

Evaluation of protective equipment for prevention of injuries in rugby union

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Background Rugby union has a high rate of injury. The increased use of protective equipment may help mitigate these injuries. This study investigated the injury prevention effectiveness of the protective equipment used in rugby union.

Methods A cohort of 304 rugby players in Dunedin, New Zealand was followed weekly during the 1993 club season to assess protective equipment use, participation in rugby, and injury outcomes. Generalized Poisson regression was used to model the rate of injury while adjusting for covariates such as level of competition, playing position, and injury history.

Results The use of mouthguards appeared to lower the risk of orofacial injury [rate ratio (RR) = 0.56, 95% confidence interval (CI): 0.07–4.63], and padded headgear tended to prevent damage to the scalp and ears (RR = 0.59, 95% CI: 0.19–1.86). Support sleeves tended to reduce the risk of sprains and strains (RR = 0.58, 95% CI: 0.26–1.27). The risk of concussion was not lessened by the use of padded headgear (RR = 1.13, 95% CI: 0.40–3.16) or mouthguards (RR = 1.62, 95% CI: 0.51–5.11). There was no evidence of protective effects for any other equipment item (taping, shinguards, and grease).

Conclusions The protective equipment used in rugby union has limited effectiveness in preventing injuries. The results are supportive, however, of a role for mouthguards and padded headgear in preventing orofacial and scalp injuries, respectively, and for support sleeves in preventing sprains and strains.

Keywords Protective devices, mouth protectors, contact sports, athletic injuries, brain concussion

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Full-contact sports are renowned for their high incidence of injury.¹⁻⁴ Protective equipment probably affords the greatest potential for the prevention and mitigation of injury in these sports. North American football and ice hockey have invested heavily in this strategy, introducing extensive body padding and helmets, while other full-contact sports (rugby union, rugby league, Australian Rules football) prohibit hard-shell helmets and permit little or no body padding.

Rugby union is a full-body-contact, ball-carrying sport that is popular internationally. Two teams of 15 players compete by attempting to carry a football across the opponent's goal line. In general, more heavily built players play as 'forwards' while more slightly built, faster players tend to play as 'backs'. In countries in which rugby union is popular, the toll of injury resulting from the game has serious public health and economic consequences.^{5,6} In comparison with players of contact sports

such as North American football and ice hockey, rugby union players are largely unprotected from impact forces. Increased use of protective equipment may afford a significant opportunity for injury prevention in this sport; however, research concerning the effectiveness of protective equipment in rugby is needed.

This study used data from the Rugby Injury and Performance Project (RIPP) to study the association of various equipment items with injury. RIPP followed a cohort of rugby union players in Dunedin, New Zealand over the course of a season and collected detailed weekly information on the use of protective equipment, participation in rugby, and injury outcomes. This study reports injury rate ratios (RRs) by comparing users with non-users of each equipment item. In addition to an analysis of overall injury, RRs are presented for specific injury subgroups based on the type of injury each equipment item is expected to prevent.

Methods

Study design

Details of the study design and the demographics of the RIPP cohort have been reported previously.^{1,7} Participants initially took part in a pre-season assessment that included a questionnaire, anthropometric measurements, and fitness testing. The cohort was subsequently followed over the course of the 1993 competitive club season. Each week, cohort members were telephoned and interviewed about their participation in rugby, injury experience, and usage of protective devices and equipment during the previous week. Follow-up over the season was 90% complete.⁷

Description of equipment used

Protective devices and equipment examined were mouthguard, shinguards, padded headgear, taping of joints, head tape, support sleeves, and grease. Mouthguards are resilient appliances worn in the mouth to protect the teeth and the soft tissues of the mouth. Shinguards are protectors with fabric cushioning that absorb and dissipate external impact forces to the front of the lower leg. Padded headgear is constructed from fabric or leather and contains thin strips of impact-absorbing material but has neither a hard outer shell nor a face mask. Taping involves the application of adhesive tape, sometimes with strips of cloth, to body joints. Players sometimes also apply adhesive tape and/or cloth strips to the head for the purpose of protecting the ears from haematoma and other injury (head tape). Support sleeves are made from neoprene or elasticized material and are used to support body joints and insulate muscular areas such as the thigh. Grease (such as petroleum jelly) is also sometimes applied to body surfaces, in part to make it harder for opponents to grasp them and in part to prevent grazing and abrasions from contact with the ground.

Assessment of equipment usage

Each week, players were asked the following question: 'Did you use any protective gear or taping during team practices or games last week?' The seven items above (mouthguard, shinguards, padded headgear, taping of joints, head tape, support sleeves, and grease) were listed with pre-coded responses and a write-in space for any additional items. During the course of follow-up,

mouthguards were used for 65% of player-weeks, shinguards for 8%, headgear for 14%, taping for 24%, head tape for 5%, support sleeves for 8%, and grease for 14%.⁸

Assessment of rugby participation and in-season injury

Weekly data were collected on two distinct types of rugby participation: organized team practices and scheduled competitive games. An in-season injury was defined as an injury occurring during the competitive club season that required medical attention or caused the player to miss a scheduled game or team practice. Data on injuries in post-season competition were collected but are not included here. Information was collected on the body site and type of injury, the phase of the game in which the injury occurred, the level of medical treatment received, and whether the injury occurred during a competition game or team practice.

We conducted analyses for all injuries combined and for specific injury subgroups. The subgroups corresponded to those injuries that each equipment item was either designed to prevent or could reasonably be expected to prevent. We examined both mouthguard and headgear use in relation to concussion, since both equipment items have been promoted as affording some protection against brain injury.^{9–11}

Covariates

The RIPP cohort included players from the following levels of competition: Senior A, Senior B, Women, Colts, Schoolboys, and Schoolgirls (schoolgirls are not included in these analyses). Playing positions were grouped into the following categories: front row, locks, loose forwards, inside backs, and outside backs.⁸ The most frequent level of competition and playing position in which each participant played over the course of the season were used in the analysis. Time-dependent variables representing playing out of one's usual position and playing outside one's usual level of competition were also included.

Injury history was operationalized as three variables: injury in the previous season, pre-season injury status, and the cumulative frequency of in-season injury.⁸ An injury in the previous season was defined as any injury resulting from rugby participation in the 12 months prior to the start of the 1993 season that prevented the player from participating in at least one game or at least two practices, or that required medical attention. Pre-season injuries were defined as any current injury, whether rugby-related or not, that affected the athlete's ability to train pre-season. The cumulative frequency of in-season injury was time-dependent and was defined as the cumulative total of in-season injuries up to, and including, the previous week of follow-up. For analyses of specific injury subgroups, the injury history variables reflected the injury outcome being analysed (e.g. analyses of concussion as an outcome adjusted for the player's history of concussion) as opposed to the player's overall injury history.

Fitness level was based on pre-season performance on the following tests: aerobic endurance test (20 m multi-stage shuttle run), vertical jump height, left and right agility runs, anaerobic endurance test (high-intensity shuttle run), 30 m sprint time (rolling start), acceleration (rolling sprint time – standing sprint time), and number of standardized push-ups completed.¹² Players were ranked individually on their performance on each

test. The ranks were summed to create an overall fitness score, which was categorized into quartiles.

Psychometric covariates included in the analysis were inward expression of anger,¹³ sport competition anxiety,¹⁴ task orientation in sport,^{15,16} and negative affect.¹⁷ These continuous scores were categorized using quartile cut-points and represented in the model using indicator variables. Somatotype was represented by endomorphy, ectomorphy, and mesomorphy variables, based on pre-season skinfold measurements, and categorized into quartiles.^{12,18} Self-reported overall health status (4-point Likert scale, dichotomized as poor/not good vs good/excellent), length of previous rugby experience (continuous years, dichotomized as <6 vs ≥6 years), and perceived importance of injury to team performance (5-point Likert scale dichotomized as <3 vs ≥3) were also included in the analysis.

Statistical model

The outcome of interest was the injury rate, defined as the number of rugby injuries in each player-week divided by the number of player-exposures (games and scheduled team practices) in each player-week. Generalized Poisson regression was used to model the injury incidence rate and estimate incidence RRs for each covariate in the model. Participation in games and practices for each player-week of follow-up (the rate denominator) was included in the model as an offset.¹⁹ Because the data were longitudinal, a generalized estimating equation approach was used to fit the model.^{20,21} Based on examination of the data preparatory to modelling, the exchangeable form of the working correlation matrix was adopted. Clustering effects were weak at the individual level and essentially non-existent at the club level.

The analysis plan involved initially estimating an RR for the use of each protective equipment item adjusted for those covariates that were theorized to be most directly related to injury causation, namely, level of competition, playing position, playing outside one's usual level of competition, playing out of position, and injury history. Estimates from these models are

referred to as 'partially adjusted' estimates. A second set of covariates, considered to be indirectly related to injury causation (fitness score, inward anger, sport competition anxiety, task orientation in sport, negative affect, somatotype, overall health status, previous rugby experience, and perceived importance of injury to team performance), were added to models that already included the directly related covariates. This additional round of covariate adjustment produced 'fully adjusted' estimates. Owing to study size restrictions, the 'fully adjusted models' were fit only for those analyses dealing with overall injury.

Results

A total of 356 players were enrolled in the RIPP cohort. Of these, 29 individuals were excluded from the analysis presented in this article for the following reasons: did not complete the full pre-season assessment ($n = 10$), not followed at all during the season ($n = 8$), intermittent follow-up (<50% of the season, $n = 4$), participated in no rugby games or team practices ($n = 3$), and participated mainly in social games with limited exposure to competitive club play ($n = 4$). In addition, the 23 schoolgirls in the cohort were excluded from these analyses because their injury rate and use of protective equipment were too low, and the length of their season too short, to permit meaningful analysis. The remaining 304 players included 240 male and 87 female participants. The cohort accumulated a total of 8149 organized team practices and 4103 scheduled competitive games in 5378 player-weeks of follow-up.

During the follow-up period there were 543 injuries. For all injuries combined, use of protective devices and equipment had no detectable effect on risk, and no particular item was associated with an increase or a decrease in the risk of overall injury (Table 1).

In order to determine whether there were any protective effects for specific devices or equipment items, risk was examined for specific injury subgroups (Table 2). The subgroups corresponded to those injuries that each equipment item was either designed to prevent or could reasonably be expected to prevent. The use of

Table 1 Risk of injury by protective equipment usage for all injuries combined

Equipment item	Unadjusted		Partly adjusted ^a		Fully adjusted ^b	
	RR ^c	95% CI ^c	RR ^c	95% CI ^c	RR ^c	95% CI ^c
Mouthguard	1.01	0.81–1.25	1.08	0.86–1.36	1.11	0.86–1.43
Shinguards	0.94	0.69–1.29	0.92	0.65–1.31	0.87	0.60–1.26
Padded headgear	0.89	0.68–1.17	0.90	0.67–1.19	0.96	0.75–1.23
Taping body joints	0.95	0.75–1.21	0.88	0.69–1.12	0.99	0.83–1.33
Head tape	0.83	0.54–1.29	0.75	0.50–1.13	0.86	0.60–1.23
Support sleeve	0.97	0.68–1.40	1.00	0.70–1.42	0.93	0.67–1.27
Grease	1.00	0.79–1.26	1.05	0.81–1.35	0.96	0.75–1.24
Overall ^d	0.89	0.68–1.16	0.92	0.70–1.22	0.93	0.68–1.27

^a Adjusted for level of competition, playing position, playing outside usual level of competition, playing out of usual position, any injury in previous season, any pre-season injury, and cumulative frequency of in-season injury.

^b Adjusted for the variables listed in note a, plus body somatotype, level of physical fitness, self-reported overall health status, length of previous rugby experience, perceived importance of injury to team performance, inward expression of anger, sport competition anxiety, task orientation in sport, and negative affect.

^c RR, rate ratio; CI, confidence interval.

^d Any use of protective equipment.

Table 2 Risk of injury by protective equipment usage for selected injuries

Equipment item	Injury outcome	Number of injuries	Unadjusted		Adjusted ^a	
			RR ^b	95% CI ^b	RR ^b	95% CI ^b
Mouthguard	Damage to the teeth, mouth, or jaw	6	0.62	0.10–3.80	0.56	0.07–4.63 ^c
Shinguards	Laceration, contusion, or abrasion to the lower leg	11	3.14	0.83–11.95	4.22	0.82–21.75 ^d
Padded headgear	Concussion, auricular hematoma, cranial fracture, scalp laceration, scalp abrasion, or scalp contusion	47	0.85	0.38–1.87	0.81	0.34–1.94 ^e
Taping body joints	Sprain or strain to the upper limb, knee, or ankle	104	1.81	1.18–2.77	1.60	0.98–2.60
Head tape	Auricular haematoma, calp laceration, scalp abrasion, or scalp contusion	19	2.72	0.92–8.06	2.29	0.74–7.05
Support sleeve	Sprain or strain to the upper limb, knee, or ankle	104	0.54	0.23–1.28	0.58	0.26–1.27
Grease	Auricular haematoma, scalp laceration, scalp abrasion, or scalp contusion	19	1.69	0.68–4.22	2.09	0.73–6.03
Overall ^f	Any of the above	182	1.07	0.66–1.73	1.08	0.65–1.78

^a Adjusted for level of competition, playing position, playing outside usual level of competition, playing out of usual position, injury in previous season, injury pre-season, and cumulative frequency of in-season injury.

^b RR, rate ratio; CI, confidence interval.

^c Not adjusted for playing out of usual grade, injury in previous season, and cumulative frequency of in-season injury. Position coded as forwards vs backs.

^d Not adjusted for injury in previous season.

^e Not adjusted for playing out of usual level of competition and cumulative frequency of in-season injury.

^f Any use of protective equipment.

mouthguards appeared to protect against damage to teeth, mouth, and jaw (the number of dental injuries was too small, $n = 2$, to permit separate analysis). The use of headgear tended to be effective in reducing risk for the combined outcome of any scalp, ear, or concussive injury, and this association appeared to strengthen when the outcome was restricted solely to damage to the scalp and ear ($n = 25$ injuries; unadjusted RR = 0.80, 95% CI: 0.27–2.34; adjusted RR = 0.59, 95% CI: 0.19–1.85). The use of shinguards was consistently associated with an increase in the risk of injury to the lower leg. The use of support sleeves tended to be protective, while head tape, body tape, and grease were apparently associated with an increase in injury risk.

Finally, the risk of concussion ($n = 22$ injuries) was examined in relation to mouthguard and headgear use. The use of headgear did not appear to be associated with a reduction in the risk of concussion (unadjusted RR = 0.93, 95% CI: 0.34–2.58; adjusted RR = 1.13, 95% CI: 0.40–3.16), while the use of mouthguards appeared to slightly increase the risk of concussion (unadjusted RR = 1.62, 95% CI: 0.50–5.25; adjusted RR = 1.62, 95% CI: 0.51–5.11).

Discussion

Our results indicate that the protective devices and equipment currently permitted in the game of rugby union have limited preventive effect on injury risk. Decreases in the risk of orofacial and scalp injury tended to be associated with the use of mouthguards and padded headgear, respectively. With the exception of support sleeves, the other equipment items studied either appeared to have no effect on, or apparently increased, injury risk.

Strengths and limitations

The application of epidemiological methods to the study of sports injury has a long history.^{22–25} The prospective cohort design, in particular, is highly applicable to the study of risk

factors for athletic injury because injuries are a rapid-onset condition (relative to outcomes such as cancer) and have a high incidence in athletic populations.^{7,24} The use of a weekly telephone interview helped minimize bias due to inaccurate recall of injury events.^{7,26} It is possible that there was some underreporting of injury, but this would create a bias in our study only if underreporting of injury was associated with the use of protective equipment.

A limitation of our study was the small numbers observed for some specific injury subtypes. This resulted in low statistical power and wide confidence intervals for some of the associations examined. Because some of our findings are based on small numbers, they should be interpreted with caution.

Orofacial injury

Considerable support has been voiced for the injury prevention potential of mouthguards in sport in general,^{27–30} and rugby in particular.^{9,31–33} However, the majority of the scientific evidence in support of mouthguards is weak, largely because of methodological limitations in the studies that have been conducted to date.^{33,34} Apart from a number of cross-sectional studies,^{9,25,35–39} which provide a weak basis for causal inference,⁴⁰ there are only three studies of mouthguards in rugby that have employed quasi-experimental^{41,42} or observational³⁴ designs. The findings from these studies are equivocal, with two positive studies^{41,42} and one negative study.³⁴

Our study included a relatively small number of orofacial injuries; nevertheless, our findings provide some assurance that the positive results previously reported^{41,42} were real effects. We were able to control for potential confounders such as playing position, a methodological limitation of all three previous studies.

Taping, head tape, and support sleeves

Our a priori expectation was that taping, head tape, and support sleeves were unlikely to be effective in preventing injury in rugby. Support sleeves tended to be associated with a decreased

risk of sprains and strains to the ankle, knee, and upper extremities. This may be the result of better stabilization of the joint, either due to increased muscle activation resulting from the presence of the sleeve or due to the sleeve itself. Alternatively, the sleeve may prevent injury by providing insulation in cold weather conditions. Future research should explore the effect of the sleeves in more detail and distinguish prophylactic use of the sleeves from therapeutic use.

We observed an increased risk of injury for taping. On the basis of the existing literature, it seems implausible that taping would increase the risk of injury.^{43–49} This inconsistency may arise from the fact that, in addition to prophylactic application in an attempt to prevent injury, taping is also used to stabilize damaged joints, or other structures, following an injury. This therapeutic use may permit a player with a minor injury to continue to participate in the sport, possibly resulting in an aggravation of the minor injury at a later point in the season, thereby creating bias in our study.^{50,51} It is also possible that athletes using these items of equipment perceive that they are better protected from injury and therefore play in a riskier manner.

Concussion

We found no evidence of a protective association between padded headgear and concussion. This finding supports the recommendation that padded headgear should be worn principally for the prevention of lacerations and abrasions and has very little potential for preventing concussion.¹¹

Some authors have actively promoted the idea that the use of mouthguards can prevent concussion in rugby.^{9,10,31,32,42} However, two previous studies of the use of mouthguards and concussion^{34,42} present contradictory findings. No evidence of a protective effect of mouthguards against concussion was observed in the current study. Given the limited scientific evidence, it would be prudent to suspend promotion of the concept that the use of mouthguards can reduce the risk of concussion in rugby, at least until further research data is available.

Shin injury

Biomechanical studies have shown that shinguards reduce the impact force transmitted to the shin;⁵² however, we observed a

positive association between shinguard use and injury. All these injuries occurred during phases of play in which one player was at risk of being stepped on or trampled by another player ($n = 2$ in mauls and $n = 6$ in rucks). It is possible that the shinguards became dislodged during these vigorous contact phases of the games.

Conclusions

Previous research indicates that there is significant potential for protective equipment as an intervention to prevent injury in contact sports.⁵³ However, our findings suggest that, beyond support sleeves, mouthguards, and headgear, the protective equipment used in rugby appears to be largely ineffective in preventing injury. Of particular concern is the finding that mouthguards and padded headgear appear to offer very little, if any, potential for the amelioration of the risk of concussion in rugby.

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KEY MESSAGES

- In general, the protective equipment used in rugby union has limited effectiveness in preventing injuries.
- However, there was some evidence of protective effects for certain items: support sleeves (for preventing sprains and strains), mouthguards (for preventing orofacial injury), and padded headgear (for preventing scalp injury).
- Neither the use of mouthguards nor the use of headgear reduced the risk of concussion.

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