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The Effect of Intense Physical Training on Lower Urinary Tract Function in Female Professional Swimmers

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ABSTRACT

Background: Lower urinary tract symptoms (LUTS) are clinically important problems in female athletes, yet the swimmer-specific literature remains relatively narrow. Literature shows that urinary incontinence (UI) and other pelvic floor complaints are common in elite female sport, with prevalence varying by sport type, training load, and individual susceptibility. Swimmer-specific studies indicate that lower urinary tract (LUT) dysfunction occurs also in aquatic sports.

Aim: This study examines the effect of intense training on LUT function in female professional swimmers, especially urinary storage symptoms, stress UI, mixed UI, quality of life, and implications for performance.

Materials and Methods: A narrative review approach was used to synthesize data on LUT function in female swimmers and elite athletes. Published swimmer-specific studies were analyzed alongside broader research on high-performance female sport to contextualize findings, given the limited volume of swimmer-focused evidence.

Results: Evidence suggest that high-performance swimmers may experience substantial LUTS and measurable changes in pelvic floor muscle activity. Although swimming differs from high-impact sports in immediate mechanical stress on the pelvic floor, elite swimmers accumulate high training volumes, dryland conditioning, breath-control maneuvers, and pressure fluctuations that may challenge continence mechanisms. Findings also link low energy availability, menstrual dysfunction, and underdiagnosis of pelvic floor symptoms in female athletes to urinary outcomes.

Conclusions: UI and LUTS are relevant concerns in elite female swimmers despite the non-impact nature of swimming. The swimmer-specific evidence is scarse, particularly regarding longitudinal training-load effects, event-specific risk profiling, and intervention trials. Current evidence suggest routine symptom screening, pelvic floor assessment, and pelvic floor muscle training within athlete support programs.

Keywords: female swimmers; lower urinary tract symptoms; urinary incontinence; pelvic floor dysfunction; elite athletes; training load; sports medicine; narrative review

1. Introduction

Lower urinary tract (LUT) function depends on coordinated interactions among the bladder, urethra, pelvic floor musculature, abdominal wall, connective tissue support and both central and peripheral neural control. In women, the lower urinary tract symptoms (LUTS) complex includes urinary incontinence (UI), urgency, increased daytime frequency, nocturia, voiding difficulty, dysuria, straining, and post-void symptoms. Terminology has been standardized by the International Continence Society and the International Urogynecological Association/International Continence Society (IUGA/ICS) reports, which is important in sports medicine because studies in athletes often use different symptom labels and assessment tools, making direct comparisons difficult (Abrams et al., 2003; Haylen et al., 2010; Bo et al., 2017). In the general female population, LUTS are common and dynamic over time; longitudinal work has shown noticeable incidence as well as remission, which underscores that symptoms in athletes should not be treated as fixed or inevitable (Milsom, 2009; Coyne et al., 2009; Wennberg et al., 2009).

The sports medicine literature now makes it clear that female athletes are not protected from pelvic floor dysfunction by youth, fitness, or nulliparity alone. On the contrary, multiple systematic reviews and cross-sectional athlete studies report that UI is frequent in elite and competitive sport, particularly in disciplines characterized by high impact, repetitive ground-reaction forces, or large spikes in intra-abdominal pressure (Teixeira et al., 2018). The strongest signal across the athlete literature concerns stress UI, but urgency, mixed symptoms, and broader LUT complaints also occur (Simeone et al., 2010). At the same time, underreporting remains common because athletes normalize leakage, fear embarrassment, or prioritize training continuity over symptom disclosure (Culleton-Quinn et al., 2022; Dakic et al., 2023; Bosch-Donate et al., 2024).

Female professional swimmers occupy a clinically interesting position within this literature. Swimming is not usually classified with trampoline, gymnastics, or volleyball as one of the most provocative impact sports for continence, yet elite swimmers train at very high volumes and intensities, often combine aquatic sessions with demanding dryland conditioning, and perform repeated breath-holding, bracing, turns, starts, and trunk-dominant movements. Because the mechanical environment differs from land-based high-impact sports, swimmers are a useful subgroup for examining whether intense training affects lower urinary tract function through pathways other than repeated impact alone. Recent swimmer-specific studies suggest that UI prevalence can still be high in high-performance swimmers and that training volume may influence pelvic floor muscle activity (Dornowski et al., 2019; Rubin et al., 2024).

The aim of this narrative review is to synthesize the literature relevant to the effect of intense physical training on lower urinary tract function in female professional swimmers. Because swimmer-specific evidence remains limited, the review intentionally integrates broader elite-athlete literature to interpret plausible mechanisms, likely risk modifiers, and clinically useful management strategies. The purpose is not to overgeneralize from other sports to swimming, but to provide a comprehensive, sport-sensitive synthesis of current medical knowledge and advancements in this important medical issue (de Mattos Lourenco et al., 2018; Cerruto et al., 2020; Gan et Smith, 2023; Petter Rodrigues et al., 2024).

2. Materials and methods

The focus of this narrative review was PubMed-indexed articles addressing one or more of the following: female athletes and UI, LUTS in sportswomen, pelvic floor dysfunction in elite athletes; swimmer-specific studies on urinary symptoms or pelvic floor function, training load and athletic incontinence, low energy availability and urinary symptoms, and conservative treatment strategies relevant to sport. Priority was given to athlete cohorts, swimmer-specific studies, systematic reviews, and terminology or epidemiology papers needed to frame the clinical problem. Because swimmer-only evidence is sparse, broader athlete literature was used to contextualize mechanisms and management, while swimmer-specific claims were kept narrow and explicit. Additional reference search was implemented in order to obtain more relevant data.

3. Characteristics of the LUT in Female Athletes

Normal continence during exercise requires the urethral closure mechanism and pelvic floor to counter rapid or sustained rises in intra-abdominal pressure. In training environments, leakage may occur when intra-abdominal pressure exceeds urethral closure pressure, when pelvic floor muscle timing is inadequate, when repeated effort induces transient muscular fatigue, or when longer-term neuromuscular and connective-tissue adaptations become maladaptive. Athlete literature has long debated two competing models: the "training strengthens the pelvic floor" hypothesis versus the "repeated loading fatigues and overloads the pelvic floor" hypothesis. Contemporary reviews conclude that both may be partly true depending on sport type, training dose, athlete morphology, and symptom phenotype (Goldstick and Constantini, 2014; Gan et Smith, 2023).

In athletes, LUT dysfunction is broader than stress leakage alone. Simeone and colleagues reported that LUTS and incontinence are prevalent in female athletes overall, with urgency, straining, dysuria, and frequency changes occurring alongside UI (Simeone et al., 2010). This is clinically important for swimmers because research and practice often frame athlete pelvic floor dysfunction as synonymous with exertional stress leakage, potentially missing urgency-predominant and mixed symptom profiles. General female LUTS studies also show that urgency, urgency incontinence, frequency, and nocturia contribute meaningfully to bother and quality-of-life impairment (Milsom, 2009; Coyne et al., 2009; Wennberg et al., 2009). A sport-specific continence history should therefore include storage, voiding, and post-void symptoms rather than limiting assessment to a single question about leakage on exertion.

The strongest epidemiologic signal in female sport remains stress UI. Early athlete studies by Bø and Borgen and by Thyssen et al. established that leakage is common even in young elite women, often during training rather than exclusively in daily life (Bø et Borgen, 2001; Thyssen et al., 2002). Later work in broader sports cohorts, systematic reviews, and meta-analyses confirmed that female athletes have higher UI prevalence than non-athletes, although estimates vary widely because of heterogeneity in sampling, symptom definitions, and sport mix (Teixeira et al., 2018; Cerruto et al., 2020; Pires et al., 2020). Meta-analytic syntheses place overall prevalence in female athletes roughly in the one-quarter to one-third range, with higher figures in selected sports and samples (Teixeira et al., 2018; Pires et al., 2020).

This broader athlete literature matters for swimmers for two reasons. First, it demonstrates that high physical competence and nulliparity do not eliminate risk. Second, it warns against assuming that non-impact aquatic sport is inherently continence-neutral. The burden of symptoms in elite sport appears to arise from an interaction of loading pattern, training volume, energy status, muscle coordination, symptom normalization, and access to informed care. This model likely applies to swimming, even if the exact weight of each factor differs compared to other disciplines with a higher risk of LUTS, such as trampoline or volleyball (Da Roza et al., 2015; Hagovska et al., 2018).

4. Reasons for the lack of swimmer-oriented research

Female swimmers are often overlooked in pelvic floor research because swimming is perceived as a low-impact discipline. This perception is partly justified: compared with sports dominated by repetitive jumping and landing, pool-based locomotion reduces vertical ground-reaction forces. However, professional swimming is not low load in the broader physiological sense. Elite swimmers may train multiple times per day, perform high total weekly volumes, and combine pool mileage with intensive dryland work including plyometrics, resistance training, medicine-ball exercises, starts, turns, underwater kicking, and repeated maximal breath-control tasks. These exposures may produce complex pressure and neuromuscular demands on the abdominal canister and pelvic floor, even without continuous land impact (de Mattos Lourenco et al., 2018; Rubin et al., 2024).

The scarcity of swimmer-specific data is itself a notable finding. Compared with studies in volleyball, trampoline, CrossFit, strength sports, gymnastics, and general elite-athlete cohorts, very few studies focus specifically on female swimmers. Dornowski et al. evaluated the effect of low- versus high-volume swimming training on pelvic floor muscle activity and concluded that heavy load training can cause fatigue symptoms along with unfavorable changes in pelvic floor muscle electrical activity among the examined female athletes , while Rubin et al. compared high-performance swimmers with sedentary controls and found a high prevalence of UI together with worse quality of life in swimmers (Dornowski et al., 2019; Rubin et al., 2024). These papers are clinically relevant, however they do not provide a complete analysis of swimmer-specific LUT function across age categories, race distances, seasonal phases, or combined pool and dryland training models.

This gap has practical implications. If clinicians rely only on the better known high-impact-sport literature, they may underestimate symptoms in swimmers. If, conversely, they overgeneralize from trampoline or volleyball data, they may exaggerate the role of impact and miss swimmer-specific contributors such as breath control, prolonged training volume, and dryland programming. The best current position is therefore cautious as elite swimming does not appear exempt from pelvic floor and LUT complaints, but its mechanisms are likely mixed and not fully captured by land-sport models (Dornowski et al., 2019; Cerruto et al., 2020).

5. Epidemiology of LUTS and UI in Female Athletes

Across female sport, UI prevalence estimates vary widely, depending mostly on the sport type, its intensity and load distribution throughout training sessions. Systematic reviews by de Mattos Lourenco et al., Teixeira et al., Pires et al., and narrative reviews by Gan et al. converge on the same core conclusion: UI is common in female athletes and is more frequent in certain sports, especially those with repetitive impact or heavy loading (Teixeira et al., 2018; de Mattos Lourenco et al., 2018; Pires et al., 2020; Gan et Smith, 2023). The variation in reported prevalence reflects differences in sport type, athlete level, nulliparity criteria, symptom instruments, and whether leakage during sport or leakage in general was measured. Nonetheless, the direction of the signal is consistent.

Early landmark studies remain influential because they established that leakage in elite athletes is more frequent than previously anticipated. Bø and Borgen reported higher prevalence of stress and urge UI in elite athletes than controls, however, this difference was negligible. (Bø et Borgen, 2001). Thyssen et al. found that more than half of surveyed elite athletes and dancers had experienced urine loss, with many reporting leakage during sport itself (Thyssen et al., 2002). These observations shifted the discussion from UI as a post-partum or aging problem to UI as a legitimate concern in young, highly trained women. Later work in Brazil and Italy confirmed that broader pelvic floor dysfunctions, not only UI, occur in sportswomen (Simeone et al., 2010; Almeida et al., 2016).

Meta-analytic estimates provide a useful benchmark, though they should not be mistaken for swimmer-specific risk. Teixeira et al. reported a pooled prevalence of UI in female athletes and found athletes had a substantially higher risk than sedentary women (Teixeira et al., 2018). Pires et al. likewise synthesized high-impact-sport data and highlighted volleyball and similarly loaded sports as especially provocative (Pires et al., 2020). Cerruto et al. extended the discussion beyond urinary symptoms, concluding that competitive sportswomen face meaningful risks not only for UI but also for related pelvic floor and gastrointestinal complaints (Cerruto et al., 2020). Taken together, these analyses support the view that intense sport participation can be associated with LUT dysfunction, but they also show that risk is not uniform across sports.

Several individual sport studies help explain why pooled prevalence is so variable. Trampolinists, volleyball players, CrossFit practitioners, dancers, and strength athletes often report high levels of leakage, frequently linked to jumping, landing, bracing, or repetitive high-force tasks (Hagovska et al., 2018; Machado et al., 2021). Da Roza et al. found that training volume and ranking level were associated with leakage in young female trampolinists (Da Roza et al., 2015), and CrossFit studies have shown relatively high prevalence in women, including in competitors (Machado et al., 2021; Dominguez-Antuña et al., 2022). These data reinforce the idea that sport biomechanics matter. For swimmers, the implication is not that their risk equals that of trampolinists, but that high training exposure can still become clinically relevant even when impact profile differs.

6. Swimmer-Specific Literature

The swimmer-specific literature is small but clinically important. Dornowski et al. studied female swimmers undergoing low- versus high-volume swimming training and demonstrated that training load influences pelvic floor muscle activity (Dornowski et al., 2019). Although the sample was small, the study is notable because it moves beyond prevalence questionnaires and examines a possible functional pathway linking swim training dose to pelvic floor behavior. This study shows that the swimmer's pelvic floor may be responsive to training, and not necessarily in a straightforward strengthening direction. That finding is especially relevant in professional settings where athletes are exposed to chronic and significant training loads.

Rubin et al. provided perhaps the most directly relevant clinical evidence for this review. In a cross-sectional observational study comparing high-performance swimmers with sedentary women, the authors reported UI in most of the swimmers and found significantly worse quality of life among swimmers with symptoms (Rubin et al., 2024). The sample was small, which limits generalizability, but the prevalence signal is striking and important because it directly challenges the assumption that aquatic training is inherently protective against continence problems. It also highlights that symptom burden in swimmers is not merely theoretical or subclinical.

At the same time, these swimmer-specific studies must be interpreted cautiously. The high swimmer prevalence reported by Rubin et al. cannot simply be taken as the prevalence of all female professional swimmers, because the sample was limited and the comparison group was sedentary rather than another athletic cohort (Rubin et al., 2024). Likewise, the training-load study by Dornowski et al. shows that swimming volume matters for pelvic floor muscle activity, but it does not by itself establish a definitive causal chain from training to clinically important LUT dysfunction in all swimmers (Dornowski et al., 2019). The correct conclusion is therefore measured: there is swimmer-specific evidence of clinically meaningful urinary symptoms and training-related pelvic floor effects, but the current database is too small to support precise prevalence estimates or firm event-specific risk stratification. There is convincing clinical evidence of swimmer-specific urinary symptoms occurrence along with pelvic floor muscle dysfunction, nevertheless more epidemiological data is needed in order to establish their exact prevalence and determine precise risk factors.

One reason the swimmer literature remains scarce may be that swimmers often fall between conventional categories. They are neither classic high-impact athletes nor sedentary controls; they are also exposed to mixed training environments. Starts, turns, explosive movement especially at the beginning of the race, and maximal bracing may matter more than steady-state swimming itself. Future swimmer research therefore needs to distinguish among pool volume, dryland intensity, race specialty, and seasonal phase rather than treating swimming as a single exposure (Dornowski et al., 2019; Rubin et al., 2024). That distinction is likely essential if clinicians want to understand who is at greatest risk and when symptoms are most likely to emerge.

7. Pathophysiological Mechanisms of LUTS in Female Swimmers

7.1. Repeated increases in intra-abdominal pressure

The main mechanism proposed across athlete studies is repetitive elevation of intra-abdominal pressure beyond the ability of the pelvic floor and urethral closure system to respond. In sports such as jumping, this relationship is obvious. In swimming, the challenge is probably more intermittent and task-specific: streamlines, turns, starts, dolphin kick sets, resisted swimming, breath-hold patterns, and heavy dryland exercises may all create transient but repeated abdominal pressure loads. If these loads are frequent and recovery is inadequate, the pelvic floor may experience fatigue, altered coordination, or inefficient co-contraction. Athlete reviews consistently describe this mechanism as probable, even though direct intratraining measurements remain scarce (Goldstick and Constantini, 2014; Gan et Smith, 2023).

7.2. Fatigue versus adaptation of the pelvic floor

The female-athlete literature repeatedly returns to a key unresolved question: does training strengthen the pelvic floor through repeated co-activation, or does it weaken continence through cumulative overload? The most likely answer is both, depending on exposure and context. Athletic women may have strong pelvic floor function in some respects, yet still leak during high-demand tasks because strength alone does not guarantee optimal timing, coordination, endurance, or reflexive pre-contraction (Casey et Temme, 2017; Ludviksdottir et al., 2018; Louis-Charles et al., 2019; Machado et al., 2021). For swimmers, this distinction is important. A highly trained swimmer may present with excellent general musculoskeletal conditioning and still develop effort-related leakage if the pelvic floor function is mismatched relative to training demands.

7.3. Training volume as an independent stressor

The swimmer-specific study by Dornowski et al. supports the idea that training volume itself may modify pelvic floor muscle activity (Dornowski et al., 2019). This observation aligns with research in other sports suggesting that more advanced level, greater training volume, or higher ranking can be associated with leakage (Poświata et al., 2014; Da Roza et al., 2015). In swimmers, where weekly volume can be very high, the accumulation of submaximal but repeated demands may be more relevant than single dramatic loading events.

7.4. Dryland training and concurrent training effects

Professional swimmers rarely train only in water. Contemporary high-performance programs usually include resistance training, land conditioning, core work, medicine-ball drills, jumps, and sprint-start practice. It is therefore possible that some urinary symptoms attributed to swimming are actually mediated by the land-based elements of swimmer preparation. This is a major conceptual issue in interpreting swimmer research. When a high-performance swimmer reports leakage, the exposure is a training system, not only aquatic locomotion. The limited current literature does not yet separate these components well enough (Dornowski et al., 2019; Gan et Smith, 2023; Rubin et al., 2024)

7.5. Low energy availability, menstrual dysfunction, and RED-S-related vulnerability

An important newer direction in athlete pelvic floor research concerns the possible contribution of low energy availability, menstrual dysfunction, and related components of Relative Energy Deficiency in Sport. Whitney et al. found that UI during athletic activities in adolescent and young adult female athletes was significantly associated with low energy availability, and Laino et al. linked UI with inadequate eating behavior in female athletes (Whitney et al., 2021; Laino et al., 2023). Although swimmer-specific low energy availability data are lacking, the issue is highly relevant to elite female swimming because weight-sensitive environments, body-composition pressures, and high energy expenditure can coexist in this population. Low energy availability may potentially affect connective tissue integrity, neuromuscular function, endocrine profile, and recovery, thereby modifying continence risk.

7.6. Behavioral contributors: fluid management, voiding patterns, and symptom suppression

Not all athlete LUT dysfunction is purely biomechanical. Broader LUTS literature and athlete-experience reviews indicate that toileting behaviors, delayed voiding, fluid manipulation, fear of leakage during training, and normalization of symptoms can shape the clinical picture (Culleton-Quinn et al., 2022; Johnston et al., 2023; Bosch-Donate et al., 2024). Athletes may reduce fluid intake, void just in case, or avoid reporting symptoms to staff. For swimmers, tightly scheduled pool sessions and limited opportunity to leave training lanes may further discourage timely symptom reporting and individualized management.

8. Profile of symptoms observed in swimmers

Although stress UI is likely the most recognizable symptom in female swimmers, a swimmer-centered evaluation should look beyond classic exertional leakage. Simeone et al. documented a broader LUTS burden in female athletes, including urgency and voiding symptoms (Simeone et al., 2010). General female LUTS studies show that urgency, mixed symptoms, and nocturia can be highly bothersome (Milsom, 2009; Coyne et al., 2009; Wennberg et al., 2009), and athlete surveys suggest that symptoms may be present during sport, outside sport, or both (Culleton-Quinn et al., 2022; Gan et al., 2024). Thus, a swimmer who reports leaking only occasionally may still have a clinically relevant symptom complex that includes urgency or frequency, particularly around intense training blocks.

Quality of life should be treated as an outcome, not an afterthought. Rubin et al. found worse quality of life in high-performance swimmers with UI (Rubin et al., 2024), and broader literature shows that athlete pelvic floor symptoms can affect confidence, concentration, uniform choices, emotional well-being, and perceived performance (Johnston et al., 2023, Gan et al., 2024). For swimmers, the problem may be particularly hidden because a wet training environment can mask symptoms outwardly while preserving internal distress.

There is also a strong risk of normalization. Mahoney et al. found normalization of stress UI in female strength athletes (Mahoney et al., 2023), and athlete experience studies consistently show that many women interpret leakage as part of sport rather than a treatable condition (Culleton-Quinn et al., 2022; Bosch-Donate et al., 2024; Gan et al., 2024). This mindset may be especially pronounced in elite settings where discomfort is normalized and high tolerance is rewarded. The practical consequence is delayed care-seeking, reduced screening sensitivity, and missed opportunities for early conservative management.

9. Screening and Assessment in Female Professional Swimmers

The current evidence supports routine, proactive screening for pelvic floor symptoms in female athletes rather than waiting for spontaneous disclosure. Dakic et al. showed that health and exercise professionals' screening practices are inconsistent (Dakic et al., 2023), and athlete-focused reviews repeatedly emphasize underrecognition (Culleton-Quinn et al., 2022; Bosch-Donate et al., 2024). In swimmer environments, routine preseason and in-season screening could include the ICIQ-UI (International Consultation on Incontinence Questionnaire-Urinary Incontinence) Short Form, symptom timing relative to training phase, symptom triggers during pool and dryland sessions, menstrual history, energy-availability screening, and performance impact. This approach is especially relevant because swimmer-specific evidence suggests meaningful symptom prevalence despite the sport's non-impact reputation (Dornowski et al., 2019; Rubin et al., 2024).

Assessment should be sport-sensitive. A generic urogynecologic history may miss the fact that a swimmer leaks only during starts, heavy kick sets, resisted pulling, dryland jumps, or maximal strength sessions. Conversely, a symptom that appears mild on a general questionnaire may matter greatly to an elite athlete if it disrupts race preparation or concentration. Clinical evaluation should therefore include questions about onset relative to training changes, weekly volume, event specialty, dryland content, hydration practices, just-in-case voiding, bowel symptoms, menstrual status, and whether the athlete has ever been taught pelvic floor contraction and pre-contraction strategies (Casey et Temme, 2017; Johnston et al., 2023).

Where expertise and athlete comfort allow, physical assessment may include pelvic floor muscle examination, endurance and coordination testing, and evaluation of abdominal-pelvic synergy. Importantly, athlete continence cannot be inferred from general fitness. Studies comparing athletes and controls suggest that stronger or better-conditioned women may still leak, and CrossFit work has shown that symptoms do not map simply onto standard pelvic floor measurements (Ludviksdottir et al., 2018; Machado et al., 2021). For swimmers, the most clinically useful question is not whether the pelvic floor is weak in a simplistic sense, but whether it performs appropriately under the athlete's real sport demands.

10. Prevention and Management

10.1. Pelvic floor muscle training

The best-supported conservative intervention in the athlete literature remains pelvic floor muscle training. Goldstick and Constantini described Pelvic Floor Muscle Training (PFMT) as first-line therapy in physically active women (Goldstick and Constantini, 2014), and Pires et al. showed in a randomized controlled pilot study that PFMT improved pelvic floor muscle contraction and reduced urine loss in elite female volleyball athletes (Pires et al., 2020). Later systematic reviews and meta-analyses conclude that PFMT has the strongest current evidence among conservative interventions for exercise-induced UI, although study quality and sport specificity remain limited (Joseph et al., 2021; Rodríguez-Longobardo et al., 2024; Petter Rodrigues et al., 2024).

For swimmers, PFMT should not be framed as a detached rehabilitation add-on. It is more likely to succeed when integrated into performance training: awareness of pre-contraction during likely triggers, coordination with breathing and trunk control, and progression from isolated contractions to sport-relevant tasks. Because swimmer symptoms may emerge during mixed exposures rather than one single movement, PFMT should be individualized to pool and dryland triggers. The evidence does not support assuming that a swimmer already gets enough pelvic floor training from general core work (Casey et Temme, 2017; Louis-Charles et al., 2019; Petter Rodrigues et al., 2024).

10.2. Training-load modification

The literature also supports adjusting exposure when symptoms flare. In swimmer-specific work, training volume has been linked to pelvic floor muscle activity changes (Dornowski et al., 2019), and in broader athlete cohorts symptoms frequently emerge or worsen during training rather than competition (Bø et Borgen, 2001; Thyssen et al., 2002). This suggests that periodization may matter. Temporary modification of certain dryland drills, jump-heavy strength work, breath-hold-intensive sets, or fatigue-inducing high-volume blocks may help while an athlete undertakes targeted conservative treatment. The goal is not de-training, but reducing provocative load enough to restore control.

10.3. Energy availability and menstrual health

Given the association between low energy availability and urinary symptoms in female athletes, management in swimmers should include screening for Low Energy Availability/Relative Energy Deficiency in Sport (LEA/RED-S) risk, menstrual dysfunction, and eating-related concerns (Whitney et al., 2021; Laino et al., 2023). When LEA is present, continence care limited to the pelvic floor alone may be incomplete. Restoring adequate energy availability, addressing menstrual irregularity, and optimizing recovery may plausibly improve tissue resilience and neuromuscular performance, even though direct swimmer trials are not yet available.

10.4. Education and destigmatization

Education is essential because stigma remains a major barrier. Athlete reviews, surveys, and experiential studies show that many women do not report symptoms, do not know that treatment exists, or assume leakage is normal in sport (Culleton-Quinn et al., 2022; Johnston et al., 2023; Bosch-Donate et al., 2024). In swimmers, where team culture and performance pressure are intense, confidential education led jointly by sports medicine staff and pelvic health professionals may be particularly useful. The practical message should be simple: leakage is common, it matters, and it is treatable.

10.5. Broader conservative measures

Evidence beyond PFMT is more limited, but conservative athlete management may also include bladder-behavior advice, voiding schedule review, trigger identification, and modification of training tasks that provoke excessive abdominal pressure until better control is achieved (Rzymski et al., 2020; Petter Rodrigues et al., 2024). For swimmers, this means avoiding overly generic advice such as indiscriminate fluid restriction, which may impair performance and recovery. Instead, conservative care should be individualized and performance-compatible.

10.6. Practical Implications for Coaches, Physiotherapists, and Team Physicians

For coaches, the key implication is that urinary symptoms in swimmers should not be dismissed simply because swimming is non-impact. A swimmer can be symptom-free during ordinary daily life and still develop clinically relevant leakage during intense training blocks or mixed pool-dryland sessions. Coaches are not expected to diagnose LUT dysfunction, but they are important in shaping the reporting climate. Programs that normalize confidential symptom disclosure, allow access to medical staff, and avoid trivializing leakage are more likely to identify problems early (Culleton-Quinn et al., 2022; Johnston et al., 2023; Rubin et al., 2024).

For sports physiotherapists, swimmers present an opportunity for nuanced pelvic health practice. Assessment should examine breathing mechanics, trunk strategy, pressure management, pelvic floor timing, and symptom triggers across both pool and land sessions. The evidence does not support one-size-fits-all core strengthening as a substitute for pelvic floor assessment. Instead, the most effective approach is likely a graded progression from symptom education to task-specific retraining and then reintegration into higher-demand training (Louis-Charles et al., 2019; Rodríguez-Longobardo et al., 2024; Petter Rodrigues et al., 2024).

For team physicians and gynecologists working with swimmers, LUTS should be integrated into routine women's health and RED-S surveillance. UI in a young elite swimmer should trigger consideration of training load, energy availability, menstrual history, bowel symptoms, and psychological burden, not just a binary referral question. Where symptoms are significant, referral to pelvic health physiotherapy is warranted early, because conservative care remains the best-supported first-line pathway in athletes (Rzymski et al., 2020; Rodríguez-Longobardo et al., 2024).

11. Limitations

The most important limitation in this field is the lack of swimmer-specific longitudinal evidence. At present, the literature contains only a small number of studies directly addressing female swimmers, and these studies are too small to establish reliable prevalence ranges for professional swimmers by age, event specialty, or training phase (Dornowski et al., 2019; Rubin et al., 2024). More prospective swimmer cohorts are needed to determine whether symptoms emerge with increasing pool volume, intensify during specific training blocks, or respond to modifications in dryland programming.

A second major gap is the failure to separate aquatic from land-based exposures in swimmer training systems. Future research should record pool mileage, start and turn load, strength-training volume, jump exposure, respiratory task profile, and seasonal periodization rather than classifying exposure as swimming alone. Without this detail, the field cannot determine whether swimmer symptoms arise primarily from aquatic mechanics, concurrent training, or whole-program fatigue (Dornowski et al., 2019; Gan et Smith, 2023; Rubin et al., 2024).

Third, the field needs better phenotyping of LUTS in athletes. Much of the literature still prioritizes UI prevalence over a fuller LUTS profile. Yet female athletes, including swimmers, may report urgency, mixed symptoms, or voiding complaints that do not fit a narrow exertional-stress model. Standardized use of IUGA/ICS terminology and validated athlete-relevant symptom tools would improve comparability across studies (Simeone et al., 2010; Bo et al., 2017).

Fourth, intervention research in swimmers is almost nonexistent. PFMT appears promising in athlete populations overall, but swimmer-specific trials are needed to test whether pelvic floor training, breathing retraining, pressure-management coaching, or training-load adjustment reduce symptoms without compromising performance. Ideally, future trials should include symptom scores, pad testing, quality of life measures, and swimmer-relevant performance outcomes (Pires et al., 2020; Petter Rodrigues et al., 2024).

Finally, more work is needed on low energy availability and menstrual health in aquatic athletes with LUT symptoms. The association between LEA and UI in female athletes is now difficult to ignore, but swimmer-specific data are absent (Whitney et al., 2021; Laino et al., 2023). Given the known relevance of RED-S in female sport, this is a high-priority area for future interdisciplinary research.

12. Conclusions

The available evidence supports the view that intense physical training can adversely affect LUT function in female professional swimmers, but the swimmer-specific evidence base remains limited and should be interpreted carefully. The strongest swimmer-specific studies indicate that high-performance swimmers may have substantial UI burden and that swimming training volume can alter pelvic floor muscle activity (Dornowski et al., 2019; Rubin et al., 2024). The broader elite-athlete literature adds biological plausibility and clinical context by showing that LUTS and UI are common in female sport, especially under high-load conditions, and are shaped by a combination of mechanical, neuromuscular, behavioral, and possibly energy-availability-related factors (Teixeira et al., 2018; Pires et al., 2020; Culleton-Quinn et al., 2022).

For clinicians and performance staff, the practical message is straightforward: do not assume that elite swimmers are protected from pelvic floor and LUT dysfunction simply because they train in water. Proactive screening, athlete-centered history taking, and early conservative management, especially pelvic floor muscle training integrated into the training environment, are justified by current evidence (Pires et al., 2020; Rodríguez-Longobardo et al., 2024). Equally important is the need to address stigma, normalize reporting, and consider low energy availability, menstrual health, and dryland exposure when symptoms arise (Culleton-Quinn et al., 2022; Laino et al., 2023; Bosch-Donate et al., 2024).

From a research perspective, swimmers deserve dedicated prospective and interventional studies rather than continued extrapolation from land-based sports. Until such evidence is available, the most defensible position is that female professional swimmers are an understudied but clearly relevant pelvic health population whose LUT function may be meaningfully affected by intense training, especially when total exposure, mixed training demands, and athlete-specific vulnerability factors are considered together.

Disclosure

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