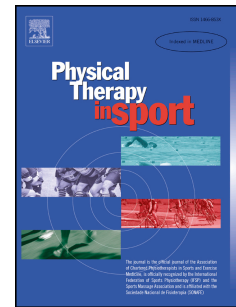


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Injury surveillance of an Australian community netball club

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Injury surveillance of an Australian community netball club

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INJURY SURVEILLANCE OF AN AUSTRALIAN COMMUNITY NETBALL CLUB

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ABSTRACT

Objectives: To describe injuries associated with netball and risk factors for lower limb injuries.

Design: Prospective study. In the preseason, risk factors were investigated using self-report questionnaires and physical measurements. During the season, injuries were reported using a standardised report, verified by follow-up phone calls. Player training and game hours were recorded.

Setting: Australian community netball club.

Participants: 269 players from 9 divisions, aged 7-42 years.

Main Outcome Measures: Injury incidence rates per 1000 exposure hours were calculated.

The most common mechanism, nature and consequence of injury were determined from frequencies. Logistic regression was used to identify predictors of lower limb injury and determine adjusted odds ratios for each risk factor.

Results: 169 injuries occurred with a rate of 13.8 / 1000 exposure hours (95% CI 11.8-16.0), majority (60%) to the lower limb. The most frequent injury mechanisms were collisions (28%) and awkward landings (27%), nature was 'Inflammation/swelling' (32%) and consequence was 'unable to continue playing/training' (50%). Previous history of injury (OR 6.9, 95% CI 3.7 - 13.0) and age greater than 13.5 years (OR 3.1, 95% CI 1.6 - 5.9) were significant risk factors for a season lower limb injury.

Conclusion: Injury rates in this community netball club were high. Results suggest that further research regarding the implementation and effectiveness of injury prevention programs for community netballers is required.

KEYWORDS

epidemiology, sports injury, prognostic factors, lower limb injury, risk factors

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INTRODUCTION

Netball is a popular team sport played worldwide. It has a high participation rate with over 20 million participants who are predominantly female (International Netball Federation). While netball is a 'non-contact' sport, injuries are common due to the high physical demands associated with the sport. Reported injury incidence rates vary for netball players, ranging from 11.3-14 injuries per 1000 player hours (Finch, Da Costa, Stevenson, Hamer, & Elliott, 2002; McManus, Stevenson, & Finch, 2006; Pringle, McNair, & Stanley, 1998). At the community level, the most recent large scale, prospective investigations were conducted over a decade ago (Finch, et al., 2002; McManus, et al., 2006).

The ankle and knee are the most commonly reported injured body sites among netball players (Finch, et al., 2002; D. Hopper, Elliott, & Lalor, 1995; Joseph, Naughton, & Antcliff, 2019; Langeveld, 2012; McManus, et al., 2006). Ankle sprains have been found to be a problem across all levels of competition (Bissell, Lorentzos, & Chung, 2018; Pillay & Frantz, 2012; Singh, Mansingh, Palmer, & Williams, 2013). A systematic review of ankle injuries in sports reported that the ankle accounted for 40% of all netball injuries (Fong, Hong, Chan, Yung, & Chan, 2007). Common mechanisms of injury reported included incorrect landing and contact with another player, with the most commonly reported nature of injuries being ligamentous sprains, muscle strains and contusions (Finch, et al., 2002; D. Hopper, Elliott, et al., 1995; McManus, et al., 2006). Interestingly, differences in injury incidence rates have been previously identified across different levels of competition (D. Hopper, Elliott, et al., 1995; Pillay & Frantz, 2012), and age divisions (D. Hopper & Elliott, 1993), which may have implications for the development of injury prevention programs for players of different ages and levels.

In an attempt to decrease the high injury rates in netball players, injury prevention programs have been developed. Examples include Netball Australia's 'Knee Program' (Netball Australia) and the University of Ballarat's 'Down to Earth' program (Saunders, Otago, & Peoples, 2006). However, the impact of these programs in community netball is currently unknown, with a lack of current information regarding the injury rates and types of injuries experienced in different age groups and levels of competition. In addition, identifying and understanding modifiable risk factors for injury is fundamental to the development of injury prevention programs. Previously reported player characteristics associated with lower limb injuries in netballers include hypermobility, jumping ability, dynamic balance, anaerobic fitness and body somatotype (Attenborough, et al., 2017; D. Hopper, Hopper, & Elliott, 1995; Smith, Damodaran, Swaminathan, Campbell, & Barnsley, 2005). A limitation of research in this area is that only a few studies have examined risk factors for injury in netballers using a prospective study design (Attenborough, et al., 2017; McManus, et al., 2006; Pickering Rodriguez, Watsford, Bower, & Murphy, 2017). Of these studies, only one was conducted at the non-elite or community level (McManus, et al., 2006), and that was conducted more than a decade ago.

The primary aim of this prospective cohort study of community level Australian netball players was to conduct surveillance of sport injuries that occurred during season playing and training time and to report the injury rate by body region, injury patterns by team division, mechanism of injury, nature of injury and consequence of injury. A secondary aim was to investigate risk factors associated with lower limb injury through analysis of demographic information, history of previous lower limb injury, characteristics of netball participation and physical measurements.

METHODS

Injury surveillance was conducted during the 2016 netball season at one community netball club in South Australia. With the support of the club's committee and coaches, all registered players across the 9 divisions of the club were considered eligible and were invited to participate via a written information letter containing details of the study. Players who were interested to participate provided written consent and players under 18 years also provided parental/guardian consent. Players who did not provide written consent were excluded from the study. This study was approved by the Human Research Ethics Committee at the Australian Catholic University (2016-48H).

At the commencement of the season, participants completed a paper-based questionnaire and physical measurements were obtained. The questionnaire included player demographics (age), information related netball participation (years playing netball, netball participation hours per week, other physical activity hours per week, use of warm-up pre game/training, use of cool-down post game/training, use of taping/bracing for games or training, age of netball shoe) and injury history in the twelve months prior to the study. Physical measurements included player height, weight and ankle dorsiflexion range of motion. Body mass index was calculated using height and weight measurements. Ankle dorsiflexion range of motion was measured on each limb using the previously established weight-bearing lunge test (Bennell, et al., 1998). In brief, players positioned their foot so that the big toe and mid-heel were along a tape measure positioned on the floor, perpendicular to the wall. Players lunged forward until their knee touched a vertical line drawn on the wall. At the maximum lunge point, ensuring the heel remained in contact with the ground, the linear distance between the hallux and wall was recorded in centimetres.

During the season, any sports injury that occurred as a result of netball participation (training or game) was recorded. A 'sports injury' was defined as 'all types of damage to the body that occurred as a result of competing, training and/or participating in a physical activity' as per Sports Medicine Australia's 'Australian Sports Injury Data Dictionary' (Sports Medicine Australia, 2018). Each sport injury was recorded using a standardised form, based on the Sports Medicine Australia netball injury reporting form (Sports Medicine Australia, 2018), see supplementary material (Figure S1). As outlined in Figure S1, injury information that was obtained included the date of injury, activity at time of injury (game/training), body location, nature, mechanism and consequence of injury. The forms were completed by the injured player (or parent/guardian) or team coach/manager, and information was verified by a research assistant via telephone follow-up. During the season, hours of netball training and playing time for each individual player were derived from attendance records maintained by each coach, based on training schedules and fixtures, and were used to calculate season playing and training exposure hours for each player. The collected data were sent by the research assistant to the university's data management service for collation and were de-identified prior to being sent to the research team for analysis.

Statistical Analysis

Data were analysed using SPSS, version 25 (IBM Inc, USA). Injuries were excluded from the analysis if they were sustained during any activity other than participation in community netball. Injuries were categorised as 'foot', 'ankle', 'shin', 'calf', 'knee', 'thigh', 'hip', 'groin', 'back', 'trunk', 'shoulder', 'upper arm/elbow', 'forearm/wrist/hand' or 'neck' or 'head'. Locations were then grouped into the following regions: 'any injury', 'lower limb', 'upper limb', 'head/neck' or 'trunk/back'. Mechanisms of injury were categorised as 'struck by ball', 'collision with other player', 'collision with fixed object', 'slip/ trip', 'jumping to

shoot or defend', 'fall/ stumble' and 'fall from height/awkward landing' and 'other'. The nature of the injury was categorised as 'abrasion/graze', 'sprain', 'strain', 'inflammation/swelling', 'fracture', 'concussion', 'blisters' and 'other'. Consequences of injury were categorised as 'continue activity', 'unable to continue activity', 'ambulance', 'hospital' and 'other'. Injury rates were calculated by expressing the number of injuries per 1000 netball exposure hours (with 95% confidence intervals) (Dean, Sullivan, & Soe., 2013). The formula used to calculate injury rates was: $(\text{number of injuries} / \text{exposure time}) \times 1000$.

To investigate risk factors associated with season lower limb injuries, players were categorised into two groups (lower limb injury or no lower limb injury). One player with no injury was excluded due to missing data. The following variables were tested as predictive factors: player age (years), height (m), weight (kg), body mass index (kg/m^2), ankle dorsiflexion range of motion (cm), history of lower limb injury in the 12 months prior to the study (yes/no), use of warm-up pre game/training (yes/no), use of cool-down post game/training (yes/no), age of netball shoe (months), use of ankle taping or bracing for netball games or training (yes/no), time spent playing netball per week (hours), time spent on other physical activity per week (hours), season game time (minutes), season training time (minutes), and total season time (minutes). For ankle dorsiflexion range of motion, the average was used. A paired t-test demonstrated that measurements for the left (mean 11.7cm, standard deviation 3.4cm) and right (mean 11.8cm, standard deviation 3.5cm) ankles were not different ($p = 0.61$). Univariate associations between categorical variables were examined using chi-square tests and between continuous variables using independent samples t-test for the lower limb injury and no lower limb injury groups. Receiver Operating Characteristic (ROC) curves were used to calculate the optimal cut-point for each continuous variable in predicting the injury outcome variable and the cut points were then used to convert the significant continuous variables ($p < 0.10$) to a binary form. Cross tabulations and chi-square

tests were used to assess the relationship between the significant binary exploratory variables ($p < 0.10$) and season lower limb injury (injury or no injury). All variables were then ranked in order of the magnitude of their univariate association and entered into a logistic regression, using a forward sequential method (Barton & Peat, 2014) to obtain their independent multivariate effects with significance level set at $p < 0.05$. Unadjusted and adjusted odds ratios (95% confidence intervals) were reported to describe the magnitude of the relationship between risk factors and lower limb injury. This was an exploratory study, and in order to minimise Type II errors, no adjustments for multiple comparisons were made (Bender & Lange, 2001). As the unit of player selection was a single club, adjustment for clustering by team was not considered necessary.

RESULTS

Participant characteristics: From the 278 registered players, 269 female netballers across 9 divisions participated in this study. Participants ranged in age from 7 years to 42 years, with a mean (standard deviation) age of 15 (5) years, weight of 58.9 (15.1) kg, height of 1.6 (0.1) m, and had played netball for an average of 7.8 years (5.1), (Table 1). In the twelve months prior to the study, 159 players (59%) reported a history of injury. Lower limb injuries in the previous 12 months comprised 71% of the injuries that were reported, followed by the upper limb (15%), trunk/back (8%) and head/neck (6%).

Injury rates: The overall time of netball exposure over the duration of the season across all 269 participants was 12,243 hours (8,919 training hours and 3,324 game hours). During the season, 169 injuries were sustained by 107 players (40%). The overall injury rate was 13.8 / 1000 player hours (95% CI: 11.8 to 16). The majority of injury incidents occurred during

games (32.2 per 1000 player hours) compared with training (4.7 per 1000 player hours). Figure 1 illustrates the injury rates across each division.

Injury location: Supplementary material (Table S1) reports injury locations across each division. Overall, lower limb injuries predominated accounting for 60% of injuries (8.3 / 1000 exposure hours; 95% CI: 6.8 to 10.1). The ankle, forearm/wrist/hand and knee were the most commonly injured locations accounting for 26% (injury rate 3.6 / 1000 exposure hours; 95% CI: 2.6-4.8), 17% (injury rate 2.4 / 1000 exposure hours; 95% CI: 1.6-3.4) and 16% (injury rate 2.2 / 1000 exposure hours; 95% CI: 1.5-3.2) respectively. Exceptions to this occurred in the junior, intermediate and senior divisions, where the head region was among the most commonly injured location. Forearm/wrist/hand injuries were particularly common in the sub-junior division.

Mechanism of Injury: The most commonly reported mechanisms of injury were ‘collision with another player’ (28%) and ‘awkward landing’ (27%), closely followed by ‘other’ (22%), supplementary material (Table S2). ‘Other’ mechanisms were usually not associated with a specific incident, for example overuse injuries. The ‘sub-junior’ division was an exception where the most common mechanism was being ‘struck by ball’ (42%).

Nature of Injuries: The most commonly reported nature of injury was ‘inflammation/swelling’ (32%), followed by ‘ligament sprain’ (24%) and ‘muscle strain’ (18%), supplementary material (Table S2). ‘Other’ nature of injuries (11%) reported included ‘headache’, ‘bruising’ and ‘skin laceration’. Of note, ‘concussion’ was only reported by junior, intermediate and senior divisions.

Consequence of Injuries: The most common consequence of injury was ‘unable to continue playing/training’ (50%), supplementary material (Table S2). This was consistent across all

divisions, with the exceptions of the 'sub-junior' and 'intermediate' divisions where the majority could continue playing/training. 'Other' consequences of injury (10%) that were reported included seeing a 'doctor', 'physiotherapist', 'tape applied to area', 'ice applied to area' and 'Band-Aid' applied'. A small number of injuries required 'hospital' (4%,) or attendance of an ambulance (1%,).

Risk factors for lower limb injury: There were 81 players who had a season lower limb injury and 187 players who did not have a lower limb injury. Univariate relationships were observed between season lower limb injury and weight ($p < 0.001$), height ($p < 0.001$), body mass index ($p < 0.001$), age ($p < 0.001$), time spent playing netball per week ($p = 0.018$), time spent on other physical activity per week ($p = 0.018$), use of taping/bracing ($p < 0.001$) and lower limb injury in the previous 12 months ($p < 0.001$), see supplementary material (Table S3). Almost all (99.6%) players did perform a warm-up pre game/training, therefore there were insufficient cases to run the chi-square analysis for this factor. There were no associations with lower limb injury observed for ankle dorsiflexion range of motion ($p = 0.848$), age of shoe ($p = 0.261$), season game time ($p = 0.216$), season training time ($p = 0.164$), total season time ($p = 0.146$) or use of cool down post game/training ($p = 0.105$). However, of the variables that demonstrated a significant univariate relationship to lower limb injury, the only significant predictors of lower limb injury from the multivariate logistic regression were a 'history of a lower limb injury in the previous 12 months' and 'player age greater than 13.5 years'. Odds ratios (95% CI) are presented in Table 2.

DISCUSSION

The overall injury rate observed in community netball players in the current investigation (13.8/1000 player hours) was consistent with the rates previously reported (between 11.3-14/1000 player hours) (Finch, et al., 2002; McManus, et al., 2006; Pringle, et al., 1998). Also

consistent with previous work, the most commonly injured body region was the lower limb, and the body location with the highest injury rates was the ankle, followed by the forearm/wrist/hand and the knee (Finch, et al., 2002; D. Hopper, Elliott, et al., 1995; McManus, et al., 2006).

The results of the current investigation showed that netball injuries differed across age groups and netball divisions. Injuries to the lower limb were the most common for all netball divisions except the sub-junior division. In the sub-junior division, high rates of forearm/wrist/hand injuries (predominately finger injuries) were reported, and the most common mechanism of injury was being 'struck by the ball'. Continuing maturation of the sensorimotor system at this age (11-13 year olds) may affect hand-eye coordination, resulting in poor ball skills and this may be one of the possible contributing factors which may help to explain the increased number of finger injuries reported (Quatman-Yates, Quatman, Meszaros, Paterno, & Hewett, 2012). Another division specific finding was that injuries to the head were more prevalent in junior, intermediate and senior divisions. A previous study of community level netballers reported that 6.2% of players sustained a head/face injury, with 1.6% sustaining concussion (Finch, et al., 2002). The higher prevalence of 'concussion' injuries (4%) reported in the current investigation may reflect an increased awareness and/or understanding of concussion. In support of this finding, a recent study showed that there was an increased number of insurance claims made for moderate to serious concussions in netballers between 2012 and 2016 (King, et al., 2018).

The only risk factors for lower limb injury that were identified in the current investigation were age and a history of a lower limb injury in the previous 12 months. This is consistent

with the results of a recent systematic review/meta-analysis regarding sporting injuries across athletic populations (Toohey, Drew, Cook, Finch, & Gaida, 2017). Whilst there is strong evidence to support history of injury as a risk factor, the mechanisms underlying this relationship are not fully understood. It is possible that following injury, there could be residual deficits which predispose the player to repeat injuries. Age greater than 13.5 years was identified as an independent predictor of lower limb injuries, which may possibly reflect a susceptibility to injury around or following the adolescent growth spurt. Whilst further research is required to examine the factors and possible mechanisms underlying these findings, the results of the current investigation could be used to select groups of players who may be more at risk of lower limb injury.

Injury prevention programs have been designed specifically for netball players. Examples include 'The Knee Program' and 'Down to Earth' (Saunders, et al., 2006). These programs include exercises that target the commonly reported mechanisms of injury, such as landing, and aim to improve lower limb neuromuscular control, postural stability and co-ordination during netball related tasks (Netball Australia). The findings from the current study of a community netball club further support this approach with lower limb injuries predominating and 'awkward landing' and 'collision with another player' being the most common mechanisms of injury. While the barriers and facilitators to uptake of the 'Down to Earth' intervention have been examined (Romiti, et al., 2009; White, et al., 2012), the effectiveness of such programs at the community level have not yet been evaluated. An injury prevention program entitled the "integrated functional stability program" has demonstrated positive results in an elite international netball squad (Elphinston & Hardman, 2006) as has a neuromuscular intervention focussed on community level (A. J. Hopper, Haff, Joyce, Lloyd,

& Haff, 2017). Future research is required to evaluate the implementation and effectiveness of injury prevention programs in community netball.

The findings of this study should be interpreted in the context of study limitations. The results were derived from surveillance of one community netball club and may therefore not be generalizable to all clubs. While injury report forms were verified by a research assistant via telephone follow-up, the injury surveillance relied on injury report from the player (parent/guardian) or team coach/manager. Due to the 'self-report' nature of the study, there was no diagnoses of injuries and results are limited to description of the body location and regions that were injured (e.g. 'ankle'), not the actual injury (e.g. 'ankle sprain'). Nevertheless, this still indicates the need for injury prevention programs that have been developed focussing on lower limb injuries. Participation rates in this club wide cohort study were high (97%), with inclusion of a wide range of ages and skill levels of netball players across nine divisions. Other strengths in the study design include the prospective collection of actual season game and training time of each participant which improves the accuracy of injury rate calculations. Although participation was limited to one club, post-hoc sample size estimation indicated that with 3 factors in the logistic regression, we would have had sufficient power with 160 players (10 per cell) and therefore our sample of 268 players was adequate to support the final model with only 2 explanatory factors (age, history of lower limb injury) (Barton & Peat, 2014).

CONCLUSION

Injury rates (13.8/1000 hours) in this community netball club studied were similar to those reported previously, with lower limb injuries predominating, particularly the ankle and knee. Awkward landing and collision with another player continued to be the most common

mechanism of injury. Together these findings support the necessity for injury prevention programs that include lower limb neuromuscular control, postural stability and co-ordination during netball related tasks, such as landing. There were some differences observed in injury profiles across divisions suggesting that there may be specific injury prevention strategies that could be of benefit for players of specific ages/divisions, such as ball skills for early adolescents. In the current study, the only significant predictors of lower limb injury were age and a history of a lower limb injury in the previous twelve months. While this finding assists the identification of players who may be at risk of a lower limb injury, the mechanisms underlying this finding require further investigation. The findings highlight that further investigation regarding the implementation and effectiveness of injury prevention programs for community netball is warranted.

TABLES**Table 1.** Participant demographic information, weight and height displayed by division.

Mean (standard deviation) values are provided.

Division	Number of players	Number of teams	Age (years)	Years playing netball	Weight (kg)	Height (m)
Sub-primary	8	1	8 (1) Range: 7-9	1.6 (0.7)	28.8 (4.4)	1.31 (0.08)
Primary	42	6	10 (1) Range: 9-11	3.1 (1.1)	40.8 (9.4)	1.46 (0.07)
Sub-junior	46	6	12 (1) Range: 11-13	4.8 (1.7)	54.6 (11.6)	1.60 (0.08)
Junior	59	7	14 (1) Range: 13-15	6.5 (1.9)	61.2 (12.0)	1.67 (0.06)
Intermediate	47	5	16 (1) Range: 13-17	8.4 (2.2)	64.8 (8.6)	1.70 (0.07)
Seniors	38	5	21 (5) Range: 17-42	13.5 (5.3)	67.1 (8.2)	1.70 (0.06)

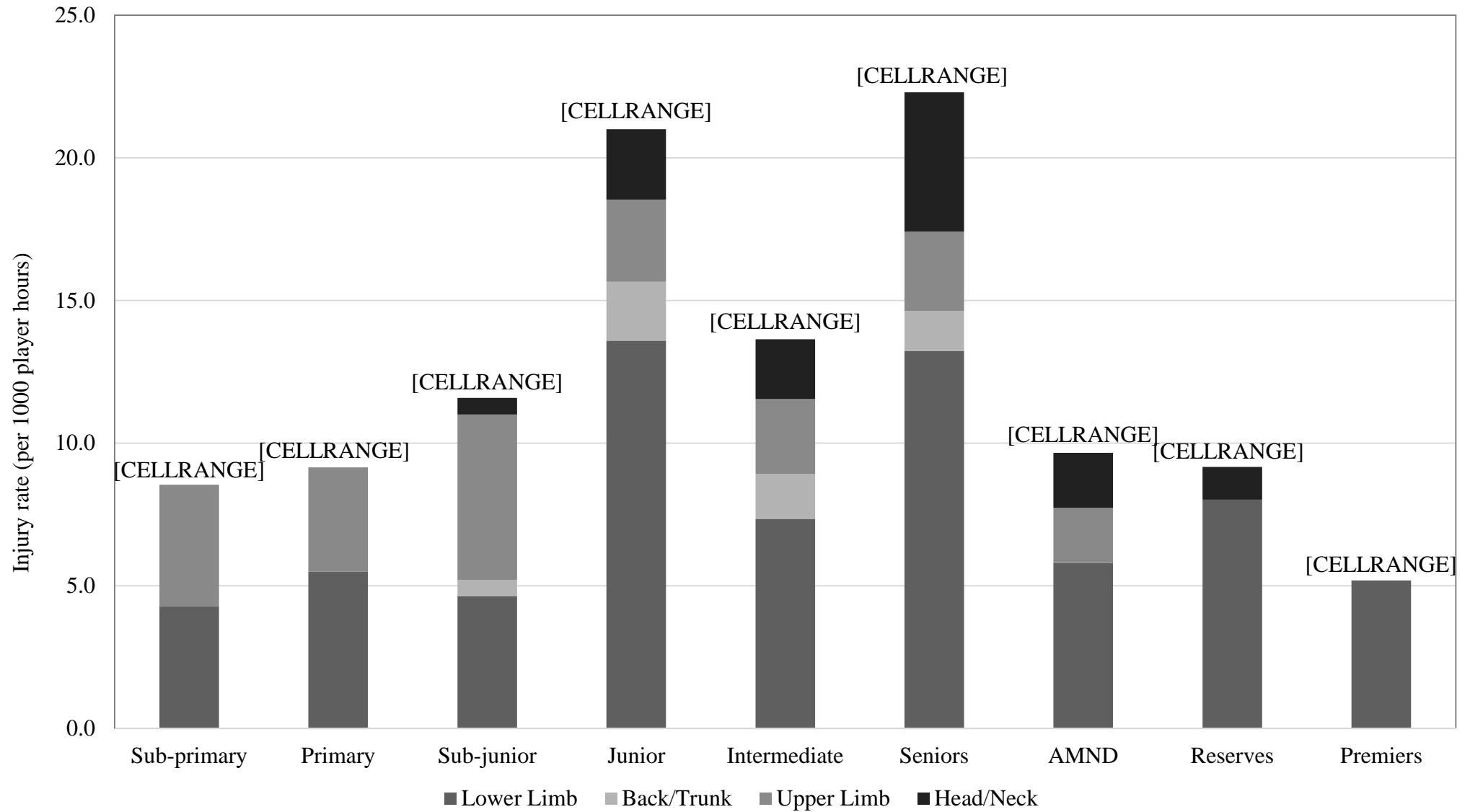
Adelaide	10	1	21 (4)	14.7 (4.1)	75.6	1.74
Metropolitan			Range:		(11.7)	(0.08)
Netball Division			18-28			
Reserves	9	1	21 (2)	13.3 (5.1)	71.2	1.74
			Range:		(13.7)	(0.08)
			18-25			
Premier	10	1	25 (4)	18.1 (4.8)	72.8	1.76
			Range:		(11.3)	(0.06)
			18-30			

Table 2. Unadjusted and adjusted odds ratios for risk factors associated with lower limb injury^a during the netball playing season

Risk Factor	% in exposed group with LL injury	% in non-exposed group with LL injury	Unadjusted odds ratio (95% CI)	P - value	Adjusted odds ratio (95% CI)	P - value
History of LL injury in previous 12 months	50.8%	11.9%	7.7 (4.1 – 14.2)	<0.001	6.9 (3.7 to 13.0)	<0.001
Age > 13.5 years	41.2%	15.7%	3.8 (2.1 – 6.9)	<0.001	3.1 (1.6 to 5.9)	0.001
Height > 1.67 m	44.4%	18.1%	3.6 (2.1 – 6.3)	<0.001		
Weight > 62.5kg	45.0%	19.7%	3.3 (1.9 – 5.7)	<0.001		
Use of ankle taping or bracing	46.1%	22.2%	3.0 (1.7 – 5.2)	<0.001		
Time spent on other physical activity per week >1.8 hours	40.6%	23.0%	2.3 (1.3 – 3.9)	0.002		
Time spent playing netball per week > 4.5 hours	38.8%	23.5%	2.0 (1.2 – 3.5)	0.007		
BMI > 21.5	36.8%	23.7%	1.9 (1.1 – 3.2)	0.019		

^aPlayers with a lower limb injury n = 81; players without a lower limb injury n = 187

Figure 1: Season injury rate for each injury region across the 9 netball divisions. Please see Table 1 for detail regarding division characteristics.



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Highlights:

- Injury rates in community level netball in Australia remain high.
- Lower limb injuries are the most common, specifically at the ankle and knee.
- Age and previous history of injury were risk factors for lower limb injury.

Conflict of interest

None declared

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None declared

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Ethical approval

This study was approved by the Human Research Ethics Committee at Australian Catholic University (approval number: 2016-48H). All subjects gave informed consent to participate in this work.