







Lowering the maximum legal tackle height in Scottish community women's rugby: an injury surveillance and video analysis study across two seasons

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ABSTRACT

Objectives The tackle carries the highest risk of concussion in women's rugby union. To reduce concussion risk, a lowered maximum tackle height (LTH) law, lowering the maximum legal tackle height from the shoulder to below the base of the sternum, was implemented across Scottish community rugby. This study aimed to assess the effect of the LTH on player head-contact events, proximity (location nearest the head (~30 cm)) and concussion incidence in Scottish women's community rugby.

Methods A retrospective video analysis study, alongside prospective injury data collection, compared differences in game metrics, tackle characteristics and time-loss injury (including concussion) between the pre-LTH (2022/2023) and LTH (2023/2024) seasons.

Results Head-to-head and head-to-shoulder proximity to the opponent for the tackler (head: rate ratio (RR):0.71 (95% CI 0.62 to 0.82), shoulder: RR:0.73 (95% CI 0.65 to 0.83)), and ball-carrier (head: RR:0.67 (95% CI 0.58 to 0.77), shoulder: RR:0.68 (95% CI 0.58 to 0.79)) were lower in the LTH season. Head contact to the opponent's shoulder decreased for the tackler (RR: 0.65 (95% CI 0.46 to 0.91)) and ball-carrier (RR: 0.52 (95% CI 0.35 to 0.78)). Tackler body position was lower (upright: RR:0.79 (95% CI 0.75 to 0.83), bent at waist: RR:1.34 (95% CI 1.25 to 1.42)), reducing red-zone (above the base of the sternum) contacts (RR:0.81 (95% CI 0.76 to 0.85)). Although non-significant, tackler concussion rates dropped (IR: 2.83 to 0.52/1000 player match hours; RR: 0.18 (95% CI 0.004 to 1.52)), while ball-carrier concussion rates increased (IR: 1.89 to 4.70/1000 player match hours; RR: 2.49 (95% CI 0.69 to 11.06)).

Conclusion Lowering the maximum tackle height to below the base of the sternum showed a reduction in red-zone contacts, head-to-head proximity and head-to-shoulder contact for the tackler and ball-carrier. There were no significant differences in concussion rates in the present study, and the limitations surrounding the small sample of injuries highlight the need for further research on the effect of injury prevention initiatives in women's rugby.

INTRODUCTION

Rugby Union (rugby) is a high-intensity evasion team sport characterised by

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Previous studies have assessed the effect of lowering the maximum legal tackle height in men's rugby, in a bid to reduce injuries, especially concussions.
- ⇒ Improvements in tackler behaviour were reported, although there were no reductions in tackler or ball-carrier concussion rates.

WHAT THIS STUDY ADDS

- ⇒ This is the first study to assess the effect of a lowered maximum tackle height in women's community rugby, presenting clear evidence of reductions in head-to-head and head-to-shoulder contacts over a season.
- ⇒ There were improvements in tackler behaviour, reducing height into contact, leading to reductions in red-zone (above the base of the sternum) contacts.
- ⇒ Aligning with previous studies, there were no significant differences in tackler or ball-carrier concussion rates.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ The lowered maximum tackle height can be effective in women's rugby to reduce head contact and head proximity to high-risk areas, without negative changes in ball-carrier contact behaviour in response to tackler height.
- ⇒ Further rigorous community-wide injury surveillance, in combination with video analysis, is required to fully understand the effect of a lowered tackle height on injuries and concussions in women's rugby.

intermittent bouts of contact and non-contact activity.¹ Due to its contact nature, injury rates are high, with 35.6–166.7 injuries/1000 hours reported across playing levels in women's rugby using a >24 hour time-loss injury definition.^{2–4} Sport-related concussion (SRC) is among the top injury diagnoses,^{4,5} with rates of 5.5/1000, 15/1000 and 26.7/1000 hours

reported in women's amateur, professional and international levels, respectively.^{2,3,6}

The tackle is the most common contact event⁷ and is responsible for 66% of match injuries in community women's rugby.⁸ In women's rugby, 70% of SRC (3.4/1000 tackle events) are reported to occur during the tackle,^{9,10} with tacklers sustaining more SRCs than ball-carriers (18.1 vs 11.5/1000 match hours).¹¹ Weaker neck strength in women has been documented across the literature,^{12,13} and decreases in head stability could increase whiplash occurrences,¹⁴ which may be a key contributor to concussive events in women's rugby.¹²

With high rates of SRC in women's rugby, questions persist regarding how to make rugby safer across playing levels.¹⁵ As such, the tackle, as the most injurious and concussive match event, has come under increasing scrutiny.¹⁶ In 2023, World Rugby published global guidance to lower the maximum legal tackle height. Scottish Rugby adopted this guideline and implemented a reduced legal tackle height to below the base of the sternum.¹⁷ The goal of this global law variation was to minimise the prevalence of shared head space between the tackler and ball-carrier to reduce dangerous head-proximity and head-contact events. Changes in maximum tackle-height laws, to the line of the armpit, have been previously observed in professional and university men's rugby with mixed results.^{18,19} However, it is unclear whether these findings can be translated to the women's game.

This study aims to evaluate the effect of the lowered maximum tackle height (LTH) law variation on: (1) tackle-related head-to-head and head-to-shoulder contact and proximity, between the ball-carrier and tackler; and (2) tackle-related injury and SRC rates, in women's community rugby players in Scotland.

METHODOLOGY

As part of a larger international project funded by World Rugby, a retrospective video-analysis study was used to assess the effect of the LTH law variation on tackle characteristics in community women's rugby in Scotland. Additionally, prospective injury surveillance (from a pre-existing World Rugby project held at the University of Edinburgh) was used to supplement the current LTH law variation study as this provided injury data across the same seasons and the same Scottish leagues and teams.

This study compared 'pre-LTH variation' (season 2022/2023) law, 9.13, 'A player must not tackle an opponent early, late or dangerously. Dangerous tackling includes, but is not limited to, tackling or attempting to tackle an opponent above the line of the shoulders even if the tackle starts below the line of the shoulders', with 'LTH variation' (season 2023/2024) law, reducing the maximum legal tackle height to below the base of the sternum. Ethical approval was gained from the University of Edinburgh Moray House School of Education and Sport research ethics committee (HGOR20102023; DPAL29062022).

Video footage and injury data were collected across Scottish community women's rugby from: (1) the Premiership and Sarah Beaney Cup (highest level community rugby in Scotland) and (2) lower league tiers (eg, regional leagues, Shield, Plate and Bowl competitions). Scottish women's league competitions are played from August to January and cup competitions from February to May. The average number of league games played by a team in a season is 14, with additional cup games possible (depending on team success), although not all fixtures are filmed.

The sample size for this study was set as part of the larger World Rugby Project, estimating approximately 10 000 tackle actions for analysis. Across both seasons, within the Premiership, there were 98 fixtures, with additional cup, plate, shield and bowl fixtures (n=54). All available fixtures were acquired by the SRU and subsequently shared with the research team (n=87; 57% of fixtures). To assess the quality of the match footage, a video quality assessment framework was used (online supplemental file 1).²⁰⁻²² 34 matches from pre-LTH (n=16) and LTH seasons (n=18) were considered suitable for coding (online supplemental file 3), following a quality review assessment, yielding 11 332 tackle actions for analysis. 28 (82%) matches (incorporating seven teams) were from the Premiership or Sarah Beaney Cup competitions, the remaining six games (18%; incorporating nine teams) were from the shield, plate and bowl competitions in regional leagues (including both home and away teams in some matches). Due to the limited availability of high-quality footage, randomised selection was not feasible.

Coding

An SRU-specific NacSport (NacSport Scout, Las Palmas De Gran Canaria) coding template was generated based on an adapted version of the Rugby Union Video Analysis Consensus statement.²⁰ Inter-rater and intra-rater reliability measures, using international footage with gold standard coding, were used to assess framework suitability following an initial workshop. Poor scoring variables (ie, variable reliability $\alpha < 0.61$) were reviewed using further group workshops, during which some variable categories were condensed, and variable interpretation was refined. HW achieved substantial reliability, using standardised 10-tackle, with the wider group ($\alpha = 0.82$). A mid-point inter-rater and intrarater reliability check halfway through the video coding period was conducted with the wider group to ensure coding quality was maintained ($\alpha = 0.92$). Scottish Rugby coders also completed an internal reliability measure, using a community-level 20-tackle test. HW achieved substantial agreement (inter: 86%, $\alpha = 0.80$; intra: 94%, $\kappa = 0.91$).²³

All 34 games were coded by HW, and coding was split into two phases: (1) tagging match events and (2) tackler(s) and ball-carrier tackle characteristic labelling (online supplemental file 2). Following SRU guidance, initial points of contact to the ball-carrier were combined postcoding, creating contact zones that were labelled as

(1) red-zone: head/neck and upper-torso; (2) amber-zone: hip, upper-leg, knee and lower-leg; (3) green-zone: arm and lower-torso. During video coding, inconclusive labels were used for unclear events, and tertiary tackler actions were excluded. The tertiary tackler was not included in labelling as they were not being targeted within this law change and constraints surrounding sample and time.

Injury surveillance

Prospective injury data were collected in a cohort of Scottish community women's rugby players using standardised forms as part of a pre-existing World Rugby-funded study (grant no. UofE10875751). Injury data were reported from 10 teams (208 players) involved in: (1) the Premiership and Sarah Beaney Cup (highest level community rugby in Scotland; n=4 teams) and (2) lower league tiers (eg, regional leagues, shield, plate and bowl competitions; n=6 teams). In line with community rugby consensus guidelines,²⁴ injuries with >24 hour time-loss were reported by team representatives, who, most commonly, were non-medical. All match injuries were recorded, including the location, type and mechanism of injury (ie, tackle related). Match exposure was calculated weekly using online forms, assuming 80-minute matches with 15 players per team (eight forwards, seven backs). Overall, there were 2117 match exposure hours in the pre-LTH season and 1915 match exposure hours in the LTH season.

Outcome measures

The primary video outcomes were head-contact (location the head contacts) and head-proximity (location nearest the head (within ~30 cm)) of each player to their opponent at the first point of contact. Tackle events

were differentiated from tackle actions (all tacklers per event, eg, one tackle event with a primary and secondary tackler equals two tackle actions).²⁰ Injury outcomes were reported as injury incidence (>24 hour time-loss; injuries/1000 match-hours, 95% CI), encompassing suspected and medically diagnosed SRC.²⁴

Data analysis

Data analysis was completed using Stata statistical software, V.12, released in 2021 (StataCorp, College Station, Texas, USA). Rate ratios (RR) with 95% CI were calculated for game events (table 1), tackle characteristics (table 2) and injury and SRC (table 3) to compare each outcome from the pre-LTH season (reference) with the LTH season. Statistical significance was determined using 95% CIs, with overlapping CIs considered non-significant. Data were checked for overdispersion. A negative binomial regression was used when overdispersion was present. A Poisson regression was used otherwise.

Patient and public involvement

There was no direct patient or public involvement in the study. The coding framework and research questions were informed by the requirements of the larger World Rugby study and SRU.

Equality, diversity and inclusion statement

The author group is gender balanced and consists of researchers from different disciplines, at varying stages of their careers, from multiple countries (UK, South Africa). The study population used a selection of community women's rugby players in Scotland and is the first evaluation of a law change in women's rugby.

Table 1 Game events for pre-LTH and LTH seasons expressed as average per game with 95% CI

Game event	Pre-LTH (season 2022/2023) (95% CI)	LTH (season 2023/2024) (95% CI)	Rate ratio (95% CI)
Ball in play time	32:46 (30:09 to 35:22)	30:03 (27:48 to 32:19)	0.92 (0.82 to 1.02)
Tackle events (primary)	257 (234 to 280)	224 (205 to 243)	0.87 (0.77 to 0.99)*
Total tacklers (tackle actions)	362 (329 to 394)	308 (282 to 334)	0.85 (0.75 to 0.96)*
Secondary tacklers	105 (94 to 116)	84 (75 to 93)	0.80 (0.69 to 0.93)*
Passes	295 (263 to 327)	259 (232 to 286)	0.88 (0.76 to 1.02)
Kicks out of hand	13 (10 to 17)	16 (12 to 20)	1.19 (0.85 to 1.67)
Rucks	85 (72 to 98)	75 (62 to 88)	0.89 (0.73 to 1.08)
Jackals	55 (49 to 61)	51 (40 to 61)	0.92 (0.75 to 1.14)
Attempted offload	35 (27 to 43)	32 (29 to 38)	0.91 (0.70 to 1.19)
High tackle (HT) sanction†	3 (2 to 5)	8 (5 to 10)	2.38 (1.31 to 4.34)*
Other sanction‡	22 (18 to 26)	22 (19 to 26)	1.00 (0.78 to 1.28)

* Indicates statistical significance.

† HT sanctions include advantages, penalties and yellow cards.

‡ Other sanctions include all other advantages, penalties and yellow cards.
LTH, lowered maximum tackle height.

Table 2 Tackle characteristics (tackle type, tackler and ball carrier body position and initial contact point) expressed as events per 100 tackle actions

Tackle type†	Pre-LTH (Season 2022/2023) (95% CI)	LTH (Season 2023/2024) (95% CI)	Rate ratio (95% CI)
Active shoulder	1.19 (0.90 to 1.48)	1.96 (1.58 to 2.34)	1.65 (1.21 to 2.24)*
Passive shoulder	21.56 (20.34 to 22.79)	26.57 (25.17 to 27.97)	1.23 (1.14 to 1.33)*
Smother	19.27 (18.12 to 20.43)	15.69 (14.61 to 16.77)	0.81 (0.74 to 0.89)*
Arm	49.12 (47.27 to 50.96)	45.53 (43.70 to 47.36)	0.93 (0.88 to 0.98)*
Push down	2.20 (1.81 to 2.59)	2.42 (2.00 to 2.85)	1.10 (0.86 to 1.41)
Ball rip	2.31 (1.91 to 2.71)	1.75 (1.39 to 2.11)	0.76 (0.58 to 0.99)*
Other‡	3.37 (2.89 to 3.86)	3.35 (2.85 to 3.84)	0.99 (0.81 to 1.22)
Illegal high tackle	0.88 (0.64 to 1.13)	2.60 (2.16 to 3.03)	2.94 (2.12 to 4.07)*
Illegal§	0.09 (0.01 to 0.17)	0.13 (0.03 to 0.23)	1.49 (0.47 to 4.70)
Tackler body position¶			
Upright	61.91 (59.86 to 63.95)	48.92 (47.04 to 50.79)	0.79 (0.75 to 0.83)*
Bent at Waist	30.13 (28.70 to 31.55)	40.26 (38.56 to 41.96)	1.34 (1.25 to 1.42)*
Falling or diving	7.97 (7.23 to 8.70)	10.82 (9.94 to 11.70)	1.36 (1.20 to 1.54)*
Ball-carrier body position¶			
Upright	87.68 (85.24 to 90.11)	86.18 (83.69 to 88.66)	0.98 (0.94 to 1.02)
Bent at waist	7.96 (7.23 to 8.70)	8.65 (7.86 to 9.44)	1.09 (0.95 to 1.24)
Falling or diving	1.56 (1.24 to 1.89)	1.12 (0.84 to 1.40)	0.72 (0.52 to 0.99)*
Pick and go	2.79 (2.36 to 3.23)	4.05 (3.51 to 4.59)	1.45 (1.18 to 1.78)*
Tackler contact point on ball-carrier body**			
Head/neck	0.84 (0.60 to 1.09)	0.31 (0.16 to 0.46)	0.36 (0.21 to 0.64)*
Arm	3.79 (3.28 to 4.30)	3.91 (3.38 to 4.45)	1.03 (0.85 to 1.25)
Upper torso	46.73 (44.93 to 48.53)	38.04 (36.37 to 39.71)	0.81 (0.77 to 0.86)*
Lower torso	32.93 (31.42 to 34.44)	34.37 (32.78 to 35.96)	1.04 (0.98 to 1.11)
Hip	3.54 (3.05 to 4.03)	3.23 (2.74 to 3.71)	0.91 (0.74 to 1.12)
Upper leg	11.26 (10.38 to 12.15)	17.76 (16.62 to 18.90)	1.58 (1.42 to 1.74)*
Knee	0.34 (0.19 to 0.49)	0.74 (0.51 to 0.98)	2.18 (1.26 to 3.77)*
Lower leg	0.56 (0.36 to 0.75)	1.64 (1.30 to 1.99)	2.95 (1.96 to 4.45)*

*Indicates statistical significance.

† Inconclusive tackle type n=589 excluded.

‡ Other Tackle category inclusive of chop, jersey, seatbelt and tap tackles.

§ Illegal Tackle category inclusive of late and tip tackles.

¶ Inconclusive body position n=296 (tackler) n=290 (ball-carrier) excluded.

** Inconclusive initial contact point n=529 excluded.

LTH, lowered maximum tackle height.

RESULTS

The pre-LTH variation sample consisted of 4111 tackle events and 5791 primary and secondary tackle actions. The LTH variation sample consisted of 3926 tackle events and 5541 primary and secondary tackle actions.

Game events

Between the pre-LTH season and LTH seasons, significant reductions in tackle events and actions were observed (table 1). During the LTH season, the mean number of sanctions per match remained consistent. However, the mean number of high tackle (HT) sanctions significantly

increased from three to eight per match (RR 2.38 (95% CI 1.31 to 4.34)) (table 1).

Tackle characteristics

During the LTH season, active shoulder, passive shoulder and sanctioned (illegal) HT increased, while arm and ball-rip tackles decreased (table 2). Tacklers entered contact more often bent at the waist or falling/diving during the LTH season (bent at waist: RR 1.34 (95% CI 1.25 to 1.42); falling/diving: RR 1.36 (95% CI 1.20 to 1.54)) and the rate of upright tacklers reduced from 62 (60 to 64) events per 100 tackle actions to 49 (47 to 51)

Table 3 Injury and SRC rates for overall and tackle-related injuries across the pre-LTH and LTH seasons

		Pre-LTH (Season 2022/2023)		LTH (Season 2023/2024)		Rate Ratio (95% CI)
		No. of Injuries	Injuries/1000 hours (95% CI)	No. of Injuries	Injuries/1000 hours (95% CI)	
All injuries	Match	55	25.98 (19.57 to 33.81)	34	17.76 (12.30 to 24.81)	0.68 (0.43 to 1.07)
	Tackle-related	31	14.64 (9.95 to 20.78)	23	12.01 (7.61 to 18.02)	0.82 (0.46 to 1.45)
	Ball carrier	17	8.03 (4.68 to 12.86)	18	9.40 (5.57 to 14.86)	1.17 (0.57 to 2.42)
	Tackler	14	6.61 (3.61 to 11.09)	5	2.61 (0.85 to 6.09)	0.39 (0.11 to 1.16)
Concussion	Match	15	7.08 (3.97 to 11.68)	15	7.83 (4.38 to 12.92)	1.11 (0.50 to 2.43)
	Tackle-related	10	4.72 (2.26 to 8.69)	10	5.22 (2.50 to 9.61)	1.11 (0.41 to 2.96)
	Ball carrier	4	1.89 (0.51 to 4.84)	9	4.70 (2.15 to 8.92)	2.49 (0.69 to 11.06)
	Tackler	6	2.83 (1.04 to 6.17)	1	0.52 (0.01 to 2.91)	0.18 (0.004 to 1.52)

LTH, lowered maximum tackle height.

(RR 0.79 (95% CI 0.75 to 0.83)). Ball-carriers reduced falling/diving entry and entered contact more often with a pick-and-go body position (table 2). When assessing the interaction between ball-carrier and tackler body position, tacklers bent their body position more frequently regardless of ball-carrier body position (online supplemental file 4). Conversely, no changes in ball-carrier body position were seen as a function of the tackler.

The rate of tackler initial contact point to ball-carrier head/neck and upper-torso decreased significantly (head: RR 0.36 (95% CI 0.21 to 0.64) and upper-torso: RR 0.81 (95% CI 0.77 to 0.86)), while the rate of contact to the upper-leg, knee and lower-leg significantly increased (upper-leg: RR 1.58 (95% CI 1.42 to 1.74), knee: RR 2.18

(95% CI 1.95 to 4.45) and lower-leg: RR 2.95 (95% CI 1.96 to 4.45)) in the LTH season (table 2). Initial contact point variables were combined to create contact zones (figure 1). The rate of red-zone contact was significantly less in the LTH season (RR 0.81; (95% CI 0.76 to 0.85)) and amber-zone contact increased significantly (RR 1.49 (95% CI 1.36 to 1.62)), from the pre-LTH season to LTH season (figure 1).

Tackler's head-contact and head-proximity

Figure 2A shows the location of tackler head-contact to ball-carrier (figure 2A right) and tackler head-proximity to the ball-carrier's body at the first point of contact (head-contact; figure 2A left). There was a 35%

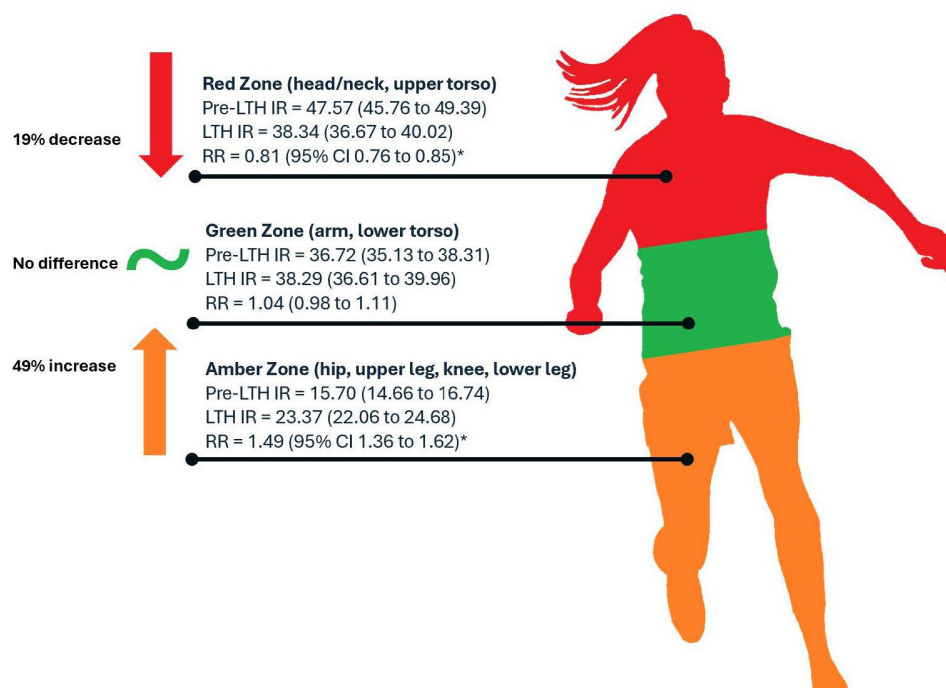
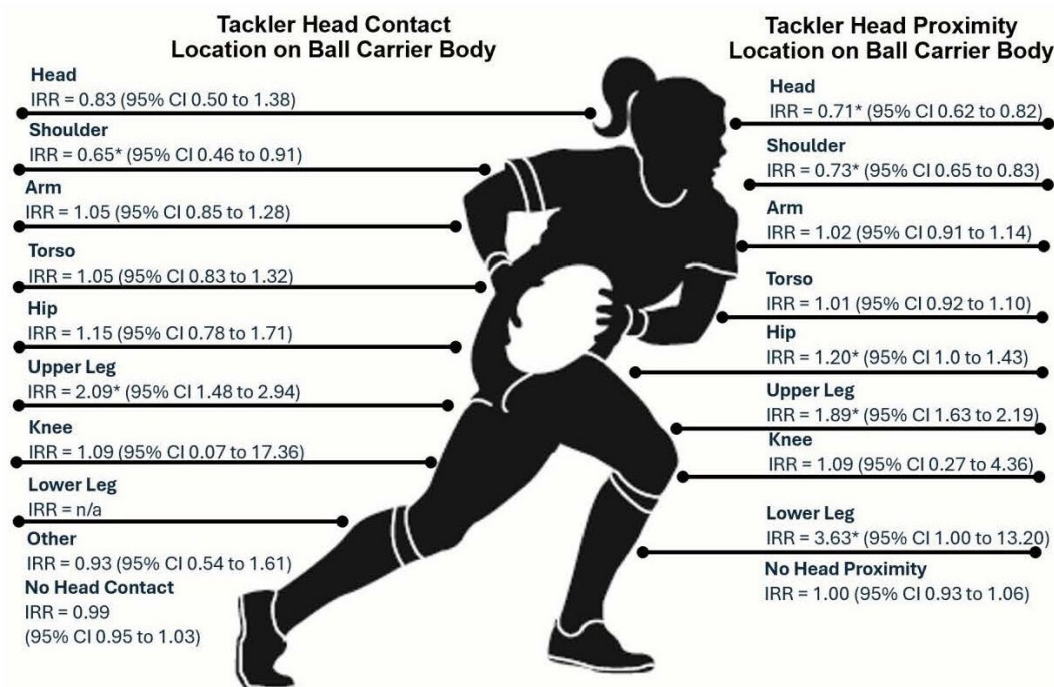


Figure 1 Tackle contact zones pre-lowered tackle height (LTH) versus LTH expressed per 100 tackle actions. IR, incidence rate; RR, rate ratio. *Indicates statistical significance.

A



B

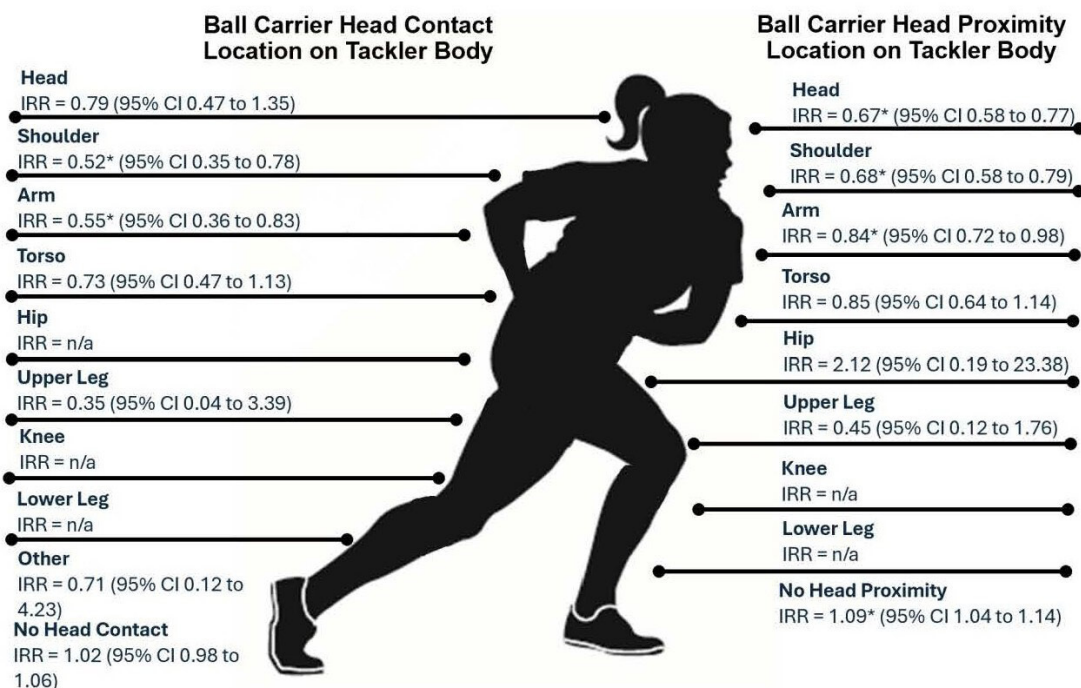


Figure 2 (A) Rate ratios for tackler head contact and head proximity to the respective body location of the ball-carrier. (B) Rate ratios for ball-carrier head contact and head proximity to the respective body location of the tackler. IRR, incidence rate ratio. *Indicates statistical significance.

reduction in the rate of tackler head-contact with ball-carrier shoulder (RR 0.65 (95% CI 0.46 to 0.91)) and a 2-fold increase in the rate of tackler head-contact to ball-carrier upper-leg (RR 2.09 (95% CI 1.48 to 2.94)).

There was a reduction in the rate of tackler head-proximity to ball-carrier head (RR 0.71 (95% CI 0.62 to 0.82)) and shoulder (RR 0.73 (95% CI 0.65 to 0.83)) and an increase in the rate of tackler head-proximity

with ball-carrier upper-leg in the LTH season (RR 1.89 (95% CI 1.63 to 2.19)).

Ball-carrier head-contact and head-proximity

Figure 2B highlights the location of ball-carrier head-contact to tackler (figure 2B right) and ball-carrier head-proximity to the tackler at the first point of contact (head-proximity; figure 2B left). There were reductions in the rate of ball-carrier head-contact to tackler shoulder and arm (shoulder: RR 0.52 (95% CI 0.35 to 0.78); arm: RR 0.55 (95% CI 0.36 to 0.83)). There was a decrease in the rate of ball-carrier head-proximity to tackler head, shoulder and arm (head: RR 0.67 (95% CI 0.58 to 0.77); shoulder: RR 0.68 (95% CI 0.58 to 0.79); arm: RR 0.84 (95% CI 0.72 to 0.98)). An increase in the rate of the ball-carrier head not being in proximity with any part of the tackler (RR 1.09 (95% CI 1.04 to 1.14)) was observed. All head-contact and head-proximity rates with 95% CI are provided in online supplemental files 5 and 6.

Injury and SRC rates

There were no significant differences in all or tackle-related injury or SRC rates between the two seasons (table 3). In total, 30 concussions (15 in pre-law variation, 15 in law variation) were observed. Approximately, 67% (20/30) of all reported concussions were tackle-related (pre-LTH variation: 10/15, 67%; LTH variation: 10/15, 67%).

DISCUSSION

This is the first study evaluating a LTH and its effect on tackle characteristics, head contact and injury in Scottish community women's rugby. Tacklers entered the tackle with a lower body position, resulting in a significant reduction in red-zone contacts (above the base of the sternum). Tackler head-proximity to ball-carrier head and shoulder and head-contact to ball-carrier shoulder reduced with the introduction of the LTH. Similarly, the rate of ball-carrier head-proximity to tackler head and shoulder and head-contact to the shoulder decreased during the LTH season. There were no statistically significant differences in injury or concussion rates between the pre-LTH and LTH seasons.

Lowered tackle height

The LTH variation decreased the rate of upright tackles, in turn increasing green-zone (below the sternum) contacts to the ball-carrier. The tackle is an optimal target for injury prevention in rugby due to its frequent nature² and heightened concussion risk.¹⁰ An LTH variation has been proposed as a means of reducing the number of instances in which the tackler and ball-carrier share the same head space, in order to reduce head contact and SRC.^{18 25} Results in the present study show a positive change in player behaviour, where a significant reduction in the number of times tacklers made red-zone contacts (above the sternum), and a concurrent increase in green-zone contacts with the ball-carrier was observed. Two

previous studies, evaluating a smaller reduction in the maximum legal tackle height (ie, below the line of the shoulder to below the line of the armpit), in professional and university men's rugby reported similar differences in player behaviour and reductions in tackler height into contact.^{18 26} They also reported decreases in tackler upright tackles and tackler contact to ball-carrier head and neck during the LTH period.¹⁸

Body position, head-proximity and head-contact

Lowering the maximum legal tackle height increased the rate tacklers entered the contact bent at waist, which reduced the rate of head-contact and proximity to the high-risk body areas (eg, ball carriers head and shoulder). Similar to the study by Stokes *et al*,¹⁸ significant differences in tackler body position, regardless of ball-carrier body position, were observed in the present study, with tacklers more frequently entering contact bent at the waist rather than upright, during the LTH period. Conversely, there were no observed differences in ball-carrier body position into the tackle (ie, a concurrent reduction in height into the tackle, meaning the chances of tackler and ball-carrier heads sharing the same space likely reduced). During the LTH season, there were significant reductions in tackler and ball-carrier head-to-head and head-to-shoulder contact and proximity. In professional men's rugby union, the risk of tackler head injury assessments is lower when players enter the contact bent at the waist versus upright.^{27 28} In contrast, in professional women's rugby league, the rate of head injury events did not differ based on the body position of the players entering the tackle.²⁹ In a varsity women's rugby union cohort, the odds of suspected SRC also did not change based on tackler body position into contact.²⁵ Neither of these women's studies directly involved an LTH evaluation and were based on video-coded risk factor analyses.

Injury and concussion

In the present study, there were no significant differences in tackle-related injury and SRC rates between seasons, as observed in similar studies.^{18 19} Overall, there were six tackler concussions in the pre-LTH season and one in the LTH season, and conversely, there were four ball-carrier concussions in the pre-LTH season and nine in the LTH season. While overall injury numbers were low, the present study suggests the effect of the LTH variation may vary within women's rugby when comparing the tackler and the ball-carrier. In an Irish rugby community study, women were reportedly more likely to be injured being tackled than tackling, while there were no differences observed in men.² Differences in study methodology, injury reporting, cohorts used and periods of observation may explain some of the results. There are also known differences in SRC risk between the men's and women's game which may influence the results from the present evaluation. For example, there are differences in player speed and acceleration in contact,^{25 28} cervical musculature and mechanisms for concussion,¹² and

playing experience and tackle proficiency.^{30 31} Hence, these results highlight the need for further tackle-related prevention research specific to the women's game.

To date, evidence is limited and equivocal on the SRC risk effect of lowering the tackle. In university men's rugby, injury and SRC rates did not differ during an LTH.¹⁹ In professional men's rugby, despite decreases in head-contact events, overall SRC rates did not change and tackler SRC rates unexpectedly increased.¹⁸ There remains a lack of data on the effect of an LTH in women's rugby, particularly at the community level, where skill level and playing experience vary greatly compared with men's professional and elite cohorts.³²

Unintended consequences

Unintended consequences were an exploratory analysis of the study. Although there were no significant differences in SRC between the two seasons, further research should be completed to understand if changes in tackle technique may lead to increases in ball-carrier head accelerations. A key risk factor for tackle-related injury is poor technique, both for the tackler and the ball-carrier.³³ In a community women's context, the variation in playing ability and experience, and hence, tackle technique is likely even greater.³⁴ This could result in more pronounced effects when considering the implications of a tackle-targeted prevention intervention, such as a change in tackle height like the current study. Increases in dominant, active shoulder tackles coupled with a lowered point of contact on the ball-carrier, in the present study, may have influenced ball-carrier head acceleration.³⁵ Altering ball-carrier head acceleration and the risk of head-to-ground contacts (due to uncontrolled whiplash mechanisms) may be responsible for possible higher ball-carrier SRC rates observed.¹² Implementing tackle-related training for both the tackler and ball-carrier, inclusive of tackle and falling proficiency, as well as training of player cervical musculature, may be beneficial in reducing this risk in women's rugby.^{12 30 36 37}

Exploratory analysis also highlighted no changes in ball-carrier body position regardless of tackler position. Some nations involved in the wider World Rugby study introduced an additional law variation to prevent ball-carriers dropping height prior to contact.^{38 39} This was done to avoid dangerous play, whereby the tackler and ball-carriers' heads would still occupy the same space and to stop players exploiting tackler height reductions to gain a competitive or penalty advantage.³⁸ In Scotland, this additional law variation was not adopted. Positively, when the relationship between ball-carrier and tackler body position was assessed in the present study, there were no significant increases in ball-carriers entering the tackle bent at the waist in response to the tackler's lower position. This implies that the LTH variation was effective at reducing the frequency of 'shared head space' in the Scottish community women's rugby.

Research/policy implications

The present study provides key insights into the effects of a lowered maximum legal tackle height law on head-contact, head-proximity and SRC in community women's rugby. Future research should build on current knowledge encompassing robust, community-wide injury surveillance with video analysis to understand the effect of the law on injury and SRC.

Strengths and limitations

This is the first study assessing an LTH in community women's rugby, using over 11 000 tackles alongside prospective injury surveillance reporting across two seasons. The rigorous two-phase reliability process, completed using gold-standard coding and differing playing levels with: (1) the wider World Rugby group and (2) the SRU, included re-assessment of reliability halfway through the coding process, ensuring robust findings. Ahead of the LTH season, the SRU delivered workshops and online resources to coaches, referees and players, to help community engagement with the LTH. Anecdotally, this likely had a positive influence on the uptake and success of the LTH in Scotland.¹⁸

A study limitation was the lack of available high-quality footage in women's community rugby. Only 34 games met the inclusion requirements, which prevented randomised selection. Furthermore, lower quality match footage meant there were an increased number of inconclusive events, thus reducing the tackle sample size. Despite this, the number of coded tackles still met World Rugby's study sample size calculation. The study is, therefore, sufficiently powered to assess the primary aim. No correction for multiple comparisons was applied during data analysis due to the exploratory nature of the study. Such an overly conservative approach could inflate type II error rates with the current sample. The LTH variation has only been evaluated over a single season, and a longer assessment period would provide additional time for players and officials to adjust to the LTH. Subsequent seasons would allow for temporal differences to be evaluated, providing further insight into the effect of the LTH and adherence to the law change over time.

Finally, for the prospective community surveillance data, injuries and SRC were reported by largely non-medical team representatives rather than qualified medical personnel (as in previous studies) and not linked to video coding. Although the analysis of match footage alongside injury reporting was a strength of the current study, precise causal interpretation between the two datasets cannot be made as postmatch injury diagnoses could not be aligned with video events. Overall injury numbers were low and, as such, the study is likely underpowered to assess the secondary aim. Despite this, across a typical eight-team league season, it is estimated that approximately 154 tackler and 158 ball-carrier head-to-head and head-to-shoulder contacts may have been prevented. While not all head contacts would necessarily result in a concussion, this does indicate a potential meaningful

reduction in these concussive events. Continued rigorous community-wide injury surveillance data, linked directly with video footage, would help improve knowledge and understanding of the true effect of large-scale injury reduction initiatives such as this law change, in the future.

CONCLUSION

Reducing the maximum legal tackle height in Scottish women's community rugby resulted in the desired differences in tackler behaviour, alongside reductions in tackler and ball-carrier head contact and head proximity to the opposition's head and shoulder. There were no significant differences in ball-carrier or tackler injury or concussion rates between seasons. This may help provide key insights into the effects of the LTH in this cohort and provide information that can inform future injury prevention initiatives in women's community rugby in Scotland and beyond. This study also highlights that further research on the effect of injury prevention initiatives in women's rugby continues to be much needed.

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