Western Cape High School Injury Tracking Survey

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ABSTRACT

Background:

Regular physical activity through organised school sports has far-reaching health benefits for adolescents. However, participation in sports may result in injury. Sports injuries are the main cause of injury in this population group and are a significant contributing factor to both the low adolescent sports participation numbers and the high attrition rate during these years. To reduce injury incidence rates, these first need to be quantified accurately through large injury surveillance systems that are standardised for comparative and scientific sharing purposes, are of high quality and allow for ease of access to the sports science research field. Internationally there is a distinct lack of these databases for adolescent, non-elite sport and the South African landscape of injury surveillance mirrors this situation. South African adolescent sports injury incidence rates overall, and across sporting codes, are poorly reported and understood, which may put our youth at risk and at a distinct disadvantage regarding the development and implementation of injury prevention programmes.

Aim:

To collect high-quality injury data across various sporting codes and socio-economic profiles to determine sports injury incidence rates for adolescents attending Western Cape high schools. In addition, the objective was to provide additional information on the injuries sustained and potential risk factors involved. This study aimed to support the development of an ongoing longitudinal sports injury surveillance database in South Africa that will provide epidemiological information and injury incidence rates which can be used to motivate for and support targeted injury prevention programmes and drive policy development to reduce injury rates.

Study Design:

Prospective descriptive cohort.

Methodology:

Private and government schools in the Western Cape region, South Africa, were approached to participate in the study. Three schools enrolled in the study. Exposure-based injury data from participating teams in the sporting codes rugby, football and cricket were reported between 2019–2023 for male and female adolescent learners. Coaches, teachers or dedicated medical staff recorded the injuries and exposure time information to provide injury incidence rates overall, in practice and in competition. A sports injury in this study was defined as any physical dysfunction or soft tissue damage that occurred during organised school sport — acute or repetitive in nature — and included injuries that did not cause time loss from participation in activity. Injury details were recorded to identify potential risk factors such as phase of play, mode and mechanism of injury and playing position, as well as information on injury type, site and severity in time loss. These definitions and data parameters were based on recommendations from the IOC consensus statement for recording and reporting sports injuries (Bahr et al.).

Results:

An overall injury incidence rate of 4.31 / 1 000 athlete-exposure hours was established, with competition injury incidence being significantly higher than practice rates: 28.78 / 1 000 and 1.18 / 1 000 respectively.

Contact and collision sports had higher injury incidences, with rugby match injury rates being similar to those found in professional leagues at 85.98 / 1 000 athlete-exposure hours.

Injury patterns showed statistically significantly increased risk during competition *($p < 0.001$)*, and through acute mode *($p < 0.001$)* and direct contact mechanisms *($p < 0.001$).* The lower limb was the most injured region with 42.31% of overall injuries recorded and the shoulder the most at-risk joint overall, at 25.64% of all injuries. Joints and ligaments were the most susceptible structures, contributing to 29.75% of all injuries. Injuries that resulted in time loss from sports predominated, 70.51%, and these were mostly moderate in severity with 8–28 days off.

Results were heavily influenced by rugby data which contributed to the majority of the documented injuries (68 of the 78 total recorded) and the lack of variety in participating sporting codes, which may influence the high incidence rates in this study. Rugby-specific findings saw strong associations between player position and injury patterns. Forwards sustained more upper limb *($p < 0.05$)*, shoulder *($p < 0.05$),* knee *($p < 0.001$)* and ankle *($p < 0.05$)* injuries and this position was strongly associated with injuries to joint and ligamentous structures *($p = 0.014$).* Back line players were more susceptible to muscular injuries *($p < 0.001$)* and injuries of the calf *($p < 0.001$)* area.

Conclusion:

This study investigated the incidence, patterns, and risk factors of sports injuries among non-elite adolescent athletes in three Western Cape high schools. The overall injury rate was 4.31 / 1 000 athlete-exposure hours, with higher rates observed during matches compared to practices. Rugby exhibited the highest match-related injury rate (85.99 / 1 000 athlete-exposure hours), comparable to professional levels, while football and cricket also displayed notable injury rates. Time-loss injuries, particularly in the moderate category (requiring 8–28 days of recovery), were common across all sports, with joint and ligament injuries in the lower limbs being the most prevalent. The findings highlight the need for larger longitudinal injury surveillance systems to establish reliable injury incidence rates and provide in depth epidemiological information on adolescent sports injury. This information is vital to establish and guide sports policy related to targeted injury prevention strategies and sport-specific conditioning programmes to reduce injury rates and severity, and promote sustained sports participation among adolescents.

Clinical Relevance:

Sports science research and provincial / national government should invest resources into establishing and managing an Injury Surveillance database for longitudinal studies investigating adolescent sports injuries across all sporting codes and socio-economic groups in South Africa to provide insights which may inform practices to reduce injury rates and mitigate risk factors and ultimately uplift the universal health of this vulnerable population group.

CHAPTER 1: LITERATURE REVIEW

1.1 PARTICIPATION IN ORGANISED SCHOOL SPORTS AND ADOLESCENT HEALTH

Physical activity during adolescence promotes physical and mental health, as well as social development (Chaput *et al*., 2020). The WHO recommends at least 60 minutes of moderate to vigorous daily activity for children and adolescents (aged 5–17yrs) as well as muscle and bone strengthening activity at least 3 times each week (Chaput *et al*., 2020) in order to reduce the risk and burden of chronic diseases such as Obesity, Type 2 Diabetes and Cardiovascular disease. Non-communicable diseases (NCDs) account for 60% of all deaths and are largely preventable through the adoption of a healthy lifestyle (Matheson *et al*., 2013). The US Centre for Disease Control stated in 2010 that high activity levels are seen to improve academic performance, decrease the risk of developing cardiac and metabolic disease and correlate with a reduction in psychological disease burden (Ullrich-French *et al*., 2012).

Osteoporosis is a disease which carries a high socioeconomic burden. Global incidence was found to be 41.5 million cases in 2019 and is expected to reach 263.2 million by 2034 (Zhu et al., 2023). Research shows that the amount of bone mass gained during early childhood accounts for 60% of the risk of developing osteoporosis, with high intensity weight-bearing physical activity during this development phase being strongly protective and giving continued benefit into adulthood (Gunter et al., 2012). A Danish study (Larsen et al., 2018) following children aged 8-10yrs over a school year, showed that organised intense activity of 40 minutes three times a week significantly improved bone mineral density and content as well as muscular fitness.

By encouraging physical activity as a habitual behaviour in the formative years, school sports participation may be an intervention in the treatment and prevention of NCDs (Zwinkels *et al*., 2015) (Zwinkels *et al*., 2018). Supporting this school of thought, the gross motor skill, cognitive and social benefits developed during childhood sports participation may increase the likelihood that these activities will be continued into adulthood (Loprinzi *et al*., 2012). In the instance of obesity, childhood occurrence predicts adult patterns (Whitaker *et al*., 1997) and therefore by increasing energy use through organised sports and improving weight control, this cycle can be positively influenced. Other authors have found similar evidence that, along with the metabolic benefits, adolescents who participated in regular exercise were found to have lower levels of depression and anxiety, higher self-esteem, and lower feelings of stress. Cognitive function may also be improved (Biddle *et al*., 2019) with regular physical exercise.

Despite the known benefits of exercise participation, research demonstrates that more than 80% of American youth do not meet the WHO exercise recommendations (Landry & Driscoll, 2012). South African data reveals similar findings; a longitudinal study of children in Urban Soweto found 82% of males and 100% of females failed to meet the WHO recommendations (Hanson *et al*., 2019).

In Europe, sports participation rates decline concerningly during adolescence (Emmonds *et al*., 2024) with the beginning of puberty — around 11 years of age for girls and 14 years of age for boys — marked as the crucial point of decline in both genders (Alberga *et al*., 2012). Male participation rates are higher than female — 80% vs 20% — and a more intense activity drop-off rate occurs in females between the U/13–U/16 age groups (Emmonds *et al*., 2024). Injury risk is seen to be one of the predominant determinants of a decline in adolescent sports participation rates as seen in an Australian survey of 11 to 16-year-olds (Grimmer *et al*., 2000) where there was an 8% per annum sports attrition rate due to injury, or fear of it. Mid-adolescence (14–17 years of age) sees the highest sport drop-out rate (Merkel, 2013) and a 2011 study states that injury risk and occurrence is one of the most influential factors for this (Habelt *et al*., 2011).

Information on adolescent activity levels in South Africa is limited, but the impact that the COVID19 pandemic has had is evident. Already at a low base, those meeting the recommended activity criteria dropped to 3.1% due to the restrictions imposed on society to slow the spread of the virus. Schools were shut down, which curtailed organised school sports and club activities (Mata *et al*., 2022). The perceived barriers to physical activity in this study were time restrictions, lack of access to facilities or clubs, lack of motivation and fear of injury. A review of global participation in sports activities (Hulteen *et al*., 2017), including three African countries, showed that participation rates and the predominant types of sports varied across regions. Athletics was the most popular activity among African youth, with netball and rugby being the two most popular team sports.

Counterposing the benefits of being physically active and being involved in organised sport are several physical, psychological and social risks, a summary of which is provided in Table 1. Injury risk is a significant factor in the low activity levels seen in adolescents and participation in high school sports. Injuries number more than 1.4 million annually in US high school athletes (Yard *et al*., 2009). These injuries span acute and chronic overuse injuries and can affect health negatively as well as have long-term financial and social consequences for young athletes and their families (Yard *et al*., 2009). The adolescent years are a particularly vulnerable period with regard to certain injury types and patterns (Merkel, 2013). Despite the effects of weight-bearing exercise on adolescent bone density described earlier, rapidly growing bones and slower-growing muscles and ligaments put enormous strain on growth plates, apophyses and joints, which make these structures prone to injury (Merkel & Molony Jr, 2012). Adolescent bone is relatively weaker than its supporting structures, which also increases fracture risk (Merkel & Molony Jr, 2012). Balance, flexibility and co-ordination also decline with growth, which further increases injury risk (Merkel & Molony Jr, 2012). Sports injuries are the leading cause of injury in adolescents (Emery, 2003) and therefore pose a significant issue when advocating for youth sports participation. Reliably and accurately quantifying the extent of the problem through establishing injury incidence rates and identifying risk factors — both those specific to adolescents and then those that are attributable to different sporting codes — is crucial in the field of Sports Science in order to reduce injury rates through scientifically guided prevention strategies (Emery, 2003). It has been shown that science-based injury prevention programmes can successfully reduce injury rates for many sports, including football (Bizzini & Dvorak, 2015) and rugby (Gabbett, 2004).

Van Mechelen, Hlobil and Kemper (1992) suggest a framework for injury prevention: Firstly, establish the incidence and severity of sports injuries; secondly, establish the etiology and injury mechanisms, then introduce injury prevention strategies. Lastly, look at incidence and severity again to evaluate the success of these strategies (van Mechelen et al., 1992). It is therefore clear that strategies to reduce injury rates require prior accurate data for incidence, exposure, risk and protective factors (Yard *et al*., 2009) but high-quality, large-scale longitudinal Injury surveillance systems are scarce. The literature shows that barriers to these systems include the cost and the time-consuming nature of collecting injury data on a large scale. Injury study methodology is also problematic due to differences in definitions of, for example, injury terminology and analysis methods (Yard *et al*., 2009).

Fifteen Sports Injury Surveillance systems were identified by authors in a recent meta-analysis, the majority of which assessed professional sports. Of these, only seven published data quality findings and four had provided data validation by comparative measures with other systems. Four of these systems recorded non-professional collegiate sports injuries and none looked specifically at childhood sports injuries (Ekegren *et al*., 2016). This highlights the lack of high-quality injury surveillance, particularly in non-elite adolescent sport. In the South African setting, rugby is well positioned with a number of injury surveillance studies having been conducted (Brown *et al*., 2015; Burger *et al*., 2014) but there is a lack of ongoing surveillance for sporting injury rates across other sporting codes in the South African school-going population.

Table 1: Positive and negative impact of youth sports – adapted from (Merkel, 2013)

POSITIVE	NEGATIVE
Physical • Increased physical activity • Improved fitness • Lifelong physical, emotional and health benefits • Decreased risk of obesity • Reduced risk of chronic disease • Improved motor skills	*Physical* • Injuries • Exposure to untrained coaches • Inconsistent safety measures • Lack of sports science research impacting policy and practices
Psychological • Decreased depression • Decreased suicidal thoughts • Decreased high-risk health behaviours • Increased positive behaviours in teens • Improved self-worth	*Psychological* • Increased stress over performance and competition • High rates of attrition • Inappropriate pressure to achieve for scholarships and professional career
Social • Enhanced social skills • Learn life lessons • Improved positive social behaviours • Improved time management skills • Improved academic performance • Development of goal setting • Improved character	*Social* • Funding inequality for safety equipment, venues and equal participation • Financial pressures • Socio-economic, ethnic, geographic and gender inequality

1.2 INJURY INCIDENCE

Injury Incidence is defined as the number of newly identified cases of a condition during a specific time period for the population at risk; in other words, a measure of risk of the condition for a specific population in a specific time period (Knowles *et al*., 2006). Establishing school sports injury incidence rates that are accurate and comparable across studies is the first step towards making organised sport safer in adolescent populations.

In epidemiology, three measures of injury incidence can be described:

1. Epidemiologic Incidence Proportion which measures the average risk of injury in a defined period through dividing the number of injured athletes in a season by the number of athletes at risk at the start of a season.

2. The Incidence Rate which is the number of injuries divided by the number of exposures, making it a person time-based rate. Exposures, or time at risk, can be described using various measures: athlete-seasons (1 athlete participating in 1 season), athlete-games (1 athlete participating in 1 game), athlete-practices (1 athlete participating in 1 practice), athlete-exposures (1 athlete participating in 1 game or practice), or athlete-exposure hours (the amount of time in hours that athletes are exposed to an activity, game or practice).

3. Then there is Clinical Incidence which divides the number of injuries by the number of athletes at risk — a combination of rate and risk which makes it a poor epidemiologic measure to be avoided in injury reporting. Epidemiologic Proportion is useful for risk assessment and conveying this to parents, athletes and coaches, whereas Incidence Rate is more appropriate for science and sports injury research where variations in exposure occur and comparisons can be made — between specific playing situations, between different sports, between player positions and so forth (Knowles *et al*., 2006).

Supporting this is the IOC consensus document (Bahr *et al*., 2020) stating that incidence-based measures with a standard time window of exposure are best for comparisons across sports. Other authors (van Mechelen et al., 1992) also encourage that incidence be expressed as injuries per athlete exposure time in hours for comparability. Historically, injury incidence rates and expressing injury risk has not been standardised, which makes determining absolute injury rates and comparisons difficult (Bahr *et al*., 2020).

1.3 DATA COLLECTION AND CAPTURING PRACTICALITIES

Large-scale sports injury surveillance systems require standardised and consistent reporting to collect accurate injury incidence data. When examining quality and quantity of exposure and injury reporting between Certified Athletic Trainers and sports coaches in the USA, Athletic Trainers were found to be significantly superior in reporting and accuracy (Yard *et al*., 2009). This particular study concluded that Athletic Trainers should be the dedicated reporters, and if not available, then much time and financial resource will need to be invested by researchers in order to get the same level of participation, compliance and accuracy (Yard *et al*., 2009). Certified Athletic Trainers have a tertiary degree in sports injury assessment and management; there is no equivalent University qualification outside of Canada or the USA.

The IOC Consensus Statement outlines the pros and cons of paper-based and electronic collection methods. Paper-based reporting is easy to implement, cost-effective and does not require access to internet or the need for computer skills. Electronic methods allow for instant access to information and integration with other systems for knowledge sharing, although they can be costly and require technical support and backup. The choice of data collection method should therefore suit the specific situation, sport and research team, and in either method the most important aspects will be in the robustness of the data collection, analysis and reporting protocols (Bahr *et al*., 2020).

1.4 INTERNATIONAL LITERATURE — INJURY INCIDENCE RATES

Research shows that participation in high school sports increases risk of injury (Comstock et al., 2006), with injury rates varying significantly across sporting codes and in type of play. The overall injury rate in US high school sports during the 2005–06 school year was 2.44 / 1 000 athlete exposures (AEs) (Comstock et al., 2006), where one athlete exposure is one athlete participating in one practice or competition where there is a potential for injury. In this same study, the highest rates were seen in American Football (4.36 / 1 000 AEs) and Wrestling (2.50 / 1 000 AEs). Boys' and Girls' football had injury rates of 2.43 / 1 000 AEs and 2.36 / 1 000 AEs respectively. Volleyball, softball and baseball all had injury rates < 2 / 1 000 AEs. Injury rates were higher in competition across all sports, with an injury rate of 4.63 / 1 000 AEs vs 1.69 / 1 000 AEs in practice. Similarly, data from sixteen years of National Collegiate Athletic Association injury surveillance for fifteen sports (Hootman *et al*., 2007) revealed that all sports injury incidence is higher in competition (13.79 / 1 000 AEs) compared to practice (3.98 / 1 000 AEs). This is particularly evident in contact sports, with American football having the highest rates and biggest differences between competition and practice injuries: 35.9 / 1 000 AEs and 9.6 / 1 000 AEs respectively (Hootman *et al*., 2007).

Another study (Prieto-González *et al*., 2021) which surveyed athletes aged 14–21 years over a period of one year revealed an overall injury rate 2.64 / 1 000 exposure hours, with football having the highest rate at 7.21 / 1 000 exposure hours.

A retrospective survey in Calgary high schools (Emery *et al*., 2006) found an injury rate of 40.2 injuries / 100 adolescents / year.

Regarding injury rates in competition compared to practice, a prospective injury surveillance study again supports the evidence that injury rates are higher in competition at 4.63 / 1 000 AEs than practice 1.69 / 1 000 AEs (Rechel *et al*., 2008).

The most common injury types across all sports in a large injury surveillance study were lumbar muscle strains (12.24%), ankle sprains (11.98%) and bone fractures (9.31%) (Prieto-González *et al*.). Certain sports are more likely to result in specific injury types and sites, for example, in football, ankle sprains and knee injuries dominate (Emery *et al*., 2005), while rugby players are more likely to suffer from concussions and shoulder injuries (Junge *et al*., 2004). The literature shows that type of play, competition or practice, influences the mode of injury as well as the type of injuries seen. There are very few studies that specifically report on injury mode, being acute or repetitive, which is a concern as there is evidence to show that overuse injuries account for nearly 50% of youth sports-related injuries and are associated with more time off and increased future injury risk (Caine *et al*., 2006).

Injuries to the lower limbs are most frequent across all sports and account for between 50–67% of all injuries (Habelt *et al*., 2011; Hootman *et al*., 2007). The ankle was the most common injury site (22–36%), followed by the knee (19–29%) (Hootman *et al*., 2007; Prieto-González *et al*., 2021; Rechel *et al*., 2008) (Caine *et al*., 2006) which is consistent across available research. Ankle sprains are the most common injury type (Emery *et al*., 2006; Hootman *et al*., 2007; Prieto-González *et al*., 2021) consisting of 11.98–25% of injuries.

Competition play results in a higher incidence of fractures and concussions (Comstock et al., 2006) than practice. One study looking specifically at the differences in injury patterns between competition and practice (Rechel *et al*., 2008) found that lower extremity and upper extremity injuries were in equal numbers and joint / ligament sprains were more common in practice (57.8%) than in competition (47.1%). Participation in competition resulted in higher rates of contusions (15.5%) and fractures (11.1%) compared to 8.7% and 8.5% in practice respectively. Participation in competition also resulted in a greater proportion of more severe injuries requiring >3 weeks off play.

Injury severity, gauged by time loss from sports participation in both training and competition, varies greatly too. Mild injuries, resulting in less than seven days out of sport contribute to more than 50% of sports-related injuries as shown in two large studies (Comstock et al., 2006; Rechel et al., 2008).

1.5 SPORT-SPECIFIC FINDINGS

Football

Football is one of the most studied sports when it comes to youth injuries. Research shows that injury rates vary greatly between 2.0–19.4 / 1 000 exposure hours, with match injury rates being consistently higher than those of training: 9.5–48.7 / 1 000 and 3.7–11.1 / 1 000 exposure hours respectively (Watson & Mjaanes, 2019). Injuries to the lower extremities, particularly the ankle and knee, are most common (Pfirrmann *et al*., 2016).

A study of 21 male and female football teams with players aged 11–18 years old supports these findings. An overall injury rate of 5.59 / 1 000 exposure hours was found, with 78.2% of these injuries involving the lower extremities, of which 28.2% involved the ankle and 19.2% the knee. Sprains were the most common injury type. Of all injuries, 88.6% were classified as time loss, and most (74%) resulted in less than seven days off. Direct contact mode resulted in 46.2% of all injuries. Match injury rate was eight times higher than in practice (Emery *et al*., 2005).

A match injury rate of 15.3 / 1 000 exposure hours was found for a research study of a youth tournament which took place over the period from 2012–2014. Again, the lower extremities contributed to 66.7% of all injuries (Kolstrup *et al*., 2016). Further support for these findings was found in a study that collected data over four years during football tournaments for males and females aged 12–19 years. An overall match injury rate of 2.38 / 1 000 exposure hours was established. The lower extremities were the most common injury region, with the thigh contributing 21%, the knee 15% and the ankle 13%. The most common injury types were contusions (32%), sprains (21.8%), fractures (9%) and concussions (1.5%). The most common mode of injury was direct contact (56.3%) (Kibler, 1993). Another research group (Nilsson & Roaas, 1978) also found contusions to be the most common injury type (36%), followed by sprains (20%) during a youth football tournament in the 1970s. The lower limb once again was the most frequently injured region (68%).

A French elite youth football cohort study spanning ten years found an overall injury incidence of 4.8 / 1 000 exposure hours, with a match injury incidence of 11.2 / 1 000 exposure hours and a practice incidence of 3.9 / 1 000 exposure hours. The lower limb was the most injured region: the upper leg (24.5%), the ankle (17.8%) and the knee (15.3%). Contusions were the most common injury type (30.6%), followed by sprains (16.7%) and fractures (5.9%). The younger age groups, under 14 years old, had a higher incidence of growth-related repetitive injuries (osteochondroses) and injuries during practice, while the older players were more likely to experience acute injuries during matches (Le Gall *et al*., 2006).

A large US high schools injury surveillance survey conducted over nine years (Khodaee *et al*., 2017) found the overall injury rate to be 2.06 / 1 000 AEs. The match injury rate of 4.42 / 1 000 AEs was significantly higher than the practice rate of 1.05 / 1 000 AEs. Ankle (20.6%) and knee (16.6%) injuries were once again most common. A higher percentage of head and face injuries (20.9%) were seen in comparison to other research published to date. Sprains were the most common injury type (29.7%) and there was a relatively high concussion rate (17%) compared to other studies. Mild time-loss injuries of < 7 days were most frequent (45%), and only 6.3% severe resulting in >3 weeks off play. The most common injuries causing severe time loss were fractures (27.7%), sprains (43.6%) and concussions (14.9%). Acute injuries predominated (89.8%).

Rugby

Rugby has one of the highest injury rates in youth sport. A systematic review calculated a pooled estimate for overall injury incidence at 26.7 / 1 000 exposure hours in U/21 Rugby League. Rates seem to be similar for forwards and backs when comparing position injury risk. A significant proportion of injuries were severe and lead to >28 days off play. Common injuries were concussions, fractures, ligament sprains and soft tissue injuries (Freitag *et al*., 2015). The shoulder and knee were the two most frequently injured sites (Archbold *et al*., 2017). Match injury incidences were higher than in practice, with a range of 27.5–129.8 / 1 000 exposure hours (Bleakley *et al*., 2011).

A prospective injury surveillance survey in Ulster schools over a period from 2014–2015 (Archbold *et al*., 2017) gave a match injury incidence of 29.06 / 1 000 exposure hours. The most common sites for injury were the head and face (23.9%), the shoulder (15.3%) and the knee (13.1%). Sprains (31.2%), concussions (19%) and muscle injury (15.3%) were the most common injury types. Most injuries (49.1%) were severe resulting in >28 days off, while 40.8% were moderate with 7–28 days off sports participation. Only 10.1% of injuries resulted in < 7 days off. Concussions contributed to 15.9% of the severe injuries, followed by shoulder dislocations (10.6%) and knee sprains (9.1%).

Another prospective study from Australia (Leung *et al.*, 2017) supports these findings with an overall injury rate of 23.7 / 1 000 exposure hours and the upper limb being the most frequently injured region (26.8%).

A similar study in U/19 Australian Rugby League over four seasons found a match injury incidence of 56.8 / 1 000 exposure hours, where shoulder injuries were the most common and expressed as 15.6 / 1 000 exposure hours. Sprains were the most common injury type at 24.7 / 1 000 exposure hours (Gabbett, 2008).

A review comparing injury incidence in male youth football and rugby (Junge *et al.*, 2004) explores the variations between these two sports. Rugby has an overall higher injury incidence than soccer, as seen in the literature above. Football had an injury rate of 1.8 injuries / player / season while rugby injuries were 2.8 / player / season. In both groups, 66% of injuries occurred during matches, 20% in training and 15% were due to overuse. The most frequent injury mechanism in rugby was direct contact (66%), whereas football injuries were split equally between direct contact and non-contact. Seventy-seven percent of football injuries involved the lower limb compared to 43% of rugby injuries. The most common injury site in rugby was the shoulder (19%), while in football it was the ankle (17.2%). Comparing injury types, both football and rugby are similar with muscle strains being most common, followed by contusions and joint / ligament sprains. When comparing injury severity between the two sports, results were similar. The majority were mild injuries, resulting in no time loss from sports participation: rugby (79.1%) and football (69.3%). This was followed by moderate injuries leading to 1–7 days off: rugby (10.9 %) and football (19.9%). Severe injuries leading to >21 days off sports participation were least common: rugby (2.4%) and football (3.4%).

Cricket

Although less studied, youth cricket demonstrates notably significant injury rates. In a study of elite academy cricketers aged 13–18 years, the average annual injury incidence was 115 injuries / 100 players with a match injury incidence of 48.8 / 100 players / year and training injury incidence of 25.2 / 100 players / year. The lumbar spine was the most commonly injured site with match bowling resulting in the highest injury rate at 17.7 / 100 players / year (Williams *et al.*, 2024). Supporting this high match injury rate, a Sri Lankan survey of U/15 and U/17 boys cricket reports an injury rate of 28 injuries / 100 match player days (Gamage *et al.*, 2019).

An Australian study (Soomro *et al.*, 2018) highlighted the fact that the number of studies giving injury rates based on exposure hours are limited, making it difficult to standardise and compare injury rates. This prospective study found an overall injury incidence of 15.93 / 1 000 exposure hours, a match injury incidence of 41.84 / 1 000 exposure hours and training incidence significantly lower at 8.07 / 1 000 exposure hours. Bowling resulted in the highest injury rate of 30.01 / 1 000 exposure hours compared to batting (16.82 / 1 000 exposure hours) and fielding (11.16 / 1 000 exposure hours). The most common site for injury was the lower back, in keeping with the literature, followed by the elbow of the throwing arm. Overall injury mode was repetitive (50%), and muscle / tendon strains the most common injury type (66%).

1.6 SOUTH AFRICAN LITERATURE

While international studies provide a broad understanding of injury incidences and patterns in youth sports, it is essential to consider the context-specific data from South Africa to give an appropriate perspective. Significant injury rates are seen across the various sports, with rugby and cricket showing particularly high incidences.

The literature mirrors much of the international findings but also highlights the unique challenges and patterns within the local context. For instance, a significant barrier to the effective collection and surveillance of injury data in South Africa is the lack of standardised, systematic data collection systems and protocols at community and school levels. Financial and logistical restrictions compound this. The data that are collected is by individual researchers, making it inaccessible to extended research and comparison on an international level (Olivier *et al*., 2022).

Football

Football is a popular sport at South African school and community level, but data on injury incidence in youth football is sparse and the incidence of football injuries in South Africa is not known. A study on high school female football players from nine Johannesburg-based schools found a 46.1% one-year injury prevalence rate. The most common injury sites were the knees (18.6%), followed by the ankles (17.6%) (Mtshali *et al*., 2009). Another study on injury patterns in an U/20 interprovincial tournament showed a very high rate of 332 injuries per 10 000 player hours. The most frequent injury sites were the ankle (26.6%), knee (21.7%) and thigh (21.7%). The lower limb accounted for 86.4% of injuries, which is in line with international research (Frantz & Weitz, 1999).

Rugby

Rugby has one of the highest injury rates among youth sports in South Africa (SA) - A study which examined data collected between 2011–2014 in SA Rugby Union players (Mc Fie et al., 2016) found an overall match injury incidence of 55.2 / 1 000 exposure hours. Forty percent of these injuries resulted in time off play. Concussion incidence was calculated at 6.8 / 1 000 exposure hours and made up 12% of all injuries, and 31% of time-loss injuries.

Overall match injury incidence during the 2011–2012 Craven Week was calculated at 54.6 / 1 000 exposure hours, in line with the previous study. Joint / ligament injuries contributed 31% and concussion 11% of the injuries. Time-loss injury incidence was 21.4 / 1 000 exposure hours. Twenty-six percent of these were attributed to concussion and 36% to joint / ligament injuries (Brown *et al*., 2015).

Further evidence to support these injury rates and patterns was found in a study of U/16 rugby match injuries (Sewry *et al*., 2019). Match time-loss injury incidence was 28.8 / 1 000 exposure hours, which is comparable to European study rates of 24–35 / 1 000 exposure hours (Archbold *et al*., 2017; Palmer-Green *et al*., 2013). Injury rates for the lower limbs were highest at 13.9 / 1 000 exposure hours. The most common injury types were joint / ligament (12.2 / 1 000 exposure hours) and concussion (6.1 / 1 000 exposure hours).

A case study over one season of first-team school rugby examined time-loss injuries (Tee *et al*., 2017). They found a very high match injury incidence of 84 / 1 000 exposure hours, out of keeping with other youth literature and comparable to adult injury rates (Williams *et al*., 2013). The practice injury incidence was 7 / 1 000 exposure hours and total time-loss injury incidence 23 / 1 000 exposure hours. Lower limb injuries were again the most common region. Player positions and injury mode showed 75% of injuries in the forwards were direct contact.

Time-loss injuries in South African youth rugby tournaments over five years (Sewry *et al*., 2018) were analysed. Overall time-loss injury incidence was 20.4 / 1 000 exposure hours. Head and neck contributed 34% of injuries, followed by the shoulder (16%) and the knee and ankle both at 12%. The concussion incidence was found to be 5.9 / 1 000 exposure hours.

Injury incidence density was studied in 2011 at a South African Rugby Union tournament (Brown *et al*., 2012). The overall match injury incidence was 69 / 1 000 exposure hours. Time-loss injury rate in matches was 23.1 / 1 000 exposure hours and overall injury incidence density 47.9 / 1 000 match-exposure hours.

A further study, using a survey to collect rugby injury data from schools, showed injuries were more common in the first four weeks of season, and again after the mid-season holiday. The majority (68.4%) of injuries occurred during matches and 31.6% during practices. Back-line players suffered 51.8% of the injuries, with the lower limb being the most frequently injured region (32.5%), followed by the head and neck (30.4%) and upper limb (25.8%) (Roux *et al*., 1987).

Cricket

South African school cricket injury rates and patterns have been documented in several studies. One retrospective questionnaire examined the seasonal injury incidence and patterns in 116 schoolboy cricketers (Stretch, 1995) and found patterns that were similar to those seen at club and provincial level cricket (Stretch, 1993). The overall seasonal injury incidence was 49%, with bowlers experiencing the highest injury incidence at 47.4%. Injuries of the back and trunk were most common site (33.3%). Match and practice injury incidence were similar and the majority of injuries were minor (63.2%), resulting in 1–7 days off play (Stretch, 1995).

Elite U/15, U/17 and U/18 schoolboy cricket was studied over three seasons through a retrospective questionnaire (Trella, 2012). The reported injury occurrence in practice was 27% and 33% in matches. Fifty percent of injuries were acute in mode and 42% repetitive. Bowlers had the highest injury occurrence (45%). The most injured body region was the lower limb (39%), followed by the back and trunk (33%). Muscle strains were the most common injury type (31%). Most injuries were mild in severity, resulting in 1–7 days off (49%). The study highlighted that youth injury patterns were similar to those of adults, with more injuries occurring during matches and fast bowlers being at greatest injury risk.

Another seasonal retrospective study (Milson *et al*., 2007), using a questionnaire to determine injury incidence and patterns in elite schoolboy cricket, showed a significantly lower seasonal injury incidence of 34.2% when compared to other studies. Injury incidence was highest in matches (71.6%) and bowlers sustained most injuries (50.7%). The lower back was the most common injury site, and stress fractures the most frequent type of injury (47.1%). Eighty-seven percent of injuries were acute in nature and, in contrast to other studies, most injuries were severe (40.6%) resulting in >21 days off.

A more recent study (Stretch, 2015) collected injury data over five seasons of elite schoolboy cricket using a retrospective questionnaire. Supporting previous literature, injuries to the lower limb were most common (38%), followed by the back and trunk (33%) and upper limb (26%). Thirty percent of injuries occurred in matches. Bowlers sustained the most injuries (48%), followed by fielders (30%) and batsmen (11%), reflecting similar results to the above literature. Muscle strains were the most common injury type (32%) and the lower limb the most common injury region (38%).

In summary, the available literature supports the concept that participation in sport carries a significant risk of injury, particularly in contact sports and matches. A key limitation of the studies mentioned above lies in their methodology - reliance on retrospective questionnaires introduces the risk of recall bias, compromising the reliability of the findings. Gathering data through large, standardised injury surveillance databases is essential to accurately assess risk, compare patterns, and identify trends and specific risk factors. Internationally, and in South Africa, there is a distinct lack of these databases in non-elite youth sports, due to numerous logistical, financial, practical and socio-economic barriers.

CHAPTER 2: HIGH SCHOOL SPORTS INJURY SURVEILLANCE – INCIDENCE IN THE WESTERN CAPE

2.1 METHODOLOGY

2.1.1 Aims

The aim of this study was to collect high-quality data to determine the injury incidence for school sports in a Western Cape adolescent school-going population, as well as to identify potential injury patterns and associations. This study aims to form part of a greater open-ended longitudinal study collecting school sports injury data which will build evidence for the development and implementation of injury prevention strategies in this population on a national level.

2.1.2 Objectives

1. To calculate the injury incidence sustained in competition, the incidence of injuries sustained in practice, and the total injury incidence in relation to athlete exposures for high school athletes in the following sporting codes:
    - Football
    - Athletics and cross-country running
    - Tennis
    - Water polo
    - Cricket
    - Hockey
    - Swimming
    - Netball
    - Rugby

2. To provide details about the injuries sustained by athletes including:
    - Type
    - Site
    - Severity
    - Time loss
    - Outcome

3. To provide data that could give insight into potential risk factors / protective factors relating to these injuries:
   - Demographics
   - Playing position
   - Phase of play
   - Mechanism of injury
   - Mode of injury

4. To provide longitudinal data relating to injury rates and incidence so that reliable information can be given to develop and implement injury prevention programmes in the various sporting codes in the future.

2.1.3 Study design and recruitment

The study uses a Prospective Cohort Design. Thirteen schools in the Cape Peninsula region of the Western Cape Metropole were approached to participate in this survey. In order to collect data from a broad socio-economic spectrum and from both sexes, schools selected by the researcher to approach included four Independent and nine Government schools in both affluent and less affluent areas. The rationale behind this process was to include schools which were more likely to have resources already collecting injury / medical data and to provide insights as to whether demographics are a risk factor.

An initial phone call by the researcher was made to each school to identify the appropriate member of staff — identified as Head of Sport or similar. A follow-up email, or phone call for those who did not have email, was sent, outlining the study aims and objectives to determine if the school was willing to participate. A follow-up in-person meeting was then arranged with the schools who considered participation to finalise details, choose which teams to monitor, and discuss joint expectations.

2.1.4 Participants

Athletes attending the participating high schools with a sports-related injury were included. A participant information sheet and consent form (parental consent or participant consent/assent depending on age) was distributed to the athletes either through an email link to Google Docs, or a hard copy given to the students by the coaching staff. Only students who consented to participation and who met the requirements for participation based on the exclusion and inclusion criteria were enrolled.

Inclusion criteria

- Age 12–19 years old
- Parental consent to participate in the study
- Participating in a structured sporting code being investigated (2.1.2: 1)
- Sports-related injury

Exclusion criteria

- Any existing injury at enrolment into the study that did not resolve during the duration of the study
- Orthopaedic problems of the limbs or spine in the six months prior to enrolment which interfered with normal joint function during sports participation and / or changed the risk of injury
- Illness, hospitalisation or surgery in the 12 months prior to enrolment which predisposed the athlete to injury during sports participation

Participant number

Three schools (two Independent and one Government) consented to be involved in the survey, and 101 participants were recruited over three sporting codes.

2.1.5 Data collection

Data collection methodology impacts the results of injury surveillance studies and needs to be adaptable to the sporting code and resources available (Finch, 1997). A large systematic review resolved that data quality can be improved by implementing data collection guidelines that will result in reliable, valid, sustainable and comparable outcomes (Ekegren *et al*., 2016).

In view of this, the data collection methodology was developed in accordance with the IOC Consensus Statement: Methods for Recording and Reporting of Epidemiological Data on Injury and Illness in Sport including STROBE-SIIS (Bahr *et al*., 2020).

Staff responsible for coaching and managing the sporting codes in the participating schools were identified, and an initial face-to-face meeting with the researcher was arranged to discuss the nature of the study, address any concerns, and to explain the data collection spreadsheet and decide if a paper or electronic collection approach would be more suitable.

To reduce the administrative burden on the staff members, it was decided that the spreadsheet would be shared on Google Docs. Only the responsible staff member for each sporting code and the researcher had access to the document for that sporting code to ensure confidentiality and reduce the risk of unauthorised users accessing or changing data information. The researcher checked in with the staff member weekly through a telephone call to monitor and assess compliance and accuracy of data collection, and to address questions or logistical issues.

Four schools initially agreed to take part in the study with the sporting codes included being rugby, football, cricket and water polo. Over the course of the study, one school failed to collect data due to logistical and time constraints with their staff, and water polo fell away for similar reasons. Data were collected for three first team sporting codes (rugby, football and cricket) over the respective seasons. The study was conducted over summer and winter sporting seasons from 2019–2023. Of note: this period of time included the COVID-19 lockdown and cessation of school sports which began on 27 March 2020. From June 2020, a phased reduction in lockdown measures led to a slow reintroduction of students to school and school sporting programmes but with strict social distancing measures of one metre between students and no contact sports. Official resumption of school sports was staggered and by the beginning of 2021 was back to normal.

Data collection document

The preferred method of collection was through Google Docs on a spreadsheet (Appendix 4) as this was easily accessible and reproducible for the participating schools.

Definitions of the data parameters were based on the IOC Consensus Statement (Bahr *et al*., 2020) and described on the cover sheet of the document, with some minor modifications to simplify collection for the coaches and medical staff. Both body region and a further spilt into body area were used in this study.

For this study, "Sports Injury" was defined as any tissue damage or physical dysfunction occurring during participation in organised school sport (practice or match), acute or repetitive in nature.

An acute injury was defined as being of sudden onset due to an immediate transfer of force, direct or non-contact in mechanism.

A repetitive injury was defined as one occurring due to an accumulation of low-energy force over time.

A direct contact injury was defined as occurring due to contact with another person or object, and a non-contact injury was defined as occurring without contact with an external source.

Injury severity was defined as time loss from play: mild (1-7 Days); moderate (8- 28 Days) and severe (>28 Days).

For the purpose of this study, brain injuries/concussions were recorded as head injuries under Body Area and termed as an injury to an Internal organ under Injury Type.

The following parameters were set out and defined in the document:

- Number of players in training squad; Number of players in match squad; Weekly Hours spent in training; Weekly Hours spent in matches; Sports Injury Definition; Mode of Onset (Acute / Repetitive); Mechanism of Injury (Direct Contact / Non-Contact); Body Region (Head and Neck / Upper Limb / Trunk / Lower Limb); Body Area (Head, Chest, Neck / Shoulder, Spine, Forearm, Wrist, Hand, Hip, Thigh, Knee, Calf, Ankle, Foot); Injury Type (Muscle, Tendon, Nerve, Bone, Cartilage / Bursae, Ligament / Joint, Superficial tissue, Vessels, Internal Organs)
- Injury Severity in Time Loss (0 Days / 1–7 Days / 8–28 Days / >28 Days); Injury Side (Left / Right); Type of Play (Practice / Match); Time of Play in Match (First Half / Second Half)
- Player Position e.g. Forward / Back / Batsman / Bowler / Fielder.

Each subsequent sheet was pre-filled with these data parameters for each week of the season, along with a section for capturing the hours spent on Practice and Matches. Injuries were captured with the name of the student and given a numerical number. The responsible staff member, coach or team physiotherapist filled in the information on a regular basis, updating weekly.

2.1.6 Data analysis

All data collected on Google Sheets was transferred by the researcher into Microsoft Excel (version 16.87 for Macintosh, Microsoft Corporation, Redmond, Washington, United States). This compiled data set was subsequently used for the analysis. All statistical analysis was carried out using GraphPad Prism (version 9.5 for Macintosh, GraphPad Software, San Diego, California, United States). A more detailed analysis was conducted and reported on for rugby due to its majority contribution to the data set.

Injury Exposure hours in this study was described as being the time, in hours, for which an athlete is at risk for injury during practice, during matches and as a total.

Practice is defined as any training involving skill development, fitness and performance.

Matches are defined as organised play between two opposing teams.

- Injury Exposure Practice = No. athletes in squad × practice hours
- Injury Exposure Match = No. athletes in match-day team × match hours
- Total Exposures = Practice Exposure + Match Exposure

Injury Incidence was described as injuries per 1 000 athlete-exposure hours, for practice, match play and as a total metric.

- Injury Incidence Practice = No. Injuries Practice / (Injury Exposure Practice / 1 000)
- Injury Incidence Match = No. Injuries Match / (Injury Exposure Match / 1 000)
- Total Injury Incidence = (No. Injuries Practice + No. Injuries Match) / (Injury Exposure Total / 1 000)

Time off Play was grouped into severity categories: 0 days, 1–7 days (mild), 8–28 days (moderate) and >28 days (severe).

Injuries were grouped and sub-grouped into Mode (Acute and Repetitive); Mechanism (Direct Contact and Non-Contact); Type of Play (Match and Practice); Period of Play (1st or 2nd Half); Body Region (Head and Neck, Upper Limb, Trunk, Lower Limb); Body Area (Head, Chest, Neck, Shoulder, Spine, Forearm, Wrist, Hand, Hip, Thigh, Knee, Calf, Ankle and Foot); Injury Type (Muscle, Tendon, Nerve, Bone, Cartilage / Bursae, Ligament / Joint, Superficial Tissue, Vessels and Internal Organs); Time Loss (Yes or No), Time off Play (0 days, 1–7 days, 8–28 days, >28 days) and Player Position (Forward and Back).

A one-way ANOVA analysis was performed to determine statistical differences in the means for Rugby data in the sub-groups in Body Region, Body Area, Injury Type and Time off Play. Post hoc comparisons using the Tukey-Kramer analysis were done for statistical significance.

An unpaired T-test was used to determine the difference in means for groups. Further analysis was done between groups using the Chi-squared Test of Independence to determine whether there were critical associations or not. Where significant, the standardised residuals were measured in order to identify which observed counts deviated most from the expected counts to give further insight into the data. Positive Standardised residuals indicate that the observed count is higher than the expected count, and Negative Standardised residuals indicate that the observed count is lower than the expected count. A value greater than +/-2 is considered significant (Montgomery *et al*., 2021).

In order for the Chi-squared test to be valid, the expected frequencies for each category are required be >1 and at least 20% >5 which was not the case in some of the groups (Mindrila *et al*., 2013). This was due to the relatively small sample size of the data set. An exact Fisher's test was conducted in these cases where the contingency table allowed, and when the table did not allow, individual Unpaired T-tests were run or there was no further analysis done. For all data, statistical significance was accepted at $p < 0.05$.

2.1.7 Ethical considerations

This study was approved by the Human Research Ethics Committee of the Faculty of Health Sciences, University of Cape Town (HREC-REF: 112/2015). (Appendix 1)

Informed consent was obtained for all study participants, either personally via hardcopy or online via Google Forms (Appendix 3.1 and 3.2). Hardcopy consent forms are kept securely and only accessible to the primary researcher. The Google Docs consent forms are kept securely online, protected by access passwords and also only available to the primary researcher. Students' identities are not disclosed and each injury is identified by a numerical number on the data spreadsheets. Following submission of the data sheet, the data was transferred to a master spreadsheet and anonymised at that time. The original data submission was filed in an electronic database which was secured by password authentication.

Risk to participants

Due to its nature as a survey, no risk was posed to the study participants. No changes to training or match protocols were made; the only requirement was reporting of injuries in an accurate and detailed manner.

Benefits to participants

There was no direct benefit to the participants in this study. In the longer term, this study will be of benefit to young athletes and school sports programmes once injury risk patterns and factors that influence these can be reported on, fed back and the information used to develop injury prevention protocols.

Study significance

This study forms an essential part of an ongoing injury survey for High School Sports. Prior to this study, the researchers had not been able to start the school recruitment and data collection process. This study, its methodology and set-up of simple data collection methods, the connections made with participating schools and therefore the potential ability for continued quality data collection will result in a large database of school sports injuries that can be further analysed and contribute towards identifying injury patterns in adolescence and developing prevention programmes. To date there are no cohesive databases collecting injury information across the school sporting codes in the Western Cape.

2.2 RESULTS

Descriptive results are reported for all sports combined, and then individually for rugby, football and cricket. Rugby contributes 68 of the total 78 recorded injuries and therefore in-depth statistical analysis is focused on this data set. A summary of the comparative results which are described below is given in Table 2.

Table 2: Summary of comparative results between Sports

INJURY INCIDENCE	All Sports (n = 78)	Rugby (n = 68)	Football (n = 7)	Cricket (n = 3)
Total Injury Incidence	4.31	4.53	7.09	1.42
Time Loss Injury Incidence	3.04	3.06	7.09	0.94
Match Injury Incidence	28.78	85.98	51.11	0.75
Practice Injury Incidence	1.18	1.18	0	2.5
INJURY MODE	***p < 0.001 ****	***p < 0.001 *****	***p < 0.001 ******	***p < 0.001 *******
Acute	84.62%	82.35%	100%	100%
Repetitive	15.38%	17.65%	0%	0%
INJURY MECHANISM	***p < 0.001 #***	***p < 0.001 ##***	*p = 0.626*	***p < 0.001 ###***
Direct contact	69.23%	73.53%	57.14%	0%
Non-contact	30.77%	26.47%	42.86%	100%
TYPE OF PLAY	***p < 0.001 †***	***p < 0.001 ††***	***p < 0.001 †††***	*p = 0.52*
Practice	25.64%	25%	0%	66.66%
Match	74.36%	75%	100%	33.33%
BODY REGION		***p < 0.001 ϕ***		
Upper Limb	35.90%	38.24%	14.29%	33.33%
Lower Limb	42.31%	41.18%	57.14%	33.33%
Head and Neck	8.97%	7.35%	28.57%	0%
Trunk	12.82%	13.25%	0%	33.33%
BODY AREA		***p < 0.001 δ***		
Head	7.69%	7.35%	14.29%	0%
Neck	1.28%	0%	14.29%	0%
Chest	5.13%	5.88%	0%	0%
Spine	7.69%	7.35%	0%	33.33%
Shoulder	25.64%	26.47%	14.29%	33.33%
Forearm	2.56%	2.94%	0%	0%
Wrist	1.28%	1.47%	0%	0%
Hand	5.13%	5.88%	0%	0%
Hip	5.13%	4.41%	14.28%	0%
Thigh	3.85%	4.41%	0%	0%
Knee	14.10%	11.76%	28.57%	33.33%
Calf	10.26%	11.76%	0%	0%
Ankle	9.97%	8.82%	14.29%	0%
Foot	1.28%	1.47%	0%	0%
INJURY TYPE		***p < 0.001 λ***		
Muscle	17.94%	17.65%	14.28%	33.33%
Tendon	7.69%	8.82%	0%	0%
Nerve	1.28%	1.47%	0%	0%
Bone	16.66%	16.18%	28.57%	0%
Cartilage / Bursae	7.69%	7.35%	14.28%	0%
Joint / Ligament	29.74%	39.70%	28.57%	66.66%
Internal	8.97%	8.82%	14.28%	0%
TIME LOSS	***p < 0.001 ‡***	***p < 0.001 ‡‡***	***p < 0.001 ‡‡‡***	*p = 0.52*
Yes	70.51%	67.65%	100%	66.66%
No	29.49%	32.35%	0%	33.33%
TIME OFF PLAY / SEVERITY		*p = 0.021*		
0 days	29.48%	32.35%	0.00%	33.33%
1–7 days	17.94%	19.11%	14.28%	0%
8–28 days	37.18%	33.82%	57.14%	66.66%
>28 days	15.38%	14.71%	28.57%	0%
PLAYER POSITION		*p = 0.679*	*p = 0.626*	
Forward		57.35%	57.14%	
Back		42.65%	42.86%	
PERIOD OF PLAY		***p < 0.001 §***	***p < 0.001 §§***	
First half		19.61%	0%	
Second half		80.39%	100%	

Injury Incidence = injuries / 1000 athlete-exposure hours .

Significant p-values (< 0.05) marked in bold

* All Sports Injury Mode (Acute vs Repetitive), ** Rugby Injury Mode (Acute vs Repetitive), *** Football Injury Mode (Acute vs Repetitive), **** Cricket Injury Mode (Acute vs Repetitive)

All Sports Injury Mechanism (Direct contact vs Non-contact), ## Rugby Injury Mechanism (Direct contact vs Non-Contact), ### Cricket Injury Mechanism (Direct contact vs Non-contact)
† All Sports Type of play (Practice vs Match), †† Rugby Type of play (Practice vs Match), ††† Football Type of play (Practice vs Match)
ϕ Rugby Body Region comparison,
δ Rugby Body Area comparison
λ Rugby Injury type comparison
‡ All Sports Time Loss (Yes vs No), ‡‡ Rugby Time Loss (Yes vs No), ‡‡‡ Football Time Loss (Yes vs No)
§ Rugby Period of Play (First half vs Second half), §§ Football Period of Play (First half vs Second half)

2.2.1 All sports

Injury Incidence

A combined total of 78 injuries was recorded for the three sporting codes. The combined *total exposure* was 18 116. Combined *match exposure* was 2 050. Combined *practice exposure* was 16 066.

Combined *injury incidence* was 4.31 / 1 000 athlete-exposure hours. Combined *match injury incidence* was 28.78 / 1 000 and combined *practice injury incidence* was 1.18 / 1 000. This is shown in Figure 1.

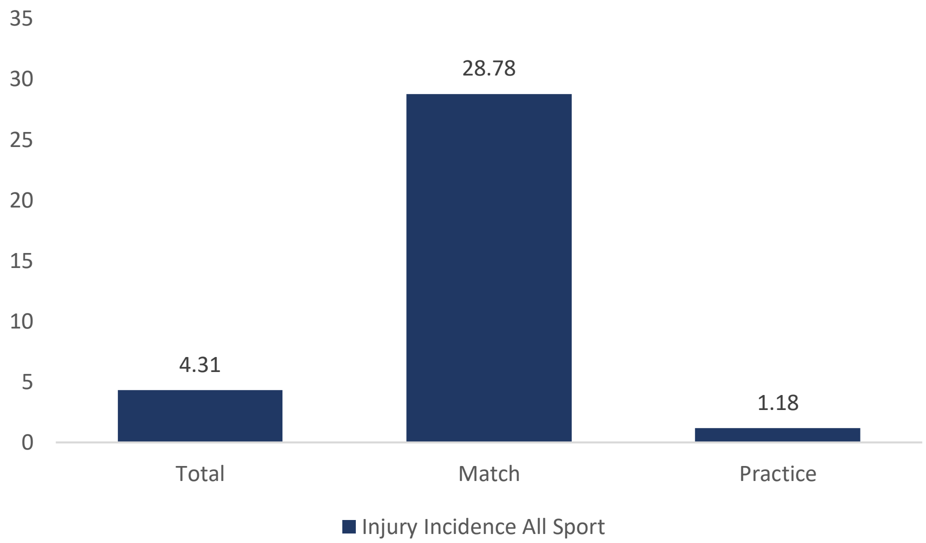

Figure 1: All Sports Injury Incidence - Total, Match and Practice per 1 000 athlete-exposure hours

Injury mode

Total acute injuries numbered 66 (84.62%) and repetitive injuries 12 (15.38%) as shown in Figure 2. There was a significant difference between acute and repetitive injuries (*$p < 0.001$*).

Injury Mode and Type of Play. Matches resulted in 52 (88.14%) acute and 7 (11.86%) repetitive injuries, while practices resulted in 14 (73.68%) acute and 5 (26.31%) repetitive injuries. This distribution is shown in Figure 3. Statistically there was no significant association between injury mode and type of play. Due to the relatively small sample size, the expected frequency for repetitive mode during practice was <5 making the Chi-squared test less reliable. A Fisher's Exact test was therefore done confirming that there is no significant association between type of play and injury mode *(Odds Ratio: 0.377; p = 0.152).*

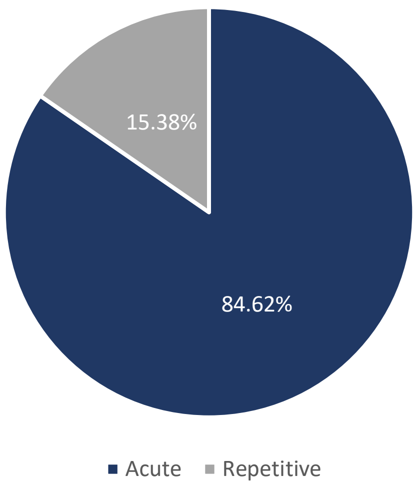

Figure 2: All Sports - Injury Mode ($p < 0.001$)

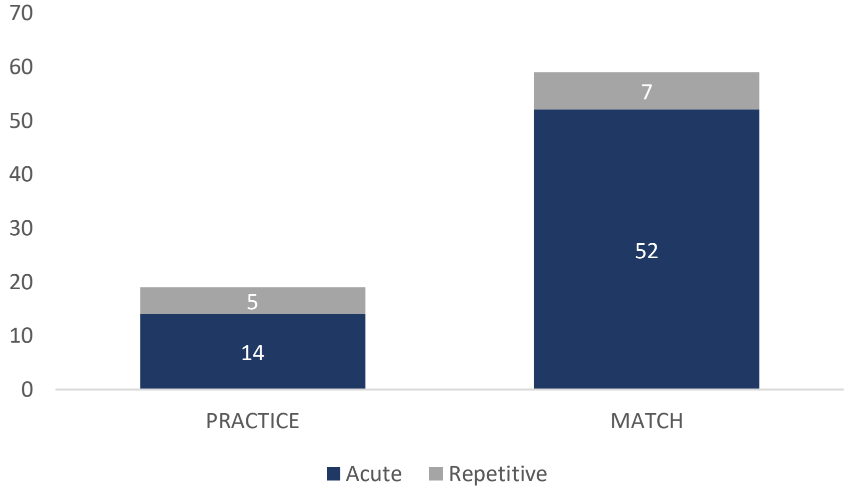

Figure 3: All Sports - Injury Mode and Type of Play ($p = 0.152$)

Injury Mechanism

Injury Mechanism for all sports, shown in Figure 4, recorded 54 direct contact injuries (69.23%) and 24 non-contact injuries (30.77%), which was statistically significantly different between mechanisms of injury (*$p < 0.001$).*

Injury Mechanism and Type of Play. Match injuries resulted in 43 (72.88%) direct contact injures and 16 (27.12%) non-contact injuries, while practices resulted in 11 (57.89%) direct contact injuries and 8 (42.11%) non-contact injuries. This distribution is shown in Figure 5. Statistically there was no significant difference between the injury mechanism and type of play (*$p = 0.345$*) with a valid Chi-squared test.

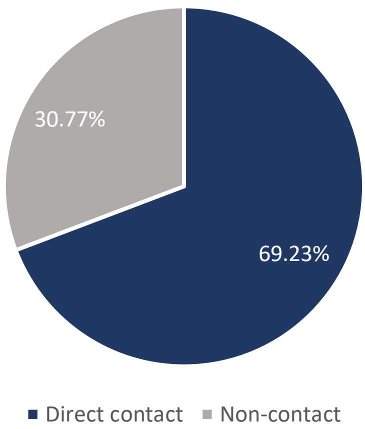

Figure 4: All Sports - Injury Mechanism (p < 0.001)

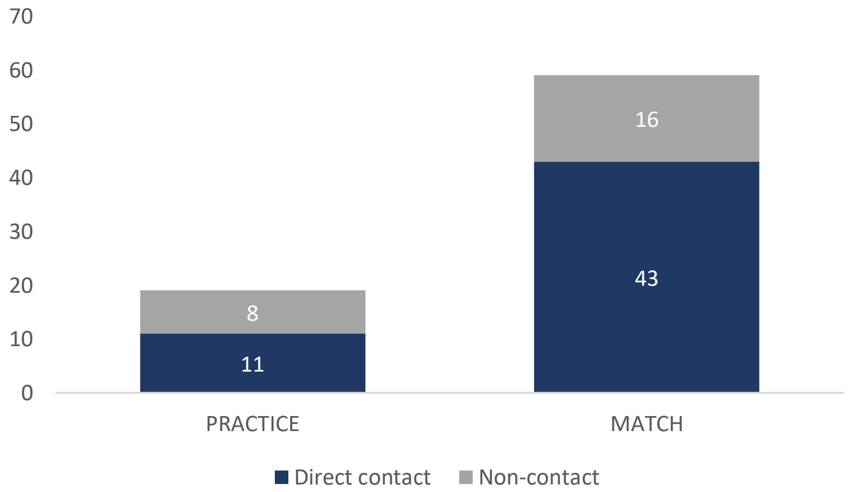

Figure 5: All Sports - Injury Mechanism and Type of Play (p = 0.345)

Type of Play

Distribution of injuries in type of play was 58 (74.36%) in matches and 20 (25.64%) during practice as shown in Figure 6. A significant difference between the types of play was found (*p < 0.001*).

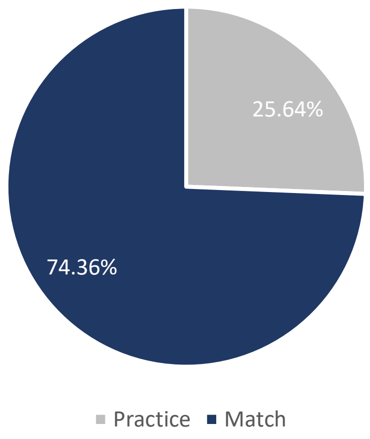

Figure 6: All Sports Injuries - Type of Play (p < 0.001)

Body Region

Lower limb injuries accounted for the majority of total injuries with 33 (42.31%), followed by upper limb 28 (35.9%), trunk 10 (12.82%) and head and neck 7 (8.97%). Figure 7 demonstrates this distribution.

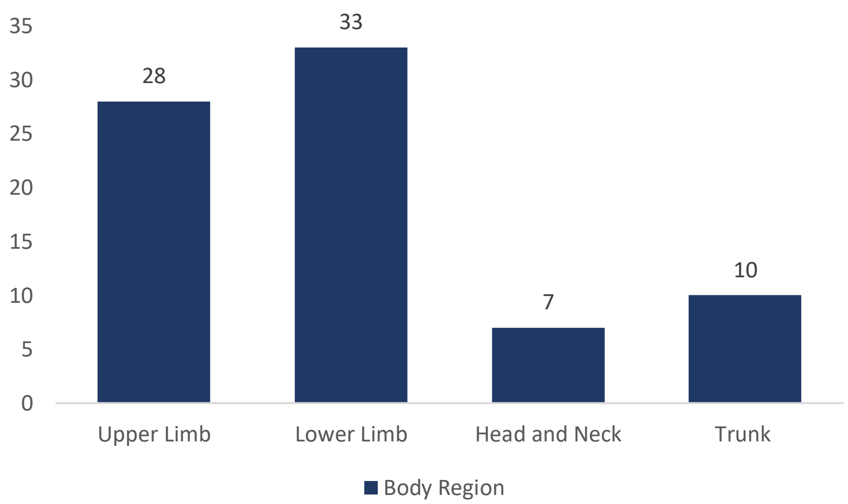

Figure 7: All Sports - Total Injuries per Body Region

Body Area

As shown in Figure 8 below, body areas most injured across all sports were the shoulder 20 (25.64%), knee 11 (14.1%), calf 8 (10.26%), ankle 7 (9.97%), head / concussion 6 (7.69%) and spine 6 (7.69%). Chest, hand and hip injuries accounted for 4 (5.13%) each, thigh 3 (3.85%), forearm 2 (2.56%) and neck, wrist and foot 1 (1.28%) each.

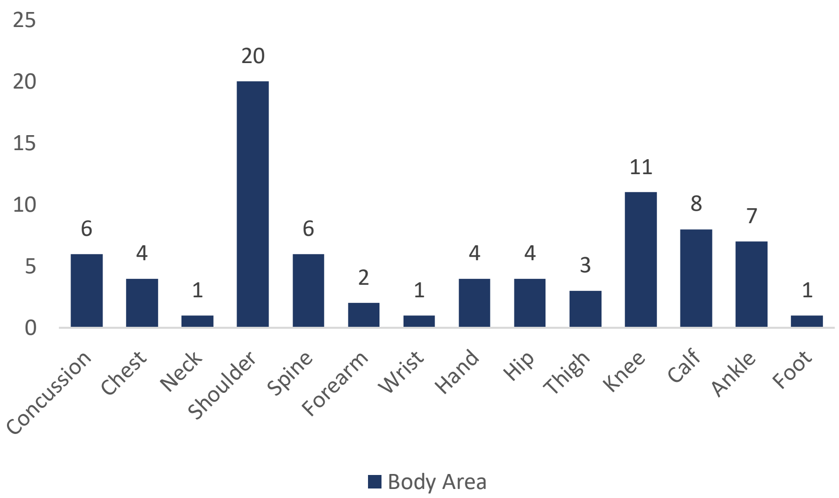

Figure 8: All Sports - Total Injuries per Body Area

Injury Type

Joint / ligament injuries were the most prevalent injury type counting for 31 (29.74%) of total injuries. This was followed by muscle 14 (17.94%), bone 13 (16.66%), internal 7 (8.97%), cartilage / bursae 6 (7.69%), tendon 6 (7.69%) and nerve 1 (1.28%) as shown in Figure 9.

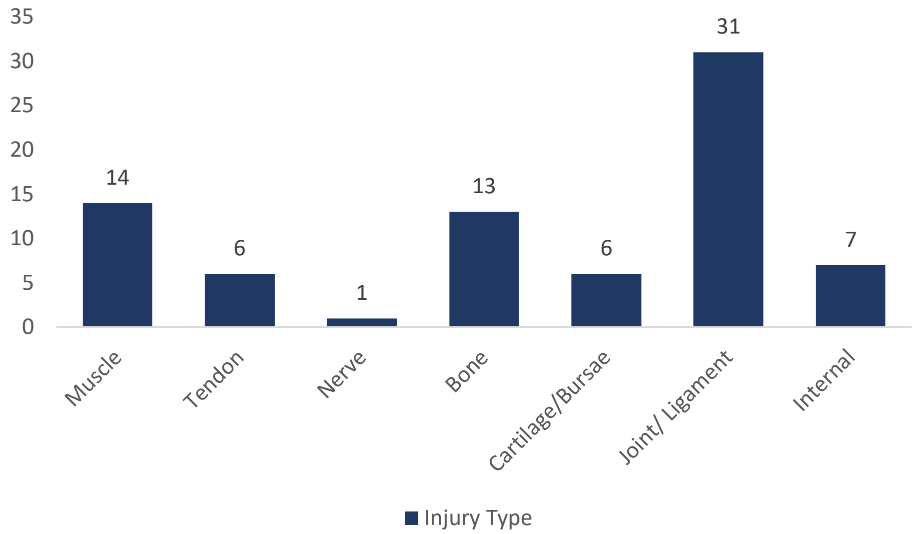

Figure 9: All Sports - Total Injuries per Injury Type

Time Loss

Time loss injuries accounted for 55 (70.51%) of total injuries, with 23 (29.49%) resulting in no time loss. This is shown in Figure 10. Statistically there is a significant difference between time loss and no time loss injuries (*p < 0.001*).

Time Loss and Type of Play. Matches produced 43 (72.88%) time loss injuries and 16 (27.11%) resulted in no time loss. During practices, 12 (63.15%) injuries resulted in time loss while 7 (36.84%) had no associated time loss. This comparison in shown in Figure 11. Statistically there is no significant difference between time loss / no time loss injuries and type of play *(p = 0.60)* with a valid Chi-squared test.

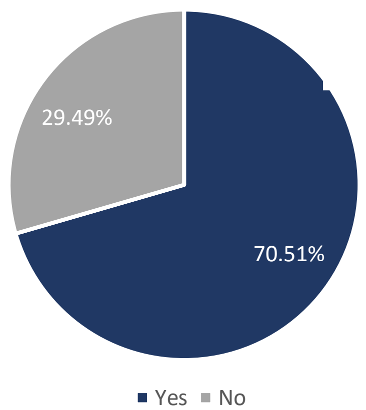

Figure 10: All Sports - Total Injuries and Time Loss vs No Time Loss (p < 0.001)

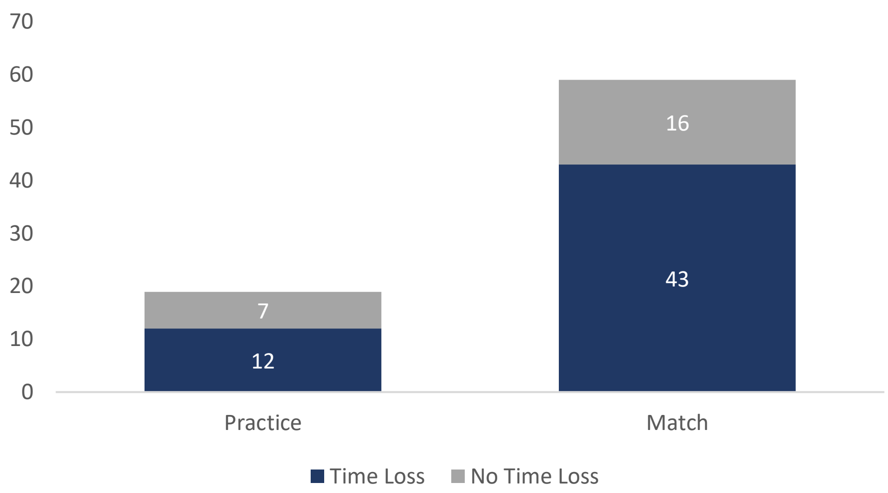

Figure 11: All Sports - Type of Play and Time Loss vs No Time Loss Injuries (p = 0.60)

Time off Play / Severity

Duration of time off play, displayed in Figure 12, shows 23 (29.48%) of the total injuries incurring 0 days off, 14 (17.94%) 1–7 days, 29 (37.18%) 8–28 days and 12 (15.38%) >28 days.

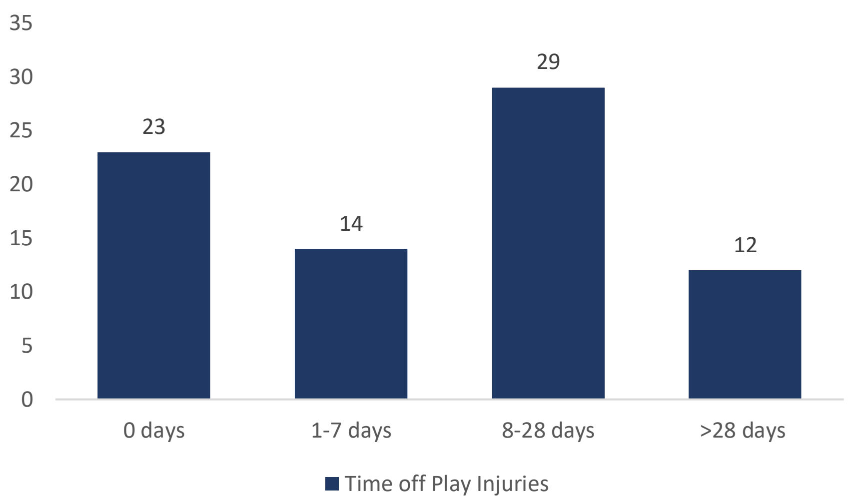

Figure 12: All Sports - Total Injuries and Time off Play Severity Categories

2.2.2 Rugby

Injury Incidence

A total of 68 injuries were sustained in a squad of n = 65 over two seasons. The match squad consisted of 15 players. A total of 17 injuries were recorded during practice training and 51 during matches. *Practice injury exposure* was 14416.35, *match injury exposure* 593.1 and *total injury exposure* 15009.45. The *total injury incidence* was 4.35 / 1 000 athlete-exposure hours, with a *match injury incidence* of 85.99 / 1 000 and a *practice injury incidence* of 1.18 / 1 000, demonstrated in Figure 13.

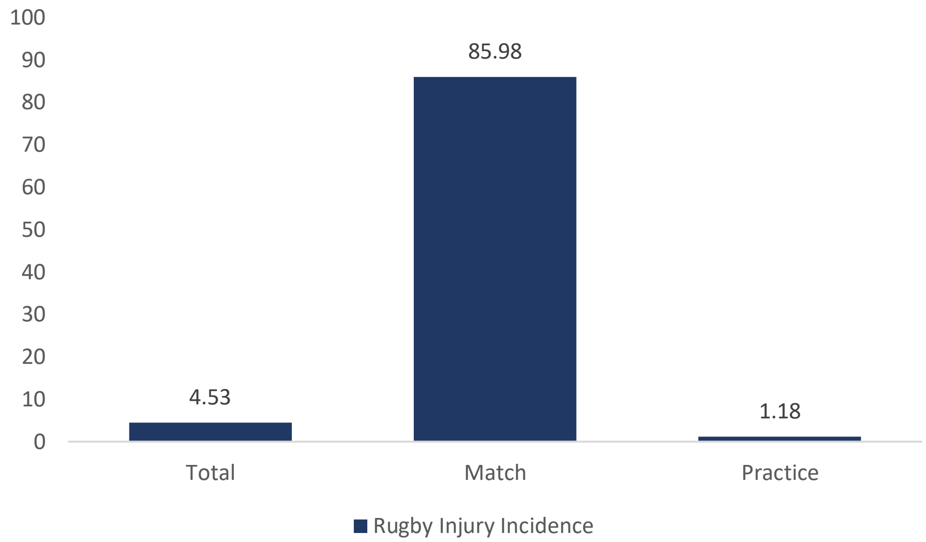

Figure 13: Rugby Injury Incidence - Total, Match and Practice per 1 000 athlete-exposure hours

Of the 68 rugby injuries, 46 resulted in time loss. Of these time loss injuries, 35 occurred during matches and 11 during practice.

As displayed in Table 3, the *total time loss injury incidence* was found to be 3.06 / 1 000, with a *match time loss injury incidence* of 35 / 1 000 and a *practice time loss injury incidence* of 0.76 / 1 000.

Table 3: Rugby Injury Incidence and Time loss Injury Incidence per 1 000 athlete-exposure hours

	Total	Match	Practice
Injury Incidence	4.53	85.98	1.18
Time loss Injury Incidence	3.06	59.01	0.76

Distribution of injuries over season

The seasons were 21 and 27 weeks in duration respectively, with week 12 being the mean mid-season point. The majority of injuries occurred in the first half of the season, 47 (69.12%) compared to 21 (30.88%) in the second half as seen in Figure 14 below.

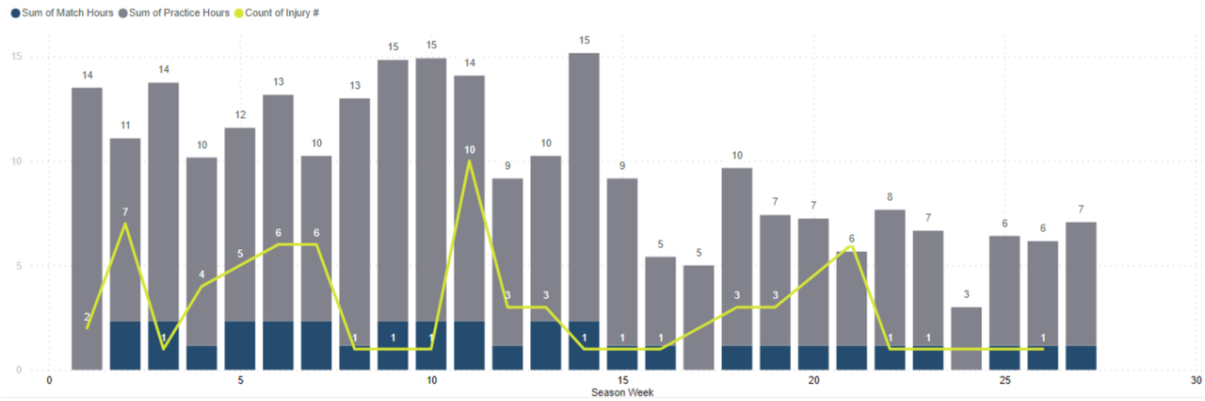

Figure 14: Rugby Seasonal Distribution of Injuries with Match and Practice Hours

Injury Mode

Total season injury mode was 56 (82.35%) acute and 12 (17.65%) repetitive, shown in Figure 15. A statistically significant difference was found between these modes *($p < 0.001$).*

Injury Mode and Type of Play. This comparison is shown in Figure 16. Acute injuries numbered 44 (78.57%) in matches, while 12 (21.43%) occurred during practice. Repetitive injuries saw 7 (58.33%) in matches, while 5 (41.66%) occurred during practice. No statistical significance was found between injury mode and type of play using the Chi-squared test *($p = 0.27$)*. A Fisher's Exact test was done *(Odds Ratio 0.38; $p = 0.16$)* as the expected injury frequency for repetitive / practice in the Chi test was <5. This confirmed no statistical association between injury mode and type of play.

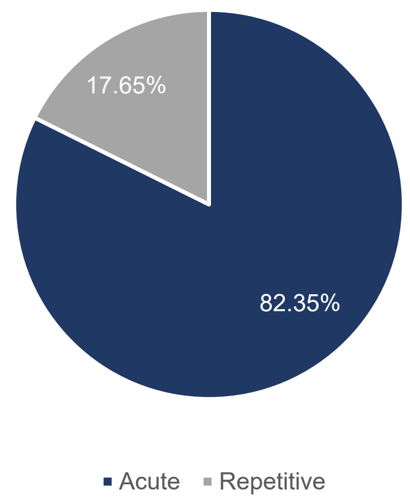

Figure 15: Rugby - Total Injury Mode (p < 0.001)

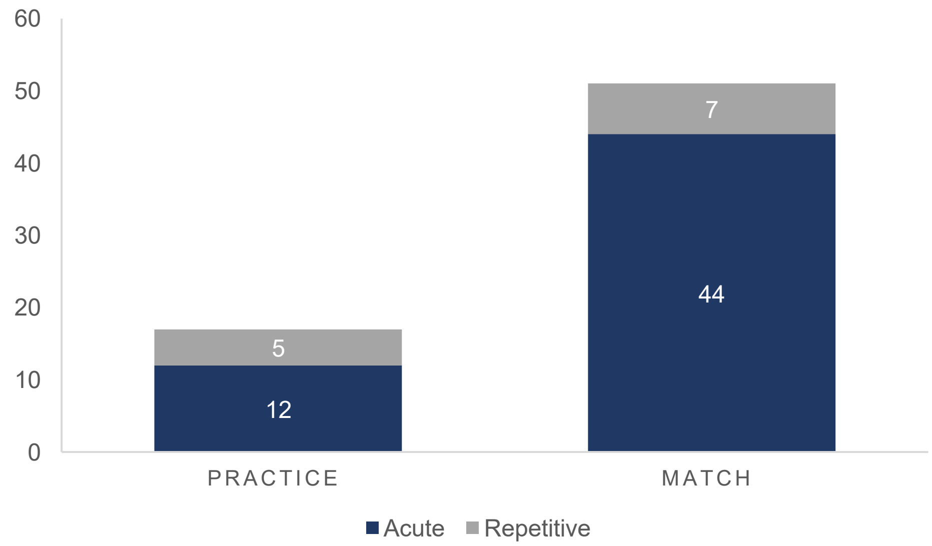

Figure 16: Rugby - Total Injuries in Mode and Type of Play (p = 0.16)

Injury Mechanism

Of the total injuries, 50 (73.53%) were direct contact in nature and 18 (26.47%) non-contact with a statistically significant value *($p < 0.001$)* between injury mechanism. This is shown in Figure 17.

Injury Mechanism and Type of Play. Figure 18 shows this comparison where match play saw 39 (78%) and practice 11 (22%) direct contact injuries. Non-contact injuries accounted for 12 (66.66%) during matches and 6 (33.33%) during practice. No significant associations were found between injury mechanism and type of play *(p = 0526)* with a Chi-squared test, but the expected frequency of practice / non-contact injuries was <5 making the test less reliable. An Exact Fisher's test was therefore conducted *(Odds Ratio 0.564; p = 0.357)* which confirmed no significant differences.

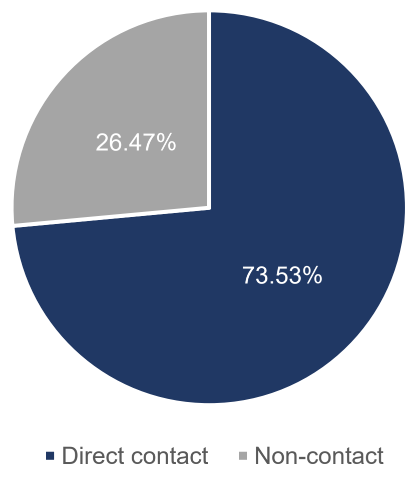

Figure 17: Rugby - Total Injury Mechanism (p < 0.001)

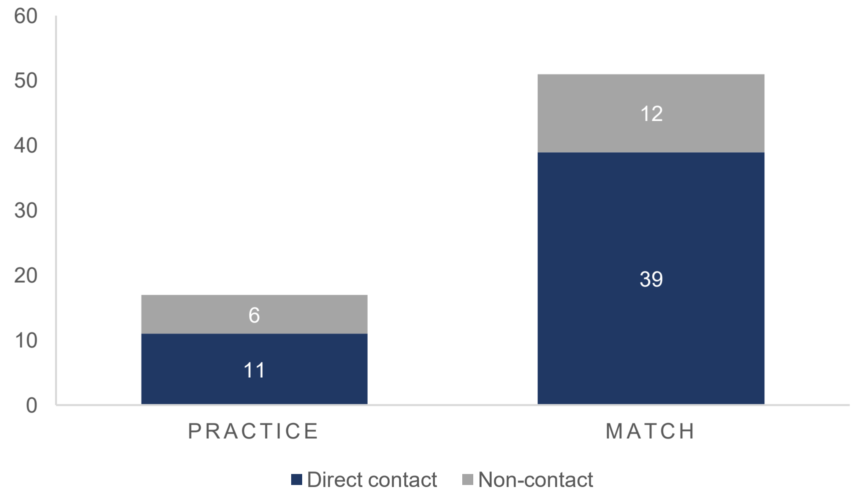

Figure 18: Rugby - Total Injuries in Mechanism and Type of Play (p = 0.375)

Type of Play

Match play saw 51 (75%) of the total rugby injuries and 17 (25%) occurred during practice, shown in Figure 19. This difference was found to be statistically significant *($p < 0.001$).*

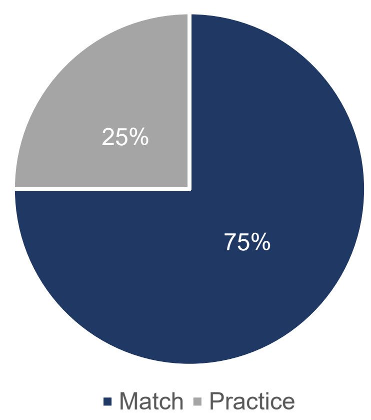

Figure 19: Rugby - Total Injuries and Type of Play (p < 0.001)

Period of Play

Of the 51 injuries occurring during matches, 10 (19.61%) occurred during the first half, and 41 (80.39%) during the second half of play, demonstrated in Figure 20. Statistically there is significance between the number of injuries and period of play *($p < 0.001$).*

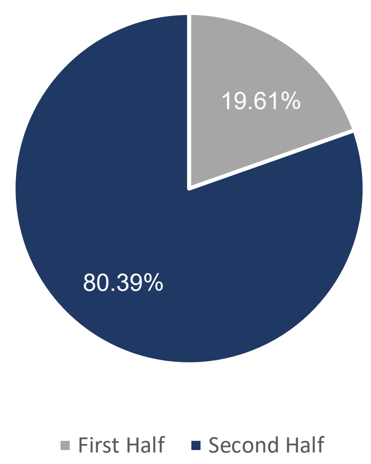

Figure 20: Rugby - Match Injuries and Period of Play (p < 0.001)

Body Region

The number of Injuries in the four body regions were: upper limb 26 (38.24%), lower limb 28 (41.18%), head and neck 5 (7.35%) and trunk 9 (13.24%). This distribution is shown in Figure 21. These were compared and the results for injury patterns between these regions were found to be highly significant *($f = 11.58$, $p < 0.001$).*

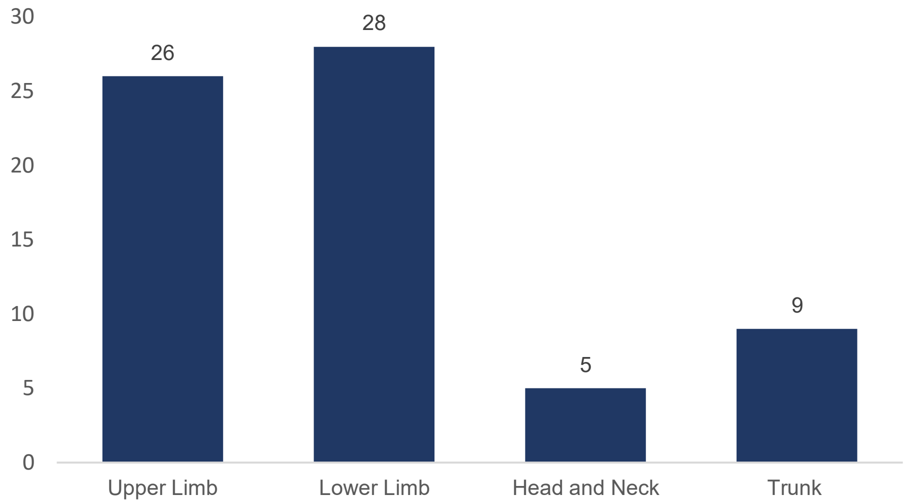

Figure 21: Rugby - Total Injuries and Body Region (ANOVA f = 11.58, p < 0.001)

A Tukey's multiple comparisons test showed statistical injury pattern differences between upper limb vs head and neck *($p = 0.0001$)*, upper limb vs trunk *($p = 0.003$)*, lower limb vs head and neck *($p < 0.0001$)* and lower limb vs trunk *($p < 0.0007$)*. These are shown in Table 4.

Injuries were significantly more frequent in the upper and lower limbs compared to the trunk and head and neck. The upper limb and lower limb injuries have comparable frequencies, as do the trunk and head and neck regions. This data indicates there may be specific risk factors contributing to the predominance of limb injuries.

Table 4: P-values for pairwise comparisons between Body Regions

	Lower Limb	Upper Limb	Trunk	Head and Neck
Lower Limb		0.9764	**0.0007***	**< 0.0001***
Upper Limb	0.9764		**0.003***	**0.0001***
Trunk	**0.0007***	**0.003***		0.8433
Head and Neck	**0.0001***	**< 0.0001***	0.8433	

Significant p-values (p < 0.05) marked in bold with *

Body Area

Injuries involving the body area groups counted: head (concussion) 5 (7.35%), chest 4 (5.88%), shoulder 18 (26.47%), spine 5 (7.35%), forearm 2 (2.94%), wrist 1 (1.47%), hand 4 (5.88%), hip 3 (4.41%), thigh 3 (4.41%), knee 8 (11.76%), calf 8 (11.76%), ankle 6 (8.82%) and foot 1 (1.47%). This is shown in Figure 22. This distribution was analysed and results showed significant differences between the areas *($f = 4.679$, $p < 0.001$)*.

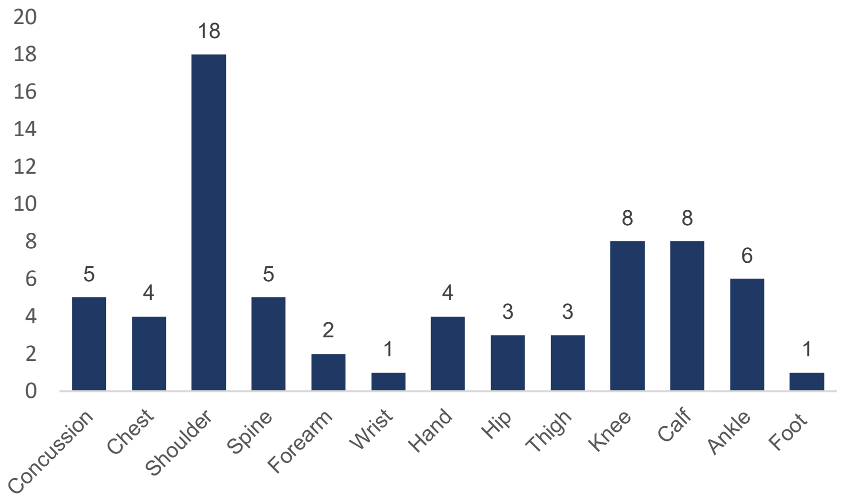

Figure 22: Rugby - Total Injuries and Body Area (ANOVA f = 4.679, p < 0.001)

A Tukey's multiple comparisons test was done which showed the statistically significant correlations. Head (concussion) vs shoulder *(p = 0.0009),* chest vs shoulder *(p = 0.0002),* neck vs shoulder *(p < 0.0001),* shoulder vs spine *(p = 0.0009),* shoulder vs forearm *(p < 0.0001),* shoulder vs wrist *(p < 0.0001)*, shoulder vs hand *(p = 0.0002),* shoulder vs hip *(p < 0.0001),* shoulder vs thigh *(p < 0.0001),* shoulder vs knee *(p = 0.0449),* shoulder vs calf *(p = 0.0449),* shoulder vs ankle *(p = 0.0039),* shoulder vs foot *(p < 0.0001)*.

The shoulder was the most frequently injured body area, seeing 18 (26.47%) injuries, with the knee and calf also having relatively high injury counts of 8 (11.76%) each. The most significant differences were seen with the shoulder compared to all other body areas, suggesting it is more prone to injury and there may be risk factors specific to this pattern.

Injury Type

Joint / ligament injuries were the most common at 27 (39.7%), followed by muscle 12 (17.65%) and bone 11 (16.18%). Tendon and internal injuries numbered 6 (8.82%) each, with cartilage / bursae 5 (7.35%) and nerve 1 (1.47%). This is shown in Figure 23.

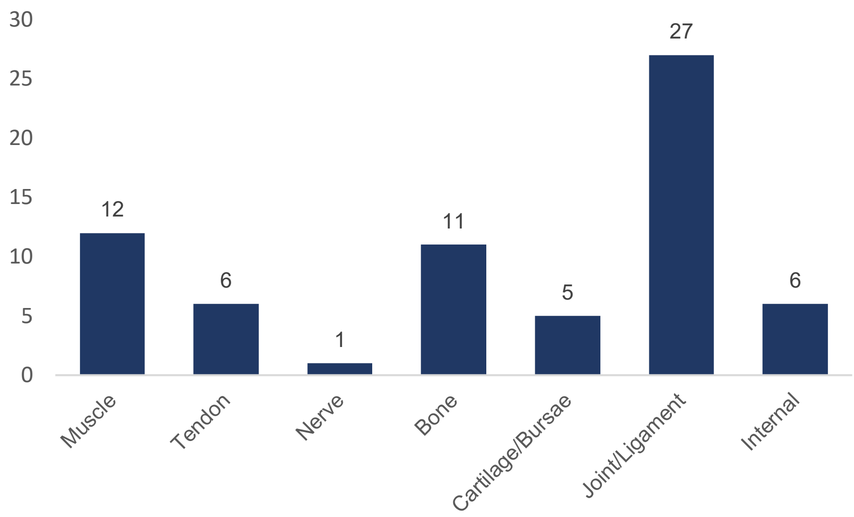

Figure 23: Rugby - Total Injuries and Type (ANOVA f = 12.1, p < 0.001)

The injury types were compared and differences were found to be highly significant (*f = 12.1, p < 0.001).*

A Tukey's multiple comparisons test was done showing the statistically significant injury patterns. These were muscle vs nerve *(p = 0.0406),* muscle vs joint / ligament *(p = 0.0006),* muscle vs superficial tissue *(p = 0.0161),* muscle vs vessels *(p = 0.0161),* tendon vs joint / ligament *(p < 0.0001),* nerve vs joint / ligament *(p < 0.0001),* bone vs joint / ligament *(p = 0.0002*), bone vs superficial tissue *(p = 0.0406),* bone vs vessels *(p = 0.0406),* cartilage / bursae vs joint / ligament *(p < 0.0001),* joint / ligament vs superficial tissue *(p < 0.0001),* joint / ligament vs vessels *(p < 0.0001),* joint / ligament vs internal organ *(p < 0.0001).*

Table 5 below depicts the significant differences in joint / ligament injuries compared to all other injury types as described, indicating they are statistically more frequent than the others. Muscle injuries differ significantly from nerve, joint / ligament, superficial tissue and vessel injuries, indicating different injury risk factors may be associated.

Table 5: P-values for pairwise comparisons between Injury Types for Rugby

	Muscle	Tendon	Nerve	Bone	Cartilage / Bursae	Joint / Ligament	Superficial Tissue	Vessels	Internal
Muscle		0.724	**0.0406***	> 0.999	0.526	**0.0006***	**0.0161***	**0.0161***	0.724
Tendon	0.724		0.879	0.879	> 0.999	**< 0.0001***	0.724	0.724	> 0.999
Nerve	**0.0406***	0.879		0.092	0.964	**< 0.0001***	> 0.999	> 0.999	0.879
Bone	> 0.999	0.879	0.092		0.724	**0.0002***	**0.0406***	**0.0406***	0.879
Cartilage / Bursae	0.526	> 0.999	0.964	0.724		**< 0.0001***	0.879	0.879	> 0.999
Joint / Ligament	**0.0006***	**< 0.0001***	**< 0.0001***	**0.0002***	**< 0.0001***		**< 0.0001***	**< 0.0001***	**< 0.0001***
Superficial Tissue	**0.0161***	0.724	> 0.999	**0.0406***	0.879	**< 0.0001***		> 0.999	0.724
Vessels	**0.0161***	0.724	> 0.999	**0.0406***	0.879	**< 0.0001***	> 0.999		0.724
Internal	0.724	> 0.999	0.879	0.879	> 0.999	**< 0.0001***	0.724	0.724	

Significant p-values ($p < 0.05$) marked in bold with *

Injury Type and Injury Mechanism. Figure 24 shows this comparison below. Direct contact resulted in 11 (100%) bone, 1 (100%) nerve, 23 (85.18%) joint / ligament, 5 (83.33%) internal, 4 (66.66%) tendon, 3 (60%) cartilage / bursae and 3 (25%) muscle injuries. Non-contact mechanisms led to 9 (75%) muscle, 2 (40%) cartilage / bursae, 2 (33.33%) tendon, 1 (16.67%) internal and 4 (14.81%) joint / ligament injuries. A significant association between *Injury Type* and *Injury Mechanism* was found *($p = 0.00141$)* with a *Chi-squared statistic 21.64*.

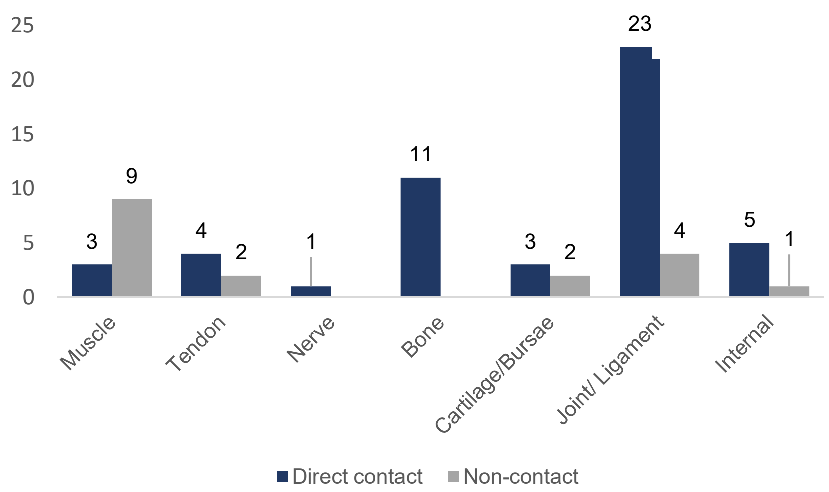

Figure 24: Rugby - Injury Type and Injury Mechanism ($p < 0.001$)

Standardised residuals (Table 6 and Figure 25) were calculated to show deviations between the observed counts and expected frequencies. Muscle injuries occurred more frequently than expected in non-contact scenarios with a positive residual of 3.27. A negative residual of −1.96 between muscle injuries and direct contact is just below threshold but indicates a lower than expected injury count. It is also noted that bone injuries have a strong negative correlation of −1.706 with non-contact mechanisms, close to a significant value indicating a possible direct contact injury pattern.

Table 6: Standardised Residuals for Injury Type vs Mechanism in Rugby

	Direct Contact	Non-contact
Bone	1.02	−1.71
Cartilage / Bursae	−0.35	0.58
Internal	0.28	−0.47
Joint / Ligament	0.71	−1.18
Muscle	**−1.96**	**3.27**
Nerve	0.31	−0.51
Tendon	−0.19	0.33

Critical Value +/- 2.
Significant values between injury type and mechanism marked in bold

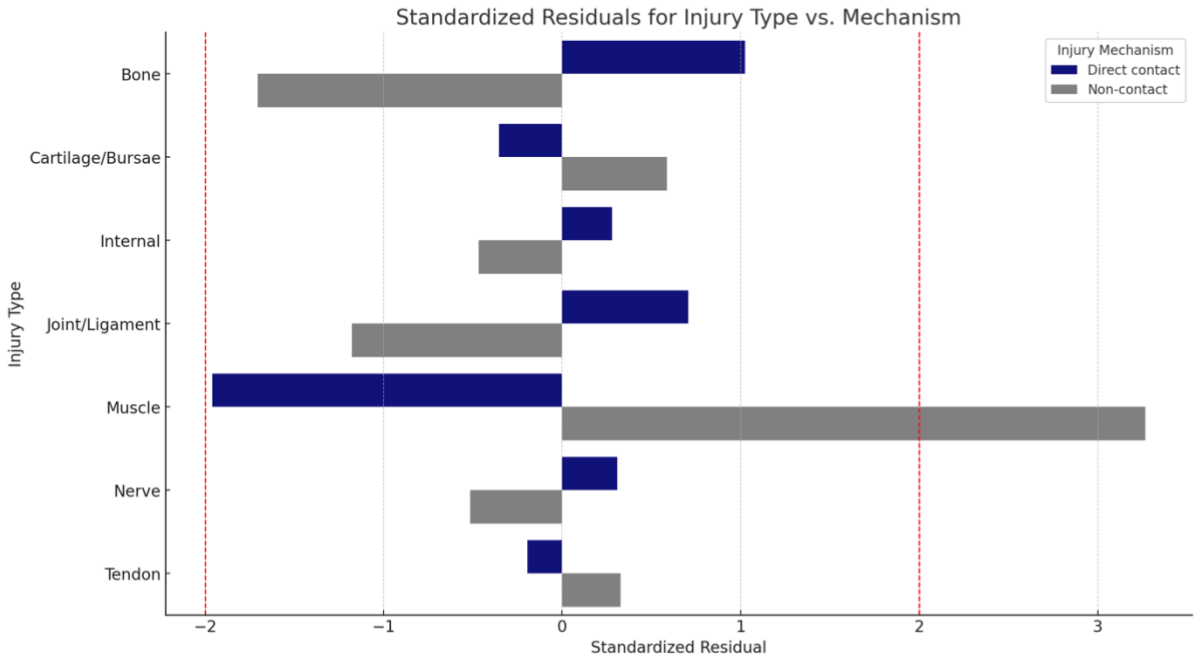

Figure 25: Bar graph of Standardised Residuals for Injury Type vs Mechanism in Rugby

Due to the relatively small sample size, some of the expected frequencies were <5 which made the Chi-squared test less reliable for this analysis. A Fisher's Exact test would be useful in this situation but could not be performed due to the large table size. Unpaired T-tests were run for each injury type and mechanism except for Nerve as there was only one documented injury. The significant results are shown in Table 7 below. Bone injuries and direct contact mechanism are significantly related, which agrees with the Chi-squared test, but due to lack of variability again may be unreliable. Internal and joint / ligament injuries have significant association with direct contact mechanism, and muscle injuries are strongly associated with non-contact mechanism, which is in line with the Chi-squared test.

Table 7: Significant p-values * for Injury Type vs Injury Mechanism in Rugby

Injury Type and Mechanism	p-value
Bone – Direct contact	< 0.001*
Internal – Direct contact	0.018*
Joint / Ligament – Direct contact	<0.001*
Muscle – Non-contact	0.013 *

Injury Type and Injury Mode. Figure 26 below shows this comparison. Acute mode resulted in 11 (100%) bone, 6 (100%) internal, 1 (100%) nerve, 26 (96.23%) joint / ligament, 4 (66.66%) tendon, 6 (50%) muscle and 2 (40%) cartilage / bursae injuries. Repetitive factors resulted in 3 (60%) cartilage / bursae, 6 (50%) muscle, 2 (33.33%) tendon and 1 (3.7%) joint / ligament injury. The Chi-squared test in this analysis was significant (*p < 0.001)* with a *Chi-squared statistic 23.30* indicating there are statistical associations between injury type and injury mode.

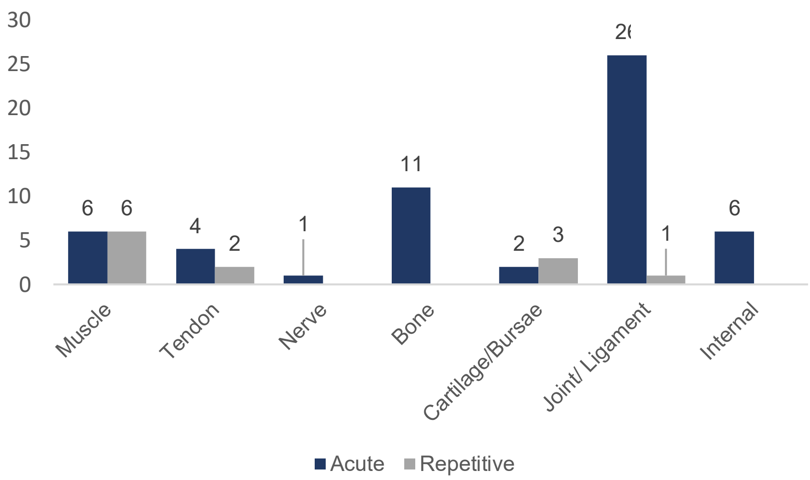

Figure 26: Rugby - Injury Type and Mode (p < 0.001)

Standardised residuals (Table 8 and Figure 27) calculated were strongly positive for repetitive modality and injuries of cartilage / bursae (2.25), and muscle (2.66). These significant associations suggest there may be unique factors leading to these injuries being more frequent in a repetitive mode.

Table 8: Standardised Residuals for Injury Type vs Mode in Rugby

	Acute Mode	Repetitive Mode
Bone	0.65	−1.39
Cartilage / Bursae	**−1.04**	**2.25**
Internal	0.48	−1.03
Joint / Ligament	0.80	−1.72
Muscle	**−1.24**	**2.66**
Nerve	0.19	−0.42
Tendon	−0.42	0.91

Critical Value +/- 2.
Significant values between injury type and mechanism marked in bold

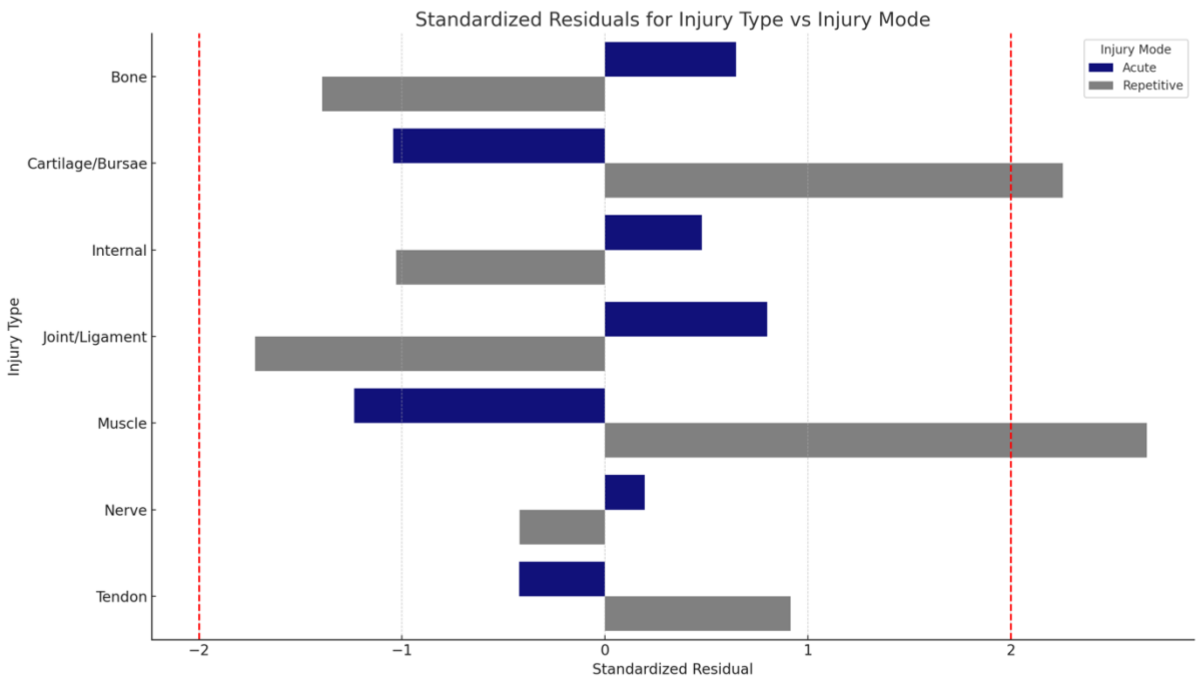

Figure 27: Bar graph of Standardised Residuals for Injury Type vs Mode in Rugby

It is noted that the expected frequencies in some categories above were <5 which makes the Chi-squared test less reliable. This is again due to the relatively small sample size. A Fisher's Exact test, which is useful in this situation, was not possible due to the large table size.

Unpaired T-tests were run for each injury type and mode, except for Nerve as there was only one documented injury. The significant values are shown in Table 9. Bone and internal injury types had significantly increased association with acute injury mode *($p < 0.001$)* compared to repetitive mode, but lacked variability in each group as all injuries were acute. Statistical significance was found between joint / ligament injuries and acute injury mode *($p < 0.005$)*, showing a higher acute injury risk versus repetitive injuries, and suggesting a potential injury pattern.

Table 9: Significant p-values * for Injury Type vs Injury Mode in Rugby

Injury Type and associated Mode	p-value
Acute – Bone	<0.001*
Acute – Internal	<0.001*
Acute – Joint / Ligament	<0.005 *

Time Loss

Time loss injuries counted 46 (67.65%) of the documented injuries, and 22 (32.35%) resulted in no time loss from play, as shown in Figure 28. The difference between time loss and no time loss injuries is significant *($p < 0.001$).*

Time Loss and Type of Play. This comparison is shown in Figure 29. Of the time loss injuries, 35 (76.1%) occurred during matches, and 11 (23.9%) during practice. Match play resulted in 16 (72.72%) of the no time loss injuries, while 6 (27.27%) occurred during practice. There was no significant association *($p = 1.0$)* between time loss and the type of play as seen in valid Chi-squared test.

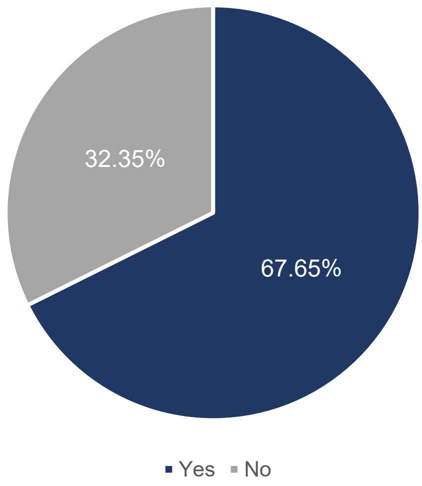

Figure 28: Rugby - Total Injuries and Time Loss vs No Time Loss (p < 0.001)

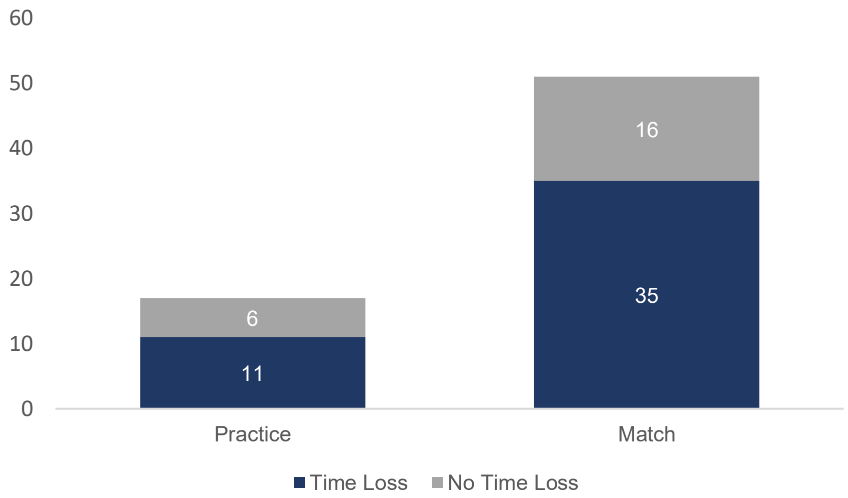

Figure 29: Type of Play and Time Loss vs No Time Loss Injury (p = 1.0)

Time off Play / Severity

Of the 46 injuries that led to time off play, Figure 30 demonstrates that 23 (50%) resulted in 8–28 days off, 13 (28.26%) 1–7 days off and 10 (21.74%) resulted in >28 days out of play. A One-Way Anova was conducted for time off play with resultant significant findings *(f = 3.285, p = 0.0212)*. The Tukey's Multiple Comparisons test, however, showed that there was no statistical significance between the 4 time off play categories.

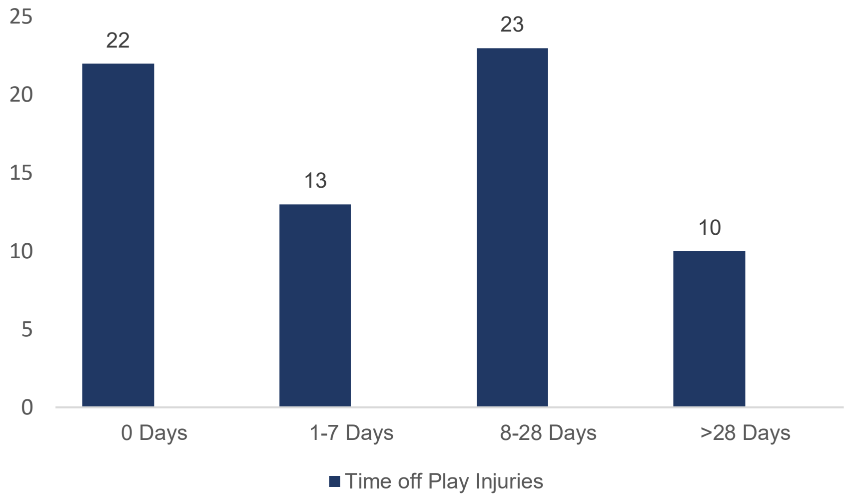

Figure 30: Rugby - Time off Play Injuries and Severity (ANOVA f = 3.285 p = 0.021)

Time off Play and Injury Type. Shown in Figure 31, most time-loss injuries were joint / ligament injuries counting 19 (41.13%). In the 1–7 day time-loss category: Cartilage / bursae injuries contributed 4(30.77%), joint / ligament 4 (30.77%), bone 2 (15.38%), muscle 2 (15.38%) and nerve 1 (7.69%). In the 8–28 day time-loss category: Joint / ligament contributed 9 (39.13%) injuries, internal 5 (21.74%), bone 4 (17.39%), muscle 2 (8.69%), tendon 2 (8.69%) and cartilage / bursae 1 (4.35%). In the >28 day time-loss category: Joint / ligament injuries counted 6 (60%), bone 3 (30%) and internal 1 (10%). A significant association between time off play categories and injury type was found, with p = *0.0031* and a *Chi-squared statistic of 38.69*.

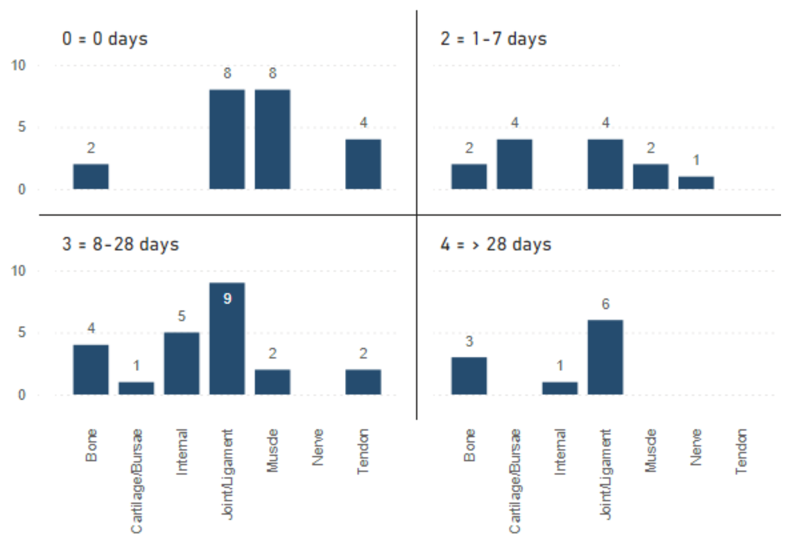

Figure 31: Rugby - Injury Type and Time off Play (p < 0.001)

Standardised residuals (Table 10 and Figure 32) were calculated to identify specific deviations. Strong positive residuals were found with muscle injuries and 0 days off (2.09), cartilage / bursae injuries with 1–7 days off (3.11) and internal injuries and 8–28 days off (2.09). These injury types were seen to be associated with the specific durations off play more than would be expected by chance, suggesting an association between them and the respective time off play categories.

Table 10: Standardised residuals Injury Type vs Time off Play in Rugby

	0 Days	1–7 Days	8–28 Days	>28 Days
Bone	−0.75	−0.10	0.15	1.19
Cartilage/Bursae	−0.81	**3.11**	−0.53	−0.54
Internal	−1.39	−1.07	**2.09**	1.25
Joint/Ligament	−0.26	−0.54	−0.04	1.02
Muscle	**2.09**	−0.19	−1.03	−1.21
Nerve	−0.57	1.84	−0.58	−0.50
Tendon	1.47	−1.07	−0.01	−1.25

Critical Value +/- 2.
Significant values between injury type and time off play marked in bold

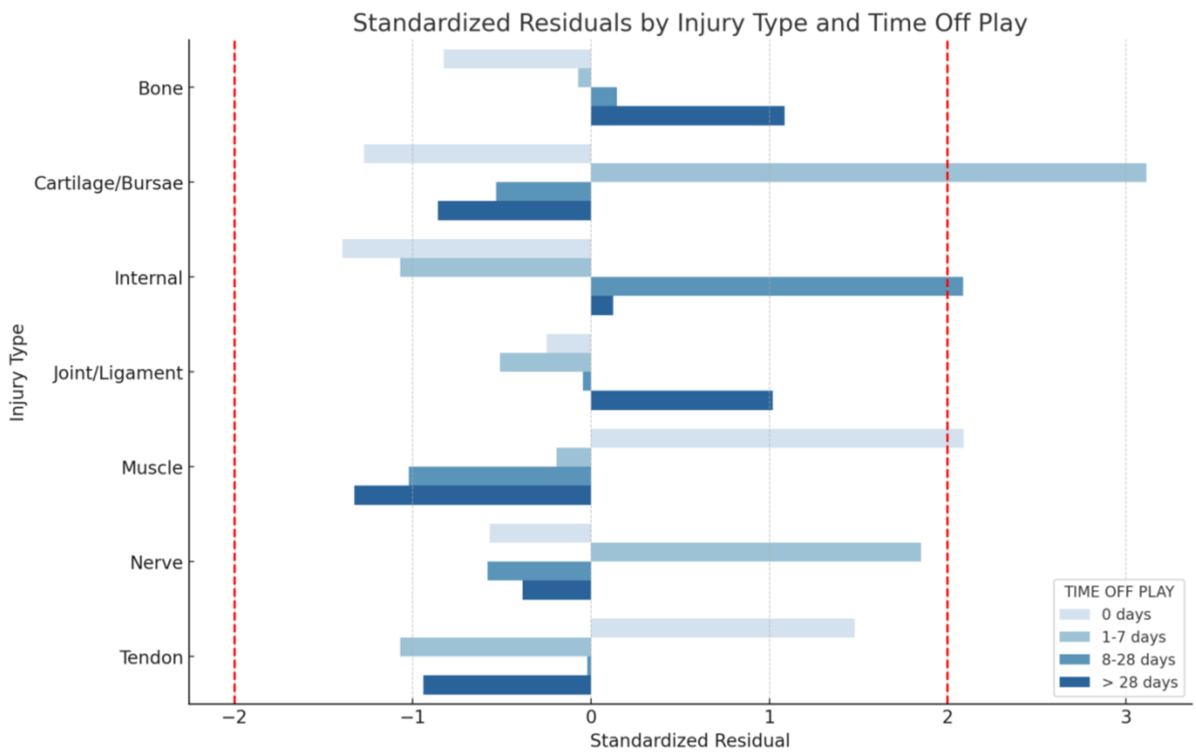

Figure 32: Bar graph of Standardised Residuals for Time off Play and Injury Type in Rugby

Notably, the Chi-squared test may not be completely valid as multiple expected frequencies were <5 and some <1. Even when categories were combined to correct the low sample sizes, the expected frequencies were not sufficient and a Fisher's Exact test could not be run due to the size of the table.

Time off Play and Body Area. As shown in Figure 33, shoulder injuries counted for most of the time-loss injuries at 13 (28.26%). In the 1–7 day time-loss category: Shoulder injuries contributed 5 (38.46%), knee 3 (23.08%); with ankle, calf, chest, hand and thigh all contributing 1 (7.69%) injury each. In the 8–28 day time-loss category: Shoulder injuries numbered 7 (30.43%), concussion 5 (21.74%), knee 3 (13.04%); with calf, hand and spine all 2 (8.69%) injuries each and chest and thigh 1 (4.35%) each. In the >28 day time-loss category: Ankle, knee and spine all contributed 2 (20%) injuries each; with chest, hand, hip and shoulder 1 (10%) injury each. Statistically, no significant differences between time off play and body area were found *(p = 0.207),* although the Chi-squared test may not be completely reliable due to expected frequencies <5 in some categories as a result of the small sample size. A Fisher's Exact test could not be run due to the large table size.

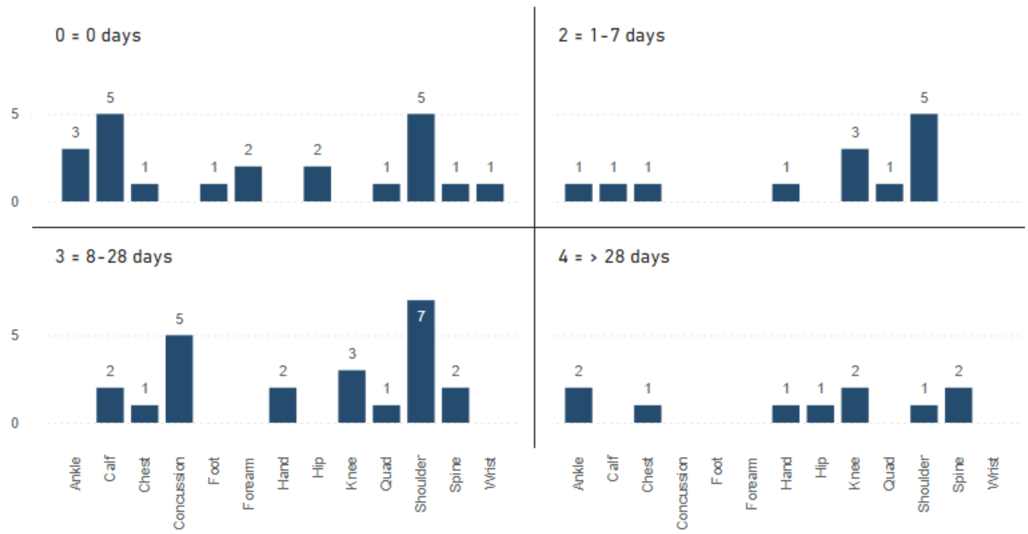

Figure 33: Rugby - Body Area and Time off Play (p = 0.207)

Player Positions

Injury distribution between forwards and backs over the collection period was 39 (57.35%) and 29 (42.65%) respectively and shown in Figure 34. Statistically this difference is not significant *(p = 0.679).*

Player Position and Injury Mode. Forwards sustained 33 (58.92%) acute injuries, while backs sustained 23 (41.07%). Of the repetitive injuries, there was equal distribution between forwards and backs. No significant association between player position and injury mode was found in a valid Chi-squared test *(p = 0.805).*

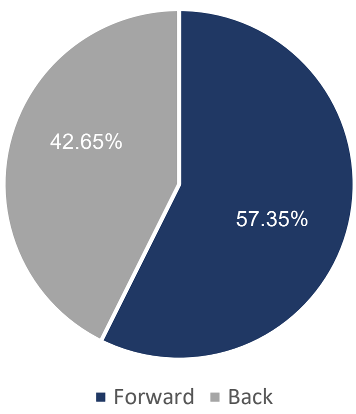

Figure 34: Rugby - Total injuries in Forwards vs Backs (p = 0.679)

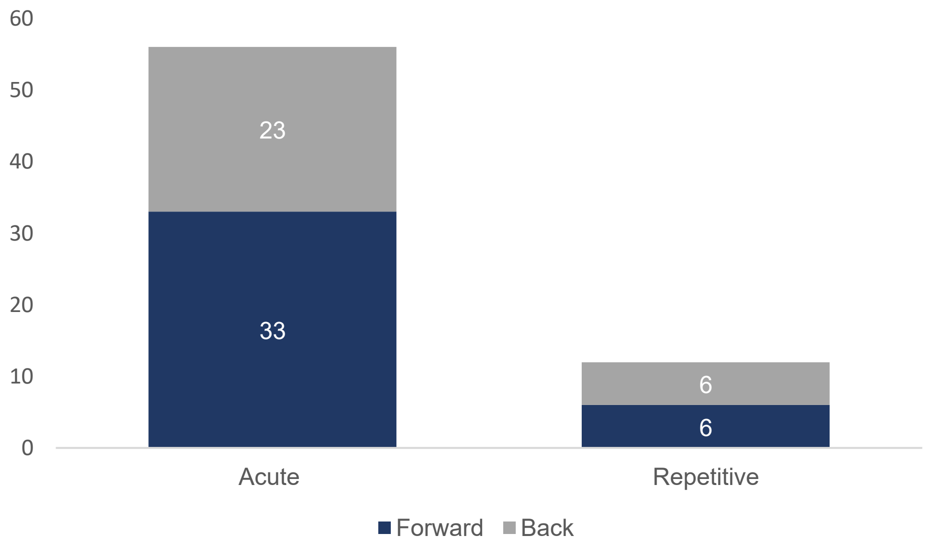

Figure 35: Rugby - Player Position and Injury Mode (p = 0.805)

Player Position and Injury Mechanism. This comparison is shown in Figure 36. Forwards sustained 31 (62%) direct injuries, while backs sustained 19 (38%). Of the non-contact injuries, forwards sustained 8 (44.44%) and backs 10 (55.55%). Statistically there was no significant association between player position and injury mechanism with a valid Chi-squared test *(p = 0.311).*

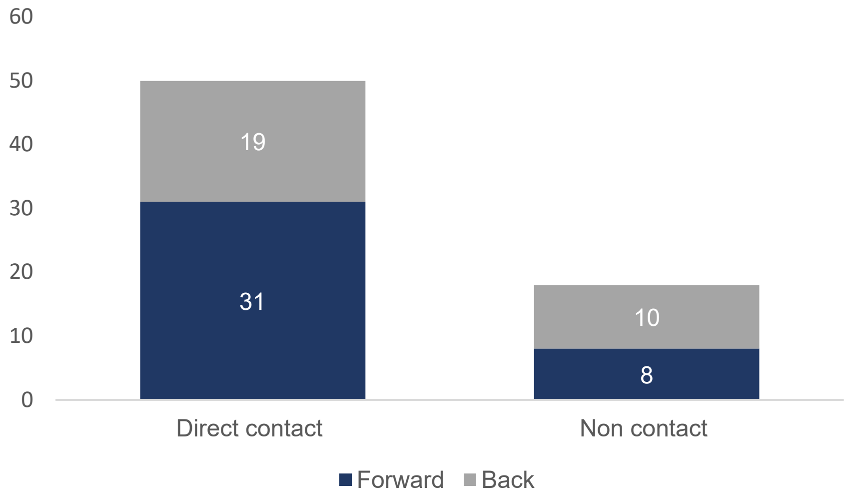

Figure 36: Rugby - Player Position and Injury Mechanism (p = 0.311)

Player Position and Body Region. The distribution of injuries in the upper limb was forwards 18 (26.47%) and backs 8 (11.76%). The lower limb saw equal injuries between forwards and backs at 14 (20.59%) each. Forwards had 6 (8.82%) trunk injuries and backs 3 (4.41%). Head and neck injuries in forwards counted for 1 (1.47%) and backs 4 (5.88%). These results are demonstrated in Figure 37 below. A Chi-squared test showed no statistically significant associations between player position and body region *($p = 0.152$)* but the expected frequencies for both forwards and backs and head and neck injuries were <5 which indicates the test may not be completely valid. A Fisher's Exact test could not be done due to the large table size.

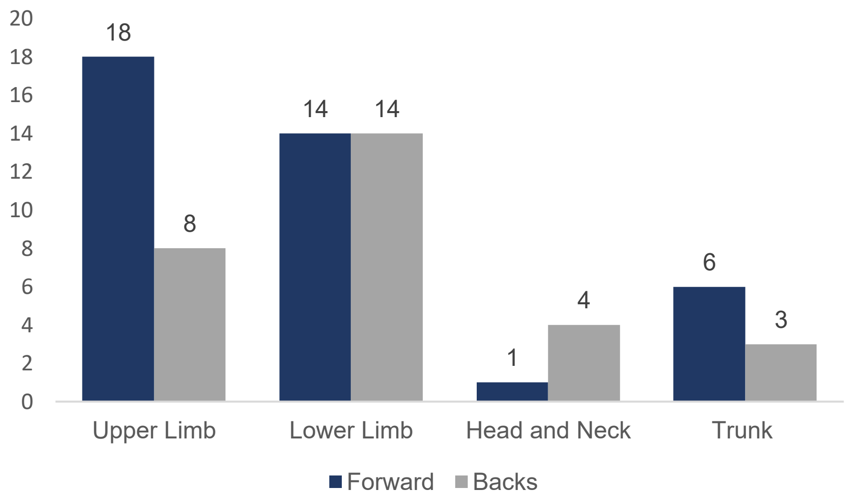

Figure 37: Rugby - Injuries for Player Position and Body Region (p = 0.152)

Unpaired T-testing was conducted for player position and each individual body region. The only significant difference was in the upper limb *(p = 0.0049),* with forwards being more susceptible to these injuries.

Player Position and Body Area. Figure 38 below shows that forwards sustained 1 (20%) of head / concussion injuries, 3 (75%) chest, 12 (66.66%) shoulder, 3 (60%) spine, 3 (75%) hand, 7 (87.5%) knee, 1 (12.5%) calf, 5 (83.33%) ankle and 100% of forearm, wrist and foot injuries. Backs sustained 4 (80%) head / concussion injuries, 1 (25%) chest, 6 (33.335) shoulder, 2 (40%) spine, 1 (25%) hand, 1 (12.5%) knee, 7 (87.5%) calf, 1 (16.66%) ankle and 100% of the hip and thigh injuries at 3 and 2 respectively. A Chi-squared test determined a significant association between player position and body area *(p = 0.0083)* with a *Chi-squared statistic of 26.77.* Due to the majority of the expected frequencies being <5, this test is deemed very unreliable due to the small numbers and a Fisher's Exact test is not possible due to the large table size.

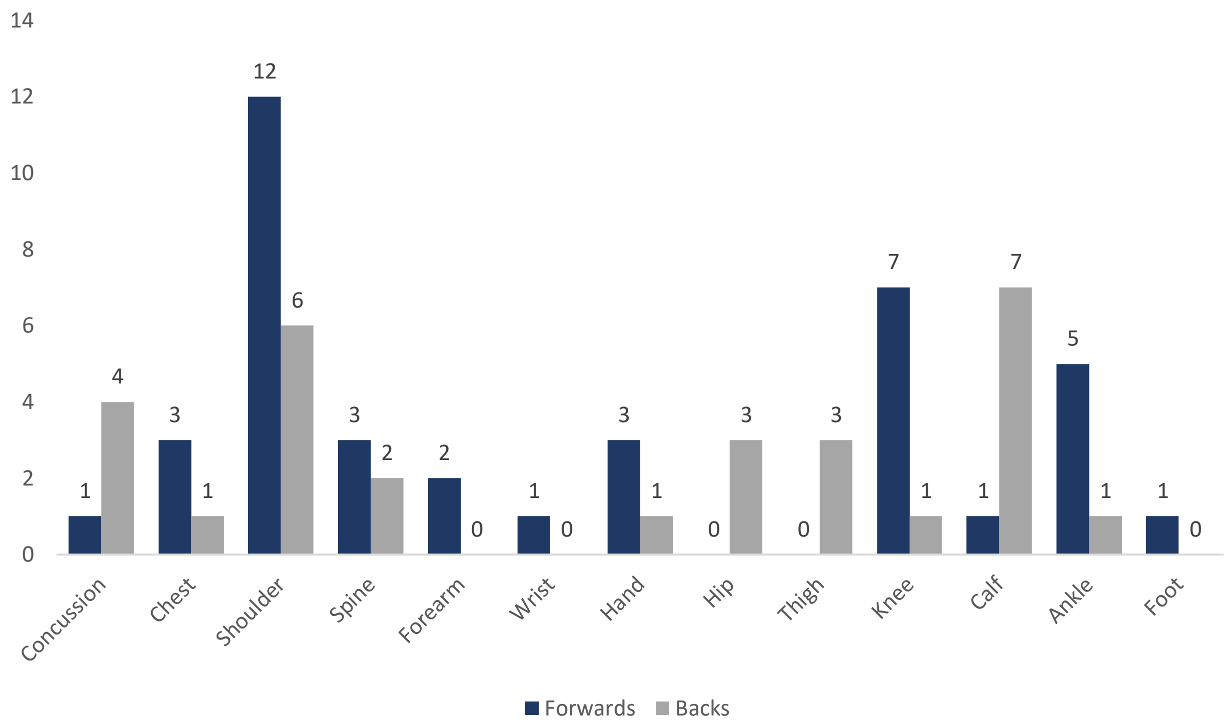

Figure 38: Rugby - injuries for Player Position and Body Area (p = 0.0083)

Individual Unpaired T-tests were therefore run for player position and each individual body area, except for Wrist as there was only 1 injury. Some significant differences in injury patterns were found and these are demonstrated in Table 11. Forwards were more likely to have shoulder *(p = 0.047)*, ankle *(p = 0.018)* and knee *(p < 0.001)* injuries. Backs were more likely to have calf injuries *(p < 0.001)*. The other significant findings were for forwards with forearm injuries, and backs with hip and thigh injuries *(p < 0.001)*. However, this may not be reliable due to lack of variability in the data.

Table 11: Significant p-values * for Player Position and Body Area in Rugby

Player Position and associated Body Area	p-value
Forwards – Shoulder	0.047 *
Forwards – Forearm	<0.001 *
Forwards – Ankle	0.018 *
Forwards – Knee	<0.001 *
Backs – Hip	<0.001 *
Backs – Thigh	<0.001 *
Backs – Calf	0.001 *

Player Position and Injury Type. All 5 (100%) cartilage / bursae injuries were found in the forwards, as were nerve injuries 1 (100%). For muscle injuries, forwards sustained 1 (8.33%) and backs 11 (91.66%). Bone injuries in forwards counted 7 (63.63%) and in backs 4 (36.36%). Internal injuries in forwards saw 2 (33.33%) and backs 4 (66.66%). Tendon injuries in forwards counted 5 (83.33%) and backs 1 (16.66%). This is shown in Figure 39. A significant association between player position and the types of injuries sustained was seen *(p = 0.002)* and *Chi-squared statistic of 20.46.*

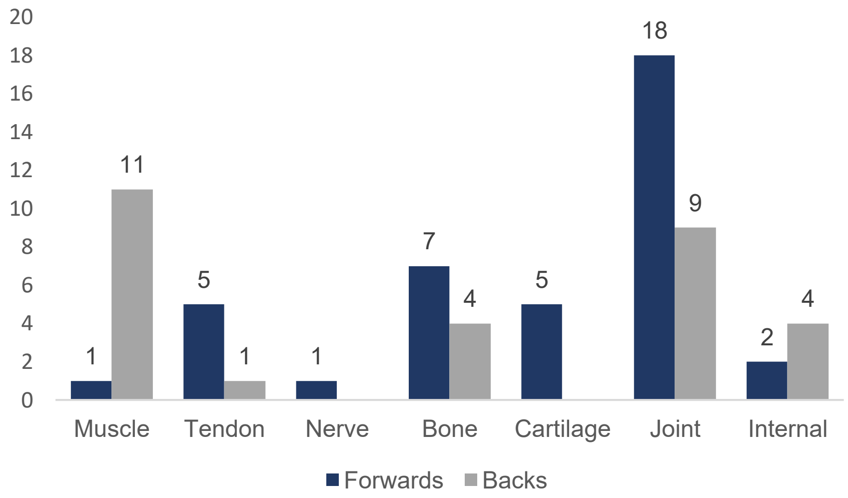

Figure 39: Rugby - Player Position and Injury Type (p = 0.002)

Calculating the *standardised residuals* (Table 12 and Figure 40), a strong positive residual of 2.60 between backs and muscle injuries indicates these injuries were more common than expected. Forwards have a strong negative residual of −2.24 with muscle injuries, meaning a lower-than-expected injury count. Although not reaching the threshold, a residual of 1.26 between forwards and cartilage / bursae injuries may indicate a trend.

Table 12: Standardised residuals Player Position vs Injury Type in Rugby

	Backs	Forwards
Bone	−0.32	0.28
Cartilage / Bursae	−1.46	1.26
Internal	0.90	−0.78
Joint / Ligament	−0.74	0.64
Muscle	**2.60**	**−2.24**
Nerve	−0.65	0.56
Tendon	−0.97	0.84

Critical Value +/- 2.
Significant values between injury type and player position marked in bold

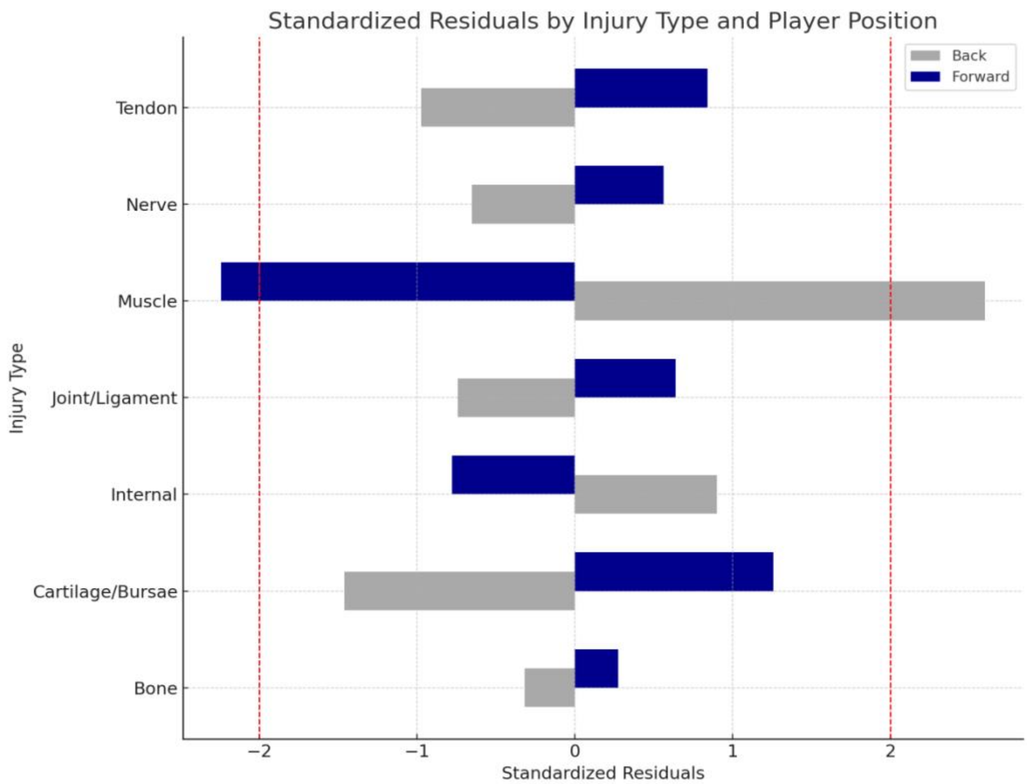

Figure 40: Bar Graph of Standardised residuals for Player Position and Injury Type in Rugby

Due to the small data set and therefore some of the expected frequencies being <5, the Chi-squared test may not be completely reliable. A Fisher's Exact test could not be run due to the large size of the table.

Table 13 shows the significant results from individual Unpaired T-tests that were run for player position and each injury type, except for Nerve as there was only 1 injury. There was a significant association found between muscle injuries and back line players, being more frequent *($p < 0.001$)*. Tendon injuries *($p = 0.0179$)* and joint / ligament *($p = 0.014$)* injuries were more common in forwards. Cartilage / bursae injuries were also found to be more common in forwards *($p < 0.001$),* but this may be unreliable due to all of these injuries being found in this group.

Table 13: Significant p-values * for Player Position and Injury Type in Rugby

Player Position and associated Injury Type	p-value
Backs – Muscle	< 0.001 *
Forwards – Tendon	0.00179 *
Forwards – Cartilage / Bursae	< 0.001 *
Forwards – Joint / Ligament	0.014 *

2.2.3 Football

Injury Incidence

A total of 7 injuries were sustained in a squad of n = 20 over a 17-week season. The Match squad consisted of 11 players.

Practice injury exposure was 850, *match injury exposure* 136.95 and *total injury exposure* 986.95.

Total injury incidence was 7.09 / 1 000 athlete-exposure hours, with *match injury incidence* being 51.11 / 1 000 and *practice injury incidence* 0 as shown in Figure 41.

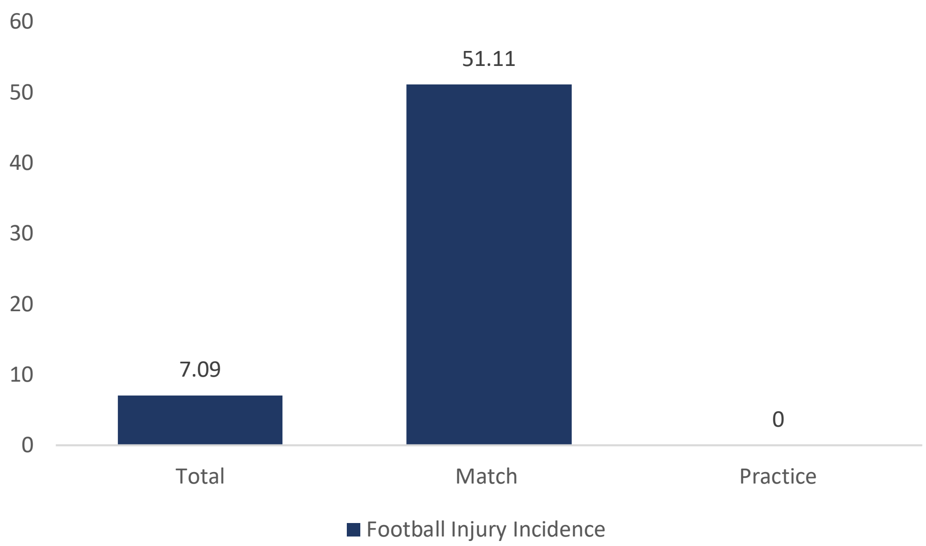

Figure 41: Football Injury Incidence - Total, Match and Practice per 1 000 athlete-exposure hours

Injury Mode

All 7 injuries were of acute mode. Statistically this gives a highly significant result ($p < 0.001$).

Injury Mechanism

Injury Mechanism was direct contact 4 (57.14%) and 3 (42.86%) non-contact, shown in Figure 42. There is no statistical difference between injury mechanisms *(p = 0.626).*

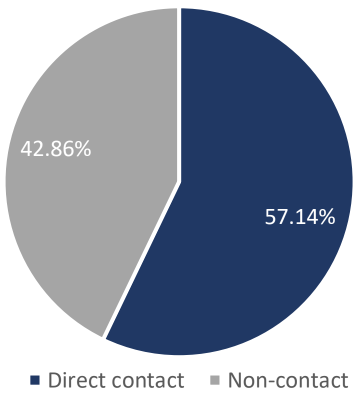

Figure 42: Football - Total Injuries per Injury Mechanism (p = 0.626)

Type of Play

All 7 injuries occurred during match play. Statistically the difference is highly significant *($p < 0.001$).*

Period of Play

All 7 injuries occurred in the second half of play. Statistically the difference is highly significant *($p < 0.001$).*

Body Region

Figure 43 demonstrates the distribution of injuries between body regions. The lower limb counted 4 (57.14%), head and neck 2 (28.57%) and upper limb 1 (14.29%).

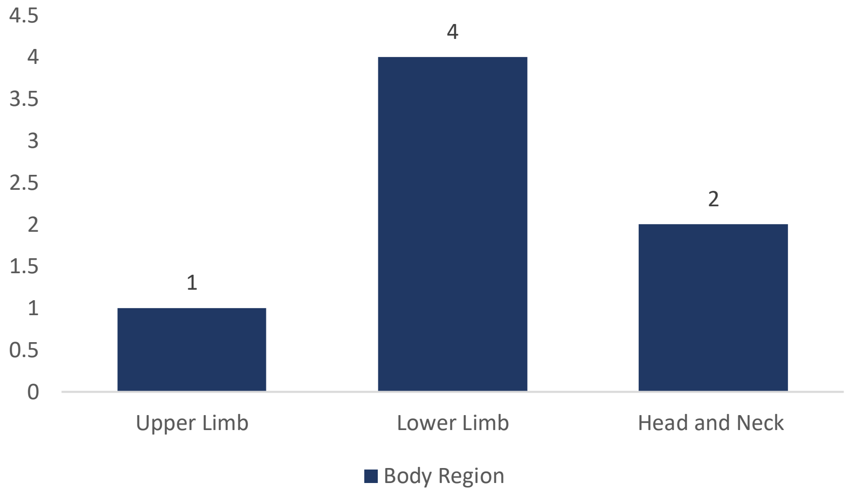

Figure 43: Football - Total Injuries per Body Region

Body Area

Injuries were distributed equally across head (concussion), neck, shoulder, hip and ankle all 1 (14.29%) each, and 2 (28.57%) injuries involved the knee. This is shown in Figure 44.

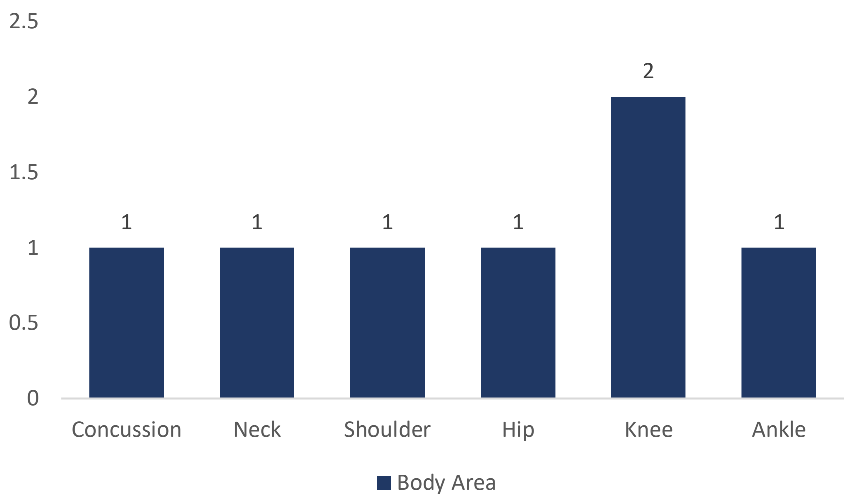

Figure 44: Football - Total Injuries per Body Area

Injury Type

Injury number by type is shown in Figure 45. Bone and joint / ligament injuries being in the majority with 2 (28.57%) each. There was 1 (14.28%) cartilage / bursae injury, 1 (14.28%) internal (concussion) and 1 (14.28%) muscular injury.

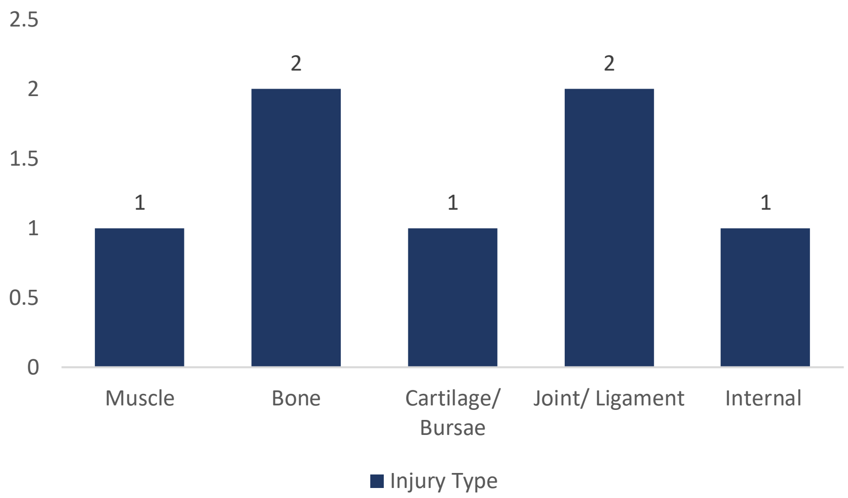

Figure 45: Football - Total Injuries per Injury Type

Time Loss

All 7 injuries resulted in time loss from play.

Time off Play / Severity

Considering the amount of time off play, 4 (57.14%) of the injuries resulted in 8–28 days off play, 2 (28.57%) in >28 days off and 1 (14.28%) in 1–7 days off play, as shown in Figure 46.

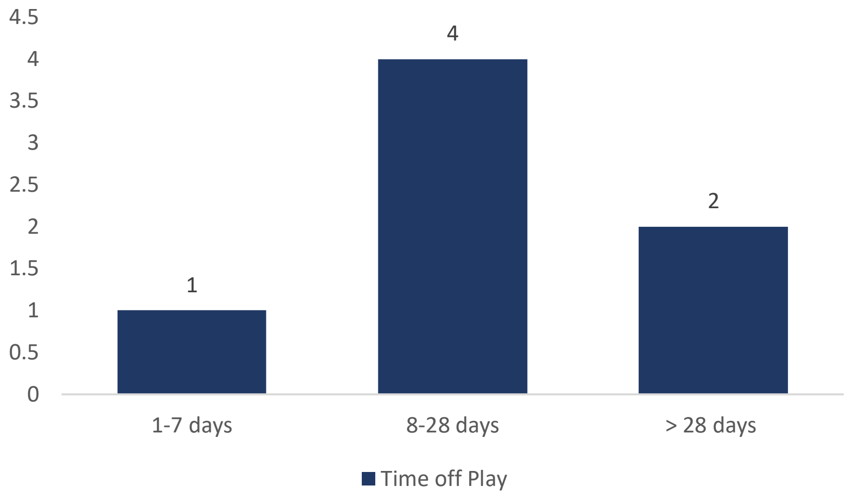

Figure 46: Football - Total Injuries and Time off Play Severity

Figure 47 shows that of the 8–28 day off play injuries, the injury type was joint / ligament in 2 (50%) cases, muscle and internal (concussion) counted 1 (25%) each. The injuries resulting in >28 days off play involved bone and cartilage / bursae 1 (50%) each.

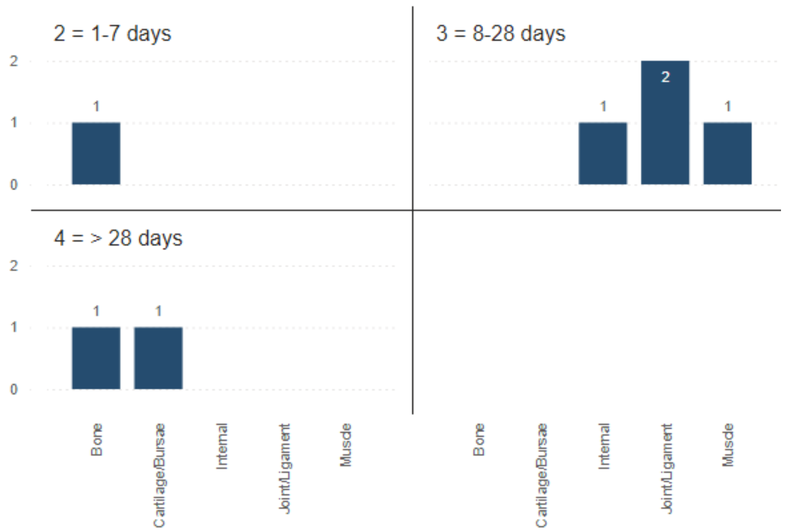

Figure 47: Football - Time off Play and Injury Type

Body areas involved in the most time off play were the hip and knee >28 days, as shown in Figure 48 below.

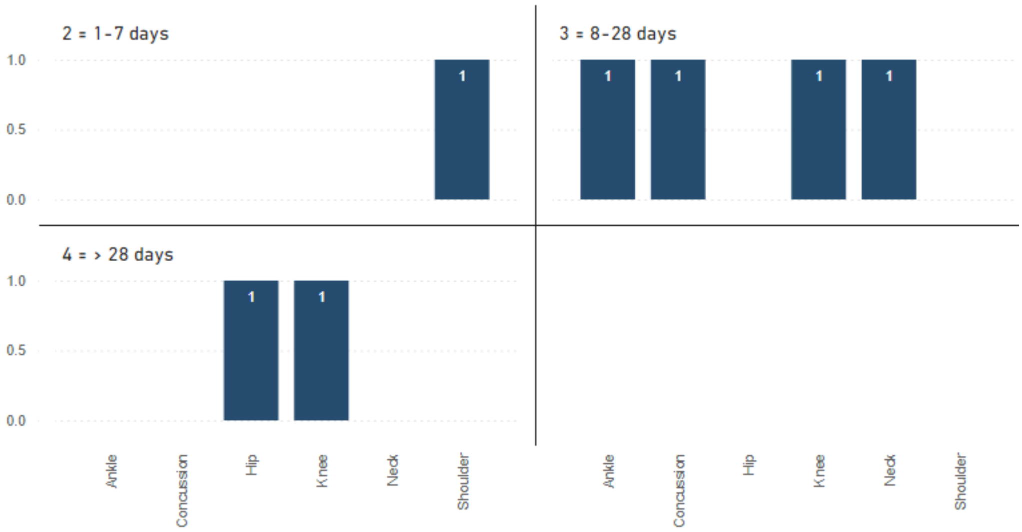

Figure 48: Football - Time off Play and Body Area

Player Positions

Injury distribution was 4 (57.14%) in the forwards and 3 (42.86%) in the backs, shown in Figure 49. No statistically significant difference was found between player position and number of injuries *(p = 0.626).*

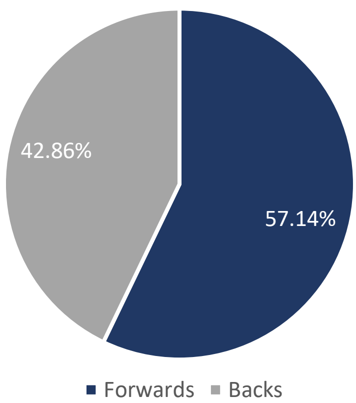

Figure 49: Football - Total Injuries per Player Position (p = 0.626)

Player Position and Injury Mechanism. Figure 50 shows this comparison. Forwards and backs sustained 2 (50%) direct contact injuries each, while the number of non-contact injuries were 2 (66.66%) in the forwards and 1 (33.33%) in the backs.

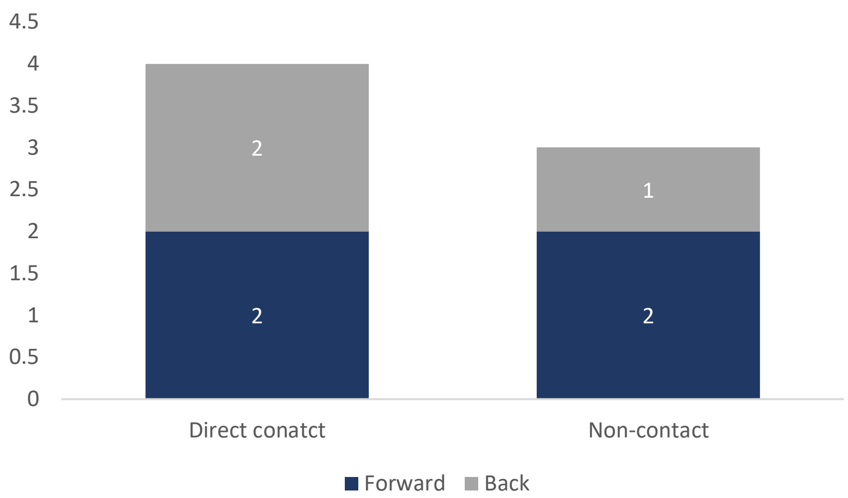

Figure 50: Football - Total Injuries in Player Position for Injury Mechanism

Player Position and Injury Type. Forwards sustained 2 (100%) joint / ligament injuries, 1 (100%) cartilage / bursae injury and 1 (50%) bone injury. Backs sustained 1 (100%) muscle injury, 1 (50%) bone injury and 1 (100%) internal injury as shown in Figure 51.

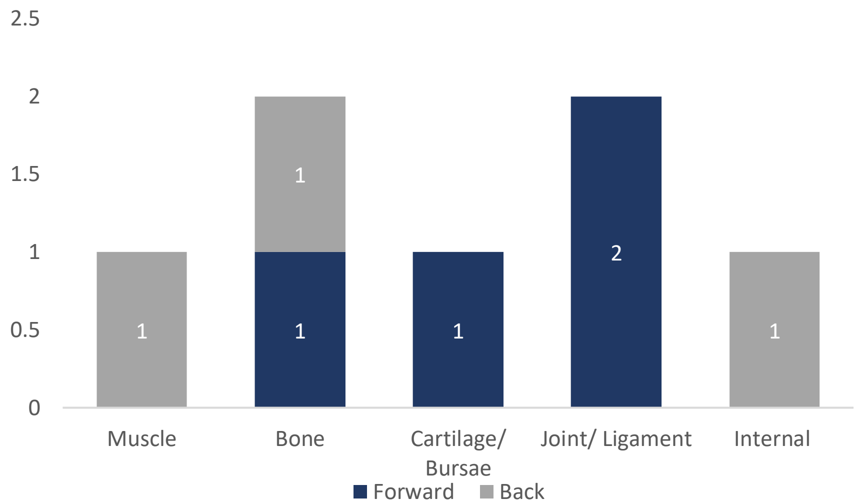

Figure 51: Football - Total Injuries in Player Position for Injury Type

2.2.4 Cricket

Injury Incidence

A total of 3 injuries were sustained in a squad of n = 16 over an 11-week season. The match squad consisted of 11 players.

Practice injury exposure was 100, *match injury exposure* 593.1 and *total injury exposure* 2120. The *total injury incidence* was 1.41 / 1 000 athlete-exposure hours, with a *match injury incidence* of 0.76 / 1 000 athlete-exposure hours and a *practice injury incidence* of 2.5 / 1 000 athlete-exposure hours. This is shown in Figure 52.

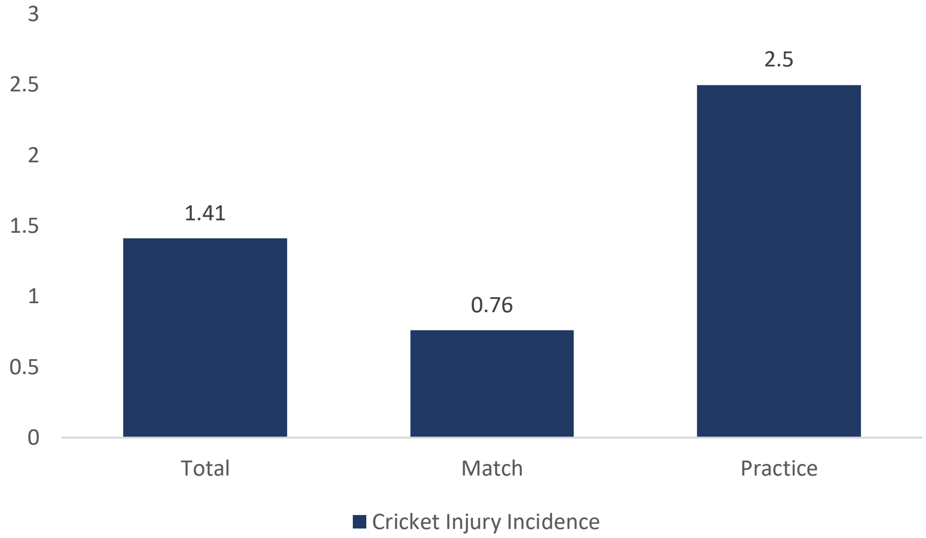

Figure 52: Cricket Injury Incidence - Total, Match and Practice per 1 000 athlete-exposure hours

Injury Mode

All 3 injuries were acute in mode.

Injury Mechanism

All 3 injuries were non-contact in mechanism.

Type of Play

Match play saw 1 (33.33%) injury and 2 (66.66%) occurred during practice, shown in Figure 53. Statistically there is no difference between type of play *($p = 0.52$).*

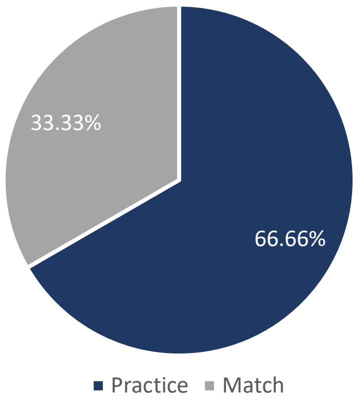

Figure 53: Cricket - Total injuries per Type of Play (p = 0.52)

Body Region

As shown in Figure 54, injuries were equally distributed between upper limb, lower limb and the trunk at 1 (33.33%) each.

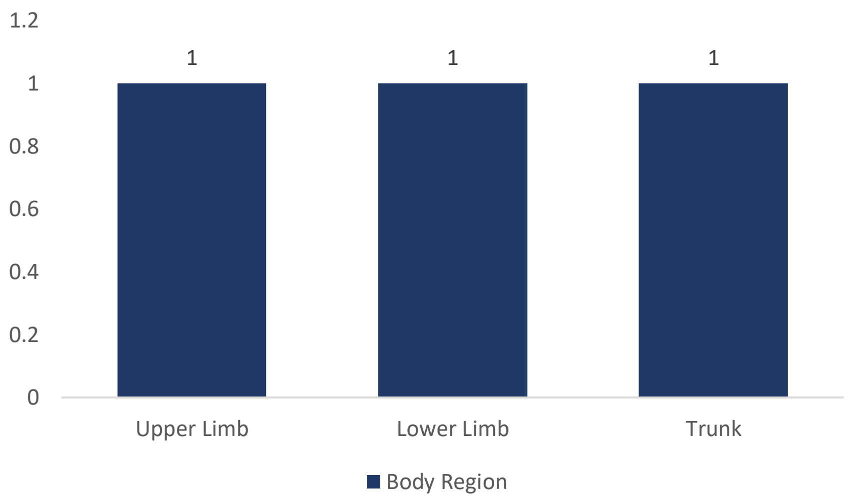

Figure 54: Cricket - Total Injuries per Body Region

Body Area

Body areas involved were the spine, knee and shoulder with 1 (33.33%) injury each, demonstrated in Figure 55.

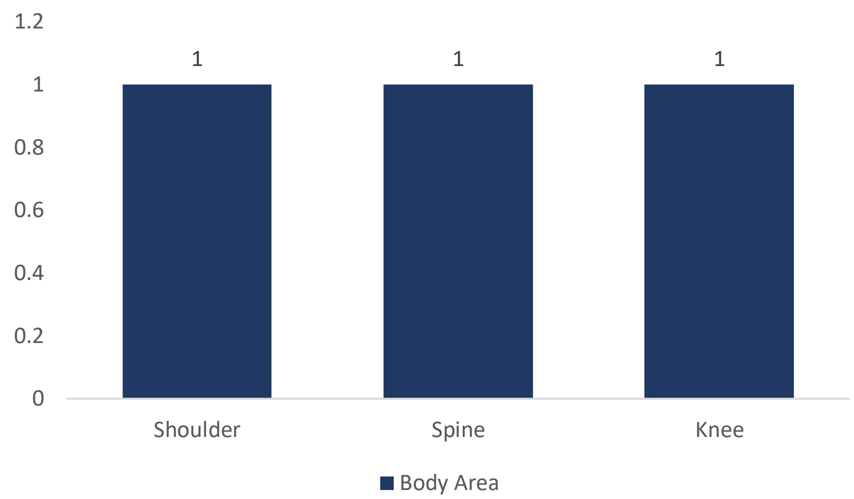

Figure 55: Cricket - Total Injuries per Body Area

Injury Type

Looking at injury type, 2 (66.66%) involved joint / ligament and 1 (33.33%) was muscular, shown in Figure 56.

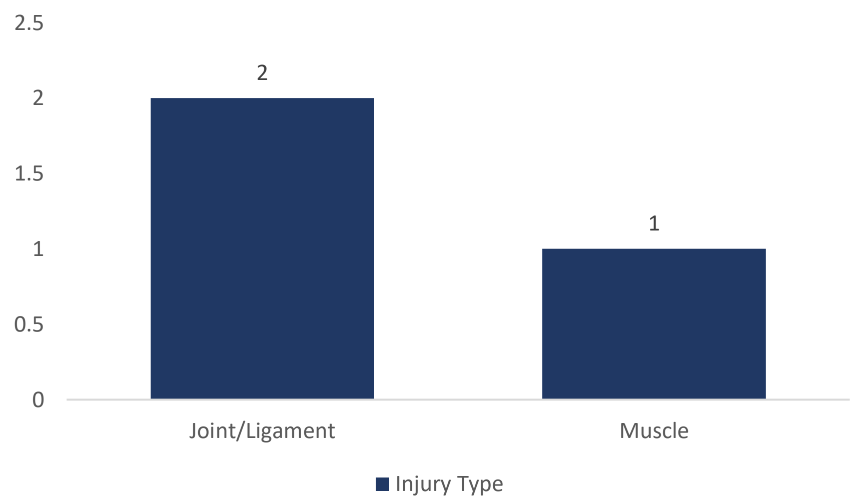

Figure 56: Cricket - Total Injuries per Injury Type

Time Loss

Of the 3 injuries, 2 (66.66%) were time loss injuries and 1 (33.33%) a no time loss injury. This is shown in Figure 57. There is no significant difference between time-loss and no time-loss injuries *(p = 0.52)*.

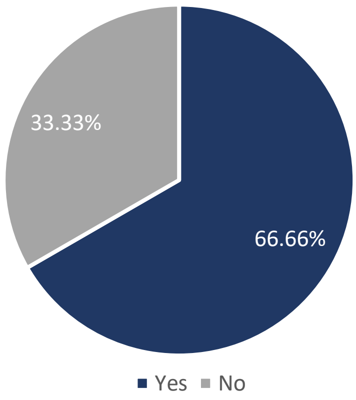

Figure 57: Cricket - Total Time Loss and No Time loss injuries (p = 0.52)

Time Loss and Type of Play. Of the two injuries resulting in time loss, 1 (50%) occurred during match play and 1 (50%) during practice. The 1 (100%) injury resulting in no time loss occurred during practice.

Time off Play / Severity

The duration of time off play for both the time loss injuries was 8–28 days.

Time off Play and Injury Type. As seen in Figure 58, both the time loss injuries were joint / ligament injuries and involved the knee and spine respectively. The no time loss injury was muscular in type.

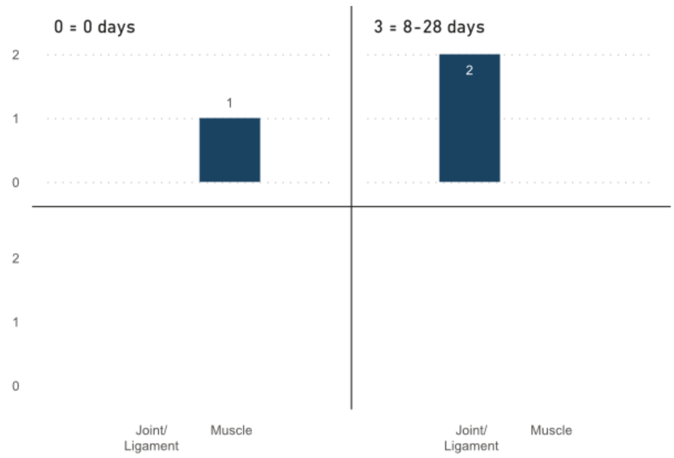

Figure 58: Cricket - Total injuries and Time off Play vs Injury Type

Player Position

Figure 59 shows the equal distribution of injuries between batsman, bowler and fielder with 1 (33.33%) each. All were acute in mode and non-contact in mechanism.

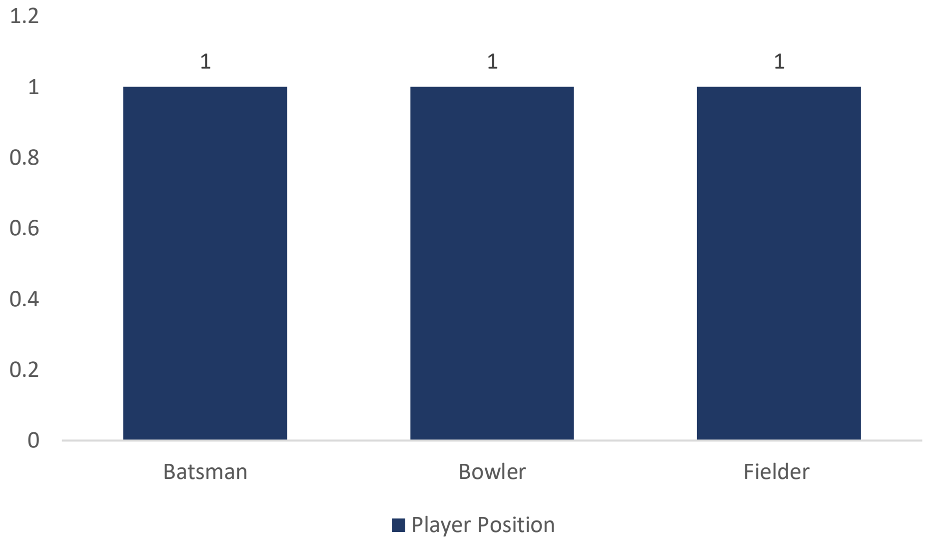

Figure 59: Cricket - Total injuries and Player Position

Player Position and Injury Type is shown in Figure 60. Bowler and batsman sustained 1 joint / ligament injury each, while the fielder position sustained 1 muscular injury.

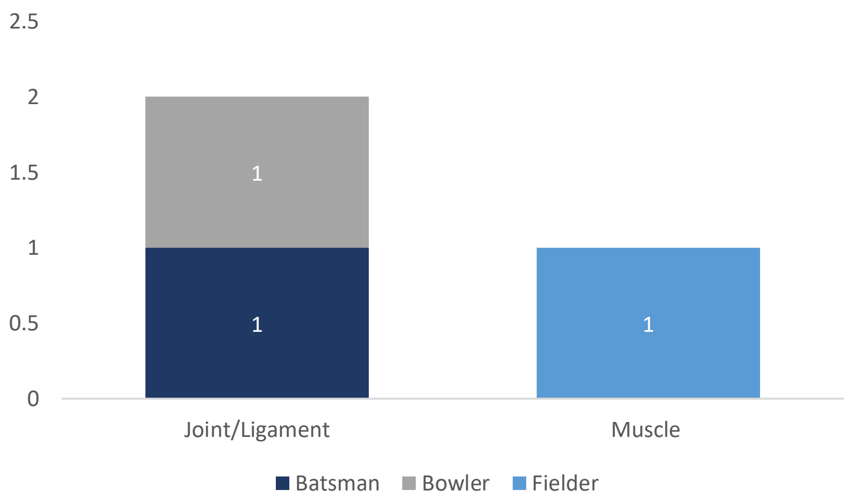

Figure 60: Cricket - Total injuries for Player Position and Injury Type

CHAPTER 3: DISCUSSION

The aim of this thesis was to establish sports injury incidence rates in a non-elite Western Cape high school adolescent population as well as to identify potential injury patterns and risk factors. Longitudinal data in this area is necessary in order to establish injury prevention strategies to reduce injury rates and make sporting participation safer, and encouraging participation to allow for the known physical and mental benefits it provides. This discussion highlights the significant findings of our data.

3.1 INJURY INCIDENCE

The combined injury incidence for all sports in this study was 4.31 / 1 000 athlete-exposure hours. This is higher than other studies reviewed. Match injury incidence was much higher (28.78 / 1 000 athlete-exposure hours) compared to practice (1.18 / 1 000 athlete-exposure hours) which is consistent with the literature that typically shows higher injury rates during competition than practice. The higher overall rate may be attributed to the predominance of rugby data, small sample size, and lack of sport code variability in the study.

Sport-specific injury incidence shows the variations between the different sporting codes and, in line with literature, indicates that contact sports have the highest rates and highlights differences between match and practice incidences (Hootman *et al*., 2007).

3.1.1 Rugby-specific findings

Total injury incidence in rugby was 4.35 / 1 000 athlete-exposure hours and match injury incidence 85.99 / 1 000 athlete-exposure hours. This is similar to previous studies reporting 85 / 1 000 match hours in youth rugby and is also comparable to professional rugby (Williams *et al*., 2013), but higher than other studies that report lower match injury rates of 54.6 and 55.2 / 1 000 exposure hours (Brown et al., 2015; Mc Fie et al., 2016). Practice injury incidence was 1.18 / 1 000 AE hours.

This study included injuries that did not lead to time off from play, contributing to higher injury rates compared to other studies that report only time-loss injuries. To make comparisons, match time-loss injury incidence was determined at 35 / 1 000 athlete-exposure hours which is more in line with existing research (Archbold *et al*., 2017; Palmer-Green *et al*., 2013).

3.1.2 Football-specific findings

Total injury incidence in football was 7.09 / 1 000 athlete-exposure hours. Match injury incidence was 51.11 / 1 000 athlete-exposure hours, which is higher than the range of 9.5–48.7 / 1 000 exposure hours reported in other studies (Watson & Mjaanes, 2019). Practice injury incidence was 0, possibly due to under-reporting or missed injuries during data collection.

3.1.3 Cricket-specific findings

Total injury incidence was 1.42 / 1 000 athlete-exposure hours. Interestingly, practice injury incidence was higher (2.5 / 1 000 athlete-exposure hours) compared to match injury incidence. This is contrary to the trend seen in most sports, where match injury rates are higher. Comparison to the available cricket literature is difficult as injury incidence has been expressed as a percentage of total injuries recorded, with only one study reporting exposure-based injury incidence (Soomro *et al*., 2018). This study reported higher all-round injury rates at 15.93 / 1 000 exposure hours.

Pertinent insights can be made from these findings. Rugby, especially during matches, is associated with a significantly high injury rate. The study's findings align with professional adult rugby injury rates, indicating that, even at the youth level, rugby is a high-risk sport.

In particular, the absence of reported injuries during football practices, generally lower practice injury rates across other sports, and overall low injury numbers suggests under-reporting or the difficulty in capturing injuries and an underpowered study for these sporting codes. To put this into perspective, of the 15 Sports Injury Surveillance systems identified in a systematic review (Ekegren *et al*., 2016), only four are following non-professional younger athletes in College and High School. In all four of these studies, injury data are recorded on online databases by Certified Athletic Trainers who specialise in identifying, managing and preventing sports injuries. In contrast, the football and cricket data captured in this study was recorded by school teachers and coaches with different qualifications and understanding of these topics, and limited by time constraints and medical knowledge. The study's rugby injury data were collected by a dedicated team physiotherapist in a private school setting, which could explain the higher number of documented injuries and overall better data quality in comparison. This highlights the need benefits of appropriate financial, professional and logistical resourcing support for future studies or injury surveillance systems to improve data quality.

Cricket, though traditionally seen as less physically intense than rugby or football, had a relatively low match injury rate but a higher practice injury rate. This anomaly could be due to the compromised study power mentioned above.

This study includes no time-loss injuries, which may have given a more comprehensive picture of the overall injury burden. However, this also makes comparisons with other studies that focus on only time-loss injuries more complex. Injury surveillance systems should consistently record all injuries, including no time-loss injuries, for a better understanding of the injury landscape.

3.2 INJURY MODE, MECHANISM, TYPE OF PLAY, PERIOD OF PLAY

Across all sports, injuries are predominantly acute in mode (84.62%) with a high statistical significance *($p < 0.001$).* There are very few studies which specify injury mode across a range of sporting codes, but those that do also report this finding. Most injuries resulted from direct contact, contributing to 73.53% of rugby injuries. In contrast all reported cricket injuries were non-contact in nature. Match accounted for 74.36% of overall injuries *($p < 0.001$),* with 80% of rugby injuries and 100% of football injuries occurring in the second half of play, which was also statistically significant.

High-impact and contact sports involve exposure to sudden and extreme forces, especially in competitive situations which could explain the high rates of match-, acute- and direct contact-related injuries. Adolescents, due to their growth spurts, experience reduced soft tissue flexibility and strength of their elongating bones and are more prone to acute injuries, with other risk factors including inadequate physical conditioning and stretching prior to exercise, immature neuromuscular control and improper technique (Shanmugam & Maffulli, 2008).

Potential areas of focus should be for coaches and players to work on strength, flexibility and conditioning, sport-specific drills, safe playing techniques and to ensure correct sport-dependent protective gear is worn. A number of systematic reviews investigating the efficacy of youth Injury Prevention Programmes (IPP) give supporting evidence that programmes including warm-up, neuromuscular, proprioception and strength training can reduce overall injury rate by 40% (Soomro *et al*., 2016). Those that included Plyometric exercise resulted in superior improvements (Rössler *et al*., 2014). The protective effect of movement control exercise programmes were seen to be dose dependent, and most effective in reducing injury incidence when completed three or more times a week (Hislop et al., 2017).

The use of protective gear in injury reduction is unclear, with headgear and bracing particularly in contact sports showing higher injury rates (Abernethy & Bleakley, 2007), although some sports like snowboarding show significant reductions in wrist injuries with the use of wrist bracing. This highlights the need for evaluation of sport-specific protective gear more closely.

Competition brings a higher intensity of play and increased physical demand, and over the match period, injury risk is seen to increase. A possible factor involved is fatigue which could potentially be addressed with implementing endurance and conditioning programmes, as well as improved in-match management of substitutions, hydration and fuelling. Post-game recovery protocols and training load management could reduce overall fatigue and therefore injury rates. Multifaceted injury prevention programmes that start pre-season, and continue throughout, show injury rate reduction of around 75%, similar to those seen in the adult population. Rule modification, particularly the policies surrounding contact play in high-collision and contact sports, needs to be focused on and is an area for further research (Emery & Pasanen, 2019). It is not uncommon for young athletes to participate in multiple sports throughout seasons and examining the effect of such workloads on both acute and repetitive injuries needs to be investigated.

3.3 TIME LOSS AND INJURY SEVERITY

A significant percentage, 70.51%, of total reported injuries resulted in time loss from sport. Injury severity for this study was measured using the number of days for which the athlete was unable to participate in either practice or competition, as recommended by multiple consensus statements for its simplicity and ease (Bahr *et al*., 2020). The majority of time loss injuries across all sports were moderate and resulted in 8–28 days off sports participation at 37.18%. This is in contrast to literature reporting that more than 50% of injuries are mild with <7 days off (Comstock et al., 2006; Rechel et al., 2008). The load of moderate injuries suggests that there is opportunity to address these intermediate recovery time injuries and make the most impact in terms of reducing lost sports participation time. Most time loss injuries occurred during competition, 72.88%, highlighting the high risk that comes with the intensity and unpredictability of match play.

3.3.1 Rugby-specific findings

Rugby injuries saw 67.75% result in time loss and 76.1% of these injuries occurred during match play. The majority (50%) were moderate with 8–28 days off. Most time loss injuries were joint / ligament injuries at 41.13%. Previous literature reports many rugby injuries are severe, resulting in >28 days off, with concussion being a significant contributor (Freitag *et al*., 2015).

Some strong associations with injury type and the amount of time off play were identified. Although these associations may statistically be influenced by the low injury numbers in some categories, they still reveal potential patterns. Muscular injuries were strongly associated with no time loss from sport, cartilage / bursae injuries with 1–7 days off and internal injuries — which include concussion — were more likely to be moderate with up to 28 days off. The body area with the most time loss injuries was the shoulder at 28%. Rugby had a significant number of joint and ligament injuries, with the shoulder being especially prone to time loss injuries.

3.3.2 Football-specific findings

One hundred percent of reported football injuries resulted in time loss, with the majority (57.14%) being in the 8–28 day category. This is higher than reported findings in the literature, where the majority of injuries are mild, resulting in less than 7 days off (Khodaee *et al*., 2017). The more severe injuries, resulting in more than 28 days off sport, involved bone and cartilage / bursae injuries of the hip and knee. Football stood out with severe injuries and the hip and knee appear to be a particular risk.

3.3.3 Cricket-specific findings

Injuries were mostly moderate (8–28 days off) with the predominant injury type being joint / ligament involving the knee and spine. Literature reports varying injury severity, with some studies reporting most injuries are mild (Stretch, 2015) and others that most injuries are severe, with more than 28 days off (Milson *et al*., 2007). Cricket, despite being a less physically confrontational sport compared to rugby or football, still showed a high frequency of time loss joint / ligament injuries, especially of the spine and knee.

3.4 BODY REGION, AREA, POSITION AND TYPE

Representing 42.31% of total injuries, lower limb injuries are the most common across all sports. This is consistent with numerous studies that highlight the vulnerability of the lower extremities in adolescent sport. The most injured body area was the shoulder across all sports at 25.64%, followed by the knee at 14.10%. The prominence of shoulder injuries is well documented, particularly in contact sports like rugby and football, where players often experience direct collisions and falls. The lower limbs, particularly the knee, are prone to injury due to high-impact movements and rapid direction changes.

Joint and ligament injuries are the most prominent type and make up 29.74% of the total, suggesting these injuries are particularly common in high-intensity, high-impact sports. These injuries often result from contact, falls, or awkward landings that place sudden pressure on joints. This is in line with the literature and suggests that limb joint injuries are a particular concern in adolescent sport.

3.4.1 Rugby-specific findings

When comparing body regions, injuries of the lower limbs (41.18%) and upper limbs (38.24%) were significantly more frequent than others, indicating that players' entire bodies are subjected to high levels of impact and there may be specific risk factors involved for these injury patterns. A Tukey's multiple comparisons test showed that the most frequently injured area, the shoulder at 26.47%, has significantly higher injury risk than all other body areas. This emphasises the need for injury prevention strategies specific to the upper body.

Joint / ligament injuries were the most frequent injury type at 39.70% and results from the Tukey's comparisons test gave statistically significantly higher injury occurrence compared to all other injury types. This suggests that injury prevention strategies in rugby should focus on strengthening ligaments and improving joint stability through conditioning programmes. The strong association between joint / ligament injuries and direct contact further indicates the need for technique training, such as proper tackling form, to reduce injury risk.

Injury type and mechanism showed important associations. Muscle injuries occurred more frequently than expected in non-contact scenarios, suggesting that fatigue or inadequate warm-up may lead to overuse or strain-type injuries. On the other hand, bone and joint / ligament injuries are more closely tied to direct contact, pointing to the inherent risk of player collisions in rugby.

Injury type and mode were also significantly linked. Cartilage, bursae, and muscle injuries are linked to repetitive modality, while bone, internal, and joint / ligament injuries are often acute. This differentiation is key for understanding injury prevention and strategies to mitigate repetitive injuries may include better conditioning and technique modification, while reducing acute injuries may involve improving protective equipment and improved enforcing of rules to limit high-risk contact.

3.4.2 Football-specific findings

The predominance of lower limb injuries (57.14%) in football mirrors findings in both the literature and other field sports. Football's high demands on running, sprinting, and quick directional changes put immense strain on the legs. Knee injuries (28.57%) are particularly prevalent, reflecting the susceptibility of this joint to both non-contact and contact injuries. Studies have highlighted the importance of neuromuscular training to prevent such injuries, especially for female athletes who tend to have higher rates of ACL injuries (Bisciotti *et al.*, 2016).

Across both rugby and football, joint / ligament injuries are particularly prominent. This finding underscores the importance of joint stability and mobility training in future injury prevention protocols. For both sports, interventions like proprioceptive training (balance, co-ordination) and strength training focused on ligaments around vulnerable joints (shoulders and knees) could be effective in reducing injury rates as seen in the literature.

The distinction between contact and non-contact injuries is crucial for understanding injury mechanisms. Non-contact injuries, particularly muscle strains, are more likely due to over-exertion, fatigue, or improper warm-up. Contact injuries, especially to the joints and bones, occur when players collide or fall awkwardly. This again highlights the need for both individual preparation (conditioning, warm-up) and rule enforcement in games to minimise risky contact situations.

The differentiation between repetitive and acute injury modes offers valuable insights for preventive measures. For sports with high levels of repetitive stress, coaches and medical staff should focus on monitoring athlete workload, ensuring proper recovery, and integrating strengthening exercises for commonly injured areas (e.g. hamstrings, shoulders). Acute injuries, often due to sudden trauma or collisions, call for stricter enforcement of rules around contact and potentially better protective gear.

These findings reaffirm the literature's emphasis on joint and ligament injuries as critical concerns in adolescent sports. They also highlight the importance of sports-specific injury prevention programmes. The association between certain injury types and both contact and non-contact mechanisms further points to the need for comprehensive prevention programmes that address both intrinsic factors (e.g. muscle strength, flexibility) and extrinsic factors (e.g. equipment, rules, playing surface).

3.5 PLAYER POSITION

3.5.1 Rugby-specific findings

This study found significant injury patterns between rugby forward and back line players. Forwards experienced statistically more upper limb *($p = 0.004$),* shoulder *($p = 0.044$)*, forearm *($p < 0.001$)*, knee *($p < 0.001$)* and ankle *($p = 0.018$)* injuries which more commonly involve the joints and ligaments *($p = 0.014$),* tendons *($p = 0.001$)* and cartilage structures *($p < 0.001$).*

Backs were significantly more likely to injure the hip *($p < 0.001$)*, thigh *($p < 0.001$)* and calf *($p < 0.001$)* areas, and playing in the back line was more strongly associated with sustaining muscular injuries *($p < 0.001$).*

Of note, although the concussion distribution is not statistically significant, back line players sustained 80% of concussions.

3.5.2 Body region, area and injury types by position

This study highlights injury patterns due to different positional demands in rugby. Forwards (props, hookers, locks and flanks) are primarily responsible for physical contests in the scrum, rucks and tackling which involve significant contact and forceful engagement with opponents. They are significantly more likely to suffer upper limb injuries due to the considerable stress on the shoulders, arms and wrists. Shoulder injuries are common, possibly due to the high impact in tackles and scrums, while forearm injuries may result from falling, binding in scrums or impacts during rucking. The forceful engagements during mauls and rucks, combined with sudden directional changes, also place significant strain on the lower limbs, leading to injuries in the knees and ankles, frequently involving joint and ligamentous structures.

Backs (fly-half, scrum-half, centres, wings and fullback) focus more on speed, agility, and open-play movement, leading to a different set of injury risks. Although they experience contact during tackling and ball-carrying, they tend to have fewer direct physical contests than forwards and more lower-limb injuries — particularly in the hip, thigh and calves. This aligns with their role in sprinting, cutting and kicking, which requires explosive lower-limb power. Hip and thigh injuries are often linked to sprinting and changes in direction. Muscle-related injuries are common in backs; sprinting and cutting manoeuvres place extreme loads on these muscle groups, increasing the risk of strains and tears. Muscle injuries are often acute, resulting from sudden acceleration or deceleration. Although less common than in forwards, backs still suffer frequent ligament injuries, possibly during tackling or when they are tackled at high speed.

3.5.3 Concussions in rugby

Though the concussion distribution between forwards and backs may not have been found to be statistically significant, backs are often reported to sustain a higher proportion of concussions (80% in this study). This may be due to the greater frequency with which backs are involved in high-speed collisions while running into or being tackled by opponents.

In youth rugby, the physiological and developmental differences between adolescents and adults must be considered. Younger players are more prone to certain injury types due to incomplete skeletal and muscular development:

- *Growth plates*: In youth athletes, growth plates in bones are still developing and can be more susceptible to injury, particularly from repetitive impact and trauma.
- *Muscle development*: Youth players may not have fully developed muscular strength or coordination, which can increase the risk of strains and ligamentous injuries during sudden, forceful actions like sprinting or tackling.

Given the position-specific injury risks, preventive strategies should be tailored for forwards and backs. Forwards should focus on developing joint stability, particularly in the shoulders, knees, and ankles, to reduce ligament and cartilage injuries. This can be achieved through strength training that emphasises the stability and endurance of these joints.

Backs should prioritise lower-limb flexibility, strength, and conditioning programmes, with an emphasis on sprint mechanics and deceleration training to minimise the risk of muscle injuries. Specific preventative approaches for concussions should be emphasised across all youth rugby positions, including proper tackling technique and player awareness.

In summary, the patterns of injuries in youth rugby should be addressed with a multifaceted approach, integrating:

- Age-appropriate strength and conditioning programmes focused on muscle groups and joints vulnerable to injury based on playing position.

- Emphasis on technical training that improves tackling and scrummaging technique for forwards and movement skills for backs to minimise injury risk.
- Load management: Reducing the likelihood of overuse injuries through appropriate training loads, rest, and recovery.
- The use of protective gear. An extensive meta-analysis reviewing injury prevention strategies for youth sport-related concussions found that mouthguards have a protective effect in contact sports (Eliason et al., 2023).

3.6 STUDY LIMITATIONS

Some of the initial aims of this study were not completely fulfilled as data collection practicalities led to fewer schools participating and a reduced number of sporting codes being included. It is noted that staff and time resources were better in private schools which impacted data quality, quantity and accuracy.

The study's results may be affected by the limited number of sporting codes and low participant numbers, with only rugby data being sufficiently powered to make meaningful inferences. Some statistical interpretation may be overstated as several p-values have very low power.

Due to the nature of the data collection methodology of this study, which relied on participants self-reporting and coaching staff recording of injuries, under-reporting and/ or incorrect recording of data may have contributed the low power of the findings.

It is noted that in the methodology of this study, an outline of the literature review search strategy was not included. This could affect transparency and reproducibility for conducting future studies, and would be an important inclusion should this research be published.

The study took place over two years that included the COVID-19 lockdown which further impacted data collection and participant numbers.

CHAPTER 4: CONCLUSION

In conclusion, this study provides valuable insights into the incidence, patterns, and risk factors of sports injuries among non-elite adolescent athletes in the Western Cape. The overall injury rate of 4.31 / 1 000 athlete-exposure hours, particularly the high rates during matches compared to practice, confirms the need for targeted injury prevention strategies. Rugby, in particular, displayed a significantly higher injury risk during matches, with a total incidence rate of 85.99 / 1 000 athlete-exposure hours, comparable to adult professional rugby injury rates. Football also showed high match injury rates, while cricket presented an unusual trend with more practice-related injuries.

A notable finding is the prevalence of time-loss injuries across all sports, with the majority being moderate (8–28 days off), suggesting a need to address recovery and prevention strategies that target these intermediate recovery time injuries. Joint and ligament injuries, particularly in the lower limbs, were the most common injury types, emphasising the importance of strength and conditioning programmes that focus on joint stability. Positional differences in rugby injury patterns further suggest that prevention strategies should be sport- and position-specific, focusing on the unique demands of different roles.

With the knowledge that the first step for injury incidence reduction is to establish large-scale injury surveillance databases, the study identifies key areas for improvement in injury surveillance in youth community and school sports, such as the need for accessible and standardised data collection systems and provision of professional resources to ensure equality for young athletes across all socio-economic conditions. Overall, these findings underscore the importance of implementing comprehensive injury prevention programmes to reduce injury incidence and severity, enhance athlete safety, and promote sustained participation in sports for the physical and mental benefits it provides.

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APPENDICES

APPENDIX 1: ETHICS APPROVAL STUDY

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room G50-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

22 January 2020

HREC REF:112/2015

A/Prof M Held
Orthopaedic Department
H49, OMB

Dear A/Prof Held

PROJECT TITLE: WESTERN CAPE HIGH SCHOOL INJURY TRACKING SURVEY

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30 January 2021.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: Lynelle Hoeks will also be involved in this study.

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
NHREC-registration number: REC-210208-007

HREC 112/2015sa

APPENDIX 2: ADDITION OF DR HOEKS AS CO-INVESTIGATOR

University of Cape Town

Department of Orthopaedic Surgery

&

UCT Division of Exercise Science And Sports Medicine

Department Of Human Biology, Faculty of Health Sciences

University Of Cape Town

RESEARCH PROTOCOL

Western Cape High School Injury tracking survey

Principal Investigator:	Dr Michael Held**
Co-investigators:	Dr Jeroen Swart* Amoray Theunissen* Dr Steven Roche** Professor Mike Lambert* Dr Lynelle Hoeks***
Contact details:	Dr Michael Held Department of Orthopaedic Surgery J-Floor OMB Groote Schuur Hospital Tel: 0844478882 Email: email.held@gmail.com

Affiliations:

*Division of Exercise Science and Sports Medicine,
Department of Human Biology, University of Cape Town,
Sports Science Institute of South Africa
**Department of Orthopaedic Surgery, University of Cape Town
***Mphil Student, Division of Sports and Exercise Science and Sports Medicine, Deprtment of Human Biology, University of Cape Town

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6.8.2018 Version 3

APPENDIX 3.1: CONSENT HARD COPY

Sports Orthopaedic Service
Department of Orthopaedic Surgery &
Exercise Science and Sports Medicine
University of Cape Town

Dear parent / legal guardian

We are doing research on injury patterns specific to school sports in Secondary Schools in the Cape Peninsula. For this we would like to record the injuries, circumstances of injuries and personal information of your child. We will use this data to prevent similar injuries in future. Our study coordinator at your school will complete an injury form to document the circumstances and type of the injury and will give information about your child's age, gender.

This study being conducted by the University of Cape Town Department of Orthopaedics and The Division of Exercise Science and Sports Medicine.

Any injuries that your child or you (if > 18 y.o) sustain in sporting practice or during sporting competition will be recorded by the coach or teacher who is co-ordinating the data collection for your child's team.

Information will be recorded about the area of the body that is injured, the type of injury, how the injury occurred, the time it takes to heal and whether there is any medical diagnosis, investigation or treatment provided.

This information will be sent by email to the researchers by the teacher / coach every week. Your child's name and identity will not be recorded.
To allow the researchers to link data from week to week for injuries that take longer than 1 week to resolve, you're the first letter of your child's name and surname will be used as an identifying code.
This study will be supervised by Dr Michael Held from the University of Cape Town. Please take time to read this form thoroughly before signing.

What will happen to my child if they take part? Your child's participation in the study will not have any influence on their sporting activities or school activities in any way. The data will merely be collected as an observation and be used anonymously to assess the number and nature of injuries in school going children in the Cape Peninsula.
Are there any disadvantages / risks in taking part? There are no disadvantages or risks in participating in this study.
Will they be compensated for participation? There is no compensation for your child's participation in the study

What if something goes wrong? There will not be any expected adverse effects as this study will only be an observation and will not require any change in any activities which you perform on a daily basis.

Confidentiality – Who will know the results? All information collected about you will be kept confidential on a password protected computer. Only the investigator and the co-investigators will have access to the information and any information about you will be anonymous. Data that may be reported in scientific journals will not include any information identifying you as a participant in the study.

What happens if they refuse to take part? Your child is under no obligation to take part. If they decide not to take part, they will not be penalised. Should you wish to withdraw your child from the study at any time please communicate this to us directly at the contact details listed below. We will then instruct the school to withdraw your child from the study. Please note that there will not be any penalty should your child withdraw from the study. They can also withdraw from the study at any time.

Questions or Concerns: If at any time, you have any questions about the study, please feel free to contact any of the individuals listed below. You are assured that all inquiries will remain confidential.

Dr. Michael Held
Physical Address: J-Floor, OMB, Groote Schuur Hospital
Tel number: 0214045108 Email: michael.held@uct.ac.za

Professor Marc Blockman
Chairperson, Faculty of Health Sciences Human Research Ethics Committee
Tel number: (021) 4066492 E-mail: marc.blockman@uct.ac.za

By signing below, it serves as confirmation that you have had adequate time to read through the study information, that you have understood the consent form and that you are willing to participate in this study. You have the right to withdraw at any time and you may ask questions at any time during the study. All information recorded during this study will remain confidential, and no participants will be identified in the event of future publication. Your signature is confirmation that you have read this informed consent and agree to participate in this study.

I, (Parent/ Guardian) of Consent to

him/her being part of this study.

Date:

APPENDIX 3.2: CONSENT GOOGLE FORMS

https://forms.gle/ohsMfNraZJFvNqoW9

Injury Tracker Survey Consent for Parent/ Legal Guardian

Dear Parent / Guardian

I write as the lead of a study being conducted by the University of Cape Town's faculty of Exercise Science and Sports Medicine.

We are doing research on injury patterns specific to school sports in Secondary Schools in the Cape Peninsula. As part of this programme, we have partnered with Reddam, whose coaches will document the circumstances behind and types of injury their players face as and when they occur. Further information provided will track the area of the body that is injured, the time it takes to heal and whether there is any medical diagnosis, investigation or treatment provided. As part of this data set, we will record your child's age and gender, but not their name nor their or your contact information (please note that the first letter of your child's name and surname will be used as an identifying code). It is our hope that this data will support us in developing programmes that decrease the frequency of school player injuries.

This study will be supervised by Dr Michael Held from the University of Cape Town.

Please read the accompanying form thoroughly before signing.

Please note that:

1. Your child's participation in the study will not have any influence on their sporting activities or school activities in any way.

2. There are no seen disadvantages or risks in participating in this study.

3. There is no compensation for your child's participation in the study

4. There will not be any expected adverse effects as this study will only be an observation.

5. All information collected about your child will be kept confidential on a password protected computer. Only the investigator and the co-investigators will have access to the information and any information about you and or your child will be anonymous. Data that may be reported in scientific journals will not include any information identifying you and or your child as a participant in the study.

6. You and your child are under no obligation whatsoever to take part.

7. Should you wish to withdraw your child from the study at any time please communicate this to us directly via the contact details listed below.

8. If at any time, you have any questions about the study, please feel free to contact me, as per the details below. You are assured that all inquiries will remain confidential.

We hope you choose to join us in this study, as we seek to find ways to ensure our children do not suffer injuries.

Sincerely,

Dr Michael Held

Physical Address: J-Floor, OMB, Groote Schuur Hospital

Tel number: 0214045108

Email: michael.held@uct.ac.za

Professor Marc Blockman

Chairperson, Faculty of Health Sciences Human Research Ethics Committee

Tel number: (021) 4066 492

Email: marc.blockman@uct.ac.za

Your
signature is confirmation that you have read this informed consent and agree to participate in this study.

* Indicates required question

1. Do you consent ? *

Mark only one oval.

- Yes, I do consent
- No, I do not consent

Injury Tracker Consent for Student

2. We are doing a research study about how many sports injuries happen each year in schools. A research study is a way to learn more about people. If you decide that you want to be part of this study, your teacher will let us know how and when you get injured. You do not need to do anything yourself. They will not use your name when your teacher or coach gives us information about you. You will not get any rewards for taking part in our research study but we will learn important facts that might help us to make sports safer in future.When we are finished with this study we will write a report about what was learned. This report will not include your name or that you were in the study.You do not have to be in this study if you do not want to be. If you decide to stop after we begin, that's okay too. Your parents know about the study too.If you decide you want to be in this study, please select Yes, i do consent. If you do not wish to be a part of the study, please select No, I do not consent *

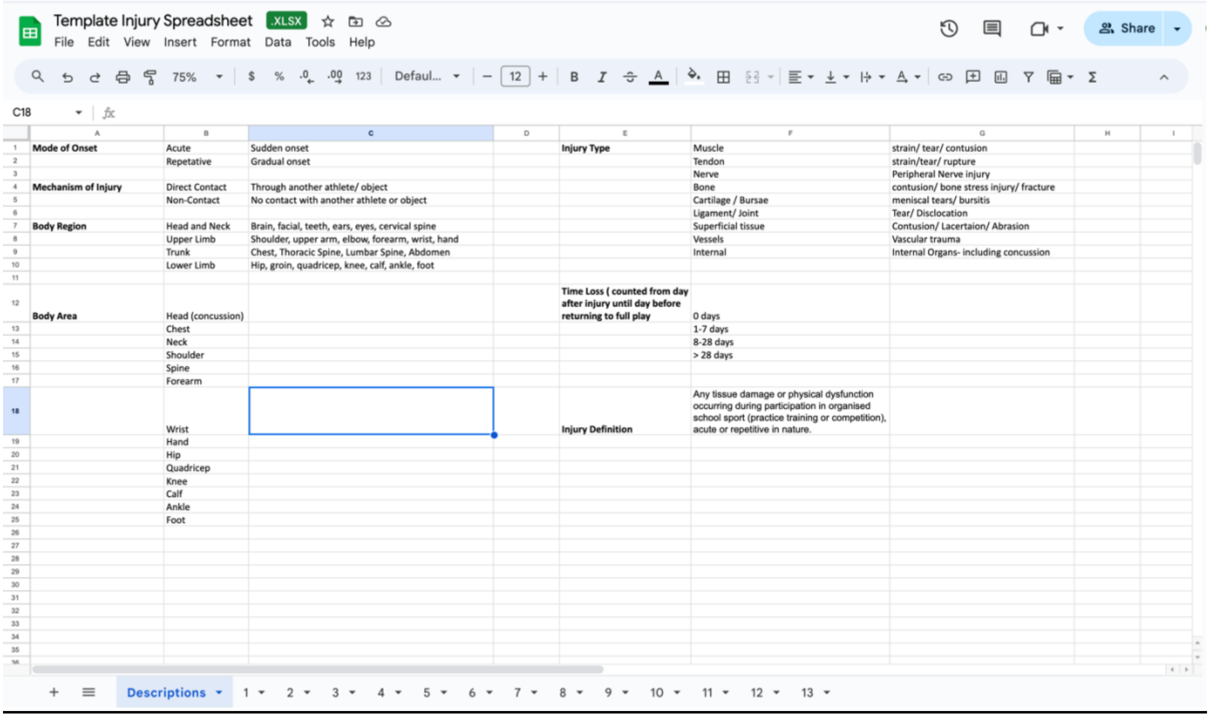
Mark only one oval.

- Yes, I do consent
- No, I do not consent

Student details

3. Name and Grade of Student *

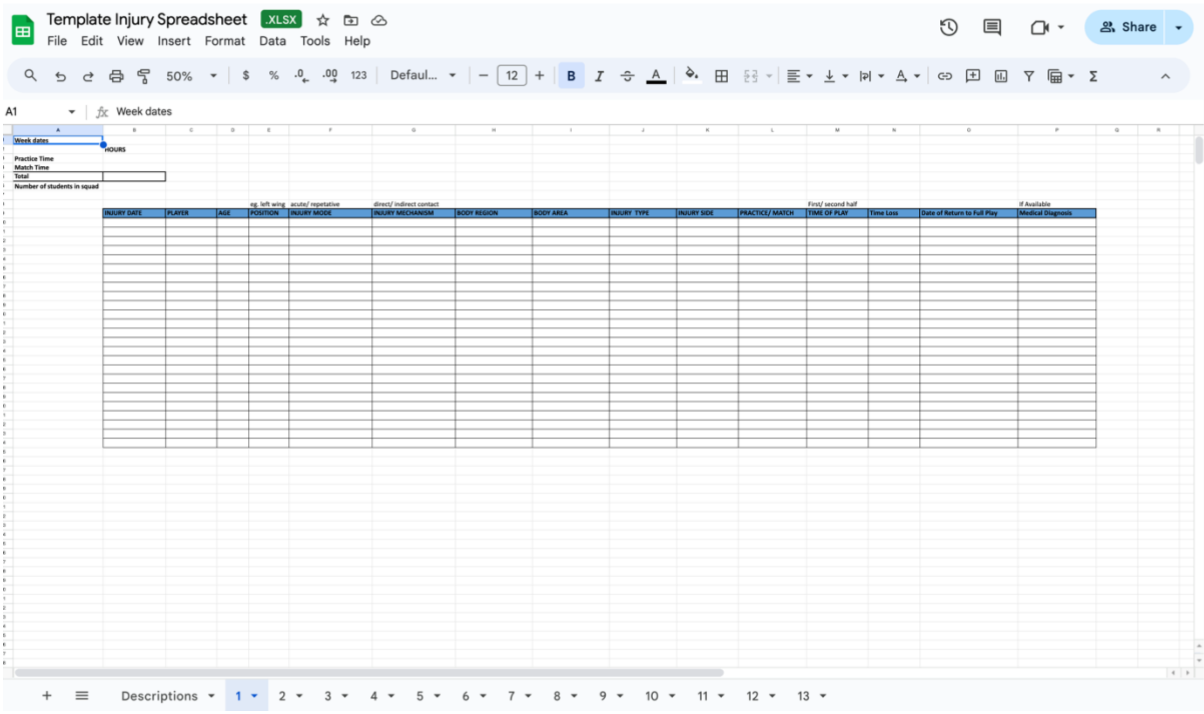
APPENDIX 4: DATA COLLECTION SPREADSHEET



Template Injury Spreadsheet

A	B	C	E	F	G
Mode of Onset	Acute	Sudden onset	**Injury Type**	Muscle	strain/ tear/ contusion
	Repetitive	Gradual onset		Tendon	strain/tear/ rupture
				Nerve	Peripheral Nerve injury
Mechanism of Injury	Direct Contact	Through another athlete/ object		Bone	contusion/ bone stress injury/ fracture
	Non-Contact	No contact with another athlete or object		Cartilage / Bursae	meniscal tears/ bursitis
				Ligament/ Joint	Tear/ Disclocation
Body Region	Head and Neck	Brain, facial, teeth, ears, eyes, cervical spine		Superficial tissue	Contusion/ Lacertaion/ Abrasion
	Upper Limb	Shoulder, upper arm, elbow, forearm, wrist, hand		Vessels	Vascular trauma
	Trunk	Chest, Thoracic Spine, Lumbar Spine, Abdomen		Internal	Internal Organs- including concussion
	Lower Limb	Hip, groin, quadricep, knee, calf, ankle, foot			
Body Area	Head (concussion)		**Time Loss (counted from day after injury until day before returning to full play**	0 days	
	Chest			1-7 days	
	Neck			8-28 days	
	Shoulder			> 28 days	
	Spine				
	Forearm				
	Wrist		**Injury Definition**	Any tissue damage or physical dysfunction occurring during participation in organised school sport (practice training or competition), acute or repetitive in nature.	
	Hand				
	Hip				
	Quadricep				
	Knee				
	Calf				
	Ankle				
	Foot				

Descriptions 1 2 3 4 5 6 7 8 9 10 11 12 13



Template Injury Spreadsheet

Week dates	
	HOURS
Practice Time	
Match Time	
Total	
Number of students in squad	

			eg. left wing	acute/ repetative	direct/ indirect contact						First/ second half			If Available
INJURY DATE	PLAYER	AGE	POSITION	INJURY MODE	INJURY MECHANISM	BODY REGION	BODY AREA	INJURY TYPE	INJURY SIDE	PRACTICE/ MATCH	TIME OF PLAY	Time Loss	Date of Return to Full Play	Medical Diagnosis

Descriptions 1 2 3 4 5 6 7 8 9 10 11 12 13