injury types were: bruise/cork/haematoma 48%; sprain/ligament injury 21%; concussion 7%; muscle tear/strain 7%. The major injuries occurred to ankle 13%; head/face 12%; shoulder/clavicle 11%; sternum 11%; quadriceps 11%. Three-quarters of injuries were tackle-related: 43% from being tackled, 32% from effecting the tackle. For the 38 injuries eliciting missed matches, ankle injuries resulted in the most match loss (3-5 games). Knee injuries (meniscus tear, ligaments) occasioned 3-4 matches lost; fractures and shoulder joint injuries resulted in 3 and 1-3 lost matches, respectively. Similarly, sternum injuries and corks/haematomas resulted in 1-2 lost matches.

Discussion

Although rugby league is a collision sport, it is relatively safe. Most injuries sustained were minor with no loss of match play. Interestingly, shoulder injuries have surpassed knee injuries (previously most prevalent) which may be attributed to changes in match rules of the 10m defensive line. There was limited adherence to documentation by teams. Whilst club personnel agreed with the importance of regular injury surveillance and supervision, only a minority were prepared to persevere with recording during the season. Given the developing musculoskeletal system in juniors, the presence of larger Polynesian players, higher intensity of play and training regimes, injury incidence warrants rigorous documentation and careful monitoring.

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