LITERATURE REVIEW

Up for the tackle? The pelvic floor and rugby

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Abstract
The pelvic floor and its associated disorders are a unique and often overlooked aspect of women's rugby. This review discusses relevant biopsychosocial considerations specific to the pelvic floor and rugby. Pelvic floor disorders (PFDs) can present at any time across the female lifespan, but are more prevalent during pregnancy and postpartum. This is because of the substantial physiological and anatomical changes experienced during pregnancy and vaginal childbirth. Consequently, PFDs can impact a player's ability to perform, maintain engagement with or return to rugby as a result of symptoms. Players need to be informed, supported and guided through focused pelvic floor muscle training to condition the muscles and "ready" them for the varied demands of rugby. Health and fitness professionals should understand the risk of PFDs across the female lifespan, and screen players for symptoms when supporting them to maintain or return to rugby. Rugby players who have symptoms of PFDs should be signposted to specialist services and/or resources to manage their symptoms. Once engaging in rugby training, ongoing evaluation of player load tolerance and implementation of individualized strategies to support managing rugby-related loads to the pelvic floor should be considered. Finally, surveillance and research focusing specifically on rugby players and pelvic floor function are needed.

Keywords: female athlete, genital hiatus, incontinence, lifespan, perinatal, return to sport.

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Introduction
The pelvic floor is a unique and often overlooked characteristic of women's rugby. Taking a cupuliform shape, the pelvic floor muscles (PFMs) span the outlet at the base of the pelvis (Herschorn 2004; Bordoni *et al.* 2023). Their role is multifactorial and includes: (1) maintaining continence (bladder and bowel); (2) facilitating excretion (bladder and bowel); (3) supporting

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the pelvic organs; and (4) enabling sexual function (Donnelly & Moore 2023). Compromise to any of these roles may lead to signs and symptoms of pelvic floor disorders, also referred to as pelvic floor dysfunction (PFD), such as incontinence (bladder or bowel), pelvic organ prolapse (POP) or pain (NICE 2021; Donnelly & Moore 2023). Symptoms of PFD can occur at any time across the female lifespan, and are attributed to combinations of anatomical, physiological, genetic, lifestyle and reproductive factors rather than a single cause (DeLancey *et al.* 2008). For example, the perinatal period (pregnancy and postpartum) is one factor that increases a woman's predisposition to PFD (DeLancey *et al.* 2008; NICE 2021; Donnelly & Moore 2023; McCarthy-Ryan *et al.* 2024). To reduce the risk of provoking, or worsening, symptoms of PFD, women's rugby players must be pelvic floor "ready" for training and performance. Therefore, it is essential that all supporting professionals, regardless of health or fitness background, are aware of the importance of including focused PFM training (PFMT) within strength and conditioning programmes, as well as screening for PFD and signposting to specialist services.

The aim of the present review is to discuss the importance of the PFMs across the lifespan of women's rugby players using a biopsychosocial-informed approach (Box 1). First, the authors outline PFM anatomy, physiology and functioning during rugby. Then they outline the prevalence and risk of PFD across the female lifespan. They cover key changes to the PFMs during pregnancy, childbirth, the postpartum period and advancing age, and also identify the signs and symptoms of PFD. The final sections discuss rugby-specific PFM load tolerance and conditioning, alongside strategies and adjuncts to aid PFD management and optimize successful female engagement in rugby.

Box 1. Highlights: (PFMs) pelvic floor muscles

- High force-related activities, such as rugby, challenge the PFMs, and can increase a player's susceptibility to pelvic floor disorders (e.g. stress urinary incontinence, and feeling a bulge inside or outside the vagina).
- Pelvic floor disorders can present at any time across the female lifespan, with pregnancy and childbirth being two commonly reported risk factors for such conditions.
- Predisposing (genetics), inciting (pregnancy and vaginal childbirth) and intervening (lifestyle and ageing) factors likely influence pelvic floor load tolerance.
- Level 1 evidence supports PFM training as a first-line treatment for urinary incontinence and pelvic organ prolapse in the general female population. The present authors encourage PFM training to be incorporated into rugby training programmes across all ages, levels and roles, regardless of whether symptoms of pelvic floor disorder are present or not.

The female pelvic floor complex

There are many distinct differences in male and female anatomy, and one of the main ones is the anatomical structure and role of the pelvic floor. The female PFMs span a wider pelvic outlet than those of males, and include an additional orifice, the vagina. As a result, the female pelvic floor relies on a more complex system of myofascial connective tissue integrity, neural innervation, vascularization and PFM function to manage the intra-abdominal pressure (IAP) and external load demands (e.g. ground reaction forces) placed upon it (Donnelly & Moore 2023). The PFMs contract during occurrences of elevated IAP (Constantinou & Govan 1982) to limit the downward displacement of the pelvic organs (Sapsford & Hodges 2001; Junginger *et al.* 2010; Lovegrove Jones *et al.* 2010; Williams *et al.* 2022). Typically, PFM activation precedes rises in IAP (Sapsford & Hodges 2001) and movement-related load (Okeahialam *et al.* 2022) in an anticipatory and feed-forward manner. It is proposed that delayed activation and impaired speed of PFM activity may predispose symptoms of stress urinary incontinence (SUI). However, research is inconsistent with regard to this mechanism (Smith *et al.* 2007; Leitner *et al.* 2017; Moser *et al.* 2018, 2019; Kharaji *et al.* 2019), and other factors relating to the anatomical integrity of the pelvic floor complex, discussed below, also influence the continence mechanism.

Looking more closely at the anatomical design of the PFMs, these can be considered in subsections (Table 1 and Fig. 1). The levator ani is a group of muscles that make up a funnel-shaped area in the lower part of the pelvis. From medial to lateral, these include the puborectalis, pubococcygeus and iliococcygeus (Kearney *et al.* 2004). The pelvic floor is further defined by two spaces, the levator hiatus and urogenital hiatus,

Table 1. Overview of pelvic floor anatomy

Consideration	Recommendation
Anatomy and grouping	Levator ani muscle group: puborectalis, pubococcygeus and iliococcygeus Urogenital diaphragm: deep transverse perineal muscles, constrictors of the urethra, and internal and external fascial coverings Urogenital hiatus: bounded laterally by the medial margins of the levator ani, specifically the pubococcygeal portion, it extends from the centre of the urethral meatus to the posterior midline of the hymen Levator hiatus: V-shaped medial component of the levator ani muscle, corresponds with the puborectalis muscle
Role	Support and maintain the position of the pelvic organs Support and maintain the continence mechanism for the bladder and bowel Normal excretion of urine and faeces Sexual function
Potential pelvic floor risk to the postpartum player	Sustained stretch and loading of the muscles during pregnancy and childbirth, alongside associated tissue trauma Hiatal ballooning leading to pelvic organ prolapse and descent of the perineal structures Potential compromise to function Birth-induced injury to the pubococcygeal muscle portion of the levator ani muscles is strongly associated with pelvic organ prolapse, and descent of the perineal structures Potential for pelvic floor muscle avulsion injury Birth-induced pudendal nerve injury
Potential consequence of pelvic floor risk to return to rugby	Slow or delay rehabilitation progression Delay return to training or matches Limit time played during training/matches Limit sport performance Negatively impacts player quality of life and sport enjoyment Negatively impacts player mental health

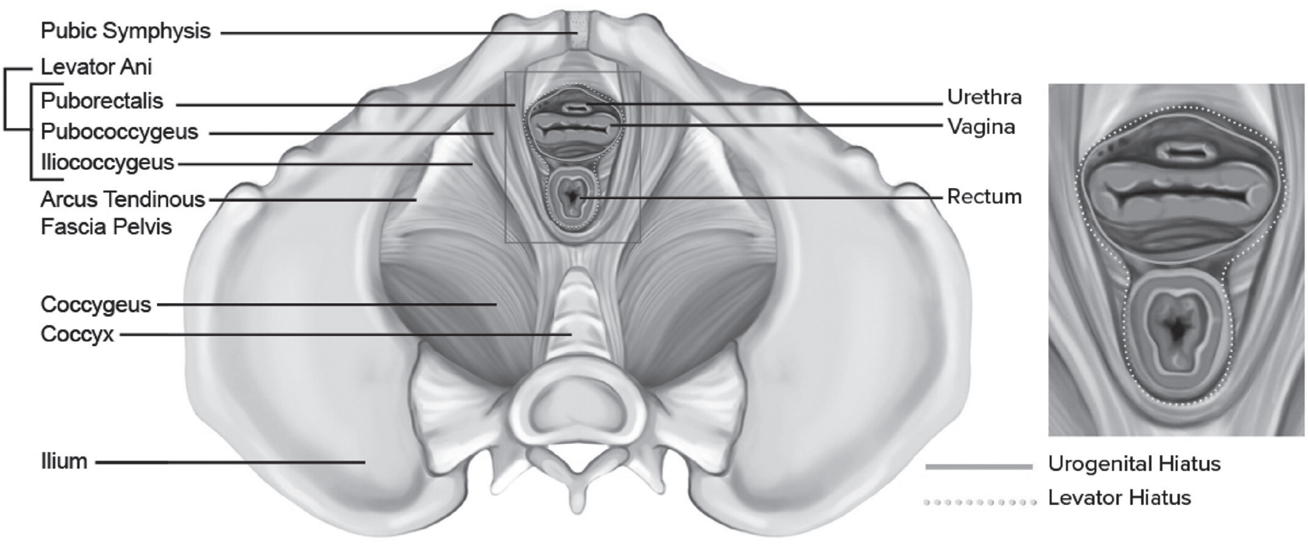

Figure 1. The female pelvic floor muscles and hiatal areas [adapted from Cheng *et al.* (2023)].

both of which are bordered by the pubic symphysis ventrally and the medial borders of the levator ani laterally (Cheng *et al.* 2023) (Fig. 1). The levator hiatus appears as a V-shaped area that extends dorsally to the sides of the anorectum, and is enclosed by the puborectalis muscle (DeLancey *et al.* 1998; Cheng *et al.* 2023). The more caudal urogenital hiatus encloses the pubococcygeal portion of the levator ani muscles, and extends dorsally from the centre of the urethra to the perineal body (DeLancey & Hurd 1998; Cheng *et al.* 2023).

While the focus has been on the deep layer of PFMs, anatomical understanding should extend to the role of connective tissue in pelvic organ support and the continence mechanism, particularly the endopelvic fascia. This layer of dense, fibrous connective tissue attaches the bladder, uterus, vagina and rectum to the pelvic walls via fascial attachments with the arcus tendinous fascia pelvis and the medial portion of the levator ani (Roch *et al.* 2021). One of the endopelvic fascia's recognized roles is to provide tensile strength to the anterior pelvic structures (e.g. the urethra and bladder) (Ashton-Miller & DeLancey 2007). In addition to compromised pelvic organ support via changes to the endopelvic fascia, poor levator hiatal closure may also negatively impact the continence mechanism as the habitual stiffness of the PFMs will be reduced, allowing greater downward movement of the pelvic viscera and possible disruption of the urethral closure mechanism. Specifically, if the PFMs are situated adequately and the levator hiatus remains closed, the stiffness in the tissues limits excessive downward movement and ballooning of the hiatus (Bø 2020).

The pelvic floor during rugby

The mechanisms and behaviour of the PFMs prior to, or during, movement are not well understood (Bø & Nygaard 2020). One research group used a novel wireless intravaginal pressure transducer during a range of movements that required regulation of effort (Shaw *et al.* 2014), and analysed the IAP of the activities relative to each individual's maximum potential IAP, determined via seated straining (Valsalva) (Dietze-Hermosa *et al.* 2020). Walking generated mean IAPs of 21% of maximum IAP, while running generated 56% of maximum IAP, with some individuals reaching as high as 203% (Dietze-Hermosa *et al.* 2020). However, findings from the studies to date regarding IAP or PFM activity should be considered with caution as intravaginal measurement devices are likely to move and pick up artefacts from surrounding muscles and tissues. Furthermore, the dynamic forces the PFMs must be able to tolerate during movements are not well understood, and are likely to be highly individualized. Valid measuring systems to quantify IAP and PFM activity during vigorous physical activities, such as those involved in rugby, need to be developed and investigated.

Several factors are likely to influence the demands and loads placed upon the PFMs, such as the ability of the body to attenuate force. For instance, a player's running technique will affect the ground reaction forces produced (Breine *et al.* 2017), and it is not known how much the lower limb attenuates these forces prior to reaching the PFMs. In addition to ground reaction forces, IAPs exert a load onto the PFMs. What constitutes a high magnitude of IAP appears to depend on an individual's capacity to generate and manage IAP.

In the context of rugby, many of the movements that a player is exposed to result in large forces (Usman *et al.* 2011; Trewartha *et al.* 2015; Nagahara & Girard 2021) being transferred either directly to the abdominal lumbopelvic region (e.g. being tackled with contact to this region), or indirectly from load transferred through the body (e.g. force transferred through the shoulders during a scrum). These forces are likely to produce high IAPs (Kawabata *et al.* 2010; Nagahara & Girard 2021), and subsequently, direct high forces toward the PFMs (Shaw *et al.* 2014; Bø & Nygaard 2020). To withstand this pressure, it is thought that PFM activity must increase from baseline to anticipate and accommodate the demands of movement or force (Moser *et al.* 2018). For example, the PFMs will theoretically be required to anticipate a tackle, and accommodate forces received while being tackled. The ability to manage and tolerate these loads is likely to be player-specific and influenced by several factors discussed further in the present paper. Furthermore, symptomatic players may be able to tolerate the load in some movements but not others, and the ability to tolerate load will most likely reduce with training and match-related fatigue (Thomaz *et al.* 2018).

Pelvic floor dysfunction

Symptoms and prevalence

Impairment to the function of the PFMs may result from compromised connective tissue support, compromised innervation, PFM weakness or injury. Symptoms of PFD (Table 2) relate to the impairment of any role in which the PFMs are involved. Players with PFD may present with specific symptoms that relate to a subset of the anatomical structures discussed previously. Each structure should, therefore, be considered in its role in pelvic organ support and continence, and contextualized by individual whole-system considerations, such as ageing and lifestyle factors (DeLancey *et al.* 2008).

Within the general population, it is estimated that one in three women experience UI, up to one in 10 experience faecal incontinence, and up to one in every two have some degree of pelvic organ descent (Brown *et al.* 2019; Woodley *et al.* 2020; NICE 2021). High force-related activities, such as rugby, challenge the PFMs and can

Table 2. Considerations for symptoms, cues, training dosage, progression, adjuncts and signposting for pelvic floor disorders: (PFMT) pelvic floor muscle training; and (PFD) pelvic floor disorders/pelvic floor dysfunction

Consideration	Recommendation
Symptoms of PFD	Urgency, frequency and/or incontinence (bladder and/or bowel, including flatus) Heaviness, pressure, bulge and dragging in the vaginal area Issues emptying bladder or bowel (e.g. obstructive defecation and post-void residual) Recurrent urinary tract infections Pelvic floor pain, dyspareunia and sexual dysfunction Vaginal dryness while lactating or associated with age-related changes
Cues for pelvic floor muscle training	"Stop gas escaping" "Squeeze and lift around the urethra, vagina and rectum" "Stop the flow or urine mid-flow" "Close a zip back passage to front passage" "Close the vagina" "Close the anus"
Training dosage and progressions	Step 1: Basic focused PFMT programme of eight to 12 maximum voluntary contractions aiming to hold each for up to 10 s. Repeat two or three times per day if symptomatic Step 2: The pelvic floor can also be recruited in preparation for a leakage-provoking event ("the Knack") Step 3: Vary positions of PFMT to reflect upright and task-specific activities in rugby Step 4: Graded exposure to resistance/weight training beginning with static, closed-chain options and progressing to dynamic options. Monitor for symptoms of PFD as weight and difficulty of training increase. Modify and regress as indicated Step 5: Graded exposure to impact activities; for example, running and jumping. Monitor for symptoms of PFD. Modify and regress as indicated Step 6: Graded exposure to spontaneous load through tackle training. Monitor for symptoms of PFD. Modify and regress as indicated Step 7: Return to simulated match play. Monitor for symptoms of PFD. Modify and regress as indicated Step 8: Return-to-sport. Monitor for symptoms of PFD as training and match volume increase Step 9: Long-term adherence – include focused PFMT once or twice a week. May be part of a wider training programme
Adjuncts to pelvic floor muscle training and symptom management	Vaginal pessaries for stress urinary incontinence and/or pelvic organ prolapse Targeted pelvic floor compression garments Female technology
Indication for signposting and onward referral	No improvement in symptoms despite adhering to regular PFMT Unsure how to locate and train the pelvic floor despite information and cues Symptom progression Persisting pelvic pain Suspected medical issues (e.g. urinary tract infection, vaginal infection, postpartum complication, poor healing postpartum and presence of red flags)

increase a player's susceptibility to PFD symptoms (DeLancey *et al.* 2008; Almeida *et al.* 2016; De Mattos Lourenco *et al.* 2018; Moore *et al.* 2021; Sandwith & Robert 2021; Campbell *et al.* 2023; Donnelly & Moore 2023; McCarthy-Ryan *et al.* 2024). In a cohort of 95 female university varsity rugby players, 54% of players leaked urine, of which 90% leaked when competing, and 88% leaked when being tackled or hit (Sandwith & Robert 2021). A larger study ($n = 396$) of the women's rugby union community to national-level players across the UK and Ireland found that 63% had general SUI and 43% leaked during rugby. The most prevalent symptom-inciting events were tackles, running and jumping. Identified risk factors for SUI during rugby included being postpartum, having a higher body mass index, being a forward and having a lower level of playing experience (McCarthy-Ryan *et al.* 2024). Furthermore, reporting constipation was associated with rugby-related SUI (McCarthy-Ryan *et al.* 2024), which may result from persistent constipation increasing the strain on the PFMs over time (DeLancey *et al.* 2008). This highlights the interaction of coexisting symptoms and behaviours, and the need to consider the wider whole-system factors in individual player presentations (Donnelly *et al.* 2022).

To date, studies have determined the prevalence of PFD in women's rugby players as a collective, but its prevalence or impact in subpopulations such as perinatal players are not understood. This is because of the lack of surveillance, and the overall paucity of research investigating

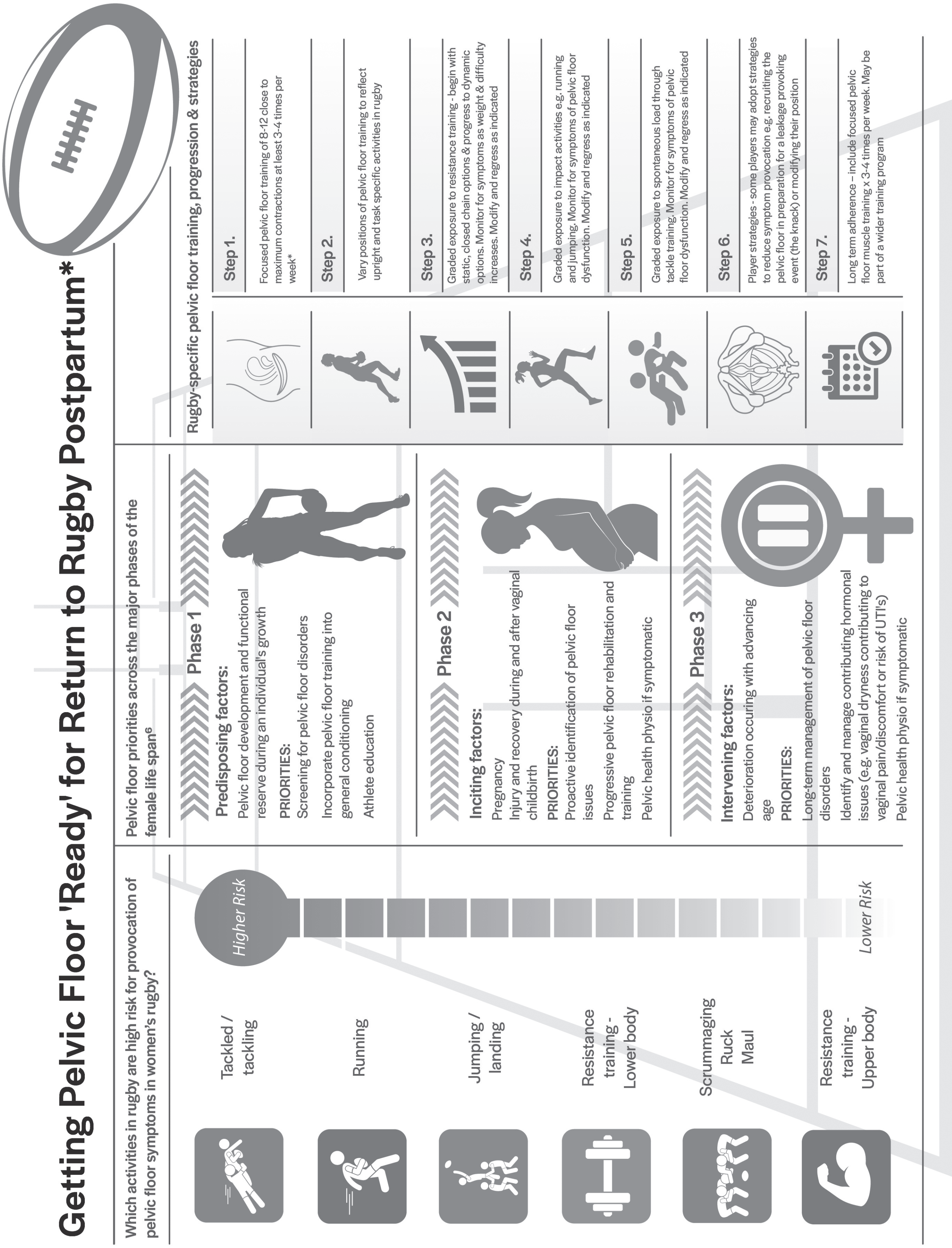

Figure 2. Getting the pelvic floor "ready" for rugby. *These recommendations are based on exercise prescription principles and research on the general population. Research specific to women's rugby players across all ages and levels is needed to better inform this population.

female-specific health domains (Moore *et al.* 2023), with previously only McCarthy-Ryan *et al.* (2024) including postpartum rugby players. Consequently, there is a need for research to investigate how the risk factor of being postpartum influences the prevalence and severity of PFD in women's rugby (Heyward *et al.* 2022; McCarthy-Ryan *et al.* 2024).

Predisposing, inciting and intervening factors

DeLancey and colleagues (DeLancey *et al.* 2008, 2024) outline three major phases across the female lifespan where PFM function and dysfunction relate (Fig. 2):

(1) predisposing factors (development and functional reserve during an individual's growth);
(2) inciting factors (variations in the amount of injury and potential recovery that occur during and after vaginal childbirth); and
(3) intervening factors (lifestyle and deterioration occurring with advancing age).

Each of these will be discussed briefly below.

Phase 1: predisposing factors – development and functional reserve. It is proposed that the development of the PFMs early in the female lifespan will influence an individual's functional reserve, and thus, future likelihood of PFD (DeLancey *et al.* 2008). Development and functional reserve of the PFMs are likely to be determined by several factors, including genetics, lifestyle, diet and environment (DeLancey *et al.* 2008). For example, a high body mass index and constipation are established risk factors for PFD (NICE 2021). Early education about physical activity (CMO 2019), lifestyle, the anatomy and function of the pelvic floor, and how to locate and train the PFMs during adolescence is advocated to promote improved development and functional reserve (NICE 2021; DeLancey *et al.* 2024). However, this theory needs to be investigated further, especially in the context of sports-specific PFM function.

Phase 2: inciting factors – pregnancy and childbirth. The PFMs are exposed to an increasing magnitude of load from the growing uterus as a pregnancy progresses. Accordingly, the dimensions of the PFMs, and associated hiatal areas (Fig. 1), increase in size to prepare for childbirth, regardless of the mode of delivery (Stær-Jensen *et al.* 2013). The levator hiatal area enlarges from the first to the third trimester of pregnancy at rest, on PFM contraction and during bearing down by an average of 13%, 10% and 29%, respectively (Cheng *et al.* 2023). These normal, anticipated changes are important to ready the body and facilitate potential vaginal childbirth. However, these also carry a risk for negative implications associated with increasing hiatal distensibility, especially when subsequent vaginal childbirth is considered too. For women who experience vaginal childbirth (approximately 80% of worldwide childbirths) (Betran *et al.* 2021), major changes to the PFMs occur including compression and stretching of PFM soft tissues that extend beyond the capacity of most other muscles in the body. Specifically, the baby's head stretches the levator ani muscle, generating predominantly passive forces in the tissue of the levator hiatus as it passes through the PFMs (Tracy *et al.* 2016). For non-pregnant muscle tissue, the maximum non-injurious stretch (lengthening) that a muscle can undergo before injury is estimated to be 150% of its original length (Brooks *et al.* 1995). Comparatively, the PFMs experience a stretch much higher than this during vaginal childbirth of up to 250% their original length (Krofta *et al.* 2017). Therefore, birth-induced injury to the levator ani muscles during vaginal childbirth includes overstretching (microtrauma), or tearing and avulsion (macrotrauma), and varying degrees of either are considered to occur in all vaginal deliveries. The prevalence of PFM injury (macrotrauma) specifically from vaginal childbirth ranges from 18% to 41% (Miller *et al.* 2015; Cardozo *et al.* 2023). Additionally, obstetric anal sphincter injuries (also known as third- and fourth-degree perineal tears) have been reported in up to 8% of vaginal deliveries in the UK (Thiagamoorthy *et al.* 2014). A recent meta-analysis of risk factors for perineal laceration covering all degrees reported that risks include primiparity, instrumental delivery (particularly forceps) and newborn birthweight (Pergialiotis *et al.* 2020).

Birth-induced injuries are associated with descent of the pelvic organs and perineal structures (Clark *et al.* 2010; DeLancey *et al.* 2012; Cheng *et al.* 2023). Specifically, the distensibility of the levator ani causes an increase in the cross-sectional area of the levator hiatus. Excessive distensibility, termed hiatal ballooning, is associated with the occurrence of POP (Xuan *et al.* 2019; Siahkal *et al.* 2021). In fact, this region is considered to have the largest potential hernia portal in the human body (Xuan *et al.* 2019). Most of the recovery in size of the levator hiatus occurs within 4–6 months of delivery (Cheng *et al.* 2023). However, it does not return to pre-pregnancy size, and this recovery time is further complicated depending on the degree of trauma at the time of delivery (Stær-Jensen *et al.* 2015; Bø *et al.* 2022; Cheng *et al.* 2023). While the transition into and beyond pregnancy is a normal bodily process, it can impair the function of the PFMs, and lead to reduced sport participation, time loss from sport and career cessation (Dakic *et al.* 2021; McCarthy-Ryan *et al.* 2024). Unlike return to sport following injury, which is widely discussed in the sports medicine and science literature, return to sport after pregnancy and childbirth has been largely overlooked. The physiological changes to the PFMs during pregnancy warrant consideration, and purposeful strengthening and conditioning, even in players who experience childbirth via Caesarean section. Given the increased size of the levator hiatal area by the third trimester of pregnancy (Bø *et al.* 2015), reconditioning to encourage a return toward baseline size, resting tone and strength is paramount, especially in the context of the load tolerance required of the PFMs during rugby. In most countries, a large focus is placed on PFMT during pregnancy, as early structured training can prevent the onset of UI in mid- and late pregnancy (Woodley *et al.* 2020), and limit the perceived symptoms of pelvic organ descent (Hagen *et al.* 2014, 2017). Evidence has shown that women with an enhanced understanding of the PFMs are 57% less likely to develop UI (Cardoso *et al.* 2018). Consequently, from a PFD prevention perspective, rugby players across all ages and levels should be educated about the anatomy and function of the PFMs.

Phase 3: intervening factors – (a) lifestyle. The type of sport that women longitudinally engage in may expose the PFMs to different loads that appear to affect PFM morphology (Menezes *et al.* 2023) and contribute to the risk of PFDs. That is, high force activities such as rugby may alter morphology in a way that increases risk. When compared to non-active/low-impact exercising controls, competitive athletes engaging in high-impact training for over 5 years exhibit greater levator hiatal width (Kruger *et al.* 2007; Menezes *et al.* 2023) and distensibility, as well as higher degrees of pelvic organ descent (Kruger *et al.* 2007). Furthermore, engaging with 30 min of exercise three times per week during pregnancy leads to a larger hiatal area at rest and during PFM contraction compared to not exercising in the third but not the second trimester (Bø *et al.* 2015). These studies highlight the potential changes that can present in nulliparous athletes through exposure to sports like rugby, with pregnancy possibly modifying this interaction. Exposure to high-impact sports can also lead to acute changes in hiatal dimensions, but this is consistent in runners with and without SUI (Bérubé & McLean 2023), and the long-term consequences are not fully understood.

Phase 3: intervening factors – (b) deterioration occurring with advancing age. With player longevity being an important consideration as more women potentially take up rugby in later life, or continue participating for longer (e.g. beyond motherhood), an understanding of the age-related deterioration of the PFMs is needed. Normal decline of the PFMs is expected with age-related changes, including increased fibre length (Alperin *et al.* 2016; Cook *et al.* 2017), fibrosis (Alperin *et al.* 2016), and a reduction in muscle mass and connective tissue tensile strength associated with the decline in oestrogen (Chidi-Ogbolu & Barr 2018). The decline of the PFMs across the lifespan may also be influenced by several factors, including obesity, arduous occupations or chronic constipation (NICE 2021; Jackson *et al.* 2022; DeLancey *et al.* 2023). For women, menopause may interact with the risk of PFD as a result of associated hormonal changes during this age-related transition (Angelou *et al.* 2020; Peinado-Molina *et al.* 2023). However, to the present authors' knowledge, no studies have examined the influence of hormonal changes or the transition into menopause in women's rugby players. Raising awareness of the impact that advancing age and the transition into menopause can have on an individual's PFMs and associated function is important.

Reconditioning the pelvic floor

Like other muscle groups, the PFMs can be trained via targeted strengthening and conditioning, and there is consistent evidence that this can induce muscle hypertrophy, reduce the levator hiatal area and improve the symptoms associated with PFD (Hoff Brækken *et al.* 2010; Cacciari *et al.* 2021, 2022; Hagovska *et al.* 2022). Regardless of the predisposing, inciting and/or intervening factor(s), symptomatic players should engage in appropriate training. For example, postpartum rugby players should be informed about commencing PFMT as soon as possible following childbirth. Following vaginal delivery, even in the presence of perineal tears and stitches, training can gently commence. Medically complicated deliveries that result in a catheter *in situ* will delay PFMT until this is removed. Based on exercise prescription principles, rugby players should follow general strength training recommendations (Garber *et al.* 2011). In terms of the PFMs, strength training dosage should aim for fatigue of the PFMs by the end of the set(s). This could involve engaging in focused PFMT of three sets of from eight to 12 close-to-maximum PFM contractions repeated daily (Bø & Aschehoug 2007; Fleck & Kraemer 2014) during early rehabilitation, and then reducing to once or twice a week for maintenance as recovery progresses or symptoms resolve (Garber *et al.* 2011; Bø & Nygaard 2020). However, more research is required in relation to PFMT dosage in athletic populations such as rugby, and players will have differing reconditioning needs depending on individual predisposing, inciting and intervening factors. Where possible, PFM reconditioning should be informed and guided by a pelvic health physiotherapist (sometimes referred to as women's health physiotherapist) (POGP 2022). Table 2 offers useful prompts to help rugby players understand how to locate and train their PFMs as well as guidance on load progression, adjuncts, and when to signpost or refer onwards for specialist support.

Vaginal tissue health

Lower levels of oestrogen in the female body can increase vaginal dryness and sensitivity (Goncharenko *et al.* 2019). These changes may have a negative impact upon sexual function, player comfort, and the ability to train or play matches. There may also be an increased risk of health problems (e.g. urinary tract infections) (Goncharenko *et al.* 2019). Lower oestrogen levels are associated with lactation (Calik-Ksepka *et al.* 2022) and ageing (menopause) (Angelou *et al.* 2020), and therefore, breastfeeding and perimenopausal rugby players are likely to be impacted. Player support staff should be aware of these challenges, and signpost players to appropriate healthcare professionals for management (e.g. a general practitioner and/or gynaecologist) when vaginal moisturizers or localized oestrogen may be indicated.

Psychological well-being

Focusing beyond localized muscle dysfunction or tissue trauma, wider whole-system factors associated with mental health, psychosexual trauma (Karsten *et al.* 2020) or birth trauma (Greenfield *et al.* 2016) can negatively impact PFM function. The reverse is also true, whereby psychological well-being (across the female lifespan) is negatively impacted by PFD (NICE 2021). The transition into motherhood, for example, can be challenging for many women, with up to 40% experiencing perinatal mental health problems such as postpartum depression (Wang *et al.* 2021). In fact, postpartum depression is three times as prevalent in women with PFD than women without it (Mazi *et al.* 2019). Furthermore, their experience of interactions and events directly related to childbirth may cause overwhelmingly distressing emotions and reactions, leading to short- and long-term negative implications for their health and well-being (Leinweber *et al.* 2022). This means that both physical and/or psychologically traumatic experiences during childbirth ("birth trauma") can have ongoing psychological consequences, including catastrophizing and compromised mental health (Leinweber *et al.* 2022; Shorey & Wong 2022). Physical symptoms of birth trauma include birth-related tissue injury, a reduction in functional capacity, fatigue and persistent postpartum pain (Kainu *et al.* 2010; Taghizadeh *et al.* 2013; Daly *et al.* 2017). Consequently, postpartum players experiencing birth trauma may be disengaged from adhering to postpartum rehabilitation advice, such as PFMT. They may also perceive the area to be vulnerable or fragile, which will have an impact on their ability to participate in reconditioning and progressive loading, and potentially increase the risk of fear of movement. Awareness of these conditions, along with regular screening and monitoring, should be in place so that players can be signposted to specialist psychological support as necessary. A validated tool, such as the Edinburgh Postnatal Depression Scale (Gollan *et al.* 2021) or the Clinician-Administered Post-Traumatic Stress Disorder Scale (De Graaff *et al.* 2018), can be used to screen players as appropriate.

Pelvic floor load tolerance

An integral part of rugby-specific training includes strength training. Progressive and functional strength training helps to prepare players for the demands of rugby, which involves player-to-player contact and multidirectional movements (Dane *et al.* 2022). The tackle is the most frequent contact event in rugby union and rugby league, with a mean of 280 (West *et al.* 2022) and 512 (Cummins *et al.* 2020) tackles per game, respectively. In both union and league matches, player-to-player contacts are higher in forwards than in backs (Cummins *et al.* 2020; Woodhouse *et al.* 2021). Additionally, players perform high-speed running, accelerations and decelerations, changes of direction, lineout lifts with high-impact landings, as well as skills-based events such as catching, passing and kicking the ball. Players must successfully execute these technical actions numerous times over the course of a game, while under pressure and experiencing fatigue (Dane *et al.* 2022). The frequency of these contact and non-contact skills is dependent on playing position, meaning that strength requirements are position-specific.

Training requirements for women's rugby should include focused PFMT (Table 2 and Fig. 2) (Donnelly & Moore 2023) alongside whole-body resistance training. The latter is an important part of conditioning a player for the demands of the sport. In the context of the PFMs, whole-body resistance training may enable insight into PFM load tolerance. If symptoms of PFD are only provoked as resistance training is progressed, it highlights the need for further focused PFMT and/or review by a pelvic health physiotherapist. While there is limited research examining the effect of whole-body resistance training and the response of the PFMs, lifting higher loads is considered to increase the IAP placed upon the PFMs (Bø & Nygaard 2020), which may increase the risk of PFD. This may explain the higher prevalence of PFD symptoms (specifically UI and anal incontinence) observed in Norwegian female powerlifters (Skaug *et al.* 2022) compared to the general population (NICE 2021). In rugby, nulliparous and parous women report SUI to be prevalent (42%) during lower-body strength training (McCarthy-Ryan *et al.* 2024). However, when considering the loads associated with strength training, women lifting heavy weights (> 50 kg) do not report more symptoms of POP compared to women lifting lighter weights (< 15 kg) (Forner *et al.* 2020). Additionally, acute exposure to heavy lifting does not appear to have a negative effect on PFM strength (Skaug *et al.* 2023). Further research is needed to understand the prevalence of PFD in rugby players exposed to acute and chronic heavy resistance training, as well as the long-term implications of whole-body resistance training for the PFMs.

The Valsalva strategy, which is often necessary to lift heavy loads and prepare for the demands of rugby, has been shown to produce high levels of IAP (Eliasson *et al.* 2008; Cummins *et al.* 2020; Woodhouse *et al.* 2021; Dane *et al.* 2022; West *et al.* 2022). Strenuous activity and sport can result in SUI even in nulliparous athletes (Kruger *et al.* 2007; Eliasson *et al.* 2008), with the risk for SUI and compromised pelvic organ support further increased in vaginally parous athletes. Studies comparing the impact of pregnancy and vaginal childbirth on the PFMs found that women who delivered vaginally had a greater hiatal area on Valsalva compared to nulliparous women (Cattani *et al.* 2022). This lack of support and low stiffness in the PFM tissues can compromise the continence mechanism and pelvic organ support. This is supported by Howard *et al.* (2000), who found that parous women with SUI demonstrate greater bladder neck descent during a cough than continent parous women. A non-significant lower stiffness was also observed for the SUI group. Teams supporting postpartum players to return to rugby should be aware of the increased risk of PFD associated with vaginal delivery, and manage players accordingly.

It is not only the mode of delivery, but also the likely generalized deconditioning incurred during the perinatal period, that should be considered for rugby players who need to cease contact-related rugby activities during pregnancy, and have individualized levels of associated rest from rugby postpartum (World Rugby 2024). Such generalized deconditioning may also present following severe injuries, such as anterior cruciate ligament rupture. As a result, most postpartum rugby players will have reconditioning needs to prepare for the physical demands, skills and high volume of contacts required during rugby (Dane *et al.* 2022). Graded exposure to postpartum strength training is encouraged and should centre on symptom-free training (Donnelly *et al.* 2024; World Rugby 2024). Evidence regarding appropriate timeframes to return to sport postpartum is lacking. Based on clinical and exercise professional expert opinion, a Delphi study recommended a minimum timeframe of 3–6 weeks relative rest prior to returning to running postpartum (Christopher *et al.* 2024), and recent World Rugby (2024) guidelines indicate 16 weeks postpartum as a minimum time for returning to matches. Individual timeframes will vary based on whole-system factors (e.g. delivery mode and psychological readiness to return), and more detail is provided by Donnelly *et al.* (2024).

When undertaking rugby training across the female lifespan, symptoms of PFD should be appropriately identified, managed and addressed according to individual needs. If symptoms are present, strength training should be modified to reduce the training load by way of lowering the weight, reducing the number of repetitions, or modifying the resistance exercise or position to reduce the PFM load. If PFM weakness has been assessed as a contributing factor to PFD symptoms, focused PFMT may need to be adjusted to address this. Strategies that may assist PFM function during return to load exposure are discussed later.

Traditionally, sports medicine and science research have focused on the training load accumulated by a player (acute and chronic volume) when assessing injury risk (Blanch & Gabbett 2016) and return-to-sport load (Ritchie *et al.* 2017). However, for a postpartum player as one example, load considerations must go beyond training volume and perceived effort. Specifically, the new life demands brought on by the role of motherhood may mean that atypical daily activity loads accumulate (e.g. lifting, carrying a baby and pushing the pram up hills). Additionally, the wider biopsychosocial challenges that may present after having a baby (e.g. sleep deprivation, lactation, inadequate nutrition and mental health) will ultimately influence a player's recovery, conditioning and tolerance for training. Therefore, psychosocial loads should also be considered when evaluating PFM load tolerance. Collectively, non-rugby-related daily physical activity loads, biopsychosocial loads and additional rugby loads will contribute to a player's readiness and return to rugby training and game play.

Pelvic floor strategies for rugby players

How different players tolerate the same PFM load may be explained by the predisposing, inciting and intervening factors (DeLancey *et al.* 2008, 2023) discussed earlier in the present review. For example, variations in player tolerance may also be related to the functional reserve each player achieved during growth and development (DeLancey *et al.* 2008). Players who progress to superior PFM strength and tolerance to load during earlier life are likely to have more functional reserve and resilience to inciting (pregnancy and childbirth) and intervening (lifestyle and age-related decline) factors that increase the risk of PFD. Furthermore, player strategies employed during rugby may add to the combination of factors influencing a player's risk including behavioural and non-behavioural approaches.

Behavioural strategies

Symptoms of PFD suggest that a player is not tolerating the load being placed upon the PFMs, but many continue to participate when experiencing symptoms (Sandwith & Robert 2021; McCarthy-Ryan *et al.* 2024). If an individual is symptomatic, clinical signs may be reduced or overcome by implementing rugby-specific strategies. Specifically, players who leak urine during contact-related activities report modifying their body position (technique), and reducing the number of contact activities in which they engage (McCarthy-Ryan *et al.* 2024). The most common strategies for non-contact activities were reducing movement speed or height jumped, as well as modifying technique and reducing the number of non-contact activities performed.

Some players may use the Valsalva manoeuvre during strenuous rugby movements (e.g. a scrum) to achieve the required magnitude of strength. This is because it results in increased trunk stiffness (Hughes *et al.* 1989) and increases IAP (Blazek *et al.* 2019). The associated increase in IAP (internal load) can elevate the load placed onto the PFMs, and therefore, may increase the risk of PFD symptoms caused by repetitive exposure to larger IAPs and potentially higher loads being transferred to the PFMs. However, further research is required to understand the consequences of the Valsalva manoeuvre in female athletes, including rugby players. Furthermore, recently published expert opinion suggests that strategies, including (1) optimizing the technique of abdominal bracing to optimize abdominal cavity force distribution, and (2) engaging in sub-threshold training while pelvic floor capacity is increased, may be worthwhile approaches for players who achieve performance benefits with the Valsalva manoeuvre (Prevett & Moore 2024).

Another strategy derived from clinical practice is changing from the Valsalva manoeuvre to purposively breathing, grunting or vocalizing during effort. This has been shown to reduce IAP in weightlifters compared to that generated during Valsalva strategies (Hagins *et al.* 2006), and therefore, may theoretically reduce the IAP forces directed toward the PFMs. Providing players with possible strategies allows them to choose the most effective approach for reducing *their* symptoms, as well as potentially helping to reduce the cumulative impact of loads on the PFMs. However, research is needed to substantiate this. Irrespective of these rugby-specific strategies, PFMT should be included as first-line management where load tolerance deficits are identified. Additionally, players should be signposted to a pelvic health physiotherapist for individualized evaluation of their rehabilitation needs.

Non-rugby behavioural strategies

Players may try to manage symptoms of PFD by altering their bladder emptying behaviour and fluid intake, which can lead to the development of further symptoms of PFD. For example, a rugby player who suffers from SUI may try to reduce symptoms by restricting their fluid intake (Culleton-Quinn *et al.* 2022; Johnston *et al.* 2023), and frequently emptying their bladder before and during training (Culleton-Quinn *et al.* 2022). This reduction in fluid intake and simultaneous purposeful increase in frequency of voiding is hypothesized to influence the risk of developing further urinary symptoms. For example, urinary frequency, urgency and urge incontinence could develop as a result of conditioning of the bladder to smaller, more-concentrated urine volumes and disruption to the normal urge capacity prior to voiding. However, such behavioural causes of overactive bladder presentations have yet to be supported by research. Nonetheless, it is important that evidence-based guidance is provided to rugby players regarding maladaptive bladder behaviours, and best-practice strategies and behaviours (e.g. adequate fluid intake and PFMT) (Booth *et al.* 2023).

Adjuncts and additional considerations

Available options to help minimize the disruption experienced and adjustment required as a consequence of PFD should be communicated to players across all ages and levels. This extends to wider roles involved in rugby (e.g. female coaches and match officials). One example includes digital applications within female technology, which can prompt reminders, direct technique and reinforce educational guidance on PFMT. However, the evidence-informed quality and efficacy of some digital applications are low (Sudol *et al.* 2019; Jaffar *et al.* 2022), and therefore, recommendations of specific applications should be carefully framed.

Players experiencing symptoms of SUI or POP may benefit from trying an intravaginal support or continence device (e.g. a vaginal pessary) to facilitate their return to training and match play, and sustain symptom management. Pessaries for SUI and POP have the potential to fully manage and alleviate symptoms (NICE 2021; Donnelly & Moore 2023), thereby allowing women's rugby players to continue engaging with training and return to sport. Players may also benefit from wearing compression garments during training and matches. Compression garments targeting the PFMs are relatively new, and have received limited research attention. Studies have highlighted that these reduce SUI, and positively influence the perception of PFD symptoms (Ninomiya *et al.* 2014; Okayama *et al.* 2019), which may subsequently improve a symptomatic player's confidence about exercising. Additionally, consideration should be given to the practicality, colour and comfort of the player's uniform: a study involving commonwealth athletes (that included a small sample of women's rugby players) found that sports involving fitted uniforms (e.g. gymnastics) raised concerns about an incontinence pad being visible (Johnston *et al.* 2023). Therefore, athletes, including rugby players, need to be able to dress in comfortable clothing that facilitates the discrete wearing of incontinence or menstrual products.

Pelvic floor surveillance and future research

Appropriate injury and illness surveillance should be in place to capture any PFD. Pelvic floor health and postpartum are two female athlete health domains that have been recently proposed as key considerations when undertaking female injury and illness surveillance (Moore *et al.* 2023). Moore *et al.* (2024) highlight that, in a rugby context, a non-time-loss health problem definition should be implemented to enable PFD data to be recorded since rugby players suffering from PFD do not necessarily stop training or discuss symptoms with their coaches, but rather, modify training activities and continue playing (McCarthy-Ryan *et al.* 2024). Annual baseline screening as well as ongoing screening during postpartum rehabilitation is advocated for PFD because of the accumulated and changing rugby exposure experienced by players. While validated questionnaires for PFD can be used, and these allow comparisons between different populations, such forms are general and not sport-specific. The first sports-specific screening tool for PFD has been developed (the Pelvic Floor Dysfunction-ScrEeNing Tool IN fEmale athLetes, i.e. PFD-SENTINEL) (Giagio *et al.* 2023), and this may assist with player screening and surveillance; however, it has not yet been validated.

Drawing on postpartum-return-to-running evidence (Donnelly *et al.* 2020; Moore *et al.* 2021; Christopher *et al.* 2024), it may be appropriate to ask the postpartum rugby player about UI and faecal incontinence, flatus incontinence, a feeling of vaginal heaviness (or a bulge inside or outside the vagina), and musculoskeletal pelvic pain during rugby-specific activities (e.g. being tackled, tackling, running, rucks and scrums) to determine the intervening event and inform management strategies. Research specific to the PFMs and rugby, which focuses on better understanding the normal behaviour of the PFMs during exercise, as well as prevention, childbirth-related injury and physical performance, is needed to better understand and guide PFM preparation and recovery in anticipation for playing rugby.

Summary

Awareness and recognition of the changes that the PFMs go through during development, pregnancy, childbirth and advancing age is the first step to understanding how to support players to be PFM "ready" for engaging in rugby. The next step is understanding the signs and symptoms of PFD, and being able to evaluate player load tolerance by considering physical and psychosocial (i.e. external and internal) loads. The present authors have outlined several strategies that rugby players may use to reduce or overcome the symptoms of PFD, while recommending that PFMT is undertaken by all rugby players as a prophylactic approach and as a first-line treatment for PFD. Being PFM ready for rugby will require symptomatic players to engage in a reconditioning programme with progressive loading. By applying the steps and recommendations identified in the present review, enhanced rehabilitation support can be provided to all women's players by health and fitness professionals, which can minimize the risk and/or symptoms of PFD, and enable continued rugby participation across all age, roles and levels of the game.

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