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Injury risk factors and barriers to their mitigation for women playing rugby league: a Delphi study

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ABSTRACT

This study aimed to 1) develop a consensus (≥70% agreement between experts) on injury risk factors specific to women playing rugby league, 2) establish the importance of the identified injury risk factors and the feasibility of mitigating these risk factors and 3) establish context specific barriers to injury risk management. Aim 1: A Delphi panel, consisting of 12 experts in rugby league and injury (e.g., physiotherapists, research scientists) were asked to identify injury risk factors specific to women playing rugby league. Aim 2: seven coaches of women's rugby league teams were asked to rate each risk factor that achieved consensus by their importance and feasibility to manage. Aim 3: Coaches reported barriers which restrict injury risk factor mitigation. Of the 53 injury risk factors which achieved consensus, the five injury risk factors with the highest combination of importance and feasibility ratings were: "poor tackle technique", "a lack of pre-season intensity", "training session are too short", "the current medical standards", and "limited access to physiotherapists". Following the identification of injury risk factors, their feasibility to manage and context specific barriers, this study proposes three constraint driven, integrated solutions which may reduce the barriers which limit injury risk factor management.

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Female sport; feasibility; injury reduction; sport safety

Introduction

The number of women playing rugby league has grown globally (Cummins et al., 2020). Participation in the United Kingdom has increased by 53% from 2017 to 2021 (The Rugby Football League, 2021), whilst the number of Australian women who played rugby league in 2018 increased by 29% compared to previous years (Cummins et al., 2020). Improved competition pathways have been established with the inauguration of the Women's Super League (WSL) in 2017 in the United Kingdom, and the National Rugby League Women's (NRLW) Premiership in 2018 in Australasia. However, whilst the sport continues to grow, research in women's rugby league remains limited, with a recent call to action highlighting the need to increase the evidence base (e.g., the identification of injury risk factors) to help inform practice (Cummins et al., 2020).

The nature and incidence of injury in men playing rugby league has been comprehensively investigated e.g., (King et al., 2010; Orr et al., 2020). Comparatively, information on injuries suffered by adult women playing rugby league is limited to two studies which examined the financial burden of moderate to severe injury claims (£1872 per claim; King et al., 2010) and injury incidence (medical attention and time loss) during a five-team tournament (306.8 injuries per 1000 hours; King & Gabbett, 2007). Furthermore, research (Orr et al., 2020) quantifying injury incidence in youth rugby league players found the injury incidence (medical attention and time loss) of U13-U18 female players (22.2 injuries/1000 player hours) to be higher than the overall injury incidence when all age groups (U6-U18) and both sexes were combined (5.9 injuries/1000 player hours). This was attributed to the U16 to U18 age group where 16 and 17 year-olds were playing against older aged females in an U18 competition (Orr et al., 2020). The increased injury incidence for female players in comparison to their male counterparts highlights the need to understand injury risk factors specific to women (both adult and youth) playing rugby league.

Given the lack of research determining injury risk factors in women playing rugby league, and therefore a limited evidence base for policy makers and practitioners, a Delphi method involving experts in the field may provide a robust multistage process to achieve consensus on this subject (Zambaldi et al., 2017). The Delphi-method facilitates knowledge generation which is an important initial step in successfully transferring evidence-based information to practice (Reade et al., 2008). However, before strategies to manage the identified injury risk factors can be implemented, consideration should also be given to the context (e.g., amateur sport) in which they are to be applied (Donaldson et al., 2015). Acknowledging any

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constraints in sport that affect female athletes will help guide intervention plans. For example, factors such as insufficient training time, a lack of resources or equipment and staff provision may limit the ability of practitioners to implement the same injury management strategies applicable to men (Emmonds et al., 2019). Therefore, the incorporation of stakeholders into the research process has been advocated to increase the application of injury prevention data into practice (Fullagar et al., 2019; Jones et al., 2019). Stakeholders, such as coaches, can bridge the gap between research and practice by defining the importance of injury risk factors within a specific context, their feasibility to manage and the barriers which may restrict their management (Donaldson et al., 2015).

Following the identification of context specific barriers which restrict the management of injury risk factors relevant to women playing rugby league, informed solutions can be applied to reduce the barriers which restrict injury risk factor mitigation. Therefore, this study included two stages. The aim of stage I was to develop a consensus on injury risk factors specific to women playing rugby league from a group of expert practitioners and researchers. Stage II aimed to establish coach perceptions of the importance of the identified injury risk factors, their feasibility to manage, and the context specific barriers that restrict their management. Combining expert knowledge of injuries in women playing rugby league alongside perceptions of injury risk factor management from coaches will facilitate the implementation of evidence-based solutions into practice.

Method

Study design

Stage I utilised expert opinion to identify injury risk factors specific to women playing rugby league. Stage II established the rating of importance and feasibility to manage the injury risk factors which achieved consensus in stage I through WSL and international rugby league coach perception. Additionally, coaches were asked to identify perceived barriers in the management of the injury risk factors.

Participants were provided with an information letter outlining details relating to the aims, procedures, and requirements of the study. Following an opportunity to ask questions participants provided written consent. Ethics approval was granted prior to data collection by the university's ethics committee (73101).

Participants

Stage I

Stage I utilised expert opinion to identify injury risk factors in women playing rugby league. To obtain reliable results, a Delphi panel needs to contain >10 experts (Vergouw et al., 2011). To be included in the Delphi panel, experts were required to meet one or more of the following criteria, (a) currently working as a strength & conditioning coach or performance support staff in women's rugby league or rugby union teams, (b) published scientific research on injuries in rugby union or league, (c) published scientific research regarding injuries in female athletes, (d) a minimum of 3 years' experience working with female athletes in a sports setting (e.g., doctor, strength and conditioning coach or physiotherapist). Experts who met the required criteria were able to recommend additional experts that met the criteria and could contribute valuable knowledge to the Delphi-process. Experts were classified via four categories, (1) research scientists, (2) strength and conditioning coaches, (3) physiotherapists, (4) medical doctors. Experts were recruited via the methods associated with higher responses rates in electronic questionnaires (Cook et al., 2000) such as contacting industry colleagues and cold contacting via email.

Of the 24 experts invited to participate, 16 experts participated in round one (1 medical doctor, 7 strength and conditioning coaches, 4 physiotherapists, 4 research scientists). Cumulatively, experts had 84 years' experience working with female athletes in a sports setting, 58 years working in women's rugby league or union teams and 5 peer-reviewed research papers on injuries in rugby. Four experts did not participate in round two. Twelve experts (1 medical doctor, 5 strength and conditioning coaches, 3 physiotherapists, 3 research scientists) participated in all three rounds.

Stage II

The coaching staff of all 10 WSL clubs and the international team were invited to participate. Seven coaches participated in total, representing six WSL teams and one international team.

Procedure

Stage I: round I

To help structure round I of the Delphi-process, factors which contribute to injury in sport were identified from previous literature and grouped into four categories by the lead researcher. The category "*individual player characteristics*" included poor body composition (Ezzat et al., 2016; Foss et al., 2012), poor physical qualities (De La Motte et al., 2017; Woolings et al., 2015) and the menstrual cycle (Herzberg et al., 2017; Oleka, 2019). The category "*lifestyle and environment*" included poor sleep (Laux et al., 2015; Von Rosen et al., 2017), poor nutrition (Close et al., 2019; Laux et al., 2015), work and academic stress (Mann et al., 2016; Tranæus et al., 2017) and family commitments (Kellmann & Beckmann, 2017; Tranæus et al., 2017). The category "*training and match factors*" included training & match schedules (Carling et al., 2016; Howle et al., 2019), the opponent (Rago et al., 2018), collisions (Gabbett & Ryan, 2009; Sewry et al., 2017) and poor conditions and facilities (Mears et al., 2018; Ryynänen et al., 2018). The category "*a lack of provision*" included injury risk factors such as limited access to staff (Tee et al., 2018), limited access to training (Gabbett, 2016; Lauersen et al., 2014), low standard of facilities (Mahler & Donaldson, 2010; McGinnis, 1985), and inappropriate monitoring systems. A category of "*other*" was also included in the questionnaire to capture any injury risk factors which may not fit into the four categories.

The questionnaire for round I was built using Qualtrics online software (Qualtrics, Provo, USA) and was split into seven sections. Section one provided study information and

required participants to provide informed consent. Sections two, three, four, five and six asked participants to list any injury risk factors relating to "*individual player characteristics*", "*lifestyle and environment*", "*training and match factors*", "*a lack of provision*", and "*other*" which may impact women's rugby league players. The final section offered experts the opportunity to recommend additional experts who may offer valuable information. Experts were given four weeks from the date the initial invitation was sent to complete the questionnaire. A reminder email was sent after two weeks if the participant was yet to complete the questionnaire. If the participant did not complete the questionnaire following the four-week deadline they were deemed unwilling to participate.

A steering committee was formed to guide the Delphi-process. The steering committee consisted of two professors with experience in rugby injury research, two senior researchers with experience of southern hemisphere rugby league and two post-doctoral researchers currently working with an international women's rugby league team. Questionnaire responses were collated and analysed by the steering committee with injury risk factors grouped under the five category headings. Duplicate responses were removed until each category contained a unique list of injury risk factors.

Stage I: round II and round III

The injury risk factors identified for each of the five categories were listed next to a five point Likert scale (Robertson et al., 2017; Zambaldi et al., 2017) ranging from 1 – *Strongly Disagree*, 2 – *Disagree*, 3 – *Neither Agree* or *Disagree*, 4 – *Agree*, 5 – *Strongly Agree*. Participants were asked to indicate their level of agreement whether they perceived the injury risk factor increased the risk of injury. To assess consensus in both rounds II and III, Likert scale ratings were combined (i.e., Disagree [1 and 2], Neither Agree nor Disagree [3], Agree [4 and 5]; Zambaldi et al., 2017). A ≥ 70% agreement threshold was used to indicate consensus between the expert panel (Van Der Horst et al., 2017; Verhagen et al., 1998). For example, if ≥70% of the expert panel strongly agreed/agreed that an injury risk factor increased the risk of injury, the injury risk factor would have achieved consensus. Of the initial 16, 12 experts provided responses for round II, indicating a 75% retention rate, typical of this study type (Mokkink et al., 2010).

The injury risk factors for each category which did not reach consensus in round II were listed in the round III questionnaire alongside the same five-point Likert scale used in round II. The mean rating of agreement from round II was listed next to each injury risk factor to allow experts the opportunity to reflect on their initial rating. All 12 participants from round II participated in round III (retention rate of 100%). Following round III, the injury risk factors that did not achieve ≥70% agreement were deemed to have not reached consensus and were discarded.

Stage II

Coaches were asked to rate the "importance" (i.e., the importance that the injury risk factor increased the risk of a women's rugby league player getting injured) and the feasibility (i.e., the feasibility that the women's rugby league injury risk factor can be managed and reduced) of all the injury risk factors which achieved consensus on a five-point Likert scale ranging from 1 to 5 (1 = *strongly disagree*, 5 = *strongly agree*). Coaches were asked to list any barriers preventing the management of the injury risk factor below each injury risk factor. Therefore, upon completion of the questionnaire, all injury risk factors had a rating of importance and feasibility, as well as a list of any barriers preventing management.

The questionnaire, built by Qualtrics online software (Qualtrics, Provo, USA), was emailed to the head coach of each WSL club and a coach of the international team. Coaches were given two weeks to complete the questionnaire. Coaches were invited to attend an online meeting held after one week with two members of the steering committee present (SS, BJ) to answer any questions regarding the completion of the questionnaire. Questionnaire responses were downloaded into an Excel file for analysis.

Data analysis

Stage I: round I

The open-ended qualitative responses from round I were downloaded into an Excel file and analysed via inductive content analysis (Crowe et al., 2015; Elo & Kyngäs, 2008). Initially, the meaning units (raw data statements) were read by three members of the steering committee (SS, BJ, CR) on numerous occasions to facilitate data familiarity and immersion. Each meaning unit was coded to represent a category. The categories were then assimilated to represent injury risk factors, with each injury risk factor placed within a theme ("*individual player characteristics*", "*lifestyle and environment*", "*training and match factors*", "*a lack of provision*", and "*other*"). Meaning units, categories and themes were examined thoroughly again by the steering committee (SS, BJ, CR) to ensure all information were represented appropriately. The research team engaged in constant discussion to cross check and confirm the distribution of data into the correct categories and themes (Braun et al., 2016). Finally, the analysis was reviewed, and results ordered in a table to display the themes generated.

Stage I – round II and round III

To assess consensus in both rounds II and III, Likert scale ratings were combined (i.e., Disagree [1 and 2], Neither Agree nor Disagree [3], Agree [4 and 5]; Zambaldi et al., 2017). Consensus was defined as an injury risk factor achieving ≥70% agreement between experts (Robertson et al., 2017; Van Der Horst et al., 2017). Additionally, Kendall's W coefficient of concordance was used to assess agreement between experts. Statistical significance was set at $P < 0.05$.

Stage II

The mean rating of importance and feasibility for each injury risk factor was calculated. Additionally, the mean rating of importance and feasibility for all the injury risk factors combined was calculated. This allowed each injury risk factor to be categorised as either "above average importance and above average feasibility" (AAI & AAF), "above average importance and below average feasibility" (AAI & BAF), "below average importance and above average feasibility" (BAI & AAF), and "below average importance and below average feasibility" (BAI & BAF).

The barriers perceived to restrict the management of injury risk factors were analysed via inductive content analysis (Crowe et al., 2015; Elo & Kyngäs, 2008) using the same process detailed in round I, stage I. However, whereas round I, stage I, grouped categories into five pre-determined themes, the themes in stage II evolved from the review, analysis, and evaluation of the coded categories by the steering committee (SS, BJ).

Results

A total of 82 injury risk factors were identified following round I, stage I. The injury risk factors were coded into the themes of "*individual player characteristics*" (n = 11), "*lifestyle and environment*"(n = 26), "*training and match factors*" (n = 25), "*a lack of provision*" (n = 12), and "*other*" (n = 8) . Following round II, 54 injury risk factors achieved consensus (48 strongly agree & agree, 2 neither agree nor disagree, 4 strongly disagree & disagree). Kendall's W was significant at 0.41 ($p < 0.0001$). The 28 injury risk factors which did not reach consensus were listed in the round III questionnaire. Following round III, an additional 14 injury risk factors achieved consensus, (5 strongly agree & agree, 3 neither agree nor disagree, 6 strongly disagree & disagree), 14 injury risk factors were deemed to have not reached consensus and were removed from the study. Furthermore, the injury risk factors which achieved a "neither agree nor disagree" or "strongly disagree & disagree" consensus were removed from the study. Kendall's W was significant at 0.41 ($p < 0.013$).

Tables 1–5 display the injury risk factors which were agreed in stage I for the themes of "*individual player characteristics*" (14 injury risk factors), "*lifestyle and environment"* (5 injury risk factors), "*training and match factors*" (17 injury risk factors), "*provision*" (10 injury risk factors), and "*other*" (7 injury risk factors) respectively. Each table contains the mean and standard deviation of coach perceptions of importance and feasibility for each injury risk factor, the risk factor grouping (i.e., AAI & AAF; AAI & BAF; BAI & AAF; BAI & BAF) and any barriers perceived to restrict the management of that injury risk factor. Forty-three barriers to injury risk factor management were coded into eight themes: "*multiple commitments limits time to train*", "a *lack of education*", "*a small player pool*", "*a lack of developmental pathway*", "*a limited training and playing age*", "*a lack of qualified staff provision*", "*a lack of facilities*", and the "*players attitude towards training*". Figure 1 ranks the combined mean ratings of importance and feasibility for each injury risk factor.

Injury risk factors perceived to have above average importance and above average feasibility (AAI & AAF)

Twelve injury risk factors were perceived to have above average importance and above average feasibility to manage, of which, two were classified under the theme "*individual player characteristics*" (*players with poor tackle technique; players with a poor attitude to training*). Four of the injury risk factors were classified under the theme "*training and match play"*, (*training at an intensity that is not appropriate; playing more minutes in a match than prepared for; a lack of pre-season length; a lack of pre-season intensity*). Five injury risk factors were categorised under the theme of "*a lack of provision*", (*not having access to qualified physiotherapists; having limited access to physiotherapists during an injury; a lack of education on prehab/injury management; the current pathway; the current medical standards of the competition*). One injury risk factor was classified under the theme of "*other*" (*players not being honest about the severity of a recurrent injury*).

Injury risk factors deemed to have above average importance and below average feasibility (AAI & BAF)

Sixteen injury risk factors were perceived to have above average importance and below average feasibility to manage, of which, one was classified under the theme "*individual player characteristics*" (*players with poor mobility*). One injury risk factor was classified under the theme "*lifestyle and environment*", (*poor recovery*). Four injury risk factors were categorised under the theme of "*training and match factors*", (*fixtures are arranged too far apart leading to player deconditioning; the training surface; players playing when not fit; training sessions are too long*). Five injury risk factors were categorised under the theme of "*a lack of provision*" (*not having access to qualified strength and conditioning coaches; a lack of coach "buy-in" to medical provision; a lack of coach "buy-in" to strength and conditioning provision; limited financial investment in facilities and infrastructure; a lack of exposure to an elite environment*). Five injury risk factors were categorised under the theme of "*other*" (*a high demand on players despite being amateur; previous injury places players at risk of re-injury; previous injury places players at risk of new injury; a lack of accountability; the sport is not professional*).

Injury risk factors deemed to have below average importance and above average feasibility (BAI & AAF)

Twelve injury risk factors were perceived to have below average importance and above average feasibility to manage, of which, four were classified under the theme "*individual player characteristics*" (*players who are younger; players with a younger training age; players with low absolute strength; players with poor movement mechanics in the gym*). Two of the injury risk factors were classified under the theme "*lifestyle*", (*poor sleep; a poor diet*). Five injury risk factors were categorised under the theme of "*training and match factors"*, (*inappropriate structure of training; inappropriate footwear; poor resistance training programme delivery; training sessions are too short; the increase in training demands when moving up in standard*). One injury risk factor was classified under the theme of "other" (*players not being honest about the severity of a new injury*).

Injury risk factors deemed to have below average importance and below average feasibility (BAI & BAF)

Thirteen injury risk factors were perceived to have below average importance and below average feasibility, of which, seven were classified under the theme "*individual player characteristics*" (*players who are older; players with muscular imbalances; players with poor movement mechanics on the field; players with poor unilateral stability; players with poor game understanding; players with high body fat; players with hyper-mobility*). Two of

Table 1. The importance, feasibility to manage, grouping and barriers restricting management of the injury risk factors categorised under the theme of "individual player characteristics".

Individual Player Characteristics	Importance (Mean ± SD)	Feasibility (Mean ± SD)	Grouping	Coach Perceived Barriers
Players who are older	3.29 ± 0.49	2.57 ± 0.98	BAI & BAF	• Multiple commitments such as family and jobs limits time to train [a] • Players lack an understanding of the need to take care of their bodies [b] • A lack of depth to rotate players who may struggle physically [c] • A lack of available players to recruit replacements [c] • Players do not possess the required physical attributes [c]
Players who are younger	3.67 ± 1.03	3.83 ± 1.17	BAI & AAF	• Multiple commitments such as family and jobs limits time to train [a] • Players require education on the training process e.g., lifting technique, training periodisation etc [b] • A lack of depth to rotate players who may struggle physically [c] • A lack of technique in the collision [d]
Players with a younger training age (i.e., players who have less years' experience of training)	3.83 ± 0.41	3.67 ± 0.82	BAI & AAF	• Players require education on the training process e.g., lifting technique, training periodisation etc [b] • A lack of depth to rotate players who may struggle physically [c] • Players do not possess the required physical attributes [d]
Players with low absolute strength (i.e., players who lack strength irrespective of their body mass)	4.00 ± 0.63	3.33 ± 1.03	BAI & AAF	• Multiple commitments such as family and jobs limits time to train [a] • Coaches (e.g., strength & conditioning, rugby) require education on good coaching practices [b] • Limited access to gym facilities so reliant on players training in their own time [f]
Players with muscular imbalances (e.g., discrepancies in strength/flexibility between muscle groups on the same or opposing limbs)	4.00 ± 0.89	2.67 ± 0.82	BAI & BAF	• A lack of player commitment to correct specific issues [g] • A lack of timely diagnosis of specific issues [h]
Players with poor mobility (e.g., a lack of flexibility)	4.33 ± 0.52	3.20 ± 0.84	AAI & BAF	• Coaches (e.g., strength & conditioning, rugby) require education on good coaching practices [b] • Players do not participate in their own recovery process [g] • A lack of medical support (e.g., strength & conditioning, physio, doctor) [h] • A lack of funding to pay players and staff for time & expertise [h]
Players with poor movement mechanics in the gym (e.g., poor technique when lifting weights in the gym)	3.83 ± 1.17	3.33 ± 1.03	BAI & AAF	• Players require education on the training process e.g., lifting technique, training periodisation etc [b] • Limited access to gym facilities so reliant on players training in their own time [f] • A lack of medical support (e.g., strength & conditioning, physio, doctor) [h]
Players with poor movement mechanics on the field (e.g., poor running technique)	3.67 ± 0.52	3.00 ± 1.00	BAI & BAF	• A lack of time to work on specific issues [a] • Players require education on the training process e.g., lifting technique, training periodisation etc [b] • Previous injuries can restrict physical development [d] • A lack of medical support (e.g., strength & conditioning, physio, doctor) [h]
Players with poor unilateral stability (e.g., poor balance with one leg)	(1) ± 0.82	3.00 ± 0.89	BAI & BAF	• A lack of time to work on specific issues [a] • Players require education on the training process e.g., lifting technique, training periodisation etc [b] • A lack of medical support (e.g., strength & conditioning, physio, doctor) [h]
Players with poor tackle technique	4.50 ± 0.84	4.00 ± 1.10	AAI & AAF	• A lack of time to work on specific issues [a] • Coaches (e.g., strength & conditioning, rugby) require education on good coaching practices [b] • A lack of available players to recruit replacements [c] • Players do not possess the required physical attributes [d] • Players have not been coached from a young age [e] • Poor training attendance [g] • A low standard of coaching (e.g., strength & conditioning, physio, doctor) [h]

(*Continued*)

Table 1. (Continued).

Individual Player Characteristics	Importance (Mean ± SD)	Feasibility (Mean ± SD)	Grouping	Coach Perceived Barriers
Players with poor game understanding (e.g., getting involved in contact situations they do not need to be in)	4.00 ± 1.55	2.67 ± 1.21	BAI & BAF	• Coaches (e.g., strength & conditioning, rugby) require education on good coaching practices [b] • Players have not been coached from a young age [e] • A low standard of coaching (e.g., strength & conditioning, physio, doctor) [h]
Players with high body fat	3.33 ± 0.82	2.67 ± 2.21	BAI & BAF	• A lack of time to work on specific issues [a] • Players lack an understanding of the need to take care of their bodies [b] • A lack of available players to recruit replacements [c] • A lack of player commitment to correct specific issues [g] • A lack of minimum standards for both players and staff [h]
Players with hyper-mobility (i.e., increased flexibility around joints)	3.40 ± 1.14	2.80 ± 0.84	BAI & BAF	• A lack of timely diagnosis of specific issues [h] • A lack of medical support (e.g., strength & conditioning, physio, doctor) [h]
Players with a poor attitude to training	4.57 ± 0.52	3.33 ± 1.51	AAI & AAF	• A lack of squad depth to replace players with poor attitude and lifestyle habits [b] • Players have not been coached from a young age [e]

Barrier theme key:
[a]Multiple commitments limits time to train.
[b]A lack of education.
[c]A small player pool.
[d]A limited training and playing age.
[e]A lack of developmental pathway.
[f]A lack of facilities.
[g]Player attitude towards training.
[h]A lack of qualified staff provision.

Table 2. The importance, feasibility to manage, grouping, and barriers restricting management of the injury risk factors categorised under the theme of "lifestyle and environment factors".

Lifestyle and Environment Factors	Importance (Mean ± SD)	Feasibility (Mean ± SD)	Grouping	Barrier Category
Poor recovery (e.g., insufficient recovery between training sessions)	4.17 ± 0.41	3.17 ± 0.75	BAI & BAF	• Multiple commitments limits athlete recovery [a] • Players lack an understanding of the need to take care of their bodies [b] • A lack of resources to facilitate recovery methods [f]
Poor sleep (e.g., a lack of sleep quality or quantity)	3.67 ± 0.52	3.33 ± 1.21	BAI & AAF	• Multiple commitments limits athlete recovery [a] • Players lack an understanding of the need to take care of their bodies [b]
A very active job (e.g., a job that is fatiguing)	3.83 ± 0.75	2.83 ± 1.60	BAI & BAF	• Multiple commitments such as family and jobs limits time to train [a]
A poor diet (e.g., a diet with insufficient calories to provide enough energy for training)	4.00 ± 0.89	3.80 ± 0.84	BAI & AAF	• Players lack an understanding of the need to take care of their bodies [b] • A lack of squad depth to replace players with poor attitude and lifestyle habits [c] • Players lack commitment to a healthy lifestyle [g]
High stress (e.g., an accumulation of stress from multiple sources such as training and work)	3.67 ± 0.52	3.17 ± 0.98	BAI & BAF	• Multiple commitments limits athlete recovery [a] • Players require education on subjects such as stress management [b] • A lack of communication channels for players to talk [h]

Barrier theme key:
[a]Multiple commitments limits time to train.
[b]A lack of education.
[c]A small player pool.
[d]A limited training and playing age.
[e]A lack of developmental pathway.
[f]A lack of facilities.
[g]Player attitude towards training.
[h]A lack of qualified staff provision.

Table 3. The importance, feasibility to manage, grouping and barriers restricting management of the injury risk factors categorised under the theme of "training and match factors".

Training and Match Factors	Importance (Mean ± SD)	Feasibility (Mean ± SD)	Grouping	Barrier Category
Large fluctuations in training volume (e.g., large increases or decreases in the amount of training a player is doing)	3.67 ± 0.52	2.83 ± 0.98	BAI & BAF	• Multiple commitments such as family and jobs limits time to train [a] • Players require education on the training process e.g., lifting technique, training periodisation etc [b] • A lack of depth to rotate players who may struggle physically [c]
Large fluctuations in training intensity (e.g., large increases or decreases in how hard a player is training)	3.83 ± 0.41	3.17 ± 0.98	BAI & BAF	• Multiple commitments limits athlete recovery [a] • Players require education on the training process e.g., lifting technique, training periodisation etc [b]
Inappropriate structure of training (e.g., the order of weights, sprinting, conditioning within a given session)	3.50 ± 1.38	3.83 ± 1.17	BAI & AAF	• Players require education on the training process e.g., lifting technique, training periodisation etc [b] • Difficult to structure training as club is reliant on pitch and gym access [f]
Inappropriate footwear (e.g., footwear that is not suitable for the training environment)	3.50 ± 1.05	4.33 ± 0.52	BAI & AAF	• Multiple commitments limits time to prepare for training [a] • A lack of funding to pay for appropriate equipment and facilities [f]
Training at an intensity that is not appropriate (e.g., training at an intensity that does not prepare players for the demands of match intensity)	4.17 ± 0.41	3.67 ± 0.52	AAI & AAF	• Scheduling (e.g., players are too sore to replicate match demands following the weekends game) [a] • Players require education on the training process e.g., lifting technique, training periodisation etc [b]
Fixtures are arranged too close together restricting recovery	3.83 ± 1.17	3.20 ± 0.84	BAI & BAF	• Scheduling (e.g., players are too sore to replicate match demands following the weekends game) [a]
Fixtures are arranged too far apart leading to players deconditioning	4.33 ± 0.52	3.20 ± 0.84	AAI & BAF	• Player injury and illness can lead to game cancellation [c]
The training surface	4.17 ± 0.41	3.17 ± 0.98	AAI & BAF	• A lack of facilities for field-based training [f]
Poor resistance training programme delivery (e.g., inappropriate coaching of correct technique in the gym)	4.00 ± 0.89	3.50 ± 0.84	BAI & AAF	• Coaches (e.g., strength & conditioning, rugby) require education on good coaching practices [b] • Limited access to gym facilities so reliant on players training in their own time [f] • A lack of funding to pay players and staff for time & expertise [h]
Playing more minutes during a match than prepared for (e.g., a player returning from injury plays longer than recommended)	4.50 ± 0.84	3.50 ± 0.55	AAI & AAF	• Multiple commitments limits player matchday availability [a] • A lack of depth to rotate players who may struggle physically [c]
A lack of demanding matches (e.g., players are not conditioned for demanding fixtures when they occur)	4.00 ± 0.63	3.17 ± 0.75	BAI & BAF	• Large differences in fitness and skill levels across the WSL [d]
A lack of pre-season length (e.g., insufficient training sessions to prepare players for the upcoming season)	4.50 ± 0.84	3.40 ± 1.34	AAI & AAF	• Multiple commitments such as family and jobs limits time to train [a] • A lack of training time during the week for field training [a]
A lack of pre-season intensity (e.g., training is not hard enough to prepare players for the upcoming season)	4.60 ± 0.55	3.80 ± 1.64	AAI & AAF	• A lack of training time during the week for field training [a] • Players require education on the training process e.g., lifting technique, training periodisation etc [b]
Players playing when not fit (e.g., playing when not fully recovered from an injury)	4.67 ± 0.52	3.00 ± 1.00	AAI & BAF	• A lack of depth to rotate players who may struggle physically [c] • A low standard of coaching (e.g., strength & conditioning, rugby coaches) [h]
Training sessions are too long (e.g., increasing player fatigue and reducing recovery)	4.67 ± 0.89	3.00 ± 0.45	AAI & BAF	• A lack of training time during the week for field training [a] • Coaches (e.g., strength & conditioning, rugby) require education on good coaching practices [b]

(*Continued*)

Table 3. (Continued).

Training and Match Factors	Importance (Mean ± SD)	Feasibility (Mean ± SD)	Grouping	Barrier Category
Training sessions are too short (e.g., not sufficient training stimulus to prepare players for competition)	4.00 ± 1.05	4.20 ± 0.89	BAI & AAF	• Multiple commitments such as family and jobs limits time to train [a] • A lack of facilities for field-based training [f]
The increase in training demands when moving up in standard (e.g., players moving from junior club to senior squad)	3.50 ± 0.52	3.60 ± 1.58	BAI & AAF	• Players require education on the training process e.g., lifting technique, training periodisation etc [b] • A big jump to the senior game [e]

Barrier theme key:
[a]Multiple commitments limits time to train.
[b]A lack of education.
[c]A small player pool.
[d]A limited training and playing age.
[e]A lack of developmental pathway.
[f]A lack of facilities.
[g]Player attitude towards training.
[h]A lack of qualified staff provision.

Table 4. The importance, feasibility to manage, grouping and barriers restricting management of the injury risk factors categorised under the theme of "a lack of provision".

A Lack of Provision Factors	Importance (Mean ± SD)	Feasibility (Mean ± SD)	Grouping	Barrier Category
Not having access to qualified strength & conditioning coaches (strength and conditioning coaches do not have sufficient qualifications or experience)	4.67 ± 0.82	3.00 ± 0.82	AAI & BAF	• Coaches (e.g., strength & conditioning, rugby) require education on good coaching practices [b] • A lack of medical support (e.g., strength & conditioning, physio, doctor) [h] • A lack of funding to pay players and staff for time & expertise [h]
Not having access to qualified physiotherapists (e.g., physiotherapists do not have sufficient qualifications/ experience)	4.33 ± 0.52	3.33 ± 1.34	AAI & AAF	• A lack of medical support (e.g., strength & conditioning, physio, doctor) [h] • A lack of funding to pay players and staff for time & expertise [h] • A lack of minimum standards for both players and staff [h]
Having limited access to physiotherapists during an injury (e.g., a physiotherapist is not present to guide the player through the return to play process)	4.67 ± 0.55	3.40 ± 1.34	AAI & AAF	• Multiple commitments limits time to prepare for training [a] • A lack of medical support (e.g., strength & conditioning, physio, doctor) [h]
A lack of education on prehab/injury management (e.g., players do not have enough knowledge about mobility excises/ routines)	4.67 ± 0.55	3.40 ± 1.30	AAI & AAF	
A lack of coach "buy-in" to medical provision (e.g., coaches do not work collaboratively with physiotherapists)	4.50 ± 0.82	3.20 ± 0.45	AAI & BAF	• Coaches (e.g., strength & conditioning, rugby) require education on good coaching practices [b] • A lack of depth to rotate players who may struggle physically [c] • A lack of medical support (strength & conditioning, physio, doctor) [h]
A lack of coach "buy-in" to strength & conditioning provision (e.g., coaches do not work collaboratively with strength & conditioning coaches)	4.33 ± 0.75	3.20 ± 0.45	AAI & BAF	• Coaches (e.g., strength & conditioning, rugby) require education on good coaching practices [b] • A lack of funding to pay players and staff for time & expertise [h] • A lot of personnel changes brought about by voluntary positions [h]
The current pathway (e.g., a lack of academies to help players develop prior to taking part in the WSL competition)	4.17 ± 0.84	3.80 ± 1.52	AAI & AAF	• A lack of depth leads to players playing open age rugby when they are not ready [c] • A lack of communication between organisational bodies with regards to the most appropriate option for players development pathways [e] • A lack of funding to establish an appropriate development pathway [e]
The current medical standards of the WSL (e.g., current concussion and injury management)	4.50 ± 0.75	3.60 ± 1.22	AAI & AAF	• A low standard of coaching (e.g., strength & conditioning, rugby coaches) [h] • A lack of funding to pay players and staff for time & expertise [h]
Limited financial investment in facilities and infrastructure (e.g., insufficient funding placed into training facilities)	4.17 ± 0.41	3.00 ± 1.00	AAI & BAF	• A lack of funding to pay for appropriate equipment and facilities [f] • The WSL does not generate sufficient income [f]

(*Continued*)

Table 4. (Continued).

A Lack of Provision Factors	Importance (Mean ± SD)	Feasibility (Mean ± SD)	Grouping	Barrier Category
A lack of exposure to an elite environment (e.g., players training habits are not aligned with the standards required)	4.83 ± 0.84	2.60 ± 0.45	AAI & BAF	• Multiple commitments such as family and jobs limits time to train [a] • A lack of squad depth to replace players with poor attitude and lifestyle habits [c] • A big jump to the senior game [e] • Limited access to gym facilities so reliant on players training in their own time [f] • A lack of funding to pay for appropriate equipment and facilities[6] • Poor training attendance [g]

Barrier theme key:
[a]Multiple commitments limits time to train.
[b]A lack of education.
[c]A small player pool.
[d]A limited training and playing age.
[e]A lack of developmental pathway.
[f]A lack of facilities.
[g]Player attitude towards training.
[h]A lack of qualified staff provision

Table 5. The importance, feasibility to manage, grouping and barriers restricting management of the injury risk factors categorised under the theme of "other".

Other factors	Importance (Mean ± SD)	Feasibility (Mean ± SD)	Grouping	Barrier Category
A high demand on players despite being amateur (e.g., players may have to use holidays from work to train/play, meaning they can't use that time for recovery)	4.83 ± 0.84	2.60 ± 0.45	AAI & BAF	• A lack of available players to recruit replacements [c] • A lack of funding to pay players and staff for time & expertise [h]
Previous injury places players at risk of re-injury	4.50 ± 0.52	2.20 ± 0.84	AAI & BAF	• A lack of depth to rotate players who may struggle physically [c] • A lack of medical support (strength & conditioning, physio, doctor) [h]
Previous injury places players at risk of a new injury	4.33 ± 0.52	2.00 ± 0.00	AAI & BAF	• A lack of depth to rotate players who may struggle physically [c]
Players not honest about severity of recurrent injury (e.g., players downplay a recurring injury to participate in training/competition)	4.17 ± 0.98	3.60 ± 0.55	AAI & AAF	• Players lack an understanding of the need to take care of their bodies [b] • A lack of timely diagnosis of specific issues [h]
Players not honest about severity of a new injury (e.g., players downplay a new injury to participate in training/competition)	4.00 ± 0.89	3.40 ± 0.55	BAI & AAF	• Players lack an understanding of the need to take care of their bodies [b]
A lack of accountability (e.g., players not accountable for choices that may affect their training)	4.17 ± 0.41	3.20 ± 1.30	AAI & BAF	• Multiple commitments limits time to prepare for training [a] • A lack of available players to recruit replacements [c]
Sport is not professional (e.g., players must work which reduces their time to train/recover)	4.67 ± 0.82	2.00 ± 1.00	AAI & BAF	• Multiple commitments limits athlete recovery [a] • Players lack commitment to a healthy lifestyle [g] • A lack of funding to pay players and staff for time & expertise [h]

Barrier theme key:
[a]Multiple commitments limits time to train.
[b]A lack of education.
[c]A small player pool.
[d]A limited training and playing age.
[e]A lack of developmental pathway.
[f]A lack of facilities.
[g]Player attitude towards training.
[h]A lack of qualified staff provision.

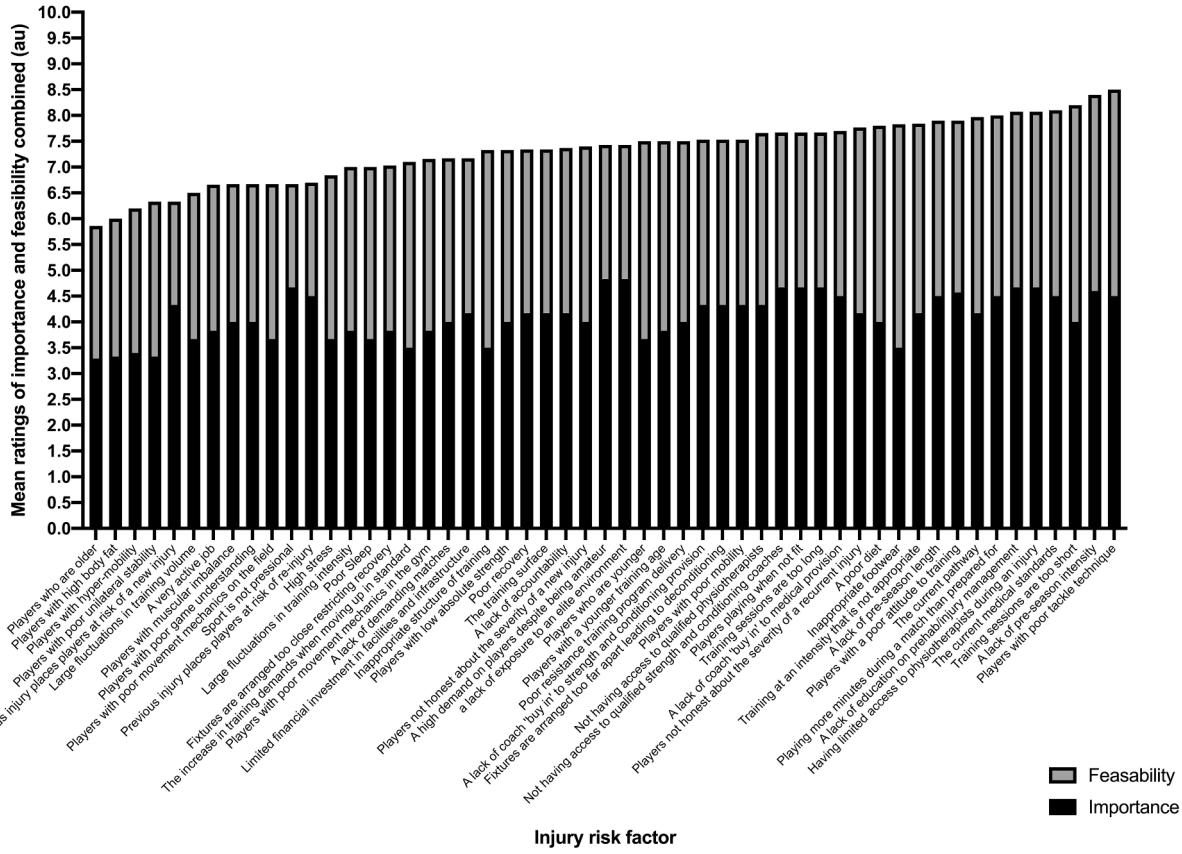

Figure 1. The combined mean ratings of importance and feasibility for each of the injury risk factors.

the injury risk factors were classified under the theme "*lifestyle and environment*", (*a very active job; high stress*). Four injury risk factors were categorised under the theme of "*training and match factors*", (*large fluctuations in training volume; large fluctuations in training intensity; fixtures are arranged too close together restricting recovery; a lack of demanding matches*).

Discussion

This study utilised expert opinion to establish a consensus on injury risk factors specific to women playing rugby league. Additionally, the study quantified the importance and feasibility to manage the injury risk factors which achieved consensus as well as any barriers which limit their management. Fifty-three injury risk factors achieved consensus (≥70% agreement between experts) and were categorised into five themes (14 in "*individual player characteristics*", 17 in "*training and match factors*", 10 in "*a lack of provision*", 5 in "*lifestyle and environment factors*" and 7 in "*other*"). Of the 53 injury risk factors, 12 were perceived by coaches (6 WSL & 1 International) to have above average importance and above average feasibility, 16 were perceived to have above average importance and below average feasibility, 12 were perceived by coaches to have below average importance and above average feasibility, and 13 were perceived to have below average importance and below average feasibility. Forty-three perceived barriers which restrict the management of injury risk factors were categorised into eight barrier themes (7 in "multiple commitments limits time to train", 4 in "a lack of education", 5 in "a small player pool", 5 in "a limited training and playing age", 4 in "a lack of development pathway", 6 in "a lack of facilities", 5 in "player attitudes towards training", and 7 in "a lack of qualified staff provision"). The identification of injury risk factors specific to women playing rugby league alongside their importance, feasibility to manage and barriers which limit their management provides a foundation on which informed, and contextually applicable solutions can be implemented through policy change.

A lack of education was perceived to be a barrier theme preventing the management of 28 injury risk factors, including three injury risk factors perceived to have above average importance and above average feasibility to manage: *poor tackle technique, a lack of training intensity* and *a lack of honesty about the severity of a recurrent injury*. Previous research provides a framework for improving tackle technique (Hendricks et al., 2018), training at an appropriate intensity (Delaney et al., 2017; Emmonds et al., 2020) and understanding why athletes may continue to compete whilst injured (Madrigal et al., 2015). However, despite the availability of knowledge, a lack of education was still perceived to be a barrier. Therefore, an important initial step towards improving education is to understand the most effective methods of knowledge transfer (Fullagar et al., 2019; Jones et al., 2019).

Establishing the most effective methods of knowledge transfer may vary depending on the individuals preferred method of delivery, their learning style and their access to

information (Fullagar et al., 2019; González-Haro et al., 2010; Trakman et al., 2019). Previous literature has found coaches prefer attaining knowledge through face to face interaction (Fullagar et al., 2019; Mesquita et al., 2010) or attending workshops (Williams & Kendall, 2007). Alternatively, athletes prefer to obtain knowledge through qualified staff members or internet articles (Trakman et al., 2019). Therefore, to facilitate the transfer and application of knowledge from research into practice, it is crucial to make information available in a multitude of ways. Hosting education workshops on specific topics (e.g., tackle technique) will provide coaches the opportunity to obtain knowledge and interact with fellow coaches, whilst providing access to qualified staff and releasing information via media platforms may improve player education.

Improving player education may help reduce the barrier of "multiple commitments limits time to train". Of the 24 injury risk factors associated with the barrier, 58% were perceived to have below average feasibility to manage, likely due to the amateur nature of women's rugby league competition meaning players are often forced to train around their work schedule. Previous literature has explored methods to increase the efficiency of training (e.g., short, intense bouts of interval training is an effective method of improving cardiorespiratory and metabolic function (Buchheit & Laursen, 2013)) and recovery (e.g., nutritional strategies (Heaton et al., 2017), stretching (Halson, 2013), massage (Halson, 2013)). Therefore, whilst providing sufficient funding to enable full time training may not be a viable option at present, educating players and staff on appropriate training and recovery practices may reduce the impact of multiple commitments which limit time to train by optimising the training time that is available. Education should be provided to players in a non-time restricted manner (e.g., pre-recorded online workshops) to allow players to obtain knowledge at their convenience.

A small player pool was perceived to be a barrier for 19 injury risk factors, including four injury risk factors with above average importance and above average feasibility to manage: "*poor tackle technique*", "*players with a poor attitude to training*", "*playing more minutes during a match than prepared for*" and "*the current pathway*". Despite this, the popularity of rugby league in women and girls is at an all-time high with the playing community increasing by 53% from 2017 to 2021 (The Rugby Football League, 2021). The increase in participation can be seen across all age groups with a 23% increase at under 12's in mixed-gender competitions, an 85% increase in 12- to 16-year-olds playing in girls-only competitions and a 36% increase in over 16's playing in women-only competitions. Despite the benefits of increased participation, the increase in physicality in girl's playing rugby at <16 years old to women >16 years old may predispose players to injury as the lack of development pathway and limited training/playing age are barriers to seven injury risk factors each. The injury risk factors "*players who are younger*", "*players with a younger training age*", "*players with low absolute strength*", "*the increase in training demands when moving up in standard*", "*players with poor tackle technique*", and "*the current pathway*" were all perceived to have above average feasibility to manage. However, to provide players with sufficient time to develop their training and playing age, the player pool must continue to expand, reducing the need to fast track younger players into open age rugby and enabling the incorporation of an appropriate development pathway.

Increasing the player pool is a long-term goal. However, as participation of women in rugby league continues to increase, the current development pathways may be strengthened through education. Educating players on correct technique (e.g., tackle technique, resistance training) during participation at girls-only competition level provides an opportunity to increase training/playing age prior to open-age rugby. Increased lower-body power and muscular strength are associated with superior skills such as tackling and ball carrying ability in men playing rugby league (Waldron et al., 2014) as well as decreased risk of injury (Gabbett et al., 2012) and enhanced recovery following match play (Johnston et al., 2015; McCormack et al., 2020). Furthermore, participation in neuromuscular training prior to 18 years of age can reduce anterior cruciate ligament injury incidence by 72% in female athletes (Myer et al., 2013). Therefore, in the absence of a structured development programme, female rugby league players and coaches should be provided with education opportunities to develop their knowledge of appropriate training techniques to facilitate an increase in training/playing age whilst the player pool continues to expand.

A lack of qualified staff provision was perceived to be a barrier to the management of 22 injury risk factors, however, only 23% of these risk factors were deemed to have above average feasibility to manage. Improving the provision of qualified staff through the application of minimum required standards may be a challenge due to the financial challenges of women's rugby league competition. However, the injury risk factor "*the current medical standards*" was perceived to have above average importance and above average feasibility to manage by coaches, highlighting the need to improve current provision. Both "*not having access to qualified physiotherapists*" and "*limited access to physiotherapists during the rehabilitation process*" were found to be important risk factors with above average feasibility to manage. Whilst employing full-time staff members (e.g., physiotherapists, strength & conditioning coaches) may not be viable, integrating a minimum qualification standard and providing education and career professional development opportunities to allow staff to obtain the required qualifications would increase the standard of provision in women's rugby league. The presence of appropriately trained clinical staff whilst recovering from an injury has been found to be an important factor increasing the adherence to rehabilitation programs (Marshall et al., 2012). Athletes valued rationale for the prescribed rehabilitation exercises as well as feedback on technique from qualified physiotherapists (Marshall et al., 2012). Therefore, facilitating access to physiotherapists should be a priority for women's rugby league clubs during the injury recovery process. Members of the medical team may not be present at all training sessions due to their roles frequently being voluntary (Emmonds et al., 2019). However, access to staff members could be enabled through alternative platforms such as online meetings or telephone. Both methods would afford staff members the opportunity to provide players with

rationale for their rehabilitation programme and feedback on technique, subsequently increasing programme adherence (Marshall et al., 2012).

Factors associated with reducing injury risk include well developed physical qualities (McCormack et al., 2020), suitable pitch conditions (Mears et al., 2018), and consistent training (Gabbett, 2016). However, coaches perceived limited access to gym and field-based training facilities to be barriers to the management of 10 injury risk factors. The inability to provide players with access to gym facilities or a suitable training pitch restricts their ability to improve physical qualities and train consistently, in turn predisposing players to increased injury risk. Therefore, improving minimum standards to require women's rugby league clubs to provide consistent and suitable gym and field access to players will provide the opportunity to mitigate the more feasible to manage injury risk factors associated with a lack of facilities such as "*players with low absolute strength*", "*players with poor movement mechanics in the gym*", "*an inappropriate structure to training*" and "*poor resistance training programme delivery*".

Limitations

The recommended number of experts required to obtain reliable results in a Delphi-panel is

>10 (Vergouw et al., 2011). The Delphi-panel in this study contained 12 experts categorised as 1 medical doctor, 5 strength and conditioning coaches, 3 physiotherapists, and 3 research scientists. Whilst the Delphi-panel contains sufficient experts to be considered reliable, a more even distribution of experts (e.g., inclusion of more medical doctors) would have been beneficial and increased the likelihood that their perspectives were represented across each stage. Additionally, stage I round I provided experts with five pre-determined injury risk factor themes "*individual player characteristics*", "*lifestyle and environment*", "*training and match factors*", "*a lack of provision*", and "*other*". These themes were established to encourage experts to consider injury risk factors from a range of perspectives. However, providing predetermined themes increased the risk of bias in the initial selection of injury risk factors and must be considered a limitation of the study.

Conclusion

Fifty-three injury risk factors relevant to women playing rugby league achieved consensus following a multi-round Delphi-process. The risk factors were then grouped by coach perceived importance and feasibility to manage. Forty-three barriers to injury risk factor management were categorised into eight broader barrier themes. Previously, injury management strategies applied to women playing rugby league relied on an evidence base generated from men's rugby league (Emmonds et al., 2019). Applying findings from men's rugby league may not be appropriate for women due to biological and contextual differences observed between the sexes/genders (Emmonds et al., 2019). Therefore, the findings of this study can inform injury prevention strategies for women playing rugby league by identifying specific injury risk factors. An important step in translating research into practice is utilising the knowledge of key stakeholders to define context specific barriers. Establishing the importance of the identified injury risk factors, their feasibility to manage and barriers to mitigation from the perspective of women's rugby league coaches facilitates the formation of constraint driven solutions through policy change.

Practical applications

Increasing education opportunities in formats which enhance knowledge transfer will help reduce the barrier themes "a lack of education" and "multiple commitments and limited time to train". Additional opportunities for women rugby league players and coaches to develop their rugby league skill (e.g., tackle technique) and their knowledge of the training process (e.g., training periodisation, recovery strategies, increasing training efficiency) will help to reduce the impact of the two barrier themes associated with 18 of the 24 injury risk factors perceived more feasible to manage.

"Limited training and playing age", "a lack of development pathway", and "a small player pool" are barrier themes associated with nine injury risk factors with above average feasibility to manage. Continuing to expand the player pool whilst simultaneously increasing player and coach education will help reduce the need to fast-track younger player into open age rugby and provide additional time for players to mature, advance their training age and develop their tackle technique through a structured development pathway.

"A lack of facilities" and "a lack of qualified staff provision" are associated with 10 injury risk factors with above average feasibility to manage. Increasing the minimum standards required for WSL clubs (e.g., consistent gym and training pitch access) and coaches (e.g., minimum qualifications required for a specific role) whilst also providing opportunities to obtain the necessary qualifications required will help to alleviate the influence of the two barriers.

Simultaneously increasing player and coach education, expanding the player pool, and increasing the minimum standards required for WSL clubs may also reduce the impact of the barrier "the players attitude to training". For example, educating players on the importance of training and living a healthy lifestyle may help manage the more feasible injury risk factors of "*a poor diet*", and "*poor tackle technique*". Concurrently expanding the player pool will increase the competition for places and reduce the need to select players who are not prepared for competition, whilst improving the minimum standards required will help to identify players who lack commitment to training and living a healthy lifestyle.

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