Physical and Technical Demands and Preparatory Strategies in Female Field Collision Sports: A Scoping Review

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ABSTRACT

Women's participation in field collision sports is growing worldwide. Scoping reviews provide an overview of scientific literature in a developing area to support practitioners, policy, and research priorities. Our aim is to explore published research and synthesise information on the physical and technical demands and preparation strategies of female field collision sports. We searched four databases and identified relevant published studies. Data were extracted to form (1) a numerical analysis and (2) thematic summary. Of 2318 records identified, 43 studies met the inclusion criteria. Physical demands were the most highly investigated (n = 24), followed by technical demands (n = 18), tactical considerations (n = 8) and preparatory strategies (n = 1). The key themes embody a holistic mod-

el contributing to both performance and injury prevention outcomes in the context of female field collision sports. Findings suggest a gender data gap across all themes and a low evidence base to inform those preparing female athletes for match demands. Given the physical and technical differences in match-demands the review findings do not support the generalisation of male-derived training data to female athletes. To support key stakeholders working within female field collision sports there is a need to increase the visibility of female athletes in the literature.

Introduction

Female field collision sport (Australian Football League (AFL), Rugby Union, Rugby League and Rugby Sevens) has grown substantially in participation and professionalism [1]. These collision field sports are characterised by intermittent high-intensity activities interspersed with lower intensity activities [2] as opposing teams compete for possession and territory to score points. Field collision athletes require well developed technical skill and physical qualities such as speed, agility, upper-body and lower-body strength and power, and aerobic capacity [3]. Technical skill can be defined as the learnt ability to select and perform the correct technique [4] as determined by the demands of the situation. Collision-based field athletes are required to perform multiple skills which can be divided into non-contact skills (for example, evasion, catching, passing, kicking) and contact skills (eg. carry into contact, tackling and aerial collisions). The frequency of these contact and non-contact skills is dependent on playing position.

Despite the increase in participation and professionalism in female sports, 4–13 % of sport science and medicine studies include women-only cohorts [5]. This evidence base comprises only four reviews investigating injury incidence in Rugby League [6] and Union [7], and match demands, anthropometric and physical qualities in Rugby Sevens [8, 9]. To compensate, practitioners generalize and adapt match demands, coaching strategies and injury prevention policies from male field collision sports to females [10]. This may be misguided given the well documented contextual, biological and biomechanical differences between the sexes [11, 12]. For example, in Rugby contact events, differences exist in the head-impact mechanisms where females are more likely to sustain uncontrolled whiplash or head-to-ground impacts compared to their male counterparts [13]. Recent calls to action propose an evidence-based framework for female athlete development and wellbeing [10]. To develop this, a scoping review can identify gaps in the knowledge base, clarify key concepts and report on the types of evidence that address and inform practice [14].

Understanding the physical and technical match demands can help formulate evidence-informed frameworks for optimising athletic performance and injury prevention in female field collision sports. The aim of this scoping review is therefore to synthesize and examine the physical and technical demands of female field collision sports, including preparatory strategies, to help inform practitioners, coaches, researchers and governing bodies.

Materials and Methods

A scoping review was undertaken as they have previously been used to map key concepts underpinning a research area [14]; are useful for bringing together literature in disciplines with emerging evidence, and address questions beyond those related to effectiveness or experience of an intervention. This review is based on Arksey and O'Malley's five-stage process, Levac et al.'s framework, the work of the Joanna Briggs Institute, and previously published relevant scoping reviews [14, 15]. The protocol was published in OSF registries (DOI: 10.17605/OSF.IO/5VZ6G). See supplementary resource 1 for the PRISMA scoping review checklist [16].

The author group developed the following research questions following a preliminary literature review:

- What is known about the technical and physical demands and preparatory strategies in female field collision sports?
- What are the evidence gaps in the field?
- What are the key research priorities?

The inclusion and exclusion criteria ▶ **Table 1** were determined based on existing frameworks [15]. ▶ **Table 2** shows the operational definitions. To ensure inclusivity in this review, studies reporting outcomes for both females and women were included in this review.

Eight key search themes were identified (collision-based, physical, technical, skill, demand, preparation, training, practice) and expanded to maximise the number of retrieved articles. The search strategy was developed by an experienced librarian (DM) and first used on the MEDLINE database and then adapted for subsequent databases (supplementary resource 2). The search was performed with no date restrictions among 4 databases (MEDLINE, Embase, Web of Science Core Collection, CINAHL) from inception until [24/01/22].

Search results were exported into EndNote X9, duplicates removed, and remaining citations imported into Covidence (Covidence systematic review software, Veritas Health Innovation). Title/abstract screening was completed by two independent reviewers (KD, FW). A high level of agreement was achieved between reviewers (Kappa 0.85). Disagreement was resolved by discussion until consensus was reached. In no cases did it need to go to a third author (SH). There was no blinding to study, author, institution or journal. The reviewers (KD, FW) undertook full-text screening.

The author group designed a data extraction form supplementary ▶ **Fig. 1**. Two researchers (KD and FW) trialled the data extraction form on three random studies, then independently extracted data from the first 10 studies using the data-charting form to establish consistency in extraction methods. KD extracted the data from 90 % of included studies and FW extracted data from 10 % of studies. The data were cross-checked, where FW checked 10 % of KD's data extractions for accuracy and vice versa. Discrepancies were resolved by discussion. No further cross-checking was performed given the high level of concordance > 97 %.

▶ **Table 1** Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Studies were included based on the following inclusion criteria:	Studies were excluded based on the following exclusion criteria:
▪ Research articles not limited by age of study, geographical location, language or setting	▪ Research articles that do not scientifically investigate physical or technical measures or preparatory strategies within female field collision sports
▪ Research articles that consider all forms of collision field sports	▪ Opinion pieces/opinions, magazine and newspaper articles
▪ Outcome variables that must consider physical and/or technical demands	▪ Studies that could not be translated into English
▪ Studies that include adult female athletes	▪ Studies that do not include adult, female athletes
▪ Studies that report preparation strategies for these physical and technical demands	

▶ **Table 2** Operational definitions.

Term	Definition
Field-based collision sports	A sport that permits deliberate collision between players without sticks
Physical demands	The level and duration of physical exertion generally required to perform match and training functions
Technical demands	The basic sport-specific skills required to perform match and training functions [4]
Preparatory strategies	All aspects related to physical and technical performance development [58]
Practitioners	Coaches, physiotherapists, clinicians, sports scientists, strength and conditioning (S&C) coaches

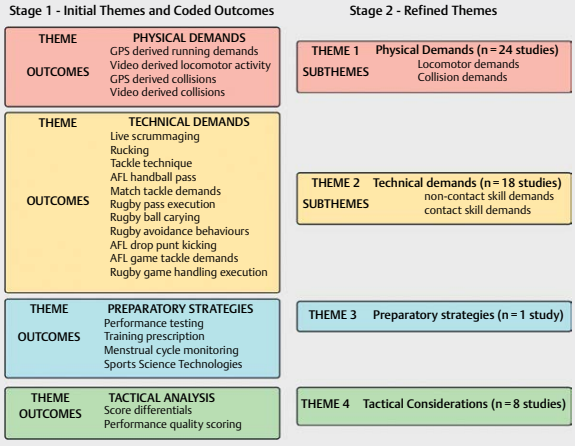
Data are presented as follows:

1. Numerically: by sport; period of publication; country of origin; study type and theme.

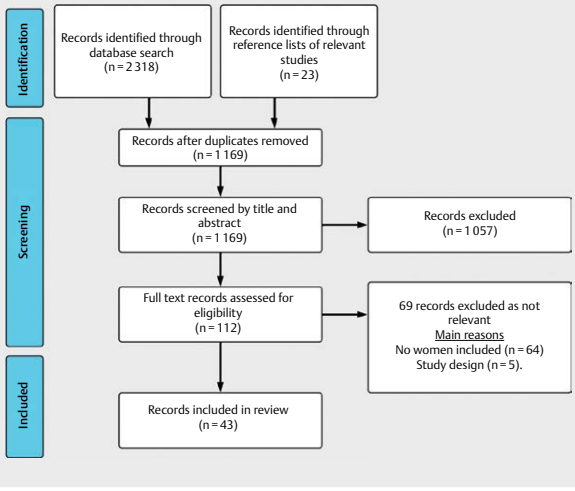
2. Thematically: using descriptive analysis to map key findings and concepts relevant to the research question. KD used an inductive thematic analysis framework, basing the analysis on Braun and Clarke's six-phase framework [17]. Data familiarisation was achieved by manually extracting study key outcomes and categorising them according to primary outcome using affinity diagramming. Categories were grouped to form themes, then refined to include subthemes [17]. A visual summary of this process is provided in ▶ **Fig. 1.**

Included studies were critically appraised by two authors (KD and FJN) using the Downs and Black 110 Quality Index (QI) checklist [18], which is a valid and reliable tool for assessing the methodological quality of experimental and non-experimental designs [18]. Each study was assigned a quality rating of 'excellent' (24–28 points), 'good' (19–23 points), 'fair' (14–18 points) or 'poor' (<14points).

The author group have played, coached, been responsible for the medical care and/or analysis of professional Rugby players. Multiple members of the group are also employed by and advise the



▶ **Fig. 1** A summary of how themes were generated, based on Braun and Clarke's six-phase framework.



▶ **Fig. 2** Study selection flowchart.

board of national Rugby governing bodies. Given the breadth of knowledge and experience within the group in working with key stakeholders, a formal external consultation exercise was not conducted. Coaches, strength and conditioning (S&C) coaches, and medical staff from elite men's and women's Rugby Union were consulted informally to help refine and define themes to ensure they were meaningful to key stakeholders.

Results

The initial search identified 2318 studies, leaving 1169 studies after duplicates were manually removed from the search. After reviewing the titles and abstracts, 112 studies were identified for full text screening; 69 were deemed unsuitable and removed (64 studies did not explicitly report the sex of their participants, ▶ **Fig. 2**). Authors were contacted where participant sex was not reported. Twenty-three additional studies were included following further

searches of reference lists and author consultation. Forty-three studies were included in the final analysis.

Thirty-two studies included only females, 12 included males and females. Seventy percent of studies collected match data, 23 % of data was collected in lab-based settings, and 7 % conducted research in training. Most research was conducted in elite playing populations (72 %, n = 31). The main findings of the 43 studies are presented in supplementary resource 4. The largest group of studies involved Rugby Union (40 %, n = 17), followed by Rugby Sevens (37 %, n = 16), Australian Football League (16 %, n = 7) and Rugby League (14 %, n = 6). A rapid recent growth in studies was observed, with 98 % of studies published between 2011 and 2021. Australia provided most of the included studies (49 %, n = 21) followed by the UK (29 %, n = 8). Canada (12 %, n = 5), Spain (7 %, n = 3), USA (5 %, n = 2), New Zealand (2 %, n = 1), Ireland (2 %, n = 1) and the Netherlands (2 %, n = 1). Most studies used cohort designs (40 %, n = 17), followed by cross-sectional (30 %, n = 13), experimental (16 %, n = 7) and longitudinal (14 %, n = 6).

The initial QI scores achieved a kappa value of 0.8. After discussion regarding disagreements, a kappa value of 1.0 (perfect agreement) was achieved. Eleven studies had a quality rating of 'fair' (14–18 points) and thirty-two studies were rated 'poor' (< 14 points). The QI score of the 43 studies had a median of 12 points (interquartile range 4) of a maximum of 28 possible points (Supplementary Resource 5). The highest subscale scores achieved were reporting and internal validity-bias. The lowest subscale scores were external validity, internal validity-confounding and power (sample size calculation).

Physical Demands

Twenty-four studies reported on the physical demands of female field collision sports, comprising locomotor (n = 21) and collision (n = 14) demands. Most research was performed in Rugby Sevens (38 %), followed by Rugby Union (33 %), Rugby League (21 %) and AFL (8 %). See supplementary resource 6 for the definitions of keywords and descriptors used. Twenty-two studies reported on female-only cohorts [19–40] and two on male and female cohorts [2, 41]. Locomotor and collision data were collected using Global Positioning Systems (GPS) (64 %), video-based notational analysis (24 %) or heart rate (HR) monitoring (12 %).

Locomotor demands

On average, across 80 minutes of match-play, Rugby Union players cover 4982 m [19]. The average ball in play percentage in varsity Rugby was 51 % [23]. Players spend 87.4 % of the total match duration on low-intensity activities (walking, jogging, low intensity running), 9.5 % at medium intensity, 1.8 % at high intensity, and 1.2 % sprinting [20]. Players are exposed to heart rates > 90 % of their maximal HR for 47 % of the game, with no difference between match halves [19]. Backs cover greater relative distances and achieve higher velocities than forwards [20, 21, 31, 34, 36]. Total weekly running volumes for varsity players measured between 12–20 km [36]. Half backs cover the greatest relative distances and the back three record the highest maximum velocities. Forwards produce significantly higher total player loads than backs [19]. Match locomotor demands can also be affected by contextual factors such as opposition. For example, International Rugby Union players experienced greater running demands against 'weaker' opposition, but the 'most intense periods' of running were faster against 'stronger' oppositions [22].

Across 14 minutes of match-play Sevens players cover an average distance of 1556.2 ± 189.3 m [24]. Players spend 74.5 % of the total match duration on low-intensity activities (walking, jogging, low 175 running), 16.4 % at medium intensity, 3.7 % at high-intensity, and 5.4 % sprinting [24]. On average, work-to-rest ratio is 1:0.4 and for 75 % of the game, players are exposed to heart rates > 80 % of their maximal HR [24]. National Sevens players achieve greater on-field movements for total time, distance and high speed running compared to State Sevens players [2, 24, 26, 37].

Across 60 minutes of match-play, Rugby League players cover a total distance ranging between 2900–5500 m depending on playing position [27] and level of competition (international vs domestic) [35]. Backs and adjustables achieve greater running and average acceleration/deceleration demands than forwards [28, 39]. Compared to outside backs, hit-up and wide-running forwards covered greater relative distances [28, 39].

Across 60 minutes of match-play AFLW players cover a total distance ranging between 4998–6255 m per match depending on playing position [29]. When expressed relative to game time AFLW athletes cover 102–128 m per minute. Midfielders and small backs cover higher total and high speed running distances compared to tall backs [29, 30]. One study found a reduction in all measures of running performance in the fourth quarter when compared to the first and second quarters of matches [30].

Collision demands

In Rugby Union, the tackle is the most frequent contact event with a mean of 280 tackles per game [23]. This is followed by carries into contact (234), rucks (200), scrums (25) and mauls (6) [23]. Collisions are higher in forwards (range: 18.3–37.2 collisions) than backs (range: 7.5–14.3 collisions). Collision counts are highest against 'stronger' opposition [22] with no difference noted between match halves [20]. Forwards spend more time (5:42 ± 1:42 minutes per game) and a higher frequency of involvements (61 ± 12) in rucks, mauls and the tackle contest [31].

Elite female Sevens players experience more impacts per game (12.6 ± 4.7) compared to senior Sevens players (10.2 ± 7.1) [2, 25, 37]. Ingestion of caffeinated energy drinks increases the rate of body impacts in international sevens players [40]. There are more missed tackles (0.5 ± 0.6 vs. 0.4 ± 0.7) in low score differential versus high score differential games [32] and physical contacts are 204 predominantly related to general muscle soreness [38].

In Rugby League, players engage in 512 tackle events (24.6 ± 6.6 per back and 34.0 ± 20.5 per forward) 207 [33]. Hookers record the most tackles per game (26.4) [27].

Sex differences in physical demands

In the comparisons seen in ▶ **Table 3** female Rugby Sevens players run less (i. e., shorter total distance and relative distances) than their male counterparts [2] and experience fewer collisions [41]. Male players sprint faster and females also spend longer periods of the game at lower velocities [2].

▶ **Table 3** Physical demands of male vs female Rugby Sevens.

		Males		Females	
Collision demands	**Collisions > 10 g**	**51**		**45**	
		Senior	**Elite**	**Senior**	**Elite**
Locomotor demands	**Total distance (m)**	1176 ± 259	1249 ± 348	1099 ± 228	1078 ± 197
	Relative distance ($mmin^{-1}$)	101 ± 9	103 ± 9	98.2 ± 12.4	85.8 ± 3.9
	Max speed (ms^{-1})	8.68 ± 0.56	8.7 ± 0.99	7.4 ± 0.52	8.05 ± 0.55
	Max acceleration (ms^{-2})	3.85 ± 0.47	4.02 ± 0.50	3.31 ± 0.41	3.49 ± 0.38
	Distance > 3.5ms^{-1} (m)	439 ± 93	483 ± 172	330 ± 97	323 ± 87
	Distance > 5ms^{-1} (m)	189 ± 41	201 ± 79	102 ± 44	120 ± 41
	Sprint distance (m)	224.3 ± 46.1	223.2 ± 104.7	126.9 ± 42.9	148.6 ± 39.1
	Mean sprint duration (s)	3.9 ± 0.9	4.2 ± 1.6	4.2 ± 1.7	4.1 ± 0.44

Note: Based on collision data from *Clarke* et al. *2017* [41] and locomotor data from *Clarke* et al. *2017* [2].

Technical Demands

Eighteen studies reported on contact skill (n = 13) and skill (n = 9) demands of collision field sport athletes across different sporting levels. Most research was performed in Rugby Union (50 %) followed by AFL (28 %) and Rugby Sevens (22 %). No relevant studies were found for technical skill in women's Rugby League. Nine studies reported on male and female cohorts [42–50] and 9 reported on female only cohorts [23, 31, 51–57].

Contact skill

In Rugby Union, the tackle is the most frequent contact match event [23]. Execution of tackle technique is influenced by playing experience. Following video instruction, experienced female players demonstrate superior tackle technique by altering the angle of knee flexion (64.2 ± 23.9 ° to 142.0 ± 3.3 [45]. Contralateral knee and ankle extensor isokinetic strength was found to be related to shoulder tackle impact force in elite female Rugby Union players [51].

In Rugby Sevens, the first arriving player to the ruck has a significant role in ruck outcome and an early jackal is the most successful opposition action at producing turnovers [49]. Successful ruck actions for the team in possession include:

1) Low body position of the first arriving support player
2) Rucking beyond the ball
3) Close support lines to the tackled player
4) Using the tackled player to assist balancing body weight in a low body height.

AFL Midfielders make significantly more tackles than other positional groups averaging 3.5 ± 2.8 239 tackles per game ($p < 0.05$) [54, 55].

Non-contact skill

Passes are the most frequent non-contact match event, averaging 323 passes per game [23]. Variation in ball carrying technique significantly influences sprint performance in Rugby Union. More experienced players exhibit faster running times whilst ball-carrying [46].

In Rugby Sevens, defensive pressure can affect a player's pass type, evasive moves and line breaks [53]. Defensive pressure has no effect on passing accuracy and catching skill. Progressively increasing the degree of defensive pressure in training could encourage the performance of 'non-conventional ' passes under pressure, more closely mimicking competition game-play.

Ankle mounted inertial measurement units (IMUs) can be used to classify four commonly used AFL kicks including the drop punt, snap kick, grubber kick and surge kick [56]. Preferred leg drop-punt kicking in elite female AFL athletes are characterised by faster foot velocities prior to ball contact, greater knee angular velocities, pelvis linear velocities, and smaller hip angular velocities compared to non-preferred leg [57]. Foot and ball velocities for elite women are lower than senior and junior elite male AFL athletes. Midfielders and small forwards execute the most inside 50 s. Tall backs have the highest number of rebound 50 s and tall forwards score more goals [54]. Regardless of previous related skill, massed practice of a discrete sport skill (AFL handball passing) can lead to better retention of learning over a two-week period [50]. The transference of findings to longer term skill acquisition or competitive match environments is not clear.

Sex differences in technical demands

During machine scrummaging, senior female international players achieve comparable peak compression forces to under 18 schoolboys' Rugby [42]. Scrummaging forces vary depending on anthropometrics and technique, with elite male packs generally showing greater magnitudes and more 'dynamic' engagement phases than female packs [43]. Female forwards show a tendency for higher 'shoulders above the hips' postures [43]. On average, elite and international male teams achieve a sustained push (kilonewton) magnitude 28 % greater than International females [43]. Compared to males, female collegiate Rugby Union players responded best to educational videos to improve tackle technique [45].

Preparatory Strategies

Resistance, cardiovascular, sprint and plyometric training, and recovery sessions are implemented by 89 % of elite S&C coaches (n = 37) within Rugby codes [58]. Performance testing is frequently assessed in pre- (97 %) and in-season (86 %). Sport science technologies (54 %), psycho-social aspects (41 %), physical differences (22 %) and menstrual cycle monitoring (22 %) are commonly meas-

ured to inform current practice in national or regional/state level female athletes [58].

Tactical Considerations

Eight studies of various designs reported on the team performance indicators associated with score differential [32], final ladder position [59] and winning/losing teams [47–49, 60–62]. No relevant studies were found in women's Rugby League. All studies reported on elite athletes.

Key performance indicators related to team success in female Rugby Union include:

Attacking success: greater line breaks, more pick and go's [61].

Defensive success: less penalties conceded, higher tackle completion [61].

Key performance indicators related to team success in female Rugby Sevens include:

Attacking success: more quick lineouts, lineout success, more passes [60], more 'perturbations', quick taps, evasive footwork out wide [48].

Defensive success: More handling turnovers and 'ball-jolting-tackles ' [60]. Less missed tackles [32].

Positive phase momentum is associated with four or more passes in women's Rugby Sevens. Wide rucks are commonly used to gain positive phase momentum [47]. Greater winning margins are associated with greater running demands and fewer match activity demands [32].

Match outcomes in AFLW can be influenced by uncontested possessions and the ratio between the number of inside 50 s and goals scored. Kicks and contested marks influence final ladder position [59]. Key high-performing individual athletes' skilled performances within matches contribute more to success rather than a collective team performance [62].

Sex differences in tactical considerations

Male and female international Rugby Union teams adopt different tactical approaches to knockout competitions [61]. Women make more line breaks (5.7 ± 3.2) than men (3.75 ± 2.6) irrespective of match outcome. Women's teams demonstrated a greater difference in tackle completions between winners (92.3 % ± 3.9 %) and losers (86.8 % ± 4.9 %) in comparison to men's teams. Women's teams used more pick and go carries (24.4 % ± 11.9 %) than men's teams (8.3 % ± 4.2 %). Men's teams had a higher percentage of carries off 9 than women's teams [61].

Male and female Rugby Sevens teams display different variables for team success [47–49, 60]. Winning women's teams more often take kick offs with no contest for possession compared with men and winning men had more effective scrums than winning women [60]. Positive phases are associated with 3 or more passes in men's sevens and 4 or more passes in women's sevens [47]. Winning women use wide rucks whilst winning men use mid rucks to gain positive phase momentum. Women have a high number of perturbations from evasive footwork in wide channels whereas men's sevens more commonly use quick taps and counter attacking opposition errors [47].

Discussion

Female field collision sports are multifaceted, and findings suggest that successful performance requires the synergy of physical, technical, and tactical proficiencies.

Implications for Practitioners

Findings suggest that collision field athletes need a capacity for intermittent endurance, repeated sprint ability, collision-based exertions, accelerations and decelerations. This review presents average demands to assist practitioners in refining training practices and physical preparation for competition. Contextual factors such as positional roles [34], opposition strength [22]; score differential [32], match quarter [20], and level of competition [35] influence the physical demands during match play. Playing positions demonstrate unique locomotor and collision demands that should be considered by practitioners when designing preparatory strategies.

Despite advances in GPS technology, quantifying locomotor and collision demands in female field collision sports is challenging. Studies used a variety of GPS technologies with different terminology and velocity bands to classify locomotor actions, limiting the comparability between studies. The analysis of loads experienced through tackles or collisions is complex due to limitations in accelerometers to differentiate between types of impacts, detect impacts in female specific playing groups [33] and substantial differences between the number of collisions identified by the manufacturer's software and those identified by video analysis [33, 41]. Until collision based metrics are validated, practitioners should integrate video-based software with GPS outputs to determine the number and severity of collisions undertaken throughout match-play [33]. Like wider sport concerns, evidence doesn't consider contextual factors on the total physical demands imposed on field collision athletes [63]. For example, the total physical demands experienced by players could be under-estimated when only considering GPS running load data because this does not account for technical demands such as tackling, rucking and scrummaging.

Despite previous studies documenting the preparatory strategies in male Rugby codes [64] and AFL [65], only one questionnaire-based study was found for female field collision sports [58]. Care should be taken to interpret questionnaire findings given the difficulty in ensuring reliable and valid responses. It can be hypothesized that current preparatory strategies for female athletes have been developed from male data as well as practitioner personal experience. Although training requirements may be similar between both sexes, it is important that female-specific considerations are accounted for to reflect female athlete needs. Heterogeneity in physical preparation practices was documented across female Rugby codes which may signify a lack of consensus on best-practice approaches. Sport science technology uptake in elite female Rugby codes is comparatively lower (54 %) than the 100 % usage in professional male Rugby Union [58, 63]. Given the proliferation in the use of sports technology in athlete management for minimising injury risk [66] and athletic development it is important to understand and address the barriers to its implementation in female sports. Barriers previously reported include a lack of resources, investment and full-time staff [10]. Addressing these barriers and establishing a stronger evidence-base for the preparatory strategies

in female field collision sports will further support practitioners to make informed decisions for female athletes.

Implications for Coaches

Female collision field players must successfully execute numerous technical actions over the course of a game, such as kicking, catching, passing, scrummaging, handballing and tackling. Players need the capacity to execute the technical skills under pressure and fatigue [53]. For example, Rugby League athletes have been found to execute significantly more tackles than other Rugby codes (34.0 ± 20.5 per forward) but don't require the same breakdown demands so coaches might prioritise effective tackle technique and sufficient contact exposures in training to ensure athletes are adequately prepared for the rigours of competition [27]. Factors influencing the selection and execution of skill based demands include playing experience [45, 46, 50, 52], positional roles [29, 30] and opposition pressure [53]. Attacking success in Women's Rugby Union is characterised by greater line breaks and pick and go's [61]. Accordingly, coaches could introduce tactics to increase the probability of line breaks or develop pick and go technique to harness greater attacking gainline success [67]. Variances in technical skill demands across different positional groups aligns with research in males [60] and could be attributable to many factors, including team tactics, whereby the coaching or playing style across teams may influence the role undertaken by individual players.

Findings show tackling is a highly technical and physical skill [23, 45, 51] essential for optimal performance in female field collision sports. From a contact perspective research has focused on female match-play including tackle injury incidence [7], collision demands [22] and associations of tackle success with team performance [61]. Few studies report on how injuries occur or how to win the contact events [68]. For example, information on how female field collision athletes get injured during the tackle, execute the tackle and tackle effectively would significantly expand the current evidence base and provide more practical information for practitioners. A technical skill training framework was developed for Rugby Union [69] to help practitioners design and implement tackle training strategies. Given the lack of evidence for contact skills and training behaviours, it can be postulated that contact skill coaching, frameworks and preparatory strategies in female field collision sports are underpinned by research and experiences in male populations. Applying contact skill evidence in male athletes to female athletes may be misguided considering the differences in locomotor and collision demands [2], physiology [5], selection and execution of technical skill [39, 44, 45] and team tactics [2, 48, 61, 62]. The data provided in this review does not support the generalisation of male-derived training data to female field collision athletes. Research efforts are required to derive appropriate technical skill frameworks for female field collision athletes.

Implications for Researchers

This review provides a foundation to understand the physical and technical demands in female field collision sports. Although much is known about the physical demands; particularly locomotion, further research is needed to understand technical factors, including the broader influence of tactical determinants on match physical demands. Performance analysis within female collision field sports continues to rely heavily on isolated measures of performance, such as tackle counts and goals scored ratios, without providing context to confounding factors such as level of competition, team tactics, opposition behaviour, pitch and match period [67, 68]. A better understanding of the synergy between physical and technical demands in female field collision sports is essential for not only answering the question of what happens during a match but also how it happens. This information may better facilitate the transfer and adoption of female specific research outcomes from research to practice [68]. Future high-quality research is needed that employs consistent terminology and research designs such as those recommended by the International Olympic Committee consensus for recording and reporting data [70]. This review has identified key research priorities that are relevant to female field collision sport ▶ **Table 4**. A number of these priorities are not unique to the female game but wider issues for collision sports [63].

Implications for Policy-makers and Governing Bodies

Growing interest, participation and professionalism of the female game requires a commensurate level of resourcing as the men's game to ensure player welfare and performance. Often, the structures for female athletes have been 'borrowed' from their male counterparts without interrogation of the sex differences that may exist [5]. Policy-makers and governing bodies can use the findings of this scoping review to help support research efforts and advance the structures for high performance in female field collision athletes.

Strengths and Limitations

Scoping reviews are comprehensive, but not exhaustive [14]. They are broader and more contextual than systematic reviews [14]. The scientific rigour and methodological quality of individual studies was low with 74 % achieving a 'poor' QI score. Studies range from broad statistical analyses of commercial databases to more in-depth cohort studies which questions the generalisability of the findings. Most included studies were observational cohorts or cross-sectional studies with low Downs and Blacks scores attributable to lack of participant blinding and non-randomisation. The overall quality of the evidence speaks to the challenges of conducting research in sports medicine. Another issue is that elite athletes are often favoured for research. Whilst it is a good starting point for creating evidence-based frameworks, attention should be directed towards dissemination and implementation strategies to adapt and apply best practice to recreational sporting contexts. To enhance reproducibility and comparability across studies additional work is needed to standardise the way sex and gender are reported in sports research. Many of the studies conducted are limited by small sample sizes, research with-in one team, and repeated measures of players, introducing potential error in interpretation. Despite this, rigorous and reproducible methods have been applied and authors were committed to publish all findings. Our chosen approach has enabled us to not only address the primary research questions but also to map the evidence in a format that is useful for key stakeholders.

▶ **Table 4** Research priorities related to female field collision sports.

	Research Priority	Comment	Rationale
Physical demands	Consensus on definitions and thresholds of physical demands in female field collision sports	Heterogeneity in wearable devices used limit comparisons. The inconsistencies in terminology and speed zone thresholds underscores the difficulties encountered in meaningful comparisons of the physical demands within and between team sports [63]. Addressing inconsistencies in metrics and thresholds used to define collision and locomotor demands would advance the practical application of physical match data for practitioners.	Inconsistencies and limitations in descriptions and definitions
	Collision demands	Heterogeneity in the wearable devices and impact thresholds (>5 g, >10 g, >15 g) limits comparison between studies. The validity of GPS derived collisions has been challenged in women's Rugby League [33] and Rugby Sevens with 62 % of match collisions were incorrectly labelled [41]. Validation and consensus on female specific impact magnitudes would advance the application of physical match data for practitioners.	Inconsistencies in descriptions and definitions, validity
	Quantification of collision demands in AFL	Collision events are major causation of injuries such as concussion in AFL and understanding the collision demands should inform injury prevention and management strategies.	Knowledge gap
	Contextualising physical demands	Assimilating the physical and technical data allows practitioners a more accurate picture of the global physical match demands and worst case scenarios [63].	Knowledge gap
Technical demands	Quantification of technical skill demands	No studies documented the technical skill demands of female Rugby League. An understanding of these technical demands is important to inform coaching strategies and athletic development. Research is required to validate IMUs and other microtechnology devices to quantify skill-based demands with greater detail in female field collision sports [56].	Knowledge gap/ Low volume of evidence
	Skill acquisition in female collision field sports	Two studies discussed skill acquisition specific to AFL [50] and Rugby Union [45]. Learning effective tackle technique in Rugby Union is influenced by playing experience. Massed practice of AFL handball passing leads to better retention of learning over a two-week period. Further behavioural research is needed to examine factors related to skill acquisition in female field collision sports to help optimise technical proficiency and coaching strategies.	Low volume of evidence
	Greater volume of technical skill research in match or training settings	Fifty percent of technical studies were conducted in lab-based settings. Lab-based findings may have limited applicability to match-play due to its controlled nature but may offer deeper insights into the effects of different conditions (eg, physical fatigue) and skill acquisition strategies. There may be scope to transfer and test promising lab-based findings to match or training settings in female field collision sports.	Low volume of evidence
Preparatory strategies	Preparation strategies in female field collision sports	One study documented the physical preparation practices of female Rugby codes [58], no studies were conducted in AFL. To develop evidence-informed physical and technical skill preparation practices in female field collision sports, further research is needed to understand the current landscape and address barriers to sports technology uptake.	Knowledge gap/ Low volume of evidence

Conclusion

The evidence base for the physical and technical demands can provide practitioners with useful information for average match demands, but lacks context, and is limited by locomotive and collision metrics. There is little research on preparatory strategies suggesting that current management strategies for female athletes have been developed empirically or based on male data. Although training requirements may be similar between both sexes, a greater evidence base must be established in female field collision athletes to develop and optimise female athlete development, coaching strategies and injury prevention policy that is informed by female cohorts. We anticipate that this scoping review will stimulate more resources and research in this area.

Practical Implications

- The evidence base for the physical and technical demands has grown rapidly and can provide useful information for average match demands but remains fragmented in terms of locomotive and collision metrics and lacks contextual information for practitioners to translate research into best practice.
- Data to inform practitioners on the preparatory strategies is lacking and should be prioritised.
- Despite the growth in participation and professionalism worldwide, female field collision athletes are significantly under-represented across all research categories in comparison to males.
- Practitioners should continue to work in 'real-world' environments to adopt best practice approaches for female field collision athletes while waiting for research to catch up.
- This review makes a case for the same level of resourcing as the men's game to advance evidence-informed frameworks to ensure minimum standards are met for player welfare and performance

Conflict of Interest

The authors declare that they have no conflict of interest.

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