

Are we tackle ready? Cross-sectional video analysis of match tackle characteristics in elite women's Rugby Union

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Abstract

The tackle contest is the most common and most injurious match contact event in rugby and is an indicator of performance. *Tackle Ready* is World Rugby's tackle technique education program. Limited research has characterized the tackle contest in women's rugby. The purpose of this study is to: (1) identify the match situational characteristics, ball-carrier and tackler technical actions demonstrated in elite women's Rugby Union and (2) to determine the extent to which *Tackle Ready* recommended tackle techniques were exhibited. Technical characteristics for 1500 tackle events in the 2022–2023 Women's Six Nations Championship were visually assessed according to a predefined coding framework and the *Tackle Ready* program. Tackles lacked full completion (0.2%) of the 22 coded *Tackle Ready* techniques with 47% of the recommended techniques demonstrated in each tackle on average (range 15%–98%). A high proportion of tackles involved two defenders (48%), approaching ball-carriers from the side (38%) or oblique angles (39%), in an upright position (30%), and with initial contact made with the arm (51%). Incorrect pre-contact head positioning and head placement upon contact accounted for 50% and 15% of tackles, respectively, and there was a mean of 14 (95% CI 11–18) head and neck contacts to a tackler and 18 (95% CI 14–22) head and neck contacts to a ball-carrier per game. Targeted interventions to encourage adoption of recommended techniques are needed to reduce tackle-related injury risk in women's rugby. This study provides valuable context for future discussion across law enforcement, coach education and gender-specific tackle coaching in the women's game.

KEYWORDS

ball-carry, rugby union, tackle, video analysis, women

Highlights

- Retrospective video analysis of a random subset of 1500 tackles from all 15 games in the 2022–2023 Women's Six Nations revealed low overall completion of recommended *Tackle*

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Ready techniques with 47% of the recommended techniques exhibited in each tackle on average.

- Incorrect pre-contact head positioning and head placement upon contact accounted for 50% and 15% of tackles, respectively, and there was a mean of 14 head and neck contacts to a tackler and 18 head and neck contacts to a ball-carrier per game.
- A high proportion of tackles involved two defenders (48%) and upright body positions (30%).

1 | INTRODUCTION

The tackle is the most common contact event in women's rugby union (henceforth “rugby”) match-play, and successful tackle completion is the key to team success (Scott et al., 2023; West, Shill, Clermont, et al., 2022). Tackle events involve one or more defenders attempting to impede the ball-carrying, attacking player from gaining territory and scoring points (Scott et al., 2023). The tackle event is also associated with the greatest risk (67% of all match injuries) and burden of injury (615 days absence per 1000 h) (Starling et al., 2023; West, Shill, Sutter, et al., 2022). As such, the tackle is a priority area of focus for injury prevention strategies (Hendricks et al., 2023).

To effectively reduce the risk of injury, Finch (2006) proposed the Translating Research into Injury Prevention Practice model, which emphasizes the importance of understanding risk factors for injury (stage 2). One of the major risk factors for tackle injury is sub-optimal tackler technique (Hendricks et al., 2015). Previous studies have used video analysis to characterize the tackle contest and tackler techniques associated with success and injury in men's rugby (Hendricks et al., 2014, 2015). Video analysis continues to rely heavily on isolated measures of performance, such as tackle counts or number of successful tackles (den Hollander et al., 2018; Colomer et al., 2020). In video analysis, these studies may be considered “what” studies as they provide the frequency of key events in matches. Arguably, these “what” studies fulfill the first step in injury prevention and performance models as they provide the epidemiological/descriptive basis for the second step, which is how these events occur—for example, actions and techniques that increase the likelihood of a successful tackle (Hendricks et al., 2014, 2015). Similarly, studies in Women's Rugby League and varsity competitions have highlighted technical components of tackling associated with suspected concussions and head impact events (McLeod et al., 2023; Shill et al., 2024). Shill et al. (2023) found that youth female tacklers had a twofold greater rate of injury compared with youth male tacklers. Furthermore, considering the differences in physical, technical and tactical aspects of rugby match play between men's and women's rugby, a detailed understanding of women's tackle technical actions (“how” studies) will help in the design of sex-specific injury prevention strategies and implementation of tackle training programmes that mirror the specific demands and requirements of the women's game (den Hollander et al., 2018; Dane et al., 2022).

To assist coaches and players execute safe tackle techniques, World Rugby have developed *Tackle Ready* which is a technique and

education program that focuses on five key stages (tracking, preparation, connection, acceleration and finish) and highlights tackle characteristics that are intended to enhance performance and mitigate injury (World Rugby, 2022). It is important that the frequency of ball-carrier and tackler techniques are described in the context of the match situation (den Hollander et al., 2018). Although *Tackle Ready* techniques have been recommended, it is not understood whether players execute these techniques during real-world match scenarios (Hendricks et al., 2023; World Rugby, 2022). Therefore, the aim of this study is to: (1) identify the match situational characteristics, performance outcomes and ball-carrier and tackler technical actions demonstrated in elite women's Rugby Union and (2) to determine the extent to which *Tackle Ready* recommended safe tackle technique was exhibited.

2 | MATERIALS AND METHODS

2.1 | Research design and participants

The study used a retrospective cross-sectional design to analyze the tackle characteristics from a sample of tackles from all 15 matches of the 2022–2023 Women's Six Nations Championship. The Women's Six Nations Championship is the most significant women's international rugby competition that takes place solely in the Northern Hemisphere (World Rugby, 2023b). A tackle was defined as “an event where one or more tacklers (player or players making the tackle) attempt to stop or impede the ball-carrier (player carrying the ball) whether or not the ball-carrier was brought to ground” (Hendricks et al., 2020). The definitions and methodology have been adapted from existing research and the video analysis model created by the Rugby Union Video Analysis Consensus (RUVAC) group (Hendricks et al., 2020). The reporting of the study follows the “Strengthening the Reporting of Observational studies in Epidemiology” (STROBE statement) (Vandenbroucke et al., 2007).

2.2 | Video collection of match data

This study retrospectively analyzed a random sample of 1500 tackle events from all fifteen games from the 2022–2023 Women's Six Nations Championship. The first author (KD) screened all 5260 tackle events across all fifteen games for the visual quality of all stages of

the tackle events (Stats Perform, 2022). Two hundred and fifty-one tackle events were removed due to visual occlusion. A randomization tool was used to generate 1500 unique numbers from the remaining total tackle events ($n = 5009$) from each game (www.random.org). Tackle events matching the randomly allocated numbers were coded. Quota sampling was used to ensure relatively equal distribution of coded tackle events between playing teams and match quarter. This also avoided a bias toward a specific team or time during the competition.

Each tackle clip included 25–50 s of footage highlighting the pre-contact, contact and post-contact event allowing for a full analysis of the technical characteristics in the build-up to the tackle and post-contact. Each tackle had a minimum of four, 25-frames-per-second camera view videos available from broadcast quality footage. Sports Code (Sportscode Elite, V.10.3.36, Sportstec) was used to record, replay and save each coded instance into an Excel database. The software offered the flexibility to adjust the viewing speed of each tackle allowing for either full-speed or frame-by-frame playback.

The included video clips were then coded using a template of three categories: match situation, tackler/ball-carrier technical characteristics and performance outcomes (a total of 43 items) adapted from the RUVAC framework (Hendricks et al., 2020) and World Rugby's *Tackle Ready* framework (World Rugby, 2022 [Table 1, Figure 1]). The *Tackle Ready* program was developed from stakeholder engagement with coaches and educators from rugby (World Rugby, 2022). Table S1 contains the descriptors and definitions used for the 43 items.

Match tackle situations were classified according to contextual information, such as match period, previous phase, tackle sequence, match status, defensive direction, pass number and playing position. The tackle was split into three main phases pre-contact (≈ 1 s preceding contact), contact (first instance of contact) and post-contact with the technical characteristics assigned to these phases for both the tackler and ball-carrier. Tackler techniques promoted by World Rugby's *Tackle Ready* framework include 5 key stages: (1) tracking; (2) preparation; (3) connection; (4) acceleration and (5) finish and 36 "key performance indicators" (KPIs). Of the 36 KPIs, techniques, such as "iron grip", "hip and core activation", "communication" and "react and reshape", could not be evaluated visually from match video footage and were consequently excluded. Thus, 22 of the 36 *Tackle Ready* recommended techniques were mapped into the pre-contact, contact and post-contact phases (Figure 2) (World Rugby, 2022). Tackle performance outcomes were defined according to the RUVAC consensus statement (Hendricks et al., 2020) and *Tackle Ready* key performance indicators (World Rugby, 2022). To ensure the coding template reflected real-life coaching terminology and practice, informal consultation was conducted with coaches ($n = 4$) from various levels of competition and a coach educational developer ($n = 1$). Stakeholders were selected based on recommendations from national representative bodies, considering their expertise, involvement in policy and diverse range of coaching and professional experiences (e.g., policy, playing and refereeing). The panel offered independent evaluation on the clarity, relevance and validity of the coding template and definitions. Two variables were modified for wording.

2.3 | Reliability

To reduce multi-coder variance, a single analyst (KD) with experience of playing and coaching women's rugby examined all 1500 tackle events (Landis & Koch, 1977). Inter-coder reliability was assessed by comparing the original coder to two external reviewers (CS and COB) (Biomedical Engineer and Elite Rugby Performance Analyst). A three-way comparison was conducted through the analysis of 10 randomly selected video clips, using the same analysis framework established for this study. Reliability was tested using Cohen's kappa (κ) in SPSS (Cohen, 1960). The κ statistic results for inter-coder reliability were shown as follows: $\kappa = 1$ (match situational variables), $\kappa = 0.90$ (pre-contact), $\kappa = 0.94$ (contact), $\kappa = 0.98$ (post-contact) and $\kappa = 0.99$ (tackle outcomes). Discrepancies in coding variables were discussed between coders and consensus were met with 100% concordance.

Intra-coder reliability was also tested with the original coder reviewing 50 tackle video clips one month post initial review and assessed using Kappa. The κ statistic results for intra-coder reliability were shown as follows: $\kappa = 1$ (match situational variables), $\kappa = 0.95$ (pre-contact), $\kappa = 0.95$ (contact), $\kappa = 0.98$ (post-contact) and $\kappa = 1$ (tackle outcomes). A Cohen's Kappa value higher than 0.81 indicates almost perfect agreement (Cohen, 1960).

2.4 | Statistical analysis

The frequencies of match situational, tackler and ball-carrier tackle characteristics were reported as count and percentages. Descriptive statistics (mean and 95% confidence intervals) were used to outline the number of ball-carrier and tackler characteristics demonstrated per game. All analyses were undertaken in STATA 18 (StataCorp, 2019, Stata Statistical Software: College Station, TX: StataCorp LLC).

3 | RESULTS

The tackle technical characteristics and performance outcomes during matches are shown in Tables 1 and 2.

3.1 | Match situation characteristics

Table 1 reports the frequency percentages for match situation characteristics. Of all the coded tackle events, most involved one ($n = 783$, 52%) or two defenders ($n = 716$, 48%). Eight percent of tackles ($n = 116$) involved a second attacker after the initial contact. Unstructured phase play accounted for the phase prior to most tackle events ($n = 1073$, 72%) followed by lineouts ($n = 191$, 13%), scrums ($n = 130$, 8%) and restarts ($n = 106$, 7%). Forwards carried the ball into contact more often ($n = 859$, 57%) and made more tackles ($n = 862$, 57%) than backs ($n = 641$, 43% and $n = 638$, 43%, respectively).

TABLE 1 Frequency percentages for match situational characteristics ($n = 1500$).

Match situation characteristics	<i>n</i>	%	Mean per match (95% CI)
Total events	1500	100	282 (274–290)
Previous phase			
Unstructured	1073	72	202 (190–214)
Restart ($n = 106$)	106	7	20 (16–24)
Scrum ($n = 130$)	130	9	24 (20–29)
Lineout ($n = 191$)	191	12	36 (31–41)
Pass number			
0	326	22	61 (54–68)
1	522	35	98 (90–107)
2	390	26	73 (66–81)
3	165	11	31 (26–36)
4	73	4	14 (11–17)
5	15	1	3 (1–5)
6+	9	0.6	1.7 (0.8–3)
Match quarter			
1st quarter	353	24	66 (60–74)
2nd quarter	393	26	74 (69–81)
3rd quarter	395	26	74 (67–82)
4th quarter	359	24	67 (61–75)
Defensive direction			
Forwards	894	60	168 (157–179)
Lateral	301	20	57 (50–63)
Backwards	102	7	19 (16–23)
No direction/stationary	203	13	38 (33–44)
Tackle sequence			
One-on-one (1v1)	755	50	142 (132–152)
One-on-two (1v2)	28	2	5 (3–8)
Defensive sequential (2v1)	591	39	111 (102–120)
Defensive simultaneous (2v1)	38	3	7 (5–10)
Defensive sequential, attacking sequential (2v2)	72	5	14 (11–17)
Defensive simultaneous, attacking sequential (2v2)	16	1	3 (2–5)
Distance of tackler from ball-carrier at ball reception			
Near (<2 m from the tackler)	328	22	62 (55–69)
Moderate (2–4 m from the tackler)	663	44	125 (115–135)
Distant (>4 m from the tackler)	509	34	96 (88–104)
Positional groupings (tackler vs. ball-carrier)			
Back versus Back	435	29	82 (74–90)
Back versus Forward	203	14	38 (33–44)
Forward versus Forward	656	44	123 (114–133)
Forward versus Back	206	14	39 (34–44)
Defensive team performance			

TABLE 1 (Continued)

Match situation characteristics	n	%	Mean per match (95% CI)
Winning	665	44	125 (116–135)
Losing	541	36	102 (93–111)
Drawing	294	20	55 (49–62)

Note: Values are numbers, percentages, mean per match and confidence intervals.

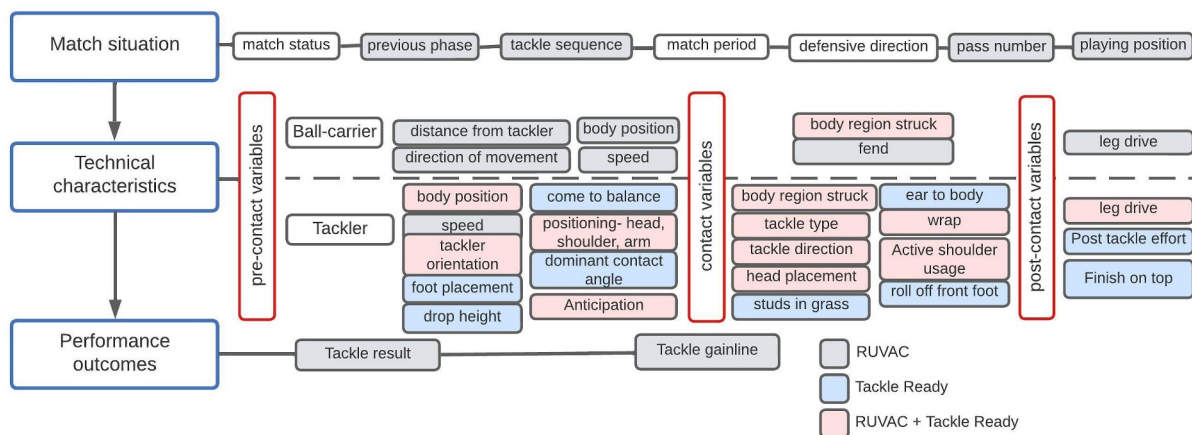


FIGURE 1 Model of key tackle technical characteristics and performance outcomes adapted from RUVAC video analysis framework (Hendricks et al., 2020) and World Rugby's Tackle Ready framework (World Rugby, 2022).

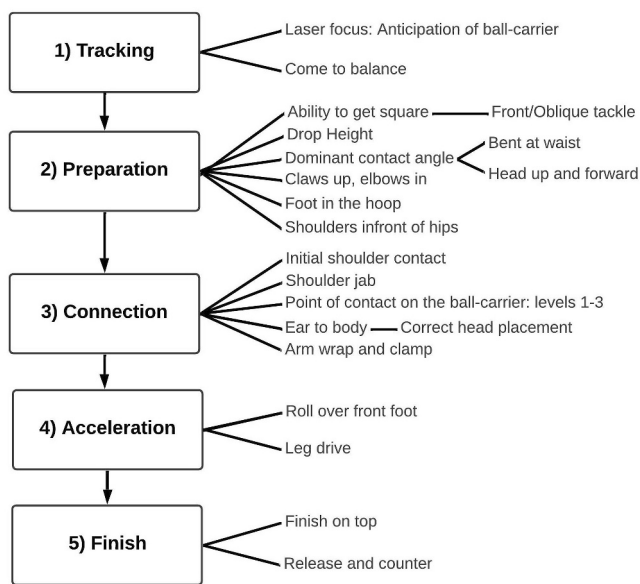


FIGURE 2 Model of 22 coded Tackle Ready variables and five stages of World Rugby's Tackle Ready framework (World Rugby, 2022).

3.2 | Ball-carrier characteristics

Typically, ball-carriers approached contact running in a straight line ($n = 486, 32\%$) at fast speed ($n = 845, 56\%$) and in an upright position

($n = 862, 58\%$; Table S2). Ball-carriers used leg drive and/or fend in 76% ($n = 1139$) and 52% ($n = 783$) of tackles, respectively.

3.3 | Tackler characteristics

Table 2 reports the frequency percentages for tackler technical characteristics.

3.4 | Pre-contact

In most cases prior to contact, tacklers approached the ball-carrier from the side ($n = 573, 38\%$) or at an oblique angle ($n = 584, 39\%$), at moderate speed ($n = 742, 49\%$), in an upright ($n = 447, 30\%$) or medium body position ($n = 677, 45\%$) and with hands dropped to side ($n = 1082, 72\%$). Tackles were evenly split between head positioning down or away ($n = 755, 50\%$) and head positioning up and forward ($n = 745, 50\%$).

3.5 | Contact

For the majority of tackles, initial contact was made by the tacklers' arm ($n = 763, 51\%$) or shoulder ($n = 536, 36\%$), to the hip ($n = 388, 26\%$) or torso ($n = 359, 24\%$) of the ball-carrier or directly with the

TABLE 2 Descriptive summary of tackler technical actions in $n = 1500$ coded tackle events.

Variable	N	%	Mean per match (95% CI)
Total events	1500	100	282 (274–290)
Pre-contact variables			
Anticipation of BC			
Apparent ^a	1468	98	276 (262–290)
Absent	32	2	6 (4–8)
Body position of tackler			
Upright	447	30	84 (76–92)
Medium ^a	677	45	127 (118–137)
Low ^a	376	25	71 (64–78)
Tackler head position			
Up and forward ^a	745	50	140 (130–150)
Away	481	32	90 (83–99)
Down	274	18	52 (46–58)
Tackler arm position			
Hands drop	1082	72	203 (191–216)
Boxer ^a	329	22	62 (55–69)
HAS	89	6	17 (13–21)
Speed of tackler			
Slow	416	28	78 (71–86)
Moderate	742	49	139 (130–150)
Fast	342	23	64 (58–71)
Orientation of tackler			
Oblique	584	39	110 (101–119)
Side	573	38	108 (99–117)
Infront	230	13	43 (38–49)
Behind	113	7.5	21 (18–26)
Contact variables			
Body region struck on tackler			
Arm	763	51	143 (133–154)
Shoulder ^a	536	36	101 (92–110)
Torso	118	7.9	22 (18–27)
Head and neck	75	5	14 (11–18)
Hip	1	0.06	0 (0–1)
Upper leg	2	0.13	0 (0–1)
Lower leg	5	0.3	1 (0–2)
Body region struck on BC			
Arm	186	12	35 (30–40)
Shoulder	115	7.7	22 (18–26)
Torso	359	24	67 (61–75)
Head and neck	94	6.3	18 (14–22)

TABLE 2 (Continued)

Variable	N	%	Mean per match (95% CI)
Hip	388	26	73 (66–81)
Upper leg	115	7.7	22 (18–26)
Lower leg	32	2.1	6 (4–8)
Ball	211	14	40 (34–45)
Tackle type			
Arm	707	47	133 (123–143)
Shoulder ^a	541	36	102 (93–111)
Jersey	61	4	11 (9–15)
Smother	188	13	35 (30–41)
Tap	3	0.2	1 (0–2)
Direction of tackle			
Oblique	431	29	81 (74–89)
Side	458	31	86 (78–94)
Front-on	78	5.2	15 (12–18)
Behind	533	36	100 (92–109)
Tackler head placement			
Above ^a	304	20	57 (51–64)
Beside ^a	379	25	71 (64–79)
Infront	231	15	43 (38–49)
Behind ^a	586	39	110 (101–119)
Tackler arm wrap			
Wrap and clamp ^a	1039	69	195 (184–208)
Failed wrap	421	28	79 (72–87)
No attempt	40	2.7	8 (5–10)
Tackler shoulder usage			
Absent	805	54	151 (141–162)
Apparent ^a	695	46	131 (121–141)
Tackler shoulder active or passive			
Active ^a	236	16	44 (39–50)
Passive	459	31	86 (79–95)
N/A	805	54	151 (141–162)
Post-contact variables			
Tackler leg drive			
Absent	1065	71	200 (188–213)
Moderate	275	18	52 (46–58)
Strong ^a	160	11	30 (26–35)
Post tackle effort			
Bounce	514	34	97 (88–105)
Trapped	171	11	32 (28–37)
Barge	25	1.7	5 (3–7)
Lying on the ground	286	19	54 (48–60)

TABLE 2 (Continued)

Variable	N	%	Mean per match (95% CI)
Poach	103	6.9	19 (16–23)
Disrupt	52	3.5	10 (7–13)
N/A	520	35	98 (90–107)

Note: Values are numbers, percentages, mean per match and confidence intervals.

Abbreviations: BC, ball-carrier; CI, confidence interval; HAS, hands above shoulders; N/A, not applicable.

^aIndicates techniques associated with correct technical proficiency based on existing research (den Hollander et al., 2021).

ball itself ($n = 211$, 14%), with the remainder making contact to the arm (12%), leg (9.8%), shoulder (7.7%) and head and neck (6.3%). The preferred tackler head placement in relation to the ball-carrier was behind ($n = 586$, 39%) followed by beside ($n = 379$, 25%), above ($n = 304$, 20%) and in front ($n = 231$, 15%). Successful arm wrap was demonstrated in 69% ($n = 1039$) of tackles. The most common tackle types were arm ($n = 707$, 47%) and shoulder tackles ($n = 541$, 36%) often from behind ($n = 533$, 36%) or to the side ($n = 458$, 31%) of the ball-carrier. On average per match, there were 14 (95% CI 11–18) head and neck contacts to the tackler and 18 (95% CI 14–22) head and neck contacts to the ball-carrier.

3.6 | Post-contact

Tackler leg drive was demonstrated in 29% ($n = 435$) of tackles and the most common post-tackle efforts included tackler bounce ($n = 514$, 34%) and poach ($n = 103$, 6.9%). Tacklers were lying on the ground or trapped in 19% ($n = 286$) and 11% ($n = 171$) of tackles, respectively.

3.7 | Tackle performance outcomes

Table S3 reports the tackle performance outcomes. The ball-carrier secured gainline territory in 52% of tackles, while the tackler achieved gainline success in 28%. Most tackles resulted in a ruck (68%) followed by tackle break (11%), or offload (7%) and the remainder resulted in a penalty (6%), turnover (5%) or other (3%).

3.8 | Tackle ready techniques

The frequency of the 22 coded *Tackle Ready* recommended tackler techniques demonstrated during tackles is illustrated in Figure 3. Data are provided in Table S4. Three tackles (0.2%) in total exhibited all 22 coded *Tackle Ready* recommended techniques (Figure S1). The range of successful completion of *Tackle Ready* recommended techniques was broad ranging from as little as 15% (square to ball-carrier)

to 98% (anticipation of ball-carrier). The mean percentage of pre-contact variables which were achieved across the 10 recommendations was 47% (Range: 15%–98%). For contact related recommendations, the mean was 40% (Range: 10%–85%), and for post contact, it was 33% (Range: 22%–60%). Only 4/10 pre-contact techniques, 3/11 contact techniques and 1/3 post-contact techniques were demonstrated in greater than 50% of tackles.

4 | DISCUSSION

The aim of this study was to identify the match situational characteristics, ball-carrier and tackler techniques demonstrated in elite women's Rugby Union and to determine the extent to which *Tackle Ready* recommended tackle techniques are exhibited. The findings indicate a low overall completion of the 22 coded *Tackle Ready* recommended techniques with only 47% of the recommended techniques exhibited in each tackle on average. A high proportion of tackles involved two defenders with tacklers adopting upright body positions, incorrect pre-contact head positioning and head placement upon contact. There was significant variability in the completion of pre-contact, contact and post-contact tackle techniques. This information highlights the imperative for greater attention to coach education, tackle law enforcement and gender-specific tackle coaching in the women's game.

The frequency of tackler technical characteristics reported in this study can be used by coaches to highlight and address shortfalls in tackler techniques (Hendricks et al., 2018). For example, in our study, 30% ($n = 447$) of tackles were made in an upright position which likely places the tacklers' head in closer proximity with the head or shoulder of ball-carriers than a tackler who was bent at the waist (70%, $n = 1053$). While data on the association between tackling techniques and concussion or suspected concussions are still emerging (Shill et al., 2024) and may not be directly comparable, in men's rugby, there is a reported 1.5 times higher likelihood of upright tacklers undergoing a Head Impact Assessment compared to tacklers who were bent at the waist (Tucker et al., 2017). To lower the risk of head-on-head contacts, World Rugby has recently introduced opt-in trials to lower the maximum tackle height in community rugby from the line of armpit to the base of the sternum or waist (England Rugby, 2023; World Rugby, 2023c). However, given that research suggests gender-specific differences in head impact mechanisms (e.g., a higher proportion of head-to-ground contacts for women), these law modifications may not address the unique challenges or risks inherent in women's rugby (Shill et al., 2024; Williams et al., 2022). Additionally, technique is the execution of a set of coordinated movement patterns, and the successful execution of technical actions (e.g., body positioning) is contingent on the completion and interaction of preceding technical actions (Hendricks et al., 2018). One such pattern prior to attaining the bent at waist tackle position is the tackler's ability to "drop height" (48%, $n = 726$), combined with the adoption of "shoulders in front of hips" postures (60%, $n = 893$), a sequence that requires precise timing for optimal power and

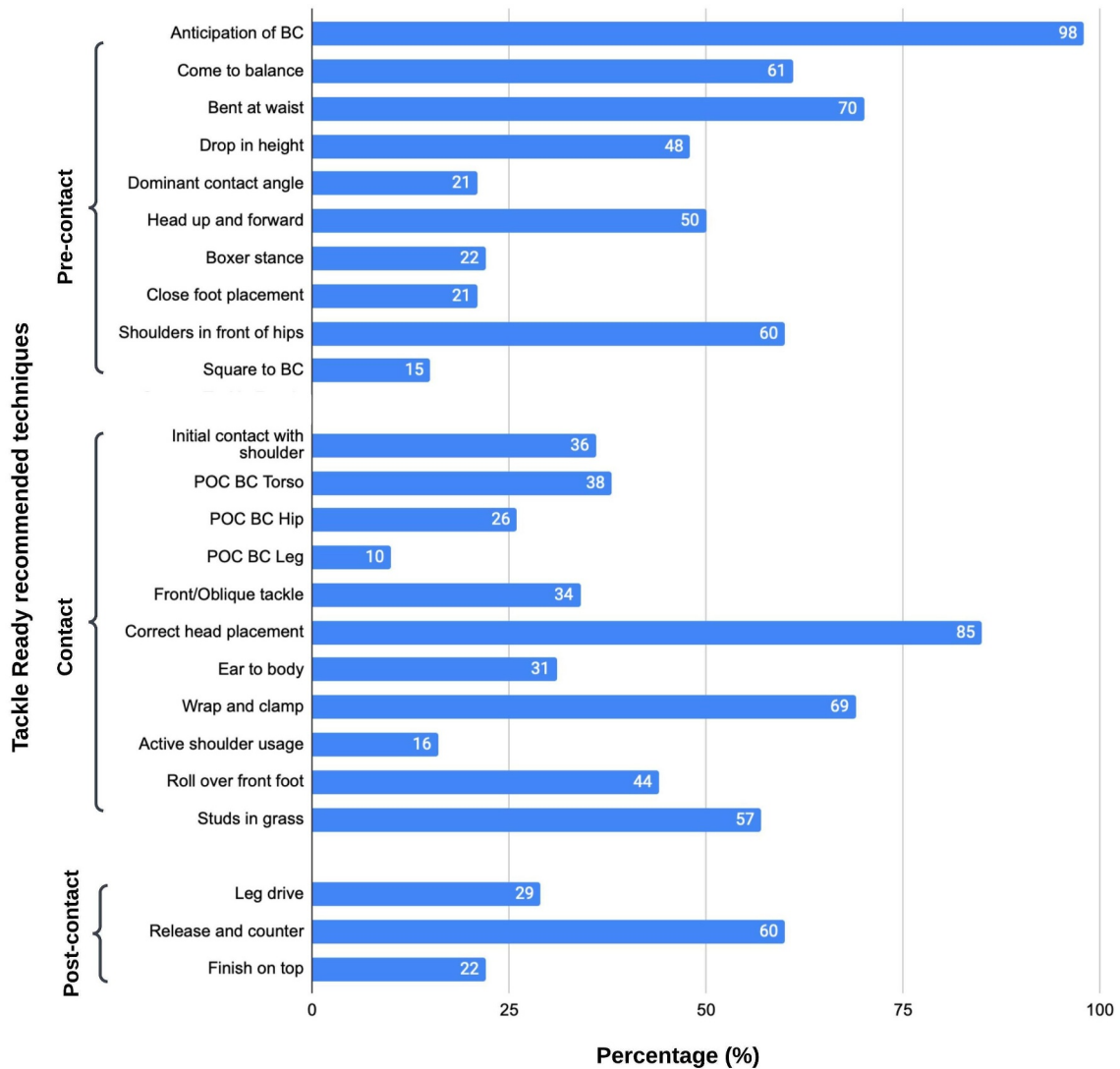


FIGURE 3 Frequency percentages for *Tackle Ready* recommended techniques demonstrated in $n = 1500$ tackles. BC POC, ball-carrier point of contact.

accuracy. If defenders drop their height too early, ball-carriers can react and fend or evade quickly. Without forward lean of the torso, tacklers may be exposed and are in a weaker position to resist front-on axial forces and sideways axial torques. Therefore, alongside law modifications, contact training interventions aimed at lowering body height and achieving better trunk positioning might enhance performance and mitigate the risk of injury.

On average, only 47% of *Tackle Ready* recommended techniques were exhibited in each tackle with 0.2% ($n = 3$) demonstrating all 22 coded recommended techniques. This prevalence is lower than the observed execution of RugbySmart recommended tackle techniques in male club rugby (57.9%) (Quarrie, 2008; Takamori et al., 2022), although the criteria are not identical. The low completion could potentially impact injury risk factors and team performance, given that the *Tackle Ready* techniques show significant alignment with actions proven to be associated with positive performance and injury outcomes in men's rugby (den Hollander et al., 2021). Results could

indicate significant deficits in tackle technique in this population and might reflect challenges related to the accessibility, adoption, perceived importance or applicability of the *Tackle Ready* education resource in women's rugby coaching practice. Adoption of recommended techniques is a process influenced by the environment, which encompasses socio-cultural-historical constraints within the rugby performance context (McKay & Verhagen, 2016). It is also shaped by the interactions and competing interests of players and coaches concerning health, performance, culture and other contextual factors (Dane, Foley et al., 2023). The Health Action Process Approach behavioral change model provides insights to help understand the observed low completion (Schwarzer, 2016). For instance, although freely available educational material on recommended tackle techniques may improve awareness of safer techniques, it does not negate the value of volitional constructs, such as action planning and maintenance self-efficacy (e.g., overcoming potential training barriers) (Dane et al., 2024). Moreover, they may not be sufficient on

their own to ensure the successful execution of recommended tackle techniques during matches. There is a critical need for research to engage coaches and players to understand behavioral determinants and address contextual barriers to maximize the adoption of recommended techniques (Barden et al., 2021; Hendricks et al., 2015).

In comparison to a study in under-18 male club rugby players, women rugby players are less likely to approach square to the ball-carrier (W:15% vs. M:87%) (Hendricks et al., 2015). *Tackle Ready* recommends defenders approaching square to the attacker to allow for stronger body positions for effective shoulder tackles (World Rugby, 2022). It may be that given size, speed and strength differences of women players relative to men players, there are different defensive strategies employed (Alonso-Aubin et al., 2021; Freitas et al., 2021). For example, the finding that almost half of the coded tackles involved two defenders (48%) may be indicative of planned defensive strategy, for example, limiting attacking offloading opportunities. This is higher than multiplayer tackles reported for Canadian female varsity rugby teams (26%) (Shill et al., 2024). It is worth noting that in varsity rugby, three defender tackles increased the odds of suspected tackler concussions (Shill et al., 2024). Interestingly, law trials in the Fédération Française de Rugby (FFR) prohibit multiplayer tackles which may force teams to revise their defensive tactics in future (England Rugby, 2023). Women's rugby is progressively shifting to professionalism with physical and technical levels increasing rapidly. However, the differences in defensive strategy and higher pre-contact values in U18 male club matches may reflect the still-early development of women's rugby due to its relative infancy in terms of infrastructures and performance pathways (Dane, Foley et al., 2023; Dane, Foley, Hendricks, & Wilson, 2023). Previous studies demonstrate the importance of sufficient training exposure for technical capabilities (Hendricks et al., 2018), whilst respecting contact load guidelines (World Rugby, 2023a). Perhaps dedicating more time to tackle training via both controlled contact and full-contact activities or incorporating video-based technical feedback could be effective (Davidow et al., 2023).

Tackler pre-contact head positioning and placement upon contact are also important risk factors for subsequent injury (den Hollander et al., 2021). In female varsity rugby, tacklers demonstrating "away" head positioning pre-contact increased the odds of suspected concussion 3-fold compared to "up and forward" head positions (Shill et al., 2024). In our study, 50% ($n = 755$) of all tackles demonstrated pre-contact head positioning that was either facing down or away. Head up and forward positioning pre-contact allows for effective tracking, footwork and subsequent head placement to the side or behind the ball-carrier in order to reduce the likelihood of heavy contact to the head (World Rugby, 2022). In our study, 15% ($n = 231$) of tackles occurred with the tackler's head placed incorrectly in front of the ball-carrier. Additionally, a number of tackles involved head and neck contact to the tackler (5%) and ball-carrier (6%). Several factors could contribute to the frequency of improper tackle technique demonstrated by defenders, including (a) fatigue; (b) suboptimal decision-making; (c) defensive line errors; (d) positional mismatches; (e) insufficient contact exposure and (f) coaching in training (Dane,

Foley, Hendricks, & Wilson, 2023). Given the associated increased risk of concussion from direct head contact, *Tackle Ready* coaching resources could be evaluated to ensure that they provide sufficient education to support proper pre-contact head positioning and placement (World Rugby, 2022). In addition, coaches could refer to World Rugby's *Contact Confident* resource that promotes a number of activities for safer head actions and neck strengthening (World Rugby, 2023a). The Laws of the Game emphasize the importance of avoiding reckless or high tackles, but the ability of tacklers to achieve this consistently is complex. Despite being illegal, it is not always possible to completely avoid head and neck tackles at all times, but match-officials can help protect players by consistently penalizing high or reckless tackles. Whilst this study did not evaluate why tackles were penalized, there is a discrepancy between the number of penalized tackles and ball-carrier head contacts (3% vs. 6%, respectively). Rugby referee stakeholders should consider these results for the implementation of interventions to reduce the frequency of head and neck contacts and mitigate the risk of tackle-related injury. Coach education, referee resources, stricter sanctioning and law trials to lower the height of the tackle might also reduce the risk of head and neck contacts to the ball-carrier and tackler.

Following arm tackles (47%, $n = 707$), shoulder tackles accounted for 36% ($n = 536$) of all tackles. In female rugby, players reported modifying the way they played (e.g., placing their hands in front of breasts) or limiting specific activities (e.g., tackling) in order to mitigate breast injuries (Comstock et al., 2005). In a rugby context, adopting these strategies may contribute to improper tackling technique (e.g., lower active shoulder usage (16%, $n = 236$)) that may impact performance and safety (den Hollander et al., 2021). Therefore, to prepare women for match contact demands, it is imperative that tackle education resources account for female-specific considerations (Dane et al., 2022; Wakefield-Scurr et al., 2023). As future areas of research, it is relevant to evaluate *Tackle Ready* recommended techniques in relation to match injury and performance outcomes as this information could have implications for how these techniques are adopted and implemented in coaching practices.

4.1 | Limitations

Using observational methodology to register the technical aspects of tackling may not fully capture the interactive, multifactorial and complex nature of tackling in rugby as other authors have discussed (den Hollander et al., 2018; Colomer et al., 2020). Only 22 out of the 36 *Tackle Ready* techniques were deemed suitable for coding, attributed to limitations in observational video analysis. Given the likely differences in physical and tactical game characteristics at different levels of rugby, these findings are unlikely to be generalised to non-elite women's rugby cohorts (Dane et al., 2022; Shill et al., 2024). Therefore, there is a need for further research across all age categories and competition levels. To facilitate more accurate sex-related comparisons, future research should evaluate the *Tackle Ready* recommended techniques demonstrated in elite men's Rugby. In addition, future studies should

include factors, such as zonal locations, assess injury outcomes and the sanctioning of illegal tackles (Hendricks et al., 2020). Nevertheless, this paper provides valuable insights on the technical characteristics of tackling in elite women's rugby that can help coaches, educators, clubs and unions not only to design suitable tackle training environments but also to refine laws and safe tackle education resources to optimize tackle performance and safety.

5 | CONCLUSION

The present study describes the match situational characteristics, ball-carrier and tackler techniques demonstrated in elite women's Rugby Union and identifies the extent to which *Tackle Ready* recommended tackle techniques are exhibited. A high proportion of tackles involved two defenders, tacklers in upright body positions, incorrect pre-contact head positioning and head placement upon contact. Considering the low completion of *Tackle Ready* techniques, to mitigate tackle-related injury risks in women's rugby, it is crucial to investigate the factors influencing end-user uptake of recommended techniques. The study findings will serve discussion within the rugby community on tackle law enforcement, gender-specific tackle coaching and targeted coach education. Further research to confirm what recommended techniques are associated with injury and match performance outcomes will prove invaluable for developing effective tackle training strategies for injury prevention and performance.

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CONFLICT OF INTEREST STATEMENT

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