CLINICAL COMMENTARY

Nuances of the Valsalva manoeuvre and bracing with regard to resistance training performance and its effects on the pelvic floor

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Abstract
There is a great deal of confusion about the use of the Valsalva manoeuvre (VM), and its potential to harm or benefit the pelvic floor when performing resistance training (RT). The VM is completed when expiratory pressure is exerted on a closed or partially closed glottis. This creates a haemodynamic response that corresponds to an increase in blood pressure and then heart rate. For the RT athlete, the VM is a term used to describe bracing of the abdominal musculature to increase trunk stiffness and lumbar stability by intensifying intra-abdominal pressure. This gives individuals a performance advantage during RT. Within pelvic health, the VM is used to assess pelvic floor dysfunction (PFD), and in particular, pelvic organ prolapse. Emerging literature demonstrates that rates of PFD are high in resistance-trained female athletes, and therefore, it has been suggested that avoidance of the VM helps to reduce pelvic floor complaints in this population. However, this is unrealistic given that an involuntary, transient VM occurs at loads greater than 80% of an individual's one repetition maximum, and removal of the VM would potentially reduce performance in RT athletes. Physiotherapists need to use their evaluation and management skills to improve the symptoms of individuals who participate in RT and experience PFD. This clinical commentary reviews the physiology of the VM, explores rates of PFD in resistance-trained female athletes, and makes recommendations for the evaluation and treatment of these individuals. Unique considerations for the pregnant female participating in RT are also discussed.

Keywords: pelvic floor muscle training, powerlifting, resistance training, Valsalva manoeuvre, weightlifting.

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Introduction
Sports such as CrossFit, Olympic weightlifting and powerlifting have seen a dramatic increase in participation in the past decade (Huebner *et al.* 2021). This has resulted in a significant rise in the number of women engaging in resistance training (RT) at both the recreational and competitive levels (Huebner *et al.* 2021). These sports include RT at both high intensities and high loads. Female athletes report elevated rates of pelvic floor dysfunction (PFD) (Rebullido *et al.* 2021), and those participating in high-load and high-impact RT appear to be no exception

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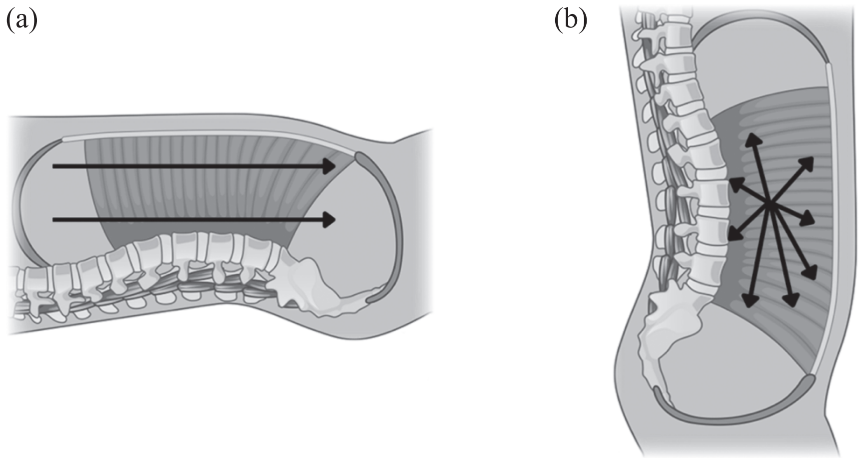

Figure 1. Demonstration of a Valsalva manoeuvre for (a) prolapse assessment and (b) bracing for resistance training. Arrows indicate the line of force with increases in intra-abdominal pressure. Image adapted from and used with the permission of Pelvic Guru, LLC (© 2021).

(Álvarez-García & Doğanay 2022; Skaug *et al.* 2022). Reports suggest that symptoms of PFD may be as high as 50% in RT (Wikander *et al.* 2021). This occurs most frequently when lifting closer to one's maximum capacity [one repetition maximum (1 RM)], and when performing the Valsalva manoeuvre (VM) (Wikander *et al.* 2021).

The VM is an important physiological phenomenon. In RT athletes, it refers to a breath strategy that involves forced expiratory flow against a closed glottis (Hackett & Chow 2013). When lifting at external loads greater than 80% of an individual's 1 RM or maximum voluntary contraction, a transient VM is performed (MacDougall *et al.* 1992). Execution of the VM during RT results in an increase in trunk stiffness (Hughes *et al.* 1989), an elevation in intrathoracic and intra-abdominal pressure (IAP) (Blazek *et al.* 2019), and increased electromyographic activation of the paraspinal musculature (Thompson *et al.* 2006). In this context, the VM confers a performance advantage since it enables an increase in force transfer, and therefore, more weight can be lifted.

In the context of urogynaecology, the VM involves bearing down against a closed glottis to evaluate changes in the range of motion of the vaginal wall (Spahlinger *et al.* 2014). This technique is an integral component of the assessment of pelvic organ prolapse (POP), in which the movement of the anterior, posterior and apical components of the vaginal walls is evaluated using measures such as the Pelvic Organ Prolapse Quantification (POP-Q) system (Madhu *et al.* 2018). An intentional bear-down, as seen in POP assessment, should not be a component of the VM while bracing during RT. However, while describing unique manoeuvres, this overlapping of terminology creates confusion in the research and clinical spaces (Bø *et al.* 2023). Pelvic floor physiotherapists and obstetrical providers may discourage the use of the VM during RT out of fear of exacerbation, or the development, of POP or other PFDs such as urinary incontinence (UI) (Bø *et al.* 2023). Figure 1 highlights differences in the direction of pressure between these two manoeuvres.

An important part of the rehabilitation of RT-focused female athletes is ameliorating the symptoms of PFD. This is because stress UI during lifting can affect athletic performance (Skaug *et al.* 2022), and PFD during exercise is a barrier to participating in it (Dakic *et al.* 2021). It is important that clinicians understand the role of RT and, specifically, the VM on pelvic floor function in women, and subsequently, interventions to improve symptoms. The aims of the present clinical commentary are to: provide readers with an understanding of the VM in the context of RT performance; highlight unique components of the evaluation process that may aid pelvic floor physiotherapists treating resistance-trained women with PFD; and offer guidance for the management of PFD in these individuals. For the purposes of this paper, and to circumvent any confusion of terminology, the VM in the context of RT will be termed "abdominal bracing".

Physiology of the Valsalva manoeuvre

The utilization of the VM increases pressure across the different segments of the body (i.e. the cranial, ocular, thoracic and abdominal regions) (Looga 2005; Pstras *et al.* 2016). The following sections highlight major features of the VM that are relevant to clinicians working with women who participate in RT.

Cardiovascular system

When investigating haemodynamics and the relative load on the cardiac system during the VM, cardiac evaluation involves a sustained strain for 15 s against a closed glottis (Ghazal 2017). A detailed account of the intricacies of the haemodynamic response to this manoeuvre is outside the scope of the present paper. For this commentary, the authors will focus on blood pressure and heart rate.

When a VM is initiated, there is a transient increase in arterial blood pressure, which is followed by a progressive decline (Pstras *et al.* 2016). As blood pressure drops, there is an increase in heart rate to counter blood pressure changes and maintain IAP throughout the duration of the manoeuvre (Pstras *et al.* 2016). Similar haemodynamic responses occur during abdominal bracing in RT (Hagins *et al.* 2004; Watanabe *et al.* 2022). The magnitude of IAP escalation and the subsequent haemodynamic response are very variable. The length of time during which individuals hold their breath differs based on the form of exercise, the number of sets and repetitions, the load, and experience (Kawabata *et al.* 2010; Kawabata & Shima 2023). More-experienced lifters generate a larger change in IAP, and therefore, a greater haemodynamic response than their untrained counterparts (Kawabata *et al.* 2010; Drury & Green 2023).

The abdominal brace may cause side effects, particularly in experienced lifters, although the manoeuvre is considered low-risk for those without significant cardiovascular disease (Hackett & Chow 2013). Elevation of intraocular pressure may lead to a subconjunctival haemorrhage (Vera *et al.* 2020). If a breath-hold is sustained for longer durations, presyncope or full syncope may occur as a result of hypotension (Hackett & Chow 2013). These side effects are generally transient and benign. If patients are experiencing these effects on a regular basis, advising them to avoid the VM and adopt an exhale-on-exertion strategy instead is recommended. Referral to a physician for cardiac testing may also be prudent.

Musculoskeletal system

Intra-abdominal pressure is an important variable for the expression of strength during RT (MacDougall *et al.* 1992; Niewiadomski *et al.* 2012). Resistance training intensity is expressed as a measure of effort. Effort can be intensified through increasing the number of repetitions in order to approach muscular failure, or an increase in load lifted compared to maximum capacity (1 RM) (Currier *et al.* 2023). Both a greater external load and a higher number of repetitions result in increases in IAP (Saldaña García *et al.* 2020). This creates more demand on the muscles of the trunk and greater fatigue (Clark *et al.* 2021). The core musculature is often conceptualized as a canister where the co-contraction of each of the “sides” is responsible for transfer of force. The muscles involved in this force transfer and, ultimately, RT performance include the abdominal wall (i.e. the internal oblique, external oblique and transversus abdominis), the chest wall, the spinal erectors (i.e. the multifidus, paraspinals and erector spinae) and the pelvic floor muscles (PFMs) [i.e. the levator ani (iliococcygeus, pubococcygeus and puborectalis)] (Thompson *et al.* 2006; Hamlyn *et al.* 2007).

Electromyographic tracings of relative activation patterns during a static VM (i.e. closing the nose and mouth, and forcefully exhaling as if you were popping your ears on an airplane) show that approximately equal contributions are made by each component of the core canister, including the PFMs (Thompson *et al.* 2006). This changes in relation to the movement being performed, the position of the trunk and the degree of spinal movement (Hamlyn *et al.* 2007). However, to date, most of the electromyographic data on RT and the VM have not been used to evaluate the contribution of the PFMs (Hamlyn *et al.* 2007; Clark *et al.* 2021). Although insights can potentially be extrapolated on the contributions of the core canister to functional performance, more research is needed to clarify role of the pelvic floor. While some pilot data exist (Dietze-Hermosa *et al.* 2020), these researchers used lower relative loads, and little is known about the IAP that the pelvic floor withstands under different RT loads (as percentages of 1 RM). Intra-abdominal pressure is highly individual, and the amount that individuals can withstand while still maintaining continence varies from person to person (Dietze-Hermosa *et al.* 2020).

There are two opposing theories relating to repetitive exposure of the pelvic floor to the VM and the risk of PFD. One postulates that a training effect will occur, and the pelvic system will adapt to the pressures to which it is exposed (Bø *et al.* 2023). The other is that RT and repetitive exposure to the VM will weaken the structures around the pelvis, making individuals more likely to experience issues such as POP (Bø & Nygaard 2020). Indeed, PFM thickness is greater in women who are regular exercisers than those who are not, but this does not translate into an increase in the strength of these muscles (Menezes *et al.* 2022). The impact of regular RT on static support around the pelvis and the subsequent risk of POP is unclear (Bø *et al.* 2023). Occupational heavy lifting is a known risk factor for the development of POP, which has led to recommendations to avoid high-load RT and the VM in order to mitigate this possibility (Currier *et al.* 2023). However, occupational heavy lifting is not equivalent to gradual and progressive voluntary RT (Cai & Davenport 2022), and despite the increased risk of PFD in female athletes, particularly those participating in a high-impact or high-load sport, there does not seem to be a greater risk of PFD later on in life when they have retired from it (Bø & Sundgot-Borgen 2010). Additionally, avoiding the VM is not possible because athletes will transiently perform a VM at loads greater than 80% of their 1 RM (MacDougall *et al.* 1992). Therefore, it is unrealistic for health professionals to advise RT athletes to avoid the VM. It is important for clinicians to: be aware of the mechanisms of PFD and risk factors for RT athletes; incorporate RT-specific components into the pelvic floor examination; and implement appropriate strategies to return athletes participating in RT to leak-free sport.

Pelvic floor dysfunction in resistance training female athletes

With the rise in popularity of resistance-focused exercise modalities such as CrossFit, powerlifting, weightlifting and functional fitness, attention has been brought to the incidence and prevalence of PFD in both recreational and elite-level athletes. A recent systematic review of cross-sectional studies of CrossFit highlighted that, when pooled across studies, approximately 36% of female athletes leak during CrossFit movements (Álvarez-García & Doğanay 2022). The majority of these symptoms occur during impact movements, such as jump rope and double-unders, or during high-load resistance exercises, such as the squat and the deadlift (Álvarez-García & Doğanay 2022).

For those engaging in powerlifting and weightlifting, the numbers appear to be equivalent or slightly higher. In a survey of female competitive powerlifters, the rate of UI in the previous 3 months was reported to be 44% (Wikander *et al.* 2021). The deadlift was the most common cause of leaking (Wikander *et al.* 2021). The incidence of UI was linked to age, parity and strength, with those who were stronger experiencing increased rates of incontinence (Wikander *et al.* 2022). A study by Skaug *et al.* (2022) involving elite-level powerlifters and weightlifters demonstrated that 50% ($n = 90/180$), 23% ($n = 23/180$) and 80% ($n = 144/180$) of female athletes surveyed experienced UI, subjective symptoms of POP and anal incontinence, respectively (Skaug *et al.* 2022).

When prompted to describe the circumstances that led to their pelvic floor symptoms, heavier loads (1–5 RM), the use of a weightlifting belt, technical faults, nutritional considerations (e.g. constipation and hydration) and parts of the menstrual cycle were reported by the participants (Wikander *et al.* 2021). These factors give valuable information to guide the clinician's subjective interview when treating individuals who are experiencing leaking during RT.

These high rates of pelvic floor symptoms in resistance-trained individuals align with the existing literature on PFD in adolescent females participating in sports (Rebullido *et al.* 2021; Álvarez-García & Doğanay 2022). This raises questions about how female athletes are being trained in these exercise modalities and the education that they receive about the pelvic floor, and highlights a need for potential modifications to the coaching of these movements to prevent the high rates of PFD seen in those participating in RT.

Additionally, despite these high rates, work by Forner *et al.* (2020) showed that subjective reports of prolapse were substantially less for those who were able to lift > 50 kg than those who could lift ≤ 15 kg (59.7% versus 15.2%, respectively). A potential hypothesis is that those with more reserves of strength place less strain on the pelvic floor during activities of daily living. During exercise, RT athletes utilize external loads that greatly exceed the requirements of activities of daily living. As such, they may exhibit an increase in symptoms when they approaching their maximum thresholds, which include those seen in sport or recreational RT in a gym setting.

Evaluation of pelvic floor dysfunction in resistance training female athletes

The evaluation and management of PFD, including stress UI and POP, is within the scope of

Table 1. Components to include in a pelvic floor evaluation of individuals who leak during resistance training

Component	Unique considerations
Subjective questions	With which movements do you notice symptoms? At what percentage or repetition range? At what point during the lift? What is the severity of your symptoms? Do you feel like you might urinate? Is it a few drops or a complete emptying of your bladder? Do you use a weightlifting belt? Does that change your symptoms? Has your training volume recently changed (i.e. at around the time of the onset of leakage)? Are you trying to change your weight? Are you getting a regular menstrual period? Do your symptoms change at different phases of your cycle? What is your nutritional intake? Do you know how many calories you are consuming? Do you notice more symptoms when you are cutting versus when you are not?
Functional evaluation	Perform in the clinic or evaluate videos of movements that are provoking symptoms If using video analysis, ideally view from 45° or a side angle Evaluate bracing strategy with and without a weightlifting belt Evaluate breath strategy during lifts
Objective measurement	Evaluation of pelvic floor muscle contraction, bracing and bearing down in supine and standing External visualization of vaginal wall range of motion with pelvic floor muscle contraction, bracing and bearing down

practice of pelvic floor physiotherapists, urologists, urogynaecologists and obstetricians, although approaches may vary depending on specialty and education (AUA 2016; CPA 2023). Stress UI occurs when there is an involuntary loss of urine during times of elevated IAP (Haylen *et al.* 2016). Increases in IAP occur when coughing, sneezing, laughing or vomiting (Haylen *et al.* 2016). Intra-abdominal pressure fluctuates to varying degrees during exercise (de Gennaro *et al.* 2019). As mentioned above, approximately half of athletes leak urine during high-load RT (Skaug *et al.* 2022), and a subset only do so during exercise-related activities (Wikander *et al.* 2021). This subcategory of UI is termed "athletic incontinence" (Araujo *et al.* 2017).

Athletic incontinence may occur because the strength and coordination of the PFMs is sufficient to meet the IAP increases of daily fluctuations such as coughing, but hits a "failure" point at impact or load thresholds generated during exercise. Therefore, it is important to include sport-specific components to a pelvic floor evaluation to cater for the individual needs of the patient. It is acknowledged that much of the following section relates to the present authors' clinical experiences, and has yet to be formally evaluated by research.

During the subjective examination, clinicians should ask a patient which movements cause urine or gas leakage, and the circumstances and severity of these symptoms. It is also important to identify known risk factors that may provide an insight into the symptom profile. Those that may influence the onset of pelvic floor symptoms during RT include age (Brito *et al.* 2022), parity (Wikander *et al.* 2022), relative strength numbers (Wikander *et al.* 2021), time of day, periodization block, caloric intake (Whitney *et al.* 2021) and phase of the menstrual cycle (Wikander *et al.* 2021). Education relating to the impact of these risk factors on pelvic health is a vital component of managing PFD in RT. Table 1 highlights unique considerations for the patient who leaks during RT.

The objective evaluation should include video or in-person analysis of high-load barbell movements. Patients often experience symptoms at a particular threshold (e.g. when lifting >75% of their 1 RM), and exploring technical faults provides relevant information at those loads. Coaching and correcting faults can lead to improvements in symptoms. Functional analysis should be done with individuals using their preferred breathing strategy.

Following functional analysis, assessment of the PFMs and visualization of the presence of POP can be completed, and this is often done in supine (Madhu *et al.* 2018; da Silva *et al.* 2021). For PFM strength assessments, individuals rest with their hips flexed and abducted. The strength of the pelvic floor is evaluated with digital palpation (i.e. the index finger, or index and middle fingers) (da Silva *et al.* 2021). This assessment method is cost-effective and commonly used in physiotherapy practice (Deegan *et al.* 2018). However, it must be noted that no gold standard approach to measurement has been established, and there are differences between pelvic floor force capacity in supine and standing assessments (Deegan *et al.* 2018). More literature

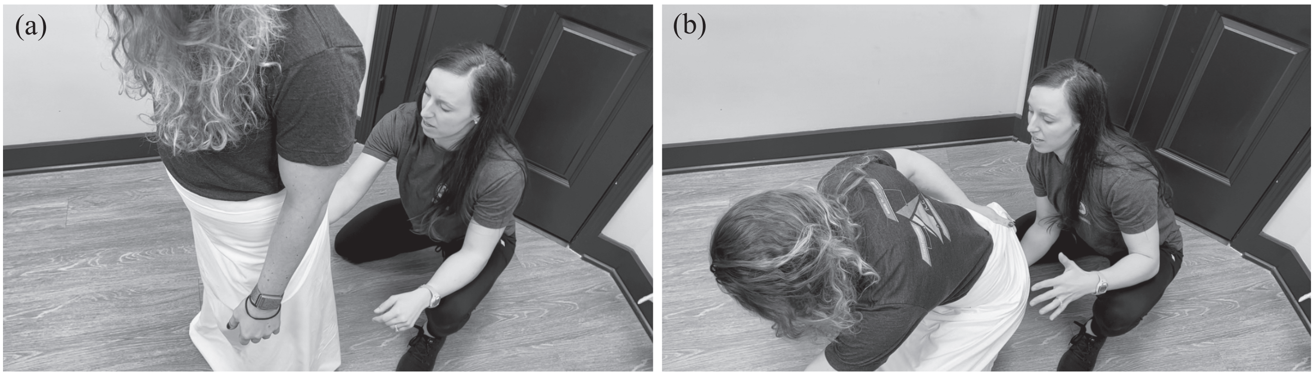

Figure 2. Pelvic floor evaluation in (a) standing and (b) a squat position. The clinician has the client lean forward, and is positioned behind her for digital insertion. In this posture, the clinician can evaluate pelvic floor muscle activity during the contraction, relaxation, Valsalva strain and abdominal bracing manoeuvres. This series of tasks can then be repeated at the bottom of a squat.

has been published on the benefit of the standing assessment for the evaluation of PFD (Bø & Finckenhagen 2003; Rodríguez-Mias *et al.* 2018; Mastwyk *et al.* 2022), and these authors believe that it is a useful tool for the assessment of RT athletes. While the standing assessment typically focuses on the PFM contraction (Bø & Finckenhagen 2003), the present authors also suggest examining pelvic floor movement during an abdominal brace and a Valsalva strain.

During a standing assessment, the clinician will ask the patient to lift a leg onto a support, such as a stool, to allow for digital insertion. After returning to the resting position of a comfortable hip-width stance, the clinician then asks her to perform: (1) a pelvic floor contraction; (2) an abdominal brace "as if you are lifting a weight in the gym"; and (3) a strain or the VM (Fig. 2). When assessing the brace, there should either be no change in PFM tone or a slight lift of the pelvic floor. A bear-down during the brace is considered to be a relevant finding, and treatment will involve teaching the patient an abdominal bracing strategy that does not involve a downward strain on the pelvic floor. While still internally palpating, she can then transition into the bottom position of a squat, and this sequence is then repeated. Note that PFM contractions will generally be weaker during a standing assessment than in supine (Bø & Finckenhagen 2003), and contractions will be weaker at the bottom of the squat than in a standing evaluation. When evaluating PFM tone while lifting a weight, the clinician is not cueing the pelvic floor during this task, but rather, characterizing any coordination issues during the abdominal brace. It may be clinically relevant to perform this evaluation after an RT session: individuals with UI show decreases in maximum voluntary contraction of the PFMs following training in contrast to their peers without incontinence (Lindland Ree *et al.* 2007). High-intensity exercise that includes RT also causes changes in resting support of the pelvic floor, and therefore, may be an important consideration for POP assessment (Middlekauff *et al.* 2016). Straining during an abdominal brace may also sensitize the pelvis, and can contribute to subjective POP symptoms.

Pelvic organ prolapse assessment is done by visual inspection during a VM strain, or with objective measurement tools such as the POP-Q in supine (Madhu *et al.* 2018). Range of motion is graded during a maximal strain relative to the hymen (Haylen *et al.* 2016). A lack of agreement exists between the evaluation of the objective signs of POP and subjective complaints (Brown *et al.* 2022). Therefore, while it is important to utilize objective assessments of POP as part of a comprehensive pelvic floor assessment, modification of subjective symptoms should be used as the primary measure of the effectiveness of an intervention. Additionally, some researchers have questioned established normative values, and have called for the integration of standing prolapse assessment into standard practice as well as the modification of these values to reflect pelvic support in the standing position (Rodríguez-Mias *et al.* 2018). With the increase in popularity of point-of-care ultrasound (Smith *et al.* 2022), it may be possible to visually assess prolapse and degree of descent with bracing and while loaded during a pelvic floor physiotherapy assessment.

Treatment of pelvic floor dysfunction in resistance training female athletes

The treatment of women who are experiencing leaking or heaviness with RT takes a three-pronged approach: (1) establish baseline awareness and coordination of the pelvic floor; (2) assess and ensure an appropriate bracing strategy to coordinate the core canister; and (3) accumulate volume sub-symptom threshold to increase strength capacity.

Establish a baseline awareness of the pelvic floor

There is high-level evidence to support the use of PFM training to improve the symptoms of incontinence (Hagen *et al.* 2020; Kharaji *et al.* 2023). A recent systematic review has also found that PFM training is beneficial in the treatment of individuals who experience incontinence during high-impact sports (Fukuda *et al.* 2023). The objective evaluation should begin with clinicians raising awareness of the coordination requirements of the pelvic floor for the abdominal brace during RT. This can begin in supine, but should quickly transfer to standing and functional tasks.

Awareness of the pelvic floor is not strictly restricted to a focus on weakness and coordination. In the present authors' clinical experience, leaking during RT can commonly occur because of hypertonicity of the PFMs as a result of over-recruitment of these muscles during RT because of previous leaking experiences. Differentiation between the need for strengthening in the case of pelvic floor weakness, and for coordination and appropriate recruitment in that of hypertonicity, is a pivotal step in building the appropriate foundation of pelvic floor function during RT.

Teach proper bracing

When an abdominal brace is performed properly, force is distributed equally along all sides of the core cannister (Fig. 1). Athletes will inhale a large breath and then contract their abdominal wall while holding it. Cues such as "tighten like someone is going to punch you in the stomach" and "tighten like a child is going to jump on you" for non-pregnant women, or "hug the baby" for pregnant individuals, can be effective ways to elicit this recruitment. Tactile cues can also be effective; for example, the athlete places her hand on her lower abdomen, feels for tension, and tries to avoid pushing out or caving in the abdominal wall. The pelvic floor is a reflexive muscle group (Luginbuehl *et al.* 2022), and as such, should not necessarily be cued to fully engage during a brace.

Teaching athletes awareness of sensations at their pelvic floor (e.g. a strain or bear-down, a contraction, or no change) in combination with symptomatic behaviour will guide interventions. If they are experiencing leakage while describing the sensation of a bear-down at the pelvic floor, cueing a PFM contraction prior to bracing may help to mitigate that response. If they have no pelvic floor symptoms and do not feel their pelvic floor engaging during a brace, it is not necessary to intentionally cue them to perform a PFM contraction. Muscle recruitment of the core canister will increase as the demand placed on the PFMs increases (Fuglsang-Frederiksen & Rønager 1988). Therefore, as the load of the weight lifted increases, the intensity of the brace required will increase as a result of the greater need for motor unit recruitment. Athletes need not perform a maximal effort core and PFM contraction to brace for light-to-moderate-weight RT, but they should increase the intensity of their brace as the relative load of the lift increases.

Encourage subthreshold training to increase musculoskeletal capacity

Intra-abdominal pressure gradually increases with changes in breathing strategy (e.g. free breathing, exhaling on exertion and an abdominal brace), and with changes in load (Hackett & Chow 2013). The aim of rehabilitation is to: (1) reduce the severity of leaking at symptomatic loads; and (2) increase the threshold before symptom onset or remove symptoms at any load.

Manipulating breathing is a useful tool for the initial reduction of the symptomatic burden. As the VM occurs naturally over 80% of an individual's 1 RM (MacDougall *et al.* 1992), for RT-focused athletes, permanent removal of the abdominal brace with a breath-hold is not appropriate. However, they can begin accumulating volume below the threshold load of leaking with an exhale-on-exertion strategy (i.e. exhaling on the most challenging portion of the movement). After a period of volume accumulation and coordination of the PFMs, a stronger abdominal brace utilizing a breath-hold strategy can be trialled. Symptom onset in this context can be seen as a sign of bodily readiness for RT loads rather than a sign of damage or dysfunction.

Unique pregnancy considerations for resistance training female athletes

Resistance training during pregnancy is generally encouraged if it is at moderate intensity because it has been shown to have both maternal and foetal benefits (Mottola *et al.* 2018). However, until recently, there was little evidence pertaining to high-intensity RT and the safety of the VM during RT in pregnant individuals. The question of safety relates to the haemodynamic response of the VM interacting with the significant changes to the maternal cardiovascular system needed to support pregnancy, the known risks of hypertension on maternal and foetal outcomes, and the potential for exacerbating the strain on the pelvic floor already present during pregnancy (ACOG 2020a).

With respect to the maternal cardiovascular system, blood volume increases by between 20% and 100% in comparison to pre-pregnancy levels (Sanghavi & Rutherford 2014). This process begins within the first few weeks of gestation (Sanghavi & Rutherford 2014). In response to the increased blood volume, resting heart rate increases between 10 and 20 beats per minute. Cardiac output shows a significant rise in the first trimester, and this continues into the second trimester and can be up to 45% higher than it was before pregnancy (Sanghavi & Rutherford 2014). The change in cardiac output is mediated by an increase in stroke volume (Soma-Pillay *et al.* 2016), which begins to rise in the first trimester, and continues to do so until the third trimester (Sanghavi & Rutherford 2014). With the changes to the cardiovascular system in the woman, and the known haemodynamic effects of the VM, initial safety and feasibility data were not established until recently (Meah *et al.* 2021).

With regard to the transient hypertension response seen during the VM, gestational hypertensive syndromes are a significant concern. These elevate the risks associated with both maternal and foetal outcomes, and this potential relationship has led to the hypothesized need for recommendations against the use of VM, and oftentimes RT, during pregnancy because of a fear of negative effects on the foetus (ACOG 2020b). During submaximal RT, no significant differences in blood pressure, heart rate, cardiac output or cardiac functional measures were reported when utilizing the VM at 40% of a 10 RM leg press versus free breathing at 20%, 40% and 60% of a 10 RM leg press (Meah *et al.* 2021). With regard to maternal cardiac function and haemodynamic effects on the placenta, the literature does not support the recommendation that women should avoid the VM to prevent adverse foetal outcomes. Hypertensive syndromes were below national averages for women who performed high-load RT during their pregnancies (Prevett *et al.* 2023). Therefore, the VM does not need to be a contraindication during exercise.

During RT and the VM, blood is pushed towards the working musculature. There has previously been concern that this could lead to a concomitant reduction in placental blood flow during the VM because of the increases in maternal blood pressure and IAP (Bø *et al.* 2016), and shunting of blood towards the periphery and away from placenta as a result of the vasodilation of maternal extremities (Gould *et al.* 2021). Emerging updated evidence via real-time ultrasound demonstrates that not only does placental blood flow not decrease during high-load RT [specifically during a 1 RM inclined chest press up to a maximum of 50 lb (i.e. 22.7 kg)], but women who had participated in RT exercises during pregnancy demonstrated a statistically significant increase in blood flow to the placenta during their 1 RM lift (Gould *et al.* 2021).

Collectively, there is no evidence of maternal or foetal harm caused by performing RT at any intensity during pregnancy. However, it must be acknowledged that, at present, there is no evidence of the specific maternal haemodynamic effects of maximal RT during pregnancy, and the subsequent acute response of the pelvic floor. To empower and inform pregnant patients who wish to continue RT, the clinician should teach them about the proper mechanics of the brace. This is because motor control and proprioceptive awareness may change as pregnancy progresses. Furthermore, patients should be educated about signs that exercise should be discontinued, including symptoms of hypotension or episodes of presyncope.

Finally, the use of the VM and high-load RT during pregnancy has been avoided since there is a belief that these activities may increase the risk of PFD because of the combined strain on the PFMs of pregnancy and elevated IAP with the abdominal brace (Bø *et al.* 2016). However, a cross-sectional survey of women who continued to lift > 80% of their 1 RM during their pregnancies and utilized a VM did not demonstrate any differences in maternal, foetal or delivery outcomes, and these were not associated with an increased risk of PFD postpartum (Prevett *et al.* 2023). Further research is still needed to clearly elucidate this relationship, but the initial findings do not support this argument.

Conclusions

Clarification of terminology is the first step towards creating clear guidelines for the use of abdominal bracing, and the impact of RT and the VM on pelvic health. Clinicians have a large role to play in improving or eliminating PFD in RT athletes. Maintaining muscular strength is an important aspect of health and longevity, and should be encouraged across the female lifespan. More research is needed on the abdominal bracing strategy in female athletes to determine protocols to prevent the high rates of PFD currently seen in women who participate in RT.

Conflict of interest

The authors have none to declare.

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References

Álvarez-García C. & Doğanay M. (2022) The prevalence of urinary incontinence in female CrossFit practitioners: a systematic review and meta-analysis. *Archivos Españoles de Urología* **75** (1), 48–59.

American College of Obstetricians and Gynecologists (ACOG) (2020a) Gestational hypertension and preeclampsia: ACOG Practice Bulletin, Number 222. *Obstetrics & Gynecology* **135** (6), e237–e260.

American College of Obstetricians and Gynecologists (ACOG) (2020b) Physical activity and exercise during pregnancy and the postpartum period: ACOG Committee Opinion, Number 804. *Obstetrics & Gynecology* **135** (4), e178–e188.

American Urological Association (AUA) (2016) *Urology 101*. [WWW document.] URL https://www.auanet.org/documents/advocacy/press-media/urology-101-fact-sheet.pdf

Araujo M. P., Sartori M. G. F. & Girão M. J. B. C. (2017) Athletic incontinence: proposal of a new term for a new woman. [Editorial.] *RBGO Gynecology and Obstetrics/Revista Brasileira de Ginecologia e Obstetrícia* **39** (9), 441–442.

Blazek D., Stastny P., Maszczyk A., *et al.* (2019) Systematic review of intra-abdominal and intrathoracic pressures initiated by the Valsalva manoeuvre during high-intensity resistance exercises. *Biology of Sport* **36** (4), 373–386.

Bø K., Artal R., Barakat R., *et al.* (2016) Exercise and pregnancy in recreational and elite athletes: 2016 evidence summary from the IOC expert group meeting, Lausanne. Part 1 – exercise in women planning pregnancy and those who are pregnant. *British Journal of Sports Medicine* **50** (10), 571–589.

Bø K., Anglès-Acedo S., Batra A., *et al.* (2023) Strenuous physical activity, exercise, and pelvic organ prolapse: a narrative scoping review. *International Urogynecology Journal* **34** (6), 1153–1164.

Bø K. & Finckenhagen H. B. (2003) Is there any difference in measurement of pelvic floor muscle strength in supine and standing position? *Acta Obstetricia et Gynecologica Scandinavica* **82** (12), 1120–1124.

Bø K. & Nygaard I. E. (2020) Is physical activity good or bad for the female pelvic floor? A narrative review. *Sports Medicine* **50** (3), 471–484.

Bø K. & Sundgot-Borgen J. (2010) Are former female elite athletes more likely to experience urinary incontinence later in life than non-athletes? *Scandinavian Journal of Medicine & Science in Sports* **20** (1), 100–104.

Brito L. G. O., Pereira G. M. V., Moalli P., *et al.* (2022) Age and/or postmenopausal status as risk factors for pelvic organ prolapse development: systematic review with meta-analysis. *International Urogynecology Journal* **33** (1), 15–29.

Brown H. W., Hegde A., Huebner M., *et al.* (2022) International urogynecology consultation chapter 1 committee 2: epidemiology of pelvic organ prolapse: prevalence, incidence, natural history, and service needs. *International Urogynecology Journal* **33** (2), 173–187.

Cai C. & Davenport M. H. (2022) Prenatal physical activity paradox: occupational versus leisure-time physical activity. *British Journal of Sports Medicine* **56** (7), 365–366.

Clark D. R., Lambert M. I., Grigson C. & Hunter A. M. (2021) Impact of resistance training status on trunk muscle activation in a fatiguing set of heavy back squats. *European Journal of Applied Physiology* **121** (2), 597–608.

College of Physiotherapists of Alberta (CPA) (2023) *Pelvic Health Guide for Alberta Physiotherapists*. [WWW document.] URL https://www.cpta.ab.ca/docs/116/Pelvic_Health_Guide_NPIb0io.pdf

Currier B. S., Mcleod J. C., Banfield L., *et al.* (2023) Resistance training prescription for muscle strength and hypertrophy in healthy adults: a systematic review and Bayesian network meta-analysis. *British Journal of Sports Medicine* **57** (18), 1211–1220.

Dakic J. G., Hay-Smith J., Cook J., *et al.* (2021) Effect of pelvic floor symptoms on women's participation in exercise: a mixed-methods systematic review with meta-analysis. *Journal of Orthopaedic & Sports Physical Therapy* **51** (7), 345–361.

Da Silva J. B., de Oliveira Sato T., Rocha A. P. R. & Driusso P. (2021) Inter- and intrarater reliability of unidigital and bidigital vaginal palpation to evaluation of maximal voluntary contraction of pelvic floor muscles considering risk factors and dysfunctions. *Neurourology and Urodynamics* **40** (1), 348–357.

Deegan E. G., Stothers L., Kavanagh A. & Macnab A. J. (2018) Quantification of pelvic floor muscle strength in female urinary incontinence: a systematic review and comparison of contemporary methodologies. *Neurourology and Urodynamics* **37** (1), 33–45.

De Gennaro J. D., de Gennaro C. K., Shaw J. M., *et al.* (2019) The relationship between intra-abdominal pressure and body acceleration during exercise. *Female Pelvic Medicine & Reconstructive Surgery* **25** (3), 231–237.

Dietze-Hermosa M., Hitchcock R., Nygaard I. E. & Shaw J. M. (2020) Intra-abdominal pressure and pelvic floor health: should we be thinking about this relationship differently? *Female Pelvic Medicine & Reconstructive Surgery* **26** (7), 409–414.

Drury K. & Green S. (2023) Effects of intensity and training on cardiovascular responses to the Valsalva manoeuvre. *Journal of Basic and Clinical Physiology and Pharmacology* **34** (1), 111–119.

Forner L. B., Beckman E. M. & Smith M. D. (2020) Symptoms of pelvic organ prolapse in women who lift heavy weights for exercise: a cross-sectional survey. *International Urogynecology Journal* **31** (8), 1551–1558.

Fuglsang-Frederiksen A. & Rønager J. (1988) The motor unit firing rate and the power spectrum of EMG in humans. *Electroencephalography and Clinical Neurophysiology* **70** (1), 68–72.

Fukuda F. S., Arbieto E. R. M., Da Roza T. & Luz S. C. T. da (2023) Pelvic floor muscle training in women practicing high-impact sports: a systematic review. *International Journal of Sports Medicine* **44** (6), 397–405.

Ghazal S. N. (2017) Valsalva maneuver in echocardiography. *Journal of Echocardiography* **15** (1), 1–5.

Gould S., Cawyer C., Bamman M., *et al.* (2021) Resistance training does not decrease placental blood flow during Valsalva maneuver: a novel use of 3D Doppler power flow ultrasonography. *Sports Health: A Multidisciplinary Approach* **13** (5), 476–481.

Hackett D. A. & Chow C.-M. (2013) The Valsalva maneuver: its effect on intra-abdominal pressure and safety issues during resistance exercise. *The Journal of Strength and Conditioning Research* **27** (8), 2338–2345.

Hagen S., Elders A., Stratton S., *et al.* (2020) Effectiveness of pelvic floor muscle training with and without electromyographic biofeedback for urinary incontinence in women: multicentre randomised controlled trial. *The BMJ* **371:** m3719. DOI: 10.1136/bmj.m3719.

Hagins M., Pietrek M., Sheikhzadeh A., Nordin M. & Axen K. (2004) The effects of breath control on intra-abdominal pressure during lifting tasks. *Spine* **29** (4), 464–469.

Hamlyn N., Behm D. G. & Young W. B. (2007) Trunk muscle activation during dynamic weight-training exercises and isometric instability activities. *The Journal of Strength and Conditioning Research* **21** (4), 1108–1112.

Haylen B. T., Maher C. F., Barber M. D., *et al.* (2016) An International Urogynecological Association (IUGA) / International Continence Society (ICS) joint report on the terminology for female pelvic organ prolapse (POP). *International Urogynecology Journal* **27** (2), 165–194.

Huebner M., Meltzer D. E. & Perperoglou A. (2021) Strength in numbers women in Olympic-style weightlifting. *Significance* **18** (2), 20–25.

Hughes L. O., Heber M. E., Lahiri A., Harries M. & Raftery E. B. (1989) Haemodynamic advantage of the Valsalva manoeuvre during heavy resistance training. *European Heart Journal* **10** (10), 896–902.

Kawabata M., Shima N., Hamada H., Nakamura I. & Nishizono H. (2010) Changes in intra-abdominal pressure and spontaneous breath volume by magnitude of lifting effort: highly trained athletes versus healthy men. *European Journal of Applied Physiology* **109** (2), 279–286.

Kawabata M. & Shima N. (2023) Interaction of breathing pattern and posture on abdominal muscle activation and intra-abdominal pressure in healthy individuals: a comparative cross-sectional study. *Scientific Reports* **13** (1): 11 338. DOI: 10.1038/s41598-023-37629-5.

Kharaji G., ShahAli S., Ebrahimi-Takamjani I., *et al.* (2023) Supervised versus unsupervised pelvic floor muscle training in the treatment of women with urinary incontinence – a systematic review and meta-analysis. *International Urogynecology Journal* **34** (7), 1339–1349.

Lindland Ree M., Nygaard I. & Bø K. (2007) Muscular fatigue in the pelvic floor muscles after strenuous physical activity. *Acta Obstetricia et Gynecologica Scandinavica* **86** (7), 870–876.

Looga R. (2005) The Valsalva manoeuvre – cardiovascular effects and performance technique: a critical review. *Respiratory Physiology & Neurobiology* **147** (1), 39–49.

Luginbuehl H., Lehmann C., Koenig I, *et al.* (2022) Involuntary reflexive pelvic floor muscle training in addition to standard training versus standard training alone for women with stress urinary incontinence: a randomized controlled trial. *International Urogynecology Journal* **33** (3), 531–540.

MacDougall J. D., McKelvie R. S., Moroz D. E., *et al.* (1992) Factors affecting blood pressure during heavy weight lifting and static contractions. *Journal of Applied Physiology* **73** (4), 1590–1597.

Madhu C., Swift S., Moloney-Geany S. & Drake M. J. (2018) How to use the Pelvic Organ Prolapse Quantification (POP-Q) system? *Neurourology and Urodynamics* **37** (Suppl. 6), S39–S43.

Mastwyk S., McClelland J., Cooper M. M. & Frawley H. C. (2022) Pelvic floor muscle function in the standing position in women with pelvic floor dysfunction. *International Urogynecology Journal* **33** (9), 2435–2444.

Meah V. L., Strynadka M. C., Steinback C. D. & Davenport M. H. (2021) Cardiac responses to prenatal resistance exercise with and without the Valsalva maneuver. *Medicine & Science in Sports & Exercise* **53** (6), 1260–1269.

Menezes E. C., da Silva Pereira F., Porto R. M., Fank F. & Mazo G. Z. (2023) Effect of exercise on female pelvic floor morphology and muscle function: a systematic review. *International Urogynecology Journal* **34** (5), 963–977.

Middlekauff M. L., Egger M. J., Nygaard I. E. & Shaw J. M. (2016) The impact of acute and chronic strenuous exercise on pelvic floor muscle strength and support in nulliparous healthy women. *American Journal of Obstetrics and Gynecology* **215** (3), 316.e1–316.e7.

Mottola M. F., Davenport M. H., Ruchat S.-M., *et al.* (2018) 2019 Canadian guideline for physical activity throughout pregnancy. *British Journal of Sports Medicine* **52** (21), 1339–1346.

Niewiadomski W., Pilis W., Laskowska D., *et al.* (2012) Effects of a brief Valsalva manoeuvre on hemodynamic response to strength exercises. *Clinical Physiology and Functional Imaging* **32** (2), 145–157.

Prevett C., Kimber M. L., Forner L., de Vivo M. & Davenport M. H. (2023) Impact of heavy resistance training on pregnancy and postpartum health outcomes. *International Urogynecology Journal* **34** (2), 405–411.

Pstras L., Thomaseth K., Waniewski J., Balzani I. & Bellavere F. (2016) The Valsalva manoeuvre: physiology and clinical examples. *Acta Physiologica* **217** (2), 103–119.

Rebullido T. R., Gómez-Tomás C., Faigenbaum A. D. & Chulvi-Medrano I. (2021) The prevalence of urinary incontinence among adolescent female athletes: a systematic review. *Journal of Functional Morphology and Kinesiology* **6** (1), 12.

Rodríguez-Mias N.-L., Subramaniam N., Friedman T., Shek K. L. & Dietz H. P. (2018) Prolapse assessment supine and standing: do we need different cutoffs for "significant prolapse"? *International Urogynecology Journal* **29** (5), 685–689.

Saldaña García J., Torremocha López A. & Dawid Milner M. S. (2020) Influence of repetitions on the Valsalva maneuver. *Clinical Neurophysiology Practice* **5** (2020), 104–111.

Sanghavi M. & Rutherford J. D. (2014) Cardiovascular physiology of pregnancy. *Circulation* **130** (12), 1003–1008.

Skaug K. L., Engh M. E., Frawley H. & Bø K. (2022) Prevalence of pelvic floor dysfunction, bother, and risk factors and knowledge of the pelvic floor muscles in Norwegian male and female powerlifters and Olympic weightlifters. *The Journal of Strength and Conditioning Research* **36** (10), 2800–2807.

Smith M., Donnelly G. M., Berry L., Innes S. & Dixon J. (2022) Point of care ultrasound in pelvic health: scope of practice, education and governance for physiotherapists. *International Urogynecology Journal* **33** (10), 2669–2680.

Soma-Pillay P., Nelson-Piercy C., Tolppanen H. & Mebazaa A. (2016) Physiological changes in pregnancy. *Cardiovascular Journal of Africa* **27** (2), 89–94.

Spahlinger D. M., Newcomb L., Ashton-Miller J. A., DeLancey J. O. & Chen L. (2014) Relationship between intra-abdominal pressure and vaginal wall movements during Valsalva in women with and without pelvic organ prolapse: technique development and early observations. *International Urogynecology Journal* **25** (7), 873–881.

Thompson J. A., O'Sullivan P. B., Briffa N. K. & Neumann P. (2006) Differences in muscle activation patterns during pelvic floor muscle contraction and Valsalva manoeuvre. *Neurourology and Urodynamics* **25** (2), 148–155.

Vera J., Perez-Castilla A., Redondo B., *et al.* (2020) Influence of the breathing pattern during resistance training on intraocular pressure. *European Journal of Sport Science* **20** (2), 157–165.

Watanabe H., Washio T., Saito S. & Ogoh S. (2022) Effect of breath-hold on the responses of arterial blood pressure and cerebral blood velocity to isometric exercise. *European Journal of Applied Physiology* **122** (1), 157–168.

Whitney K. E., Holtzman B., Cook D., *et al.* (2021) Low energy availability and impact sport participation as risk factors for urinary incontinence in female athletes. *Journal of Pediatric Urology* **17** (3), 290.e1–290.e7.

Wikander L., Kirshbaum M. N., Waheed N. & Gahreman D. E. (2021) Urinary incontinence in competitive women powerlifters: a cross-sectional survey. *Sports Medicine – Open* **7** (1): 89. DOI: 10.1186/s40798-021-00387-7.

Wikander L., Kirshbaum M. N., Waheed N. & Gahreman D. E. (2022) Association between obstetric history and urinary incontinence in a cohort of resistance-trained women. *International Journal of Women's Health* **14** (2022), 1211–1218.

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