# Application of the Subsequent Injury Categorisation (SIC) model for longitudinal injury surveillance in elite rugby and cricket: Inter-sport comparisons and inter-rater reliability of coding


Isabel S. Moore[1]

Stephen Mount[2]

Prabhat Mathema[3]

Craig Ranson[1,3]

**Affiliations**

[1]Cardiff School of Sport, Cardiff Metropolitan University, UK

[2]Sri Lanka Cricket, Sri Lanka

[3]Welsh Rugby Union, UK

Corresponding author: Isabel S. Moore

Email: imoore@cardiffmet.ac.uk

Address: Cardiff School of Sport, Cardiff Metropolitan University, Cyncoed Campus, Cardiff, CF23 6XD UK

Tel: +44 (0)2920 416342

## Abstract

**Background:** When an athlete has more than one injury over a time period it is important to determine if these are related to each other or not. The subsequent injury categorisation (SIC) model is a method designed to consider the relationship between an index injury and subsequent injury(ies).

**Objective:** The primary aim was to apply SIC to longitudinal injury data from two team sports: rugby union and cricket. The secondary aim was to determine SIC inter-rater reliability.

**Methods:** Rugby union (time-loss; TL) and cricket (TL and non time-loss; NTL) injuries sustained between 2011-2014 within one international team respectively, were recorded using international consensus methods. SIC was applied by multiple raters; team clinicians, non-team clinicians, and a sports scientist. Weighted kappa and Cohen's kappa scores were calculated for inter-rater reliability of the rugby union TL injuries and cricket NTL and TL injuries.

**Results:** 67% and 51% of the subsequent injuries in rugby union and cricket respectively were categorised as injuries to a different body part not related to an index injury (SIC code 10). At least moderate agreement (weighted and Cohen kappa ≥ 0.60) was observed for team clinicians and the non-team clinician for both sports. Including NTL and TL injuries increased agreement between team clinician and non-team clinician, but not between clinician and sport scientist.

**Conclusion:** The most common subsequent injury in both sports was an injury to a different body part that was not related to an index injury. The SIC model was generally reliable, with the highest agreement between clinicians working within the same team. Recommendations for future use of SIC are provided based on the proximity of the rater to the team and the raters' level of clinical knowledge.

**Key words:** Reliability, rugby, cricket

## Introduction

Sports injury epidemiology is used to quantify the injury risk within a sport, with injury rates varying according to the type of sport. International rugby union has a high time-loss (TL) injury incidence, reported to be between 90 and 200 injuries per 1000 match hours [1, 2]. Prevalent injuries in international rugby union include concussion and traumatic shoulder injury [2]. On the other hand, international cricket has a relatively low time-loss injury incidence (approximately 5 injuries per 1000 match hours [3]), but high non time-loss (NTL) injury incidence, with approximately two-thirds of injuries reported not involving time-loss [4]. In international cricket, priority injuries include ankle sprains and overuse lower back injuries [4]. Given the variation in injury rates, types and surveillance methods, longitudinal injury occurrence patterns across the two team sports may differ, but have not been investigated.

Injury surveillance programmes often only capture injuries sustained over one season, year or tournament [5-17]. However, longitudinal injury surveillance has clear advantages and is an important element in sports medicine and sports injury prevention [2, 4, 18]. Further, the consensus methods for injury surveillance in sports such as rugby union, cricket and soccer currently only recommend one data collection category that denotes whether an index injury relates to a previous injury ('recurrence') [19-22]. The definition or a recurrent injury is: "An injury of the same type and at the same body site as an index injury". However, the 2014 injury surveillance consensus for athletics [23] highlighted the need to record recurrent injuries and categorise subsequent injuries using an appropriate model [23].

The recently developed Subsequent Injury Categorisation (SIC) model allows injuries sustained by an athlete to be categorised as; a recurrence, exacerbation or new injury (Table 1) [24]. SIC may provide researchers with an additional tool to help understand potential links between injuries within and between body regions. However, there has been only limited and small scale application of SIC within longitudinal injury surveillance [4, 18, 24, 25]. One potential reason is that the inter-rater reliability of SIC has not yet been reported. Factors that could potentially influence the inter-rater reliability include the type of injuries sustained, the level of injury risk within a sport, the proximity of the rater to the team and the raters' level of clinical knowledge. Consequently, assessing the inter-rater reliability within sports, such as rugby union and cricket that have different injury risk, surveillance methods, and types of injuries, is warranted. Further, if SIC can be reliabily assigned by clinicians with and without direct clinical knowledge, SIC might be retrospectively applied to existing injury surveillance databases. Additionally, injury epidemiology projects undertaken outside of the elite and/or professional setting often rely on surveillance by non-clinical personnel [24, 26]. Therefore, it is necessary to assess the inter-rater reliability between clinicians and non-clinical personnel.

We aimed to utilise SIC to longitudinally assess injury patterns within an international 1) rugby union and 2) cricket team. Additionally, the second aim in our rugby union study was to examine the inter-rater reliability of SIC for time-loss injuries. The second aim for our cricket study was to examine the inter-rater reliability of SIC for time-loss and non time-loss injuries.

## Study one: Time-loss injuries in international rugby union

### *Methods*

Three-year prospective injury surveillance of one international men's rugby union team was conducted from July 1st 2011 until June 30th 2014. All definitions and procedures used were compliant with the international consensus for injury surveillance in rugby union [20]. All TL injuries were recorded by a designated team physiotherapist (PM) using Orchard Sports Injury Classification System (OSICS; version 10.1). Along with OSICS, the other diagnositic information available for all injuries were: mode of onset, activity at time of injury, number of days-lost and, surgery and other procedures. Each player selected for the team provided informed consent and ethical approval was obtained from Cardiff Metropolitan University's School of Sport Ethics Committee.

Injuries were recorded for international team players across both international and professional club rugby to allow continuous surveillance over the entire three-year study period. All injuries for each player were chronologically ordered before the SIC model was applied. Two raters (CR and IM) discussed the use of the SIC model with one of the original developers (C. Finch), before one of the researchers (CR) piloted its use prior to instructing the other raters (SM and PM). Each rater was blinded to the others' catergorisation.

Two members of the international team's medical staff (PM and CR), both having direct clinical knowledge of the included players' injury history, applied SIC to all injuries. Following the independent blind categorisation, any discrepencies were discussed and a consensus code was agreed. The data were then anonymised prior to SIC being undertaken by two further raters**,** an international cricket physiotherapist (SM) and a non-clinical sports scientist (IM), neither of whom had any direct knowledge of the players' injury histories.

### *Statistical analysis*

Cohen's kappa statistic was used to measure the level of agreement between raters, whilst a weighted kappa was used to allow marginal agreement between raters to be credited [27]. To calculate the weighted kappa statistic a weighting matrix was created based on the subsequent injury type by body area and nature (overarching SIC category) (Table 2). Raw agreement proportion scores (95% CI) were computed for the number of indices recorded by each rater. The reliability of SIC between the following raters was assessed:

a) Two clinicians working with the team
b) One clinician working with the team and one clinician not working with the team
c) One clinician working with the team and the sport scientist
d) One clinician not working with the team and the sport scientist

The level of agreement for the weighted kappa statistics were based on recommendations for health-related studies [28] as; none, 0.0 – 0.20; minimal, 0.21 – 0.39; weak, 0.40 – 0.59; moderate, 0.60 – 0.79; strong, 0.80 – 0.90; and almost perfect, > 0.90. Descriptive statistics (%) of the SIC were calculated from the consensus codes provided by the two clinicians working with the team. The first injury sustained by an athlete during the surveillance period was referred to as the 'initial' injury. Therefore, every injured player has one initial injury. Index injuries referred to either SIC code 10 injuries or initial injuries, meaning every injured player could have multiple index injuries.

### *Results*

There were 648 TL injuries sustained by 74 players, meaning 11% of the injuries were initial injuries. Based on the consensus category, the majority of the injuries were SIC code 10 (59%), which represents 67% of subsequent injuries (Figure 1). A further 21% of the subsequent injuries were categorised as recurrences or exacerbations of the 'exact same injury' (SIC codes 2, 3 or 4), but none were categorised as SIC code 5 or 6. Index injuries accounted for 71% of the injuries and there was a mean of 2.6 subsequent injuries per injured player. For any single player; the highest number of index injuries was 14, and the greatest number of injuries during the three-year period was 24.

The two team clinicians had strong SIC agreement (Table 3). When compared to the team clinician SIC consensus, the clinician not with the team and the sport scientist had moderate agreement. The agreement between the clinician not with the team and the sport scientist was minimal to weak, due to a large difference in the Weighted and Cohen kappa scores. The raw agreement was greatest between the team clinicians, and lowest when comparing; the team clinician to the clinician not with the team, and to the sport scientist.

## Study two: Time-loss and non time-loss injuries in cricket

### *Methods*

Prospective injury surveillance of players selected for one international men's cricket team was conducted over the same three-year period as the rugby union injuries. All definitions and procedures used were compliant with the updated international consensus methods for injury surveillance in cricket [22]. TL and NTL injuries were recorded by one designated team physiotherapist (SM) using OSICS (version 10.1). Along with OSICS, the other diagnositic information available for all injuries were: mode of onset, activity at time of injury, number of days-lost and, surgery and other procedures. Each player selected for the team during the three-year period provided informed consent and ethical approval was obtained from Cardiff Metropolitan University's School of Sport Ethics Committee.

Injuries recorded when playing international cricket allowed players to be tracked for the majority of each year. At the end of the three-year period all injuries for each player were chronologically ordered and sent to each rater for SIC. The data were anonymised before being categorised by two further raters; an international rugby union physiotherapist (CR) and a non-clinical sport scientist (IM).

### *Statistical analysis*

The same statistical procedures used in study one were used to determine the inter-rater SIC reliability of; all injuries, TL only, and NTL only injuries between the following raters:

a) The team clinician and one clinician not working with the team

b) The team clinician and the sport scientist

c) One clinician not working with the team and the sport scientist

Descriptive statistics (%) were calculated from the SIC determined by the team clinician.

### *Results*

There were 286 cricket injuries (NTL 66%, n =190; TL 34%, n=96) sustained by 39 players, meaning 14% of the injuries were initial injuries (30 NTL and 9 TL). Based on the team clinician, 51% of the injuries were SIC code 10, which represents 60% (NTL 39%; TL 21%) of the subsequent injuries (Figure 2). A further 15% (NTL 7%; TL 8%) of the subsequent injuries were categorised as 'same body site, different nature' (SIC codes 7 or 8) and 14% (NTL 9%; TL 5%) as a recurrence or exacerbation of the 'exact same injury' (SIC codes 2, 3, 4 or 6), but none were categorised as SIC code 5. The highest proportion of NTL injuries per SIC code was observed for SIC code 4 (88%) and 9 (72%) (Figure 3). The highest proportion of TL injuries per SIC code was observed for SIC code 2 (54%). Index injuries accounted for 65% of the injuries and a mean of 1.4 subsequent injuries per injured athlete. For any single player, the highest number of index injuries was seventeen and the most number of injuries sustained was 33 (28 NTL and 5 TL).

When compared to the team clinician, the clinician not with the team had moderate agreement for NTL and TL injuries and strong agreement for all injuries combined (Table 4). In comparison, the sport scientist and the team clinician had moderate agreement using the weighted kappa for all injuries combined, and separately for NTL and TL injuries. However, only moderate agreement was achieved for NTL injuries using the Cohen's kappa. The clinician not with the team and the sport scientist had moderate agreement for TL injuries and all injuries, but minimal agreement for NTL injuries. There was also a large difference in the weighted and Cohen's kappa scores for NTL injuries.

## DISCUSSION

This is the first study to explore whether sports of a different nature, with different surveillance methods and injury risks, have different subsequent injury patterns and inter-rater reliability for coding the sports injury characterisation (SIC) model.

### *Inter-sport comparisons of injury categorisation*

A similar proportion of the injuries were considered initial injuries in both sports. The most common injury category in both sports was SIC code 10, which is an injury to a different body part that is not related to an index injury. A high proportion of players in both sports sustained multiple injuries during the three-year period, but rugby union had, on average, more subsequent injuries per injured player than cricket. The current study's findings are similar to previous work in rugby union, showing players typically sustain multiple injuries within a few years [2]. However, data from the Rugby World Cup (2007, 2011) report a much smaller proportion of injuries being classified as recurrent ('exact same injury') than was observed in the current data (6 and 14 vs. 21% respectively) [5, 6]. Additionally, a three-year prospective rugby union study found 18% of the injuries to be recurrences [1]. Therefore based on these collective findings, it can be argued that approximately one fifth of injuries within rugby union are likely to be recurrent injuries, but data from relatively short periods and multiple teams, such as a tournament, may be affected by incomplete knowledge of player injury histories and sub-optimal player and clinician reporting behaviour.

Nearly one-third (29%) of the subsequent injuries occurred to the same body region in the cricket dataset. However, similar to the rugby union injuries, no injury was categorised as SIC code 5. Contrastingly, SIC code 5 has been assigned when categorising Australian football injuries, but only to a small percentage of subsequent injuries [24, 25]. The precise definition of SIC code 5 may limit its application and make it difficult for raters to assign it to injuries. It is defined as 'experiencing continual or sporadic pain that is the exact same injury in terms of body site and nature, but unrelated to the index injury' [24]. Future work could identify specific examples of appropriate application of this code to inform SIC model users.

Collectively, this analysis highlights that a systematic analysis of injury inter-relationships is warranted in team sports, as determing injury types likely to occur subsequent to an index injury could inform injury prevention strategy. For example, a greater proportion of subsequent rugby union injuries were the 'exact same injury' and a smaller proportion were 'same body site, different nature' compared to cricket injuries. Therefore, rugby union injury prevention strategies might best target risk factors associated with exact injury recurrences, whereas in cricket targeting the injured body area may be more effective.

### *Inter-rater reliability of injury categorisation*

At least moderate agreement was observed for team clinicians and clinicians not with the team for both sports. The sport scientist had stronger agreement with the team clinician in rugby union than in cricket. The inclusion of NTL injuries appeared to affect the level of agreement in that there was a better agreement between clinicians, but lower agreement between non-team clinician and sport scientist.

Using the weighted kappa for rugby union injuries strengthened the agreement between the team clinician and the sport scientist compared to Cohen's kappa. This means that categorisation assigned by the sport scientist was similar, but not exactly the same as the clinician. Therefore, injury epidemiology studies using the SIC model, and categorisers with limited clinical knowledge are recommended to group data using the overarching categorisation, rather than the specific numerical categories

The inclusion of NTL injuries appeared to negatively affect the reliability, particularly when an individual with limited clinical knowledge (the sport scientist) was compared to a non-team clinician. There was a high proportion of NTL injuries in cricket, especially for 'different body part, related' (SIC code 9) and 'exact same injury, related continual or sporadic pain' (SIC code 4). This appears to have contributed to lower levels of agreement, as the non-team clinican and sport scientist had the greatest differences for these SIC codes (Figure 2). Conversley, the inclusion of NTL injuries and TL injuries produced a greater level of agreement between clinicians, than when only TL injuries were considered. This appears to be mainly affected by SIC code 4 and highlights how clinicains and non-clinicians use the SIC model differently. SIC code 4 implies an athlete has not fully recovered from an injury even though they have returned to sport. Clinicians may be more aware that ongoing management for such injuries is often required and hence, applied SIC code 4 to a new injury entry rather than SIC code 2, which was used by the non-clinician in most instances. This does highlight an interesting finding, which supports recent recommendations by Clarsen and colleagues [29], as it suggests that for those with clinical knowledge, the SIC model can be improved by including as many relevant injury records as possible. However, it is important to note that inclusion of NTL injuries needs to be considered whilst conceiving the study design, as retrospectively recording injuries has been shown to be unreliable and inaccurate [30].

### *Application of subsequent injury models*

Several issues regarding consistent application of SIC arose after each rater had blindly categorised the data. For example, bilateral spinal structures e.g. left and right facet joints, and partes interarticulares, should be considered different body parts (SIC codes 9-10), in the same manner as a left or right shoulder or hamstring. However, a central spinal structure, such as an intervertebral disc injury that results in left sided pain in an index injury and right sided pain in a subsequent injury should be categorised as the same body part (SIC codes 2-6).

There is a degree of subjectivety in the assigned SIC as demonstrated by the above examples and by the strong, but not perfect agreement between raters working with the rugby union team. Future studies considering using multiple raters may wish to produce consensus SIC codes, which allow the final SIC code to be a product of agreed clinical opinion. However, relying on clinical expertise would mean that SIC could only be used in epidemiological studies that have access to such resources. When such access is not possible, researchers are recommended to group data using the overarching categorisation rather than the specific numerical categories if multiple raters are used. This was a consistent finding in both data sets.

The SIC model allows injury occurrence patterns to be quantified and was developed from a statistical perspective. But, there are other subsequent injury models within sports medicine such as the multistate framework for the analysis of subsequent injury in sport (M-FASIS) [31, 32]. The M-FASIS model was developed from a medical perspective, in particular it may overcome the issue of applying SIC code 5, as it focuses on athlete's being in 'states' based on tissue healing rather than injured or uninjured. However, use of this model needs to be considered prospectively due to monitoring an athlete's state. Therefore, it could not have been applied to our dataset.

## Conclusion

In summary, the most common subsequent injury in rugby union and cricket was an injury to a different body part that is not related to an index injury, with rugby union reporting more subsequent injuries per injured player than cricket. The findings also show that the SIC model is a reliable system for categorising subsequent injuries in team sports. The greatest level of agreement in SIC coding was obtained by two clinicians working within a team. If clinicians not with the team are to be used, recording all injuries, TL and NTL, is encouraged. Conversely if individuals with limited clinical knowledge are employed, grouping data using the overarching categorisation rather than specific numerical SIC is encouraged.

### What are the new findings

- The most common subsequent injury in rugby union and cricket was an injury to a different body part that was not related to an index injury
- Subsequent injury categorisation (SIC) is a reliabile system for categorising subsequent injuries within players of team sports
- Greatest agreement was observed between clinicians with direct clinical knowledge of the injuries

### How might it impact on clinical practice in the near future

- Rugby union injury prevention strategies might best target risk factors associated with exact injury recurrences
- Cricket injury prevention strategies might best target the injured body area
- If clinicians not with the team are applying the SIC model, recording all injuries, time-loss and non time-loss, is encouraged
- If individuals with limited clinical knowledge are applying the SIC model, grouping data using the overarching categorisation is encouraged

**Acknowledgements** The authors thank Professor Caroline Finch for advising on the application of the subsequent injury categorisation.

**Contributors** IM and CR conceived the study. IM, CR, SM and PM undertook categorisation of the data. IM analysed the data and led the writing of the manuscript. CR, SM and PM edited the manuscript. SM and PM collected injury data.

**Funding** The Welsh Rugby Union funded IM and CR to conduct rugby injury surveillance.

**Competing interests** SM works for Sri Lanka Cricket. PM and CR work for the Welsh Rugby Union.

**Ethics approval** Cardiff Metropolitan University

**Provenance and peer review** Not commissioned; externally peer reviewed.

## References


**1. Moore I S, Mathema P and Ranson C. The impact of injury in Welsh professional rugby. *Br J Sports Med* 2014;48:642.**

**2. Moore I S, Ranson C and Mathema P. Injury risk in International Rugby Union: Three-year injury surveillance of one National team. *Orthopaedic Journal of Sports Medicine* 2015;**

**3. Orchard J W, James T and Portus M R. Injuries to elite male cricketers in Australia over a 10-year period. *J Sci Med Sport* 2006;9:459-67. doi: 10.1016/j.jsams.2006.05.001.**

**4. Mount S, Moore I and Ranson C. Injury types and rates in an international cricket team: Application of subsequent injury categorisation. *Br J Sports Med* 2014;48:642. doi: 10.1136/bjsports-2014-093494.218.**

**5. Fuller C W, Laborde F, Leather R J, et al. International Rugby Board Rugby World Cup 2007 injury surveillance study. *Br J Sports Med* 2008;42:452-9. doi: 10.1136/bjsm.2008.047035.**

**6. Fuller C W, Sheerin K and Targett S. Rugby World Cup 2011: International Rugby Board injury surveillance study. *Br J Sports Med* 2013;47:1184-91. doi: 10.1136/bjsports-2012-091155.**

**7. Brooks J H, Fuller C W, Kemp S P, et al. A prospective study of injuries and training amongst the England 2003 Rugby World Cup squad. *Br J Sports Med* 2005;39:288-93. doi: 10.1136/bjsm.2004.013391.**

**8. Alonso J M, Junge A, Renstrom P, et al. Sports injuries surveillance during the 2007 IAAF World Athletics Championships. *Clin J Sport Med* 2009;19:26-32. doi: 10.1097/JSM.0b013e318191c8e7.**

**9. Alonso J M, Tscholl P M, Engebretsen L, et al. Occurrence of injuries and illnesses during the 2009 IAAF World Athletics Championships. *Br J Sports Med* 2010;44:1100-5. doi: 10.1136/bjsm.2010.078030.**

**10. Best J P, McIntosh A S and Savage T N. Rugby World Cup 2003 injury surveillance project. *Br J Sports Med* 2005;39:812-17. doi: 10.1136/bjsm.2004.016402.**

**11. D'Souza D. Track and field athletics injuries-a one-year survey. *Br J Sports Med* 1994;28:197-202.**

**12. Edouard P, Depiesse F, Branco P, et al. Analyses of Helsinki 2012 European Athletics Championships Injury and Illness Surveillance to Discuss Elite Athletes Risk Factors. *Clin J Sport Med* 2013;0:0. doi: 10.1097/jsm.0000000000000052.**

**13. Engebretsen L, Soligard T, Steffen K, et al. Sports injuries and illnesses during the London Summer Olympic Games 2012. *Br J Sports Med* 2013;47:407-14. doi: 10.1136/bjsports-2013-092380.**

**14. Engebretsen L, Steffen K, Alonso J M, et al. Sports injuries and illnesses during the Winter Olympic Games 2010. *Br J Sports Med* 2010;44:772-80. doi: 10.1136/bjsm.2010.076992.**

**15. Hendricks S, O'Connor S, Lambert M, et al. Contact technique and concussions in the South African under-18 Coca-Cola Craven Week Rugby tournament. *Eur J Sport Sci* 2015;15:557-64. doi: 10.1080/17461391.2015.1046192.**

**16. Junge A, Engebretsen L, Mountjoy M L, et al. Sports injuries during the Summer Olympic Games 2008. *Am J Sports Med* 2009;37:2165-72. doi: 10.1177/0363546509339357.**

**17. Ranson C, Hurley R, Rugless L, et al. International cricket injury surveillance: a report of five teams competing in the ICC Cricket World Cup 2011. *Br J Sports Med* 2013;doi: 10.1136/bjsports-2012-091783.**

**18. Mathema P, Ranson C and Moore I. National team rugby player injury types, rates and risk factors over two-years. *Br J Sports Med* 2014;48:635. doi: 10.1136/bjsports-2014-093494.203.**
**19. Fuller C W, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med* 2006;40:193-201. doi: 10.1136/bjsm.2005.025270.**
**20. Fuller C W, Molloy M G, Bagate C, et al. Consensus statement on injury definitions and data collection procedures for studies of injuries in rugby union. *Br J Sports Med* 2007;41:328-31. doi: 10.1136/bjsm.2006.033282.**
**21. Orchard J W, Newman D, Stretch R, et al. Methods for injury surveillance in international cricket. *Br J Sports Med* 2005;39:e22. doi: 10.1136/bjsm.2004.012732.**
**22. Orchard J W, Ranson C, Olivier B, et al. International consensus statement on injury surveillance in cricket: a 2016 update. *Br J Sports Med* 2016;doi: 10.1136/bjsports-2016-096125.**
**23. Timpka T, Alonso J M, Jacobsson J, et al. Injury and illness definitions and data collection procedures for use in epidemiological studies in Athletics (track and field): consensus statement. *Br J Sports Med* 2014;48:483-90. doi: 10.1136/bjsports-2013-093241.**
**24. Finch C F and Cook J. Categorising sports injuries in epidemiological studies: the subsequent injury categorisation (SIC) model to address multiple, recurrent and exacerbation of injuries. *Br J Sports Med* 2013;48:1276-80. doi: 10.1136/bjsports-2012-091729.**
**25. Finch C, Cook J, Gabbe B, et al. A new way of categorising recurrent, repeat and multiple sports injuries for injury incidence studies– the subsequent injury categorisation (SIC) model. . *Australasian Epidemiologist* 2015;22:22-25.**
**26. Finch C F, Orchard J W, Twomey D M, et al. Coding OSICS sports injury diagnoses in epidemiological studies: does the background of the coder matter? *Br J Sports Med* 2014;48:552-6. doi: 10.1136/bjsports-2012-091219.**
**27. Robinson G and O'Donoghue P. A weighted kappa statistic for reliability testing in performance analysis of sport. *International Journal of Performance Analysis in Sport* 2007;7:12-19.**
**28. McHugh M L. Interrater reliability: the kappa statistic. *Biochemia Medica* 2012;22:276-82.**
**29. Clarsen B, Myklebust G and Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire. *Br J Sports Med* 2013;47:495-502. doi: 10.1136/bjsports-2012-091524.**
**30. Twellaar M, Verstappen F T and Huson A. Is prevention of sports injuries a realistic goal? A four-year prospective investigation of sports injuries among physical education students. *Am J Sports Med* 1996;24:528-34.**
**31. Shrier I, Clarsen B, Verhagen E, et al. Improving the accuracy of sports medicine surveillance: when is a subsequent event a new injury? *Br J Sports Med* 2016;doi: 10.1136/bjsports-2016-096160.**
**32. Shrier I, Steele R J, Zhao M, et al. A multistate framework for the analysis of subsequent injury in sport (M-FASIS). *Scand J Med Sci Sports* 2016;26:128-39. doi: 10.1111/sms.12493.**

**Table 1. Subsequent injury categorisation (SIC) codes and definitions based on Finch & Cook [24].**

| Subsequent injury type by body area and nature (Overarching category) | Code | Definition |
|---|---|---|
| No injury | 1 | No injury. For statistical purposes only |
| Exact same injury in terms of body site and nature | 2 | Same type, same side, same body area as a fully recovered index injury, and **related** to an index injury |
| | 3 | Acute onset exacerbation or reinjury before full recovery, **related** to an index injury |
| | 4 | Continual or sporadic experiences of pain or other physical discomfort— **related** to an index injury |
| | 5 | Continual or sporadic experiences of pain or other physical discomfort—**not related** to an index injury |
| | 6 | Same type and same body area but **not related** to an index injury |
| Injury to same body site but different nature | 7 | Occurrence **related** to an index injury |
| | 8 | Occurrence **not related** to an index injury |
| Injury to different body part (irrespective of nature) | 9 | Occurrence **related** to an index injury |
| | 10 | Occurrence **not related** to an index injury |

**Table 2. Weightings given for each subsequent injury categorisation code**

| Overarching categorisation | Rater one SIC code | Rater two SIC code | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Exact same injury (body site and nature) | 2 | 1 | 0.2 | 0.2 | 0.2 | 0.2 | 0 | 0 | 0 | 0 |
| | 3 | 0.2 | 1 | 0.2 | 0.2 | 0.2 | 0 | 0 | 0 | 0 |
| | 4 | 0.2 | 0.2 | 1 | 0.2 | 0.2 | 0 | 0 | 0 | 0 |
| | 5 | 0.2 | 0.2 | 0.2 | 1 | 0.2 | 0 | 0 | 0 | 0 |
| | 6 | 0.2 | 0.2 | 0.2 | 0.2 | 1 | 0 | 0 | 0 | 0 |
| Same body site, different nature | 7 | 0 | 0 | 0 | 0 | 0 | 1 | 0.5 | 0 | 0 |
| | 8 | 0 | 0 | 0 | 0 | 0 | 0.5 | 1 | 0 | 0 |
| Different body part (irrespective of nature) | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.5 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.5 | 1 |

**Table 3. Weighted kappa scores and Cohen's kappa scores for SIC codes, and raw agreement of indices between clinicians and the sport scientist for rugby union injuries (4 raters; 648 injuries)**

| | Team clinicians | Team clinician vs. Clinician not with team | Team clinician vs. Sport scientist | Clinician not with team vs. Sport scientist |
|---|---|---|---|---|
| Weighted kappa | 0.89 (0.85 – 0.93) | 0.73 (0.68 – 0.78) | 0.75 (0.71 – 0.80) | 0.46 (0.41 – 0.51) |
| Cohen's kappa | 0.87 (0.83 – 0.91) | 0.68 (0.63 – 0.73) | 0.71 (0.66 – 0.76) | 0.28 (0.23 – 0.32) |
| Raw agreement of indices | 0.95 (0.94 – 0.97) | 0.72 (0.68 – 0.75) | 0.73 (0.69 – 0.76) | 0.80 (0.77 – 0.83) |

**Table 4. Weighted kappa scores and Cohen's kappa scores for SIC codes, and raw agreement of indices between clinicians and the sport scientist for cricket injuries (3 raters; 190 NTL injuries and 96 TL injuries)**

| | **Team clinician vs. Clinician not with team** | | | **Team clinician vs. Sport scientist** | | | **Clinician not with team vs. Sport scientist** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **NTL** | **TL** | **All** | **NTL** | **TL** | **All** | **NTL** | **TL** | **All** |
| Weighted kappa | 0.77 (0.67 – 0.86) | 0.78 (0.65 – 0.90) | 0.83 (0.77 – 0.89) | 0.60 (0.49 – 0.71) | 0.69 (0.56 – 0.81) | 0.68 (0.61 – 0.75) | 0.21 (0.10 – 0.33) | 0.70 (0.56 – 0.84) | 0.71 (0.64 – 0.78) |
| Cohen's kappa | 0.70 (0.59 – 0.80) | 0.72 (0.59 – 0.85) | 0.78 (0.71 – 0.84) | 0.52 (0.41 – 0.63) | 0.60 (0.47 – 0.73) | 0.60 (0.53 – 0.68) | 0.04 (-0.01 – 0.09) | 0.62 (0.48 – 0.77) | 0.63 (0.56 – 0.71) |
| Raw agreement of indices | 0.72 (0.66 – 0.79) | 0.79 (0.71 – 0.87) | 0.75 (0.70 – 0.80) | 0.68 (0.72 – 0.75) | 0.69 (0.59 – 0.79) | 0.68 (0.62 – 0.73) | 0.80 (0.74 – 0.85) | 0.65 (0.55 – 0.74) | 0.75 (0.69 – 0.80) |

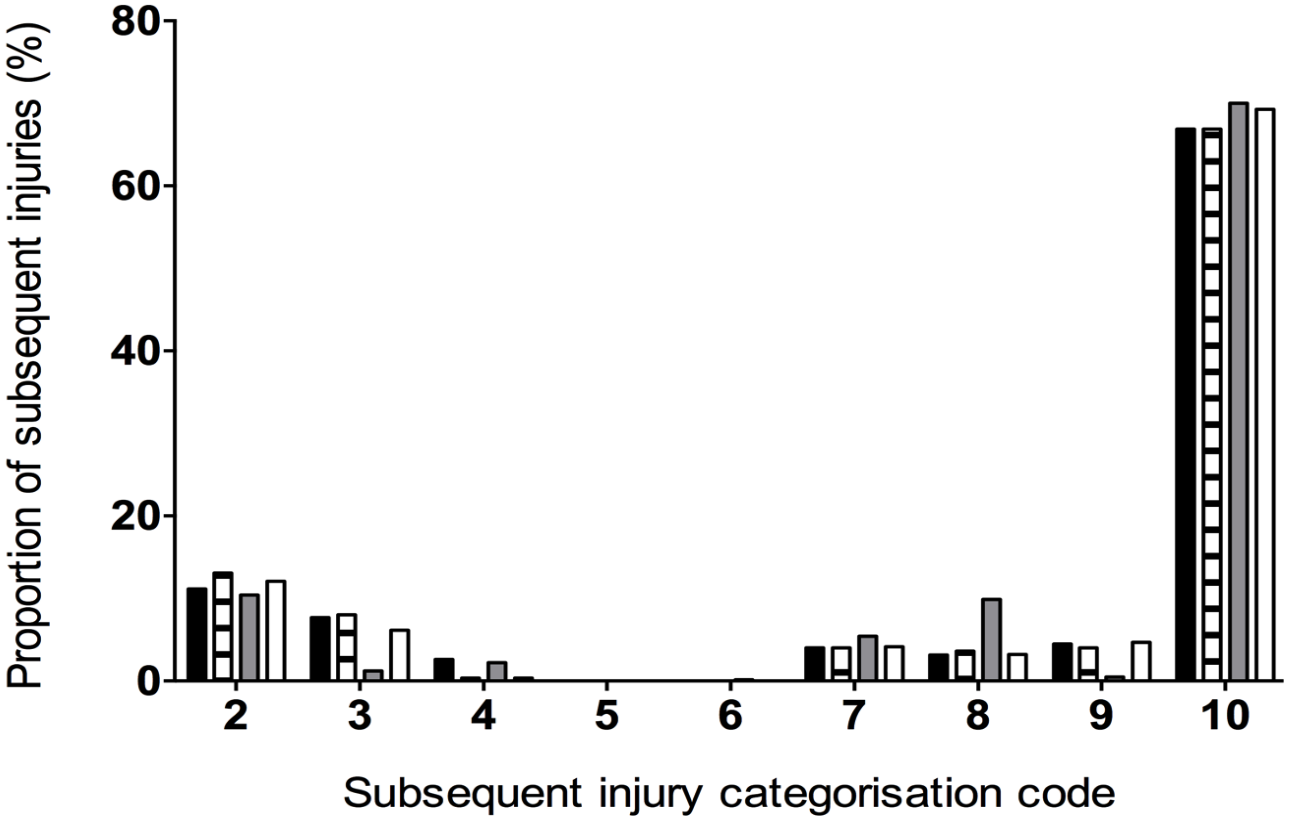


**Figure 1. Proportion of subsequent rugby union injuries per SIC code assigned by each rater. Black bars represent clinician with the team (1); Black and white striped bars represent clinician with the team (2); grey bars represent clinician not with the team and; white bars represent the sport scientist.**

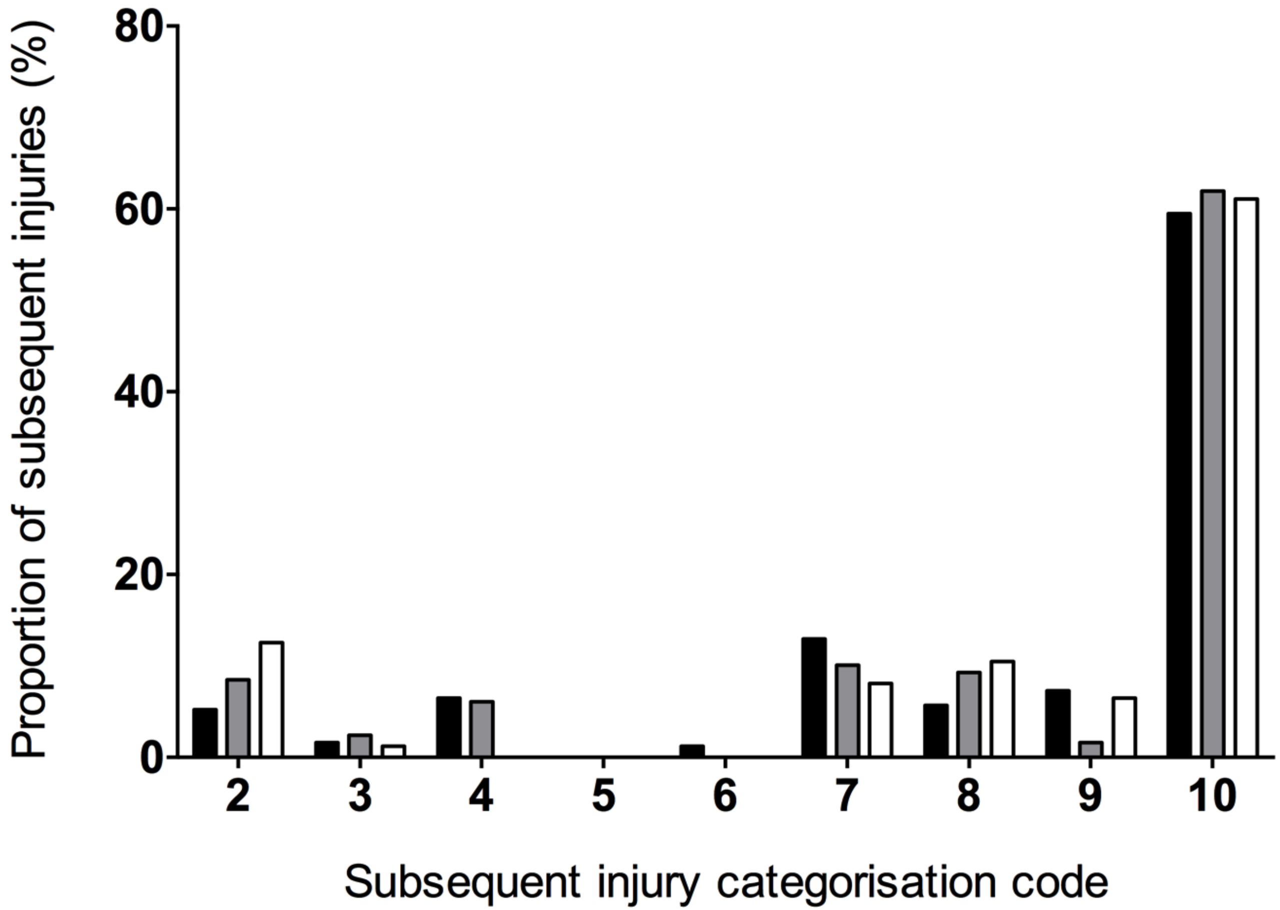


**Figure 2. Proportion of cricket injuries per SIC code assigned by each rater. Black bars represent clinician with the team; grey bars represent the clinician not with the team and; white bars represent the sport scientist.**

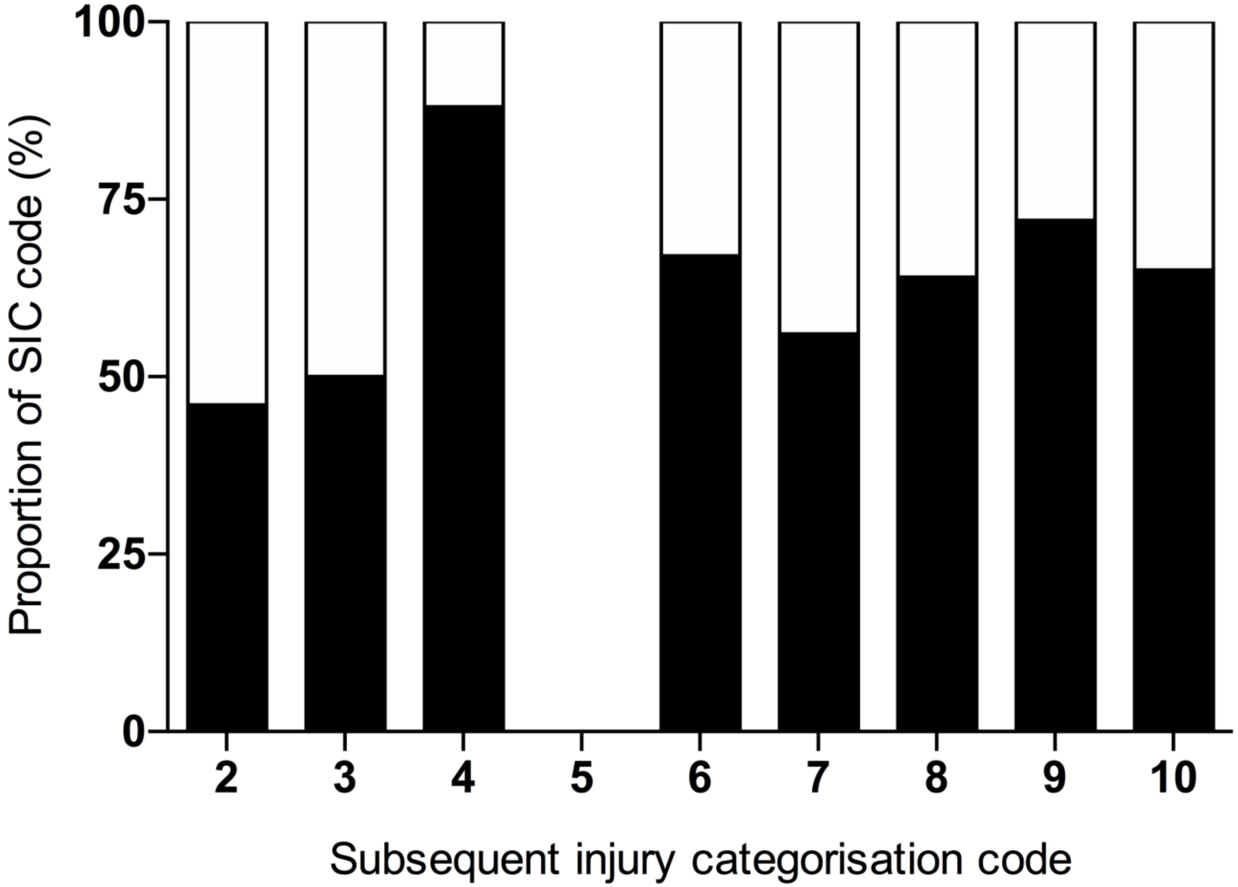


**Figure 3. Proportion of NTL and TL cricket injuries per SIC code assigned by the team clinician. Black bars represent NTL injuries and; white bars represent TL injuries.**