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# THE EPIDEMIOLOGY OF RUGBY INJURIES IN A SOUTH AFRICAN HIGH SCHOOL OVER A ONE-YEAR PERIOD

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***ABSTRACT***

*Adolescent rugby players have a high risk for injuries; however, injury prevention programmes have reduced the incidence of injuries amongst this group. The purpose of this retrospective analysis was to evaluate the epidemiology of rugby injuries at a South African high school over one season. There were 99 participants over a total of 98 matches and the participants were aged between 13 and 18 years. Information on the type of injuries was documented and the injury proportion (IP), injury incidence and 95% confidence intervals (CI) were calculated, with 1000 player-hours as the denominator. Ninety-nine injuries were recorded, with a total injury incidence of 34.1 injuries/1000 player-hours (95% CI 27.4–40.8). Injuries were predominantly of moderate severity (IP: 25.3%) with a time-loss period of 8 to 28 days. Injuries to the head, neck and spine were the most common (IP: 38.4%; incidence: 13.1; 95% CI 8.9–17.2). The findings on the nature of injuries were largely consistent with current local and international research on high school rugby, with the head, neck and spine remaining at a significant risk of injury. It is recommended that injury prevention programmes further enforce safety guidelines for the protection of the head, neck and spine amongst high school athletes.*

***Keywords**:* Adolescent athletes; Injury epidemiology; Injury surveillance; Rugby union injuries; South African schools

## INTRODUCTION

Over the past two decades, rugby union has become progressively popular amongst the developmental age groups, with approximately 30.0% of participants worldwide being of the youth population (Brooks & Kemp, 2008; World Rugby, 2021). It remains a high-contact sport with a potentially high risk of physical injuries and is reported as having the highest injury rates, compared with other popular sporting codes (Nicholl *et al*., 1995; Williams *et al*., 2013).

South Africa has documented several cases of catastrophic and fatal injuries in its rugby history (Brown *et al*., 2013). Injuries may have detrimental effects on sports participation and the long-term well-being of young athletes. This is further compounded by the resultant school absenteeism and the impact this may have on academic performance (Abernethy & MacAuley, 2003).

Internationally, the study of rugby injury epidemiology appears well documented, even at the high school level. This is evidenced by a systematic review by Freitag *et al.* (2015), which analysed 35 international articles on adolescent rugby injuries over one season and determined a pooled match injury incidence of 26.7 injuries/1000 player-hours [95% confidence interval (CI) 13.2–54.1] from five of the studies, for subjects in the age groups of 14 to 18 years of age. Moderate injuries were found to be the most frequent injury severity, ranging from 21.0% to 68.0%. Ligament injuries were the most common type, with an injury incidence of 10.1–69.2 injuries/1000 player-hours. This was followed by lacerations, contusions and haematomas (Incidence: 0.4–31.9 injuries/1000 player-hours) (Freitag *et al.,* 2015). The injury proportion (IP) for head and neck injuries ranged from 4.6% to 41.2%, while upper limb injuries ranged from 19.0% to 38.0%. The proportion of injuries to the trunk and lower limbs ranged from 6.5% to 13.0% and 3.0% to 47.0%, respectively. The tackle was the most implicated mechanism of injury and accounted for a proportion of between 40.0% to 64.0% of injuries. There was no remarkable difference between forward and backline players regarding IP, which ranged between 44.0% and 56.0%, and 46.0% and 56.0%, respectively (Freitag *et al*., 2015). Another systematic review of 15 international studies on adolescent rugby injuries (12–18 years of age), reported an injury incidence of 28–130 injuries/1000 match-hours for medical-attention injuries and an injury incidence of 12–22 injuries/1000 player-hours for time-loss injuries over the period of at least one season (Bleakley *et al.,* 2011). The review classified severe injuries as a time-loss of more than 21 days and determined an injury incidence of 1.2–1.7 injuries/1000 match-hours. The shoulder and knee were most at risk of severe injuries, and fractures, ligament sprains and joint dislocations were the most common injury types, with the tackle phase accounting for 40.0% to 60.0% of all injuries. These systematic reviews proved that injuries were still very prevalent in rugby at the youth level, for the periods that they investigated.

A rugby injury surveillance study conducted in 28 Ulster schools in Ireland over one season reported an injury incidence of 29 injuries/1000 player-hours (Archbold *et al.,* 2017). Forty-nine per cent of the injuries were classified as severe, followed by moderate injuries (40.8%) (Archbold *et al*., 2017). Ligament sprains were the most common injury type at 31.0%, followed by concussions at 19.0% (Archbold *et al*., 2017). The most commonly affected anatomical location was the head and neck, comprising 27.0% of the injuries, followed by upper limb injuries (24.0%) (Archbold *et al.*, 2017). An injury surveillance study conducted at a school in Queensland, Australia on 480 rugby players recorded an injury incidence of 32 injuries/1000 player-hours over the 2015 season (95%CI 25–39); however, this was based on a medical-attention definition of injury (Leung *et al*., 2017). Head, neck and face injuries had the highest injury incidence for anatomical location (10 injuries/1000 player-hours; 95%CI 7–15). Joint and ligament injuries were the most prevalent injury type with an injury incidence of 11 injuries/1000 player-hours (95%CI 7–15), and the tackle was the most common mechanism of injury (38.0%) (Leung *et al*., 2017). A descriptive study in the United States involving 121 high school rugby clubs over two seasons determined an injury incidence of 15 injuries/1000 match-hours (relative risk=12, 95%CI 10–15), with a total of 594 injuries. The anatomical region most frequently injured was the head (22.0%). Fractures were the most common diagnosis (16 .0% of all injuries), and the tackle was the mechanism responsible for most injuries (59.0%). Forty-seven per cent of the injuries resulted in a time-loss of fewer than 10 days, which was the biggest proportion of time-loss, followed by injuries with a time-loss of more than 21 days at 27.0%, and then injuries with a time-loss of between 10 and 21 days at 23.0% (Collins *et al*., 2008). The findings in the above studies support the conclusion of a substantial injury incidence across the international high school rugby population, with a consistent pattern of an increased prevalence for head, face and neck injuries, as well as ligament and joint injuries, and where the tackle phase appears to be responsible for most injuries.

A South African study involving a Johannesburg-based, 5-day high school rugby tournament with 626 players was monitored over the 2010 and 2011 seasons and determined an injury incidence of 41 injuries/1000 match-hours. The head and neck were found to be the most frequently injured anatomical location (42.0%), followed by the lower limbs (29.0%) (Constantinou & Bentley, 2015). Ligament sprains were the most common type of injury (24.0%), followed by contusions (13.0%) and muscle injuries (14.0%), collectively constituting soft tissue injuries. The tackle was the most common injury mechanism (Constantinou & Bentley, 2015). The study could not determine the injury incidence per player-hours due to a lack of recorded exposure-hours. A prospective study conducted many years ago monitored injuries at a Cape Town-based school over the 1982 season for players ranging from 10 to 19 years of age, where the injury incidence was 1 per 119 hours (8.4 injuries/1000 match-hours). This was much lower than the findings from more recent studies (Nathan *et al*., 1983). Concussions and muscle injuries were the most frequent injury type (22.0% each), and head and neck injuries were the most common (38.0%), followed by upper limb injuries (29.0%). Comparing forward with backline players, there was no notable difference in injury frequency (Nathan *et al*., 1983). This research study is more than three decades old, and was conducted before the introduction of the rugby injury consensus guidelines in 2007, which allowed for the standardisation of injury data collection processes (Fuller *et al*., 2007). In the context of this Cape Town-based study, an injury was defined as one that resulted in a participation time-loss of at least 7 days, meaning that milder injuries were not reported. This may explain the much lower injury incidence that was determined, yet the study still shows similar descriptive results to more recent studies in terms of injury type, playing position and anatomical locations. A cohort study conducted during the South African youth week rugby tournaments assessed four provincial tournaments (Under-13 Craven Week, Under-16 Grant Khomo Week, Under-18 Academy Week and Under-18 Craven Week) over the 2011 and 2012 seasons, involving 3652 participants (Burger *et al*., 2014). The overall injury incidences that were determined for each tournament ranged between 24 and 50 injuries/1000 exposure-hours. Ligament injuries contributed the largest proportion of injury types at 29.0%, followed by bruises and contusions at 22.0%. Head and neck injuries were the most common injury location, and the tackle phase was implicated in 60.0% of all the injuries recorded (Burger *et al*., 2014). The studies by Constantinou and Bentley (2015) and Burger *et al.* (2014) were tournament based and indicated on average a slightly higher injury incidence when compared with the season-based studies. High school rugby injury research in the South African context is found to be based mostly on tournaments.

The advent of the BokSmart National Rugby Safety Programme in 2009, which is South Africa's rugby safety and injury prevention programme, saw the introduction of structured injury prevention protocols, implementation of guidelines on field-side immediate medical care and a more concerted focus on player welfare (Brown *et al*., 2016). The impact of the BokSmart Programme has seen a reduction in catastrophic injuries of up to 24.0% in school-level rugby over a 5-year period (Patricios, 2014; Brown *et al*., 2016). The BokSmart Programme works to improve rugby safety, based on the principles of Van Mechelen's concepts of injury prevention. Firstly, the extent of the rugby injury risk is determined through continued injury surveillance and, secondly, the risk factors are identified (Van Mechelen *et al*., 1992). Lastly, an implementation programme is developed, with the aim of curtailing the risk and severity of injuries. This is achieved through the development of medical protocols and the addition or adaptation of rugby regulations based on evidence-based practices. Education on these practices is targeted at the staff who are most proximal to the players, i.e., coaches and referees. Injury surveillance is imperative to developing and maintaining safety protocols in the game of rugby and thus demands continued monitoring inputs (Leahy *et al*., 2020). The South African Rugby Injury and Illness Surveillance and Prevention Project (SARIISPP) is the feeder programme to the BokSmart Programme, where epidemiological data in South African rugby is applied to implement safety practices (Starling *et al*., 2018). The BokSmart Programme aims to reduce neck and concussion injuries. However, head, neck and spine injuries still occur frequently, with potentially dire consequences, as noted in the articles mentioned above. By identifying modifiable risk factors for high-risk injuries, this study will assist in informing injury prevention strategies that would assist the BokSmart Programme in reducing moderate to severe injuries. At the high school level, where the game continues to grow, it becomes increasingly important to continuously improve safety protocols within the game of rugby for the sake of the developing athlete, whose potential career and future well-being may be at stake (Bathgate *et al*., 2002; Leahy *et al.,* 2020).

## PURPOSE OF THE RESEARCH

Epidemiological adolescent rugby injury data aid in identifying modifiable risk factors, as part of SARIISPP, to further enhance the effectiveness of the BokSmart rugby programme. With this study, we looked to add to the body of knowledge for epidemiological research and further identify modifiable risk factors (Van Mechelen's first stage), specifically impacting high school rugby players. Subsequently the research aimed to contribute to making rugby a safer sport for all adolescent rugby players. The South African studies discussed in the preceding paragraphs were done many years ago, and information on incidences for the nature, type, mechanism, anatomical location, etc., is not always provided. Additionally, most of the South African-based studies focused on tournament-based research, with limited information available on injury epidemiology over the period of a season. This study aimed to provide epidemiological information over a full season and in accordance with the latest rugby injury consensus statement, and also to be aligned with the International Olympic Committee (IOC) consensus statement (Fuller *et al*., 2007; Bahr *et al*., 2020). The information provided by the latest rugby injury consensus statement and the IOC consensus statement guided th e study, in that the definitions provided the framework for the study design, injury interpretation, incidence and proportion calculations, as well as the categorisation of injuries according to type, location, severity and mechanism. Consequently, the purpose of this study was to investigate the epidemiology of high school rugby injuries in the age group of 13–18 years in South Africa, with the specific aims of determining (1) the injury incidence over the period of a season, and (2) the common types of injuries, the severity of the injuries, the anatomical locations of the injuries, as well as to compare contact and non-contact injury mechanisms. The results are provided for (1) all injuries, (2) medical-attention injuries and (3) time-loss injuries.

## METHODOLOGY

### Study design

The study comprised a retrospective analysis of rugby injuries documented at a Pretoria-based high school, through the prospective cohort surveillance of 2905 player-hours during the 2019 calendar year.

### Setting

The school's medical facility has a six-bed medical room that is equipped with first aid and advanced life support resources, including a defibrillator and spine board; the facility was ready to treat and stabilise minor to severe sports injuries and medical conditions. When sporting events were hosted, the medical room was staffed by either a doctor, intermediate life support paramedic or physiotherapist, and they were supported by a basic life support team, with an ambulance on standby at the scene.

Injured athletes, whether experiencing a medical problem or sustaining an injury on the sports field, were taken to the medical room for assessment, stabilisation and treatment. Patient details, clinical information and consent were recorded on a patient treatment sheet. The data were then categorised and aligned with the rugby injury and IOC consensus statements (Fuller *et al.*, 2007; Bahr *et al.*, 2020). All injured players (when applicable) were contacted on day 1, day 3, day 5, day 7, day 14 and day 28 to determine the extent of the time-loss.

The match durations varied according to the age groups, with the under-14 and under-15 matches lasting 50 minutes, the under-16 matches lasting 60 minutes and the under-18 matches lasting 70 minutes. The halftime break was 5 minutes for all matches. This information is also reported in Table 1.

**Study population**

The above-mentioned facilities allowed for a conducive environment in which players could be assessed and for the relevant data to be collected. The players were from rugby teams from eight high schools around South Africa, with the players aged between 13 and 18 years.

**Participant selection**

As part of the triage process, all the players who required medical attention on match days were brought to the medical room by the field-side medical staff, where they were requested to complete the information sheet and questionnaire while awaiting treatment. In this manner the players who received treatment became part of the study cohort. The participants completed the questionnaire, giving assent if they agreed that the data collected may be used for research purposes. All participants were reassured that their identities would not be disclosed in any way and they were also given the opportunity to ask questions.

The inclusion criterion was rugby players between 13 and 18 years of age who sustained injuries during match days at the high school during the 2019 season.

**Data collection**

The primary investigator was granted access by the custodian of the data, Mrs Annemie Klopper (Sport Scientist at the high school), to investigate the data collected from the medical room. The data were collected via the injury questionnaire from injured players in the medical room during match days. Basic demographic and biometric data of the participant were collected on the information sheet. The biometric information included the age, weight and height of the participant. The size of the player based on body mass index (BMI) was also determined. BMI was presented as mean and standard deviation and categorised into the following groups <22, 22–25, 25–27 and >27. The age groups were categorised into under-14, under-15, under-16,and under-18 groups. The playing positions of the injured participants were simply classified into forward and backline players, as reporting per exact player position did not allow for large enough sample sizes for adequate statistical power.

**Injury classification**

The terms of reference for injury definitions and data collection procedures were adopted from the rugby injury consensus statement on rugby injuries endorsed by the Rugby Injury Consensus Group (Fuller *et al.*, 2007). Additionally, the IOC consensus statement has set out guidelines for standardising the parameters pertaining to epidemiological studies and to allow for consistent reporting of injuries. The statement defines an injury as “any physical complaint, which was caused by a transfer of energy that exceeded the body’s ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match, irrespective of the need for medical attention or time-loss from rugby activities” (Bahr *et al.*, 2020). Injuries can be further classified according to time-loss and medical attention, where injuries resulting in loss of participation from match play for more than one day are regarded as time-loss injuries. Injuries that result in the athlete receiving medical treatment are regarded as medical-attention injuries (Fuller *et al.*, 2007; Bahr *et al.*, 2020).

Injury severity was determined by the duration a player was unable to participate, which is the most commonly used measure and allows for easy data collection (Fuller *et al*., 2007; Bahr *et al*. 2020). This definition of severity emphasises the impact of time-loss on athletes; longer periods of loss of participation can potentially have a bigger impact on the athlete’s progress in the sport. Medical-attention injuries were distinguished from time-loss injuries by the extent of time lost from participation as injuries that resulted in 1 day or less of time-loss from participation. An injury was only regarded as a time-loss injury if more than 1 day of participation was lost, i.e., injuries that are classified as “slight”, are by definition regarded as medical-attention injuries. The severity of time-loss injuries was further classified, according to the duration of time lost, into the following categories: slight (0–1 days), i.e., medical-attention injuries, minimal (2–3 days), mild (4–7 days), moderate (8–28 days), severe (>28 days), career-ending injury and non-fatal catastrophic injuries (Fuller *et al*., 2007).

The injuries were differentiated by the locations of injury and categorised into the following groups, as per the IOC consensus statement: “head, neck and spine”, “trunk”, “upper limbs” and “lower limbs” (Bahr *et al.*, 2020). Injuries were categorised into the following types: “bones”, “joints, muscle and tendons”, “skin”, “brain, spinal cord and nerves” and “other” (internal organs and injuries without tissue type specified). We referred to the Orchard Sports Injury Classification System (OSICS-10 coding system) as detailed in the IOC consensus statement, in the determination of diagnoses (Fuller *et al.*, 2007; Bahr *et al.*, 2020).

As per the IOC guidelines the injury mechanisms were classified into contact and non -contact categories (Bahr *et al*., 2020). The rugby injury consensus statement further classifies mechanisms into “tackle”, “tackling”, “maul”, “ruck”, “lineout”, “scrum”, “collision” and “other”. In this study all the participants specified whether their injury was sustained during contact or non-contact; however, the exact phase of play during which the injury was sustained, was not consistently specified. The classification of the mechanism of injury was therefore limited to contact and non-contact categories, this at least allowed for the determination of whether the injury resulted from an impact or not.

**Ethical considerations**

Ethical clearance was obtained retrospectively from the University of Pretoria’s Faculty of Health Sciences Research Ethics Committee (Ethics Reference Number 672/2020). Consent for data collection was obtained through the schools, and the participants provided assent.

## Data analysis

Injury data from the players who played in rugby matches at the Pretoria-based high school during 2019 were captured and transferred to an Excel spreadsheet (Microsoft Office Excel for Windows, 2019), and aggregated data were analysed using SAS 9.4 (SAS Institute injuries Inc., Cary, NC, USA). The number of injuries reported was for the duration of the season, which included 98 matches. Injuries were classified according to total injuries, time-loss (>1 day of time-loss) and medical-attention injuries (≤1 day of time-loss). Data were available for the total number of match injuries, the number of injuries per severity category, the main anatomical body areas, the number of injuries per type of injury, the number of injuries per mechanism, injuries according to age group, injuries according to BMI category and the number of injuries for forwards and backline players. The frequencies, IP and injury incidence (with 95%CI) of injuries in the total sample, as well as for subgroups, were calculated. The denominator of incidence was calculated as number of matches × time of match (hrs) × 30 players (host and opposing team players) (as shown in Table 1). Incidence was calculated as the number of injuries per 1000 player-hours. The Poisson distribution with the PROC GENMOD statement and an associated log link option were used to determine the incidence and 95% CI. Frequency counts and percentages for all different injury characteristics and types are provided. If the injury count for a specific category was four or less, the incidence and 95%CI were not calculated. The incidence ratio was calculated if a specific incidence category was significantly higher than another category.

*Table 1.* **THE TOTAL PLAYER EXPOSURE-HOURS PER AGE GROUP**

| Age group | Minutes/match | Matches played | Hours played | Player-hours |
|---|---|---|---|---|
| **U-14** | 50 | 21 | 17.5 | 525 |
| **U-15** | 50 | 21 | 17.5 | 525 |
| **U-16** | 60 | 21 | 21 | 630 |
| **U-18** | 70 | 35 | 40.8 | 1225 |
| **Total** | – | 98 | 96.8 | 2905 |

## RESULTS

Over one year of monitoring there were 99 recorded injuries from a total of 98 matches. The ages of the injured participants ranged between 13 and 18 years, with a mean age of 15 .8±1.5 years. The injuries were distributed as follows amongst the age groups: 24 players in the under-14 group, 25 players in the under-15 group, 14 players in the under-16 group and 36 players in the under-18 group. The mean biometric data for weight, height and BMI were 78.8±10.8 kg, 176.8±6.3 cm and 25.2±2.6 kg/m$^2$, respectively (Table 2). The injuries were analysed for home and away teams, with an IP of 64.6% recorded by the home-based Pretoria high school team and an IP of 35.4% for the visiting teams.

*Table 2.* **NUMBER OF INJURIES ACCORDING TO BODY MASS INDEX PER AGE GROUP**

| BMI category | U-14 | U-15 | U-16 | U-18 | All groups |
|---|---|---|---|---|---|
| <22 | 2 | 0 | 2 | 0 | 4 |
| 22-25 | 12 | 21 | 7 | 28 | 68 |
| 25.1–27 | 1 | 4 | 5 | 8 | 18 |
| >27 | 2 | 1 | 1 | 5 | 9 |
| Mean BMI & SD | 24.1±2.3 | 24.7±1.9 | 25.2±2.9 | 25.8±2.9 | 25.2±2.6 |

BMI= Body mass index (kg/m$^2$) SD=Standard deviation.

Of the 99 injuries, 23 (23%) were classified as medical-attention injuries, whereas 76 (77%) were time-loss injuries. This translated to a total injury incidence of 34.1 injuries/1000 player-hours (95%CI 27.4–40.8), a medical-attention injury incidence of 7.9 injuries/1000 player-hours (95%CI 4.6–11.2) and a time-loss injury incidence of 26.2 injuries/1000 player-hours (95%CI 20.3–32).

Most of the injuries were of moderate severity (IP: 25.3%, n=25), followed by slight severity (IP: 23.2%, n=23), mild severity (IP: 21.2%, n=21), and then minimal severity (IP: 19.2%, n=19). Severe injuries had the lowest frequency of occurrence (IP: 11.1%, n=11 injuries), while no career-ending or life-threatening injuries were recorded.

The head, neck and spine were the most prevalent anatomical locations of injury (incidence: 13.1, 95%CI 8.9–17.2). This was followed by lower limb injuries (incidence: 10.3, 95%CI 6.6–14.0), whereas upper limb and trunk injuries were notably less frequent (Table 3). Most of the severe injuries occurred in the upper limbs (n=8; 73.0%) (Figure 1).

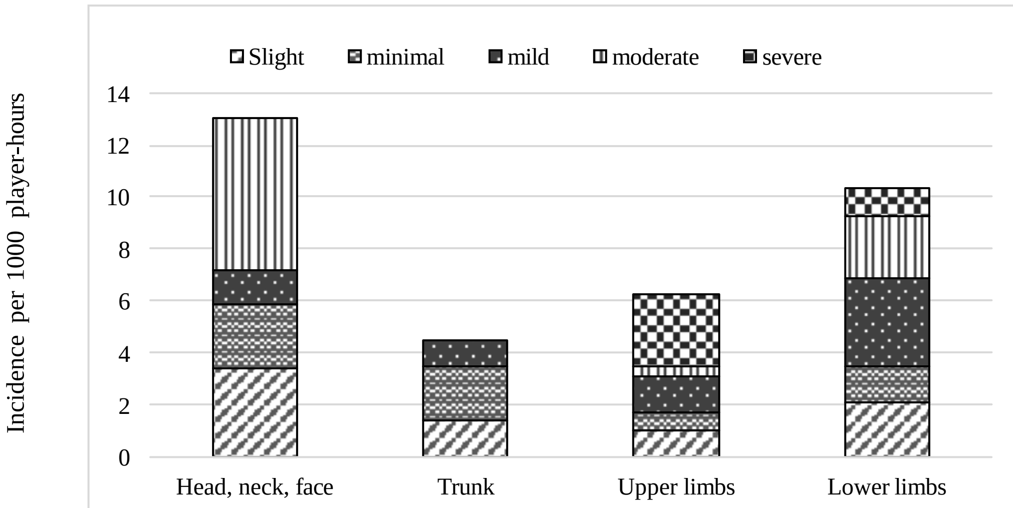
*Table 3.* **THE NUMBER, INJURY PROPORTION AND INCIDENCE FOR ALL, MEDICAL-ATTENTION AND TIME-LOSS INJURIES ACCORDING TO ANATOMICAL LOCATIONS AND INJURY TYPES**

| | *Anatomical locations* | | | |
|---|---|---|---|---|
| | **Head, neck and spine** | **Trunk** | **Upper limbs** | **Lower limbs** |
| | | **All injuries** | | |
| **N** | 38 | 13 | 18 | 30 |
| **IP** | 38.4 | 13.1 | 18.2 | 30.3 |
| **I** | 13.1* | 4.5 | 6.2 | 10.3 |
| **95%CI** | (8.9–17.2) | (2.0–6.9) | (3.3–9.1) | (6.6–14.0) |
| | | **Medical attention** | | |
| **N** | 10 | 4 | 3 | 6 |
| **IP** | 10.1 | 4 | 3 | 6.1 |
| **I** | 3.4 | – | – | 2.1 |
| **95%CI** | (1.3–5.6) | – | – | (0.4–3.7) |
| | | **Time-loss** | | |
| **N** | 28 | 9 | 15 | 24 |
| **IP** | 28.3 | 9.1 | 15.2 | 24.2 |
| **I** | 9.6 | 3.1 | 5.2 | 8.3 |
| **95%CI** | (6.1–13.2) | (1.1–5.1) | (2.6–7.8) | (4.9–11.6) |

| | *Injury types* | | | | | |
|---|---|---|---|---|---|---|
| | **Bone** | **Joints and ligaments** | **Muscle and tendons** | **Skin** | **BSN** | **Other** |
| | | | **All injuries** | | | |
| **N** | 22 | 28 | 26 | 3 | 19 | 1 |
| **IP** | 22.2 | 28.3 | 26.3 | 3 | 19.2 | 1 |
| **I** | 7.6 | 9.6 | 9.0 | – | 6.5 | – |
| **95%CI** | (4.4–10.7) | (6.1–13.2) | (5.5–12.4) | – | (3.6–9.5) | – |
| | | | **Medical-attention** | | | |
| **N** | 4 | 7 | 8 | 3 | 0 | 1 |
| **IP** | 4 | 7.1 | 8.1 | 3 | 0 | 1 |
| **I** | 1.4 | 2.4 | 2.8 | – | – | – |
| **95%CI** | (0.03–2.7) | (0.6–4.2) | (0.9–4.7) | – | – | – |
| | | | **Time-loss** | | | |
| **N** | 18 | 21 | 18 | 0 | 19 | 0 |
| **IP** | 18.2 | 21.2 | 18.2 | 0 | 19.2 | 0 |
| **I** | 6.2 | 7.2 | 6.2 | – | 6.54 | – |
| **95%CI** | (3.3–9.1) | (4.1–10.3) | (3.3–9.1) | – | (3.6–9.5) | – |

N=Number IP=Injury proportion I=Incidence per 1000 player-hours CI=Confidence interval
BSN=Brain, spinal cord and nerves.
*Significantly higher than trunk and upper limbs.

Figure 1 shows the proportion of injury severity in relation to the incidence of the anatomical location. Notably, 67.8% (n=17) of the moderate injuries involved the head, neck and spine, making up the largest proportion of injuries within a severity for an injury location. The majority of mild injuries were associated with the lower limbs (47.0%, n=10). It was also found that the players within the BMI category of 22 to 25 sustained most of the severe injuries (73.0%, n=8) (Table 4).




MA=Medical-attention injury

*Figure 1*. **THE PROPORTION OF INJURY SEVERITY IN RELATION TO THE INCIDENCE, ACCORDING TO ANATOMICAL LOCATION**

Injuries to joints and ligaments were most frequent (IP: 28%, n=28) and prevalent (incidence: 9.6, 95%CI 6.1–13.2), and 75.0% (n=21) of these injuries were severe enough to require time-loss from participation. Muscle and tendon injuries were the second most common (IP: 26%, incidence: 9.0, 95%CI 5.5–12.4), but with a majority of time-loss injuries (69.0%). All brain, spinal cord and nerve injuries were time-loss injuries (incidence: 6.5, 95%CI 3.6–9.5) (Table 3).

The documented mechanism of injury was reported as being related to contact in 71.0% of the injuries (incidence: 24.1, 95%CI 18.5–29.7), as compared with non-contact mechanisms (incidence: 9.9, 95%CI 6.3–13.6), with 2.4 times higher incidence ratio for contact injuries.

The under-15 age group had the highest incidence of injuries (incidence: 49.5, 95%CI 30.5–68.6); however, this finding was not significant when compared with any other age category (Table 4).

*Table 4.* **THE NUMBER, INJURY PROPORTION AND INCIDENCE FOR ALL, MEDICAL-ATTENTION AND TIME-LOSS INJURIES ACCORDING TO AGE GROUP AND BODY MASS INDEX CATEGORY**

| | | ***Age groups*** | | |
|---|---|---|---|---|
| | **U-14** | **U-15** | **U-16** | **U-18** |
| | | **All injuries** | | |
| **N** | 17 | 26 | 15 | 41 |
| **IP** | 17.2 | 26.3 | 15.2 | 41.4 |
| **I** | 32.4 | 49.5 | 23.8 | 33.5 |
| **95%CI** | (17.0–47.8) | (30.5–68.6) | (11.8–35.9) | (23.2–43.7) |
| | | **Medical-attention** | | |
| **N** | 3 | 5 | 6 | 9 |
| **IP** | 3 | 5 | 6.1 | 9.1 |
| **I** | - | 9.6 | 9.5 | 7.4 |
| **95%CI** | - | (1.2–17.9) | (1.9–17.1) | (2.6–12.2) |
| | | **Time-loss** | | |
| **N** | 14 | 21 | 9 | 32 |
| **IP** | 14.1 | 21.2 | 9.1 | 32.3 |
| **I** | 26.7 | 40.0 | 14.3 | 26.1 |
| **95%CI** | (12.7–40.6) | (22.9–57.1) | (4.9–23.6) | (17.1–35.2) |

| | | ***Body mass index*** | | |
|---|---|---|---|---|
| | | **All injuries** | | |
| | *BMI < 22* | *BMI 22–25* | *BMI 25.1–27* | *BMI >27* |
| **N** | 3 | 58 | 26 | 12 |
| **IP** | 3 | 58.6 | 26.3 | 12.1 |
| **I** | – | 19.9* | 8.9 | 4.1 |
| **95%CI** | – | (14.8–25.1) | (5.5–12.4) | (1.8–6.5) |
| | | **Medical-attention** | | |
| **N** | 0 | 12 | 8 | 3 |
| **IP** | 0 | 12.1 | 8.1 | 3 |
| **I** | – | 4.1 | 2.8 | – |
| **95%CI** | – | (1.8–6.5) | (0.9–4.7) | – |
| | | **Time-loss** | | |
| **N** | 3 | 46 | 18 | 9 |
| **IP** | 3 | 46.5 | 18.2 | 9.1 |
| **I** | – | 15.8* | 6.2 | 3.1 |
| **95%CI** | – | (11.3–20.4) | (3.3–9.1) | (1.1–5.1) |

N=Number IP=Injury proportion I=Incidence per 1000 player-hours CI=Confidence interval
BMI=Body mass index ($kg/m^2$).
*Significantly greater than the 25–27 and the >27 BMI category.

Injuries associated with the BMI category of 22–25 had a notably higher incidence (incidence: 20.0, 95%CI 14.8–25.1) than the other BMI categories (Table 4).

IP and injury incidence according to playing positions were equivocal, with the forwards accounting for 46.5% (incidence: 15.8, 95%CI 11.3–20.4) of the injuries, while 53.5% (incidence: 18.2, 95%CI 13.3–23.2) of the injuries were amongst the backline players (Table 5).

Injuries according to anatomical location and severity were similar between forwards and backline players (Table 5).

*Table 5.* **THE NUMBER AND INCIDENCE OF INJURIES FOR ANATOMICAL LOCATION AND SEVERITY, ACCORDING TO PLAYING POSITION**

| | Forwards | Backline |
|---|---|---|
| **N** | 46 | 53 |
| **IP** | 46.5 | 53.5 |
| **I** | 15.8 | 18.2 |
| **95%CI** | (11.3–20.4) | (13.3–23.2) |
| | **Anatomical locations, n (%)** | |
| **Head, neck and face** | 17 (37.0) | 21 (40.0) |
| **Torso** | 6 (13.0) | 7 (13.0) |
| **Upper limbs** | 10 (22.0) | 8 (15.0) |
| **Lower libs** | 13 (28.0) | 17 (32.0) |
| | **Injury severity, n (%)** | |
| **Slight/MA** | 9 (20.0) | 14 (26.0) |
| **Minimal** | 9 (20.0) | 10 (19.0) |
| **Mild** | 12 (26.0) | 9 (17.0) |
| **Moderate** | 10 (21.0) | 15 (28.0) |
| **Severe** | 6 (13.0) | 5 (10.0) |

N=Number IP=Injury proportion
I=Incidence per 1000 player-hours CI=Confidence interval.

## DISCUSSION

Over the 1-year period 99 injuries were recorded, with an overall injury incidence of 34.1 injuries/1000 player-hours, which consisted of a time-loss incidence of 26.2/1000 player-hours, and a medical-attention incidence of 7.9 injuries/1000 player-hours. The overall injury incidence is slightly higher than was found in other international studies. The systematic review by Freitag *et al*. (2015) on high school rugby union injuries in the age group of 14 to 18 years reported an overall incidence of 26.7 injuries/1000 player-hours from five studies; this review was inclusive of season-based, as well as tournament-based, studies and the injury incidence was not differentiated into medical attention and time-loss. Additionally, the Rugby Injury Surveillance in Ulster Schools study conducted on 28 Ulster schools over one season, involving players of the senior squad only, determined a total incidence of 29.1 injuries/1000 player-hours; however, there was no distinction between time-loss and medical-attention incidence rates (Archbold *et al*., 2017). Our findings, therefore, suggest a slightly higher total injury incidence at this South African high school; however, the comparative studies are older, and injury surveillance and player education has become more rigorous in recent years, which may result in more sensitive detection of rugby injuries and more awareness from the players themselves. With reference to the local context, a study conducted 8 years ago on South African provincial youth week rugby tournaments reported a mean incidence of 33.1 injuries/1000 exposure-hours over two seasons (Burger *et al*., 2014). The South African high school rugby population may have higher injury incidences; however, more comparative data according to international injury surveillance standards over a season are required to investigate this claim further.

In this study, the incidence of injuries requiring medical attention was 7.9 per 1000 player-hours (95%CI 4.6–11.2). This is significantly lower than the injury incidence found in a previous systematic review by Bleakely *et al.* (2011), which looked at rugby union players aged 12–18 years and found injury incidences ranging from 28 to 130 per 1000 player-hours. The disparity may be a matter of the definition that was applied. This study defined medical-attention injuries as any injury that received medical treatment, with a time-loss of less than 1 day, as per the rugby injury consensus guidelines (Fuller *et al.*, 2007), whereas the definition of medical attention in the studies reviewed by Bleakely *et al*. (2011) varied, from any injury during practice or match play to injuries necessitating on-field treatment or removal from gameplay, up to a broad definition of any physical complaints during participation. These varying definitions within the studies that were reviewed may explain the broad range of the medical-attention incidence that was determined. However, the medical-attention incidence in the current study remains much lower than the range provided in the systematic review, and additional consideration should be made for the fact that not all the injuries that were sustained were reported to the medical staff. By strict definition superficial injuries such as abrasions may have been overlooked, as the players would not have sought medical attention for them. These superficial injuries may not have been recorded and would in most cases not have impacted on the athlete’s ability to participate. The disparities in incidence between these studies underscores the importance of applying consistent injury definitions across all rugby research methodology, as per the IOC and rugby injury consensus guidelines.

The time-loss incidence in this study (26.2 injuries/1000 player-hours) was higher than in the systematic review by Bleakley *et al.* (2011), where the time-loss incidence ranged between 12 and 22 injuries/1000 player-hours. The definitions of time-loss injury were similar, where injuries that resulted in more than 1 day loss of participation were considered as time-loss, as per the IOC consensus statement. This may further suggest an increasing trend of injury risk in South African rugby, or it may be due to more consistent injury surveillance and reporting, compared with studies that were conducted more than 10 years ago.

When evaluating the severity of the injuries, it is evident that the predominant number of injuries carried an implication of time-loss, as 25.3% were of moderate severity, 21.2% were of mild severity and 11.1% were severe. The implication of injury for adolescent rugby players extends to the economic cost of medical treatment, estimated at US$731 per injured player (Brown *et al*., 2015; Sewry *et al*., 2017). The fact that no career-ending or catastrophic injuries were recorded speaks to the impact of initiatives such as the Bok Smart rugby programme on safety in the sport. Freitag *et al.* (2015) confirms the notable risk of moderate injuries, indicating moderate severity as the most frequent injury severity (21 .0%–68.0%, determined from seven studies). Archbold *et al.* (2017), however, reported severe injuries as being the most frequent (49.0%) in Ulster schools, which was followed by moderate injuries (41.0%). Most of the severe injuries recorded in their study were related to concussions (16.0%), sprains and dislocations (11.0%) and fractures (5.0%).

The head, neck and spine injuries (IP: 38%), as well as the lower limb injuries (IP: 30%), were the most prevalent, constituting the bulk of all injuries. Moreover, the incidence of head, neck and spine injuries was notably more than that of the trunk and upper limbs (Table 4). A similar anatomical injury location pattern was reported in a five-day Johannesburg-based high school rugby festival, in which head and neck injuries were found to be the most frequent injury (42.0%), followed by lower limb injuries (29.0%) (Constantinou & Bentley, 2015). Furthermore, McManus and Cross (2004) also reported higher frequencies for lower limbs (37.0%, n=28) and the head and neck (30.0%, n=24) in elite junior rugby union in Western Australia. Interestingly, Barden and Stokes (2018) reported lower limb injuries to be the most common in non-elite matches, while head, neck and spine, as well as upper limb injuries, were more frequent in the elite schoolboy rugby union matches in Bristol, England. These findings suggest that the head and neck are at the most risk of injury, with a considerable risk for lower limb injuries.

Joint and ligament injuries were the most prevalent type of injury with the highest incidence (incidence: 9.6, 95%CI 6.1–13.2), followed by muscle and tendon injuries (incidence: 9.0, 95%CI 5.5–12.4). These two categories were the most common (54.0% of all injuries). The Rugby Injury Surveillance in Ulster Schools study similarly found ligament sprains to be the most frequent injury at 31.2%, with muscle injuries being the second most frequent at 15 .0%. No incidences were provided by this study (Archbold *et al*., 2017). Additionally, the Johannesburg high-school-based study that was conducted during a 5-day annual tournament over 2 years also found ligament sprains to be most frequent (24.0%), followed by contusions (13.0%) and muscle injuries (14.0%) (Constantinou & Bentley, 2015). These findings suggest a notable risk of injury to ligaments and joints, and to muscles and tendons, which appear to be the most common types of injury. This may be a result of the contact-based nature of rugby. In contrast to the above findings, Barden and Stokes (2018) determined central and peripheral nervous system injuries to be the most prevalent injury type (24 injuries/1000 player-hours) in elite high school rugby. This was due to the high rate of concussions at this level which constituted 80.0% (n=12) of the injuries in this category. This study reported a high prevalence of concussions, which may be due to a greater awareness of concussion and a more sensitive threshold for diagnosing concussion, as recommended by the Rugby Football Union.

The current study reported that contact-related injury mechanisms were more frequent (71.0%) with an incidence of 24.1 injuries/1000 player-hours. Barden and Stokes (2018), whose research was conducted on elite schoolboy rugby over 3 years, showed an incidence of 56 injuries/1000 player-hours for contact mechanisms, of which tackling and being tackled comprised 75.0% of all cases. Furthermore, Lee and Garraway (1996) compared the injury mechanisms between school level and senior club level rugby and found the tackle mechanism to have contributed the highest proportion of injuries in both groups. However, the frequency was higher at school level (64.0%), compared with senior club rugby (49.0%). This may have been due to poorer tackling technique amongst the school-level athletes, compared to better-trained senior athletes.

There was no noteworthy difference between the incidence of the four age group categories. Leung *et al.* (2017) found a higher incidence in the under-18 age group in Australian school-level rugby union over a 10-week season, with the open teams (under-18 age group) recording an incidence of 56.2 injuries/1000 player-hours (95%CI 37.5–81.1). Additionally, the systematic review by Bleakely *et al.* (2011) revealed a similar finding for all six studies reviewed, with a higher incidence in the older under-17 to under-19 age groups ranging between 7.7 and 65.8 injuries/1000 player-hours. The trend of higher incidence in the older age groups could be explained by a higher level of intensity and strength amongst these athletes, with an increased impact of collisions. It is also possible that the older players play additional matches for clubs in open teams, where they are exposed to senior players. This may predispose them to overuse injuries and increased injury exposure, which may not be recorded within the setting of a study on the high school population. However, these findings are merely speculation and must be corroborated in future studies.

Players in the BMI category of 22–25 had an injury incidence of 20.0 (95%CI 14.8–25.1); this was notably higher than the other BMI categories. Additionally the players in this BMI category sustained most of the severe injuries (73.0%, n=8). The Rugby Injury Surveillance in Ulster Schools study investigated player size as a risk factor for injury and determined that players of smaller body mass were less likely to be injured; however, no absolute incidence rates were given to support this finding (Archbold *et al*., 2017). A mismatch in player sizes is an important factor to consider in assessing the risks of injury, particularly in the high school population, where players of different sizes may fall within the same age categories. It is recommended that further research is conducted on age categories as a univariate risk factor for injuries by adjusting for the confounding influence of BMI.

There was no statistically significant difference between the incidence of injuries for forward and backline players with the severity and anatomical location showing similar IP distribution. The systematic review by Freitag *et al.* (2015) found no notable difference in injury frequency between forward and backline players, with proportions ranging between 44.0% and 56.0%, and 46.0% and 56.0%, respectively. The results were collated from 13 studies on high school rugby injuries. Additionally, Barden and Stokes (2018) found no notable difference in incidence between forward and backline players for elite high school matches (incidence: 73 injuries/1000 player-hours for forwards and 83 injuries/1000 player-hours for the backline), and non-elite matches (Incidence: 38 vs. 29 per 1000 player-hours). Position-specific injury rates are poorly documented in high school rugby injury epidemiology. However, Leahy *et al.* (2022) determined that locks (position 4 and 5) sustained the most injuries (15 .0%, incidence: 8 per 1000 player-hours), followed by blindside flankers (position 6) (13 .0%, incidence: 6.7 per 1000 player-hours), over two seasons of high school rugby in Ireland, involving 15 teams. Additionally, McManus and Cross (2004) found that flankers sustained the most injuries (12.0%, n=10), followed by eighthmen (7.0%, n=6) and wingers (7.0%, n=6) over a 26-week high school rugby championship in Western Australia. These findings were, however, for a tournament held in 1997, and the dynamics for position-specific injury risk may have changed with the current growth in competitiveness of the youth game.

## RECOMMENDATIONS

The findings on the nature of injuries were largely consistent with current local and international research on high school rugby, with the head, neck and spine remaining at a notable risk of injury, despite the interventions of rugby injury prevention programmes such as BokSmart. It is recommended that injury prevention programmes further enforce safety guidelines for the protection of the head, neck and spine amongst school athletes. Measures such as mandatory protective headgear and amending of the legal tackle regulations should be considered; however, specific research is required to investigate the efficacy of these measures in alleviating the frequency of head, neck and spine injuries. A limitation in this study was the lack of detailed data on injury mechanisms, with injuries simply being classified as contact and non-contact injuries. It is advisable that future research is conducted that focuses on adolescent rugby injuries conducted over an entire season, to study the specific injury mechanisms in association with the specific phases of play, as this may reveal more information on high-risk phases. Another limitation was in the triage process, which did not specifically differentiate between home and away teams in presenting injured athletes to the medical room. Players from the home team may have been more prone to reporting injuries to the medical room, as they would have been more familiar with the environment and processes, whereas the players from the away teams may have been reluctant to report due to unfamiliar surroundings and uncertainty regarding the processes. This potential reporting bias may have contributed to the much higher IP amongst the home-based players. An additional limitation was in the underreporting of superficial injuries that may not have received medical attention or resulted in time-loss. This underreporting may have underplayed the injury incidences. However, it is likely that these injuries were of little consequence and did not impact on the safety of the athletes; their inclusion would overestimate the true risk of medical-attention injuries. This is a limitation that is shared by many other studies on rugby injury surveillance, as medical - attention and time-loss injury definitions do not have evidence of unreported injuries (Collins *et al*., 2008; Archbold *et al*., 2017; Leung *et al.*, 2017).

## CONCLUSION

This retrospective analysis of 2905 player-hours reported the epidemiology and incidences (medical-attention and time-loss) according to IOC recommendations for adolescent rugby union players, over a 1-year period. The overall incidence of total injuries (34.1 injuries/1000 player-hours, 95%CI 27.4–40.8) was larger than other international studies but similar to a South African study. This was also the case for time-loss injuries. The findings on the nature and type of injuries were largely consistent with current local and international research on high school rugby, with head, neck and spine injuries being the most prevalent anatomical injury, while ligament and joint injuries were the most prevalent injury types. There was no notable difference in injury incidence between age groups and playing positions. We further recommend that more research is conducted on the impact of the BokSmart National Rugby Safety Programme on the risk of injury in the various phases of play in high school rugby union, with a specific focus on head, neck and spine injuries.

### Conflict of interest

The authors declare no conflict of interest.

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