



# Influence of pelvic floor muscle fatigue on stress urinary incontinence: a systematic review

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## Abstract

**Introduction and hypothesis** Stress urinary incontinence (SUI) is the most common urinary complaint among women and is defined by the International Continence Society as any involuntary loss of urine due to physical effort, sneezing or coughing. Many women with SUI state that the loss of urine occurs after performing repetitive movements, which may suggest that it is the result of fatigue of the pelvic floor muscles (PFM). Thus, we performed the systematic review of the literature on the influence of PFM fatigue on the development or worsening of the symptoms of SUI in women.

**Methods** The PubMed, Scopus, EMBASE, PEDro, LILACS, SciELO, Cochrane Library, Google Scholar, CINAHL and Periódicos CAPES databases were searched for articles using the keywords “fatigue”, “pelvic floor”, “stress urinary incontinence” and “women”, in Portuguese and in English. Methodological quality was assessed using the Downs and Black scale, and the data collected from the studies were analyzed descriptively.

**Results** Of the 2,010 articles found, five met the inclusion criteria and were analyzed. They were published between 2004 and 2015, and included a total of 30,320 women with ages ranging from 24 to 53.6 years. Of the studies analyzed, three showed an association between fatigue and SUI, and two did not show such an association.

**Conclusions** This study confirmed that PFM fatigue can influence the development and/or worsening of SUI.

**Keywords** Muscle fatigue · Stress urinary incontinence · Pelvic diaphragm · Women

## Introduction

Urinary incontinence (UI), defined by the International Continence Society as any involuntary loss of urine due to physical effort, sneezing or coughing, can be classified as stress UI (SUI), urge UI (UII) and mixed UI (MUI) [1]. According to Dedicacão et al. [2], UI affects more than 50 million people in the world, and affects more women than men at a ratio of 2 to 1. SUI affects people’s quality of life, with physical, psychological, sexual and social implications.

Generally, women with SUI report physical limitations, for example, when engaging in sport and when carrying objects, as well as changes in social, occupational and domestic activities that negatively influence their emotional state [3]. The most common type of UI is SUI [1, 3]. This type of UI affects not only the elderly, but has a prevalence of 30% among middle-aged women, reaching 47% in women who exercise regularly [4].

The risk factors for SUI include advancing age, being white, obesity, vaginal delivery, instrumental delivery, multiparity and pregnancy in advanced age, estrogen deficiency, conditions associated with increased intraabdominal pressure, smoking, diabetes, collagen disease, neuropathies and previous hysterectomy [5]. Physical activity can also be a risk factor for SUI in both athletes and non-athletes [6]. One explanation for the development of SUI in people who practice physical activity is that strenuous exercise leads to increased intraabdominal pressure that overloads the pelvic floor muscle (PFM) during exercise. Another explanation is that the determining factor for SUI associated with physical activity is muscle fatigue. During physical activity type II fibers are

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recruited, which have a low capacity for maintaining the muscle tone of the pelvic floor, one of the factors that can compromise the urinary continence mechanism [4, 7].

There is only one previous systematic review [8] carried out in 2006 that assessed the involvement of muscle fatigue in UI. This indicates the importance of this systematic review, the purpose of which was to determine the influence of muscle fatigue on SUI and its relationship with the symptoms of SUI in women. The results of this study will be useful for the planning of evidence-based SUI prevention and treatment strategies.

## Materials and methods

This study followed the recommendations of the Cochrane Collaboration and the PRISMA statement [9] for the reporting of systematic reviews.

### Eligibility criteria

This systematic review included observational studies and randomized controlled trials (RCTs) analyzing the relationship between PFM fatigue and the development or worsening of SUI symptoms in women. The inclusion criteria were: (1) studies in adult women with SUI symptoms, (2) studies that addressed the subject of fatigue of the PFM, and (3) studies published from 2000 onwards. Systematic reviews, literature reviews, theses, dissertations and proceedings of scientific meetings on the subject studied, as well as studies investigating other types of voiding, or fecal or pelvic floor dysfunction related to PFM fatigue, were excluded.

### Search strategy

The studies were identified by searching the PubMed, Scopus, EMBASE, PEDro, LILACS, SciELO, Cochrane Library, Google Scholar, CINAHL and Periódicos CAPES electronic databases, and the references in studies that had already been published on the subject were also searched manually. The complete strategy used to search PubMed was as follows:

1. “Pelvic Floor” [MeSH] OR “pelvic floor” OR “Floor, Pelvic” OR “Pelvic Diaphragm” OR “Diaphragm, Pelvic” OR “Diaphragms, Pelvic” OR “Pelvic Diaphragms” OR “Pelvic Floor Muscles” OR “abdomino-pelvic musculature” OR “perineal musculature” OR “Perineum” [MeSH] OR “perineum” OR “perineums” OR “Pelvis” [MeSH] OR “pelvis” OR “Pelvic Region” OR “Region, Pelvic” OR “perineal function” OR “pelvic floor contraction”
2. “Muscle Fatigue” [MeSH] OR “Muscular Fatigue” OR “Fatigue, Muscular” OR “Fatigue, Muscle” OR “muscle fatigue”
3. “Women” [MeSH] OR “women” OR “woman” OR “Women’s Groups” OR “Group, Women’s” OR “Groups, Women’s” OR “Women Groups” OR “Women’s Group”
4. “Urinary Incontinence” [MeSH] OR “Urinary Incontinence” OR “Incontinence, Urinary” OR “Urinary Incontinence, Stress” [MeSH] OR “Urinary Incontinence, Stress” OR “Urinary Stress Incontinence” OR “Incontinence, Urinary Stress” OR “Stress Incontinence, Urinary”
5. Items 1 AND 2 AND 3 AND 4

The search was carried in January 2016 and updated in September 2016, using the keywords “fatigue”, “pelvic floor”, “stress urinary incontinence” and “women”, in Portuguese and English. Only articles indexed and published in Portuguese and English since 2000 were selected.

### Selection of studies and data extraction

In the first phase of the selection, two reviewers independently assessed the titles and abstracts of the studies identified by the search strategy. All the abstracts that did not give sufficient information regarding the inclusion and exclusion criteria were selected for assessment of the complete article. In the second stage, the same reviewers independently assessed the complete articles and selected the studies in accordance with the eligibility criteria. The data were extracted by the same reviewers, independently, using a standardized and previously prepared form containing the following information to characterize the studies: author, year of publication, study type and purpose, population and sample size, variables, assessment tools, methods of observation, and outcomes. Disagreements between reviewers during the study selection and data extraction stages were resolved by a third reviewer. The outcome assessed was the development of SUI due to PFM fatigue.

### Assessment of methodological quality

The methodological quality of the selected articles was assessed by two reviewers, independently, using the Downs and Black scale [10], that was developed and validated for the assessment of the quality and risk of bias of randomized and observational studies. This tool is composed of 27 items that assess the domains “Reporting”, “External validity”, “Bias”, “Confounding/selection bias” and “Power of the study”. The full version of the scale was used for the assessment of the randomized clinical trials. In order to assess the observational studies, an adaptation was suggested by the Cochrane Collaboration according to the Methodological Guidelines of

the Ministry of Health for the elaboration of a systematic review of observational studies [11], excluding items related to experimental studies and cohort and case-control studies (items 4, 7, 8, 12, 13, 14, 15, 17, 19, 21, 22, 23, 24 and 27), because they did not fit the methodological design of the studies analyzed.

In this systematic review, the studies were classified as having high methodological quality when their scores were equal to or greater than 70% on the scale (about 19 points for RCTs and 9 points for observational studies) following the criteria adopted by other authors for systematic reviews [12]. Disagreements between the reviewers were resolved by consensus.

## Data analysis

The heterogeneity identified in the designs and sample numbers of the studies made it impossible to carry out a meta-analysis. Therefore, a descriptive analysis of the studies included in the systematic review was performed.

## Results

### Description of the studies

The search strategy revealed 2,010 studies, of which 81 were excluded because they were duplicated in the databases. No new studies were identified through manual searches of the references of published articles on the subject. Analysis of the titles and abstracts led to the exclusion of 1,923 studies because they did not meet the previously established eligibility criteria, and six studies remained for detailed analysis. Of the six studies analyzed, one was excluded because it was published only in the proceedings of a scientific meeting [13]. Therefore, five studies [14–18] were included in this systematic review. Figure 1 shows a flow chart of the selection of studies and Table 1 presents the characteristics of the studies and their quality scores according to the Downs and Black scale [10].

The five included studies [14–18] were published between 2004 and 2015 and included a total of 708 women, with an average age ranging from 24 to 53.6 years. Two of the studies were performed in Norway [15, 16], and the other three were performed in three different countries: Brazil [17], USA [14] and France [18]. Three studies [15, 17, 18] included women with and without SUI for comparison, one [16] included women with symptoms of SUI, and one [14] included female nurses without specifying the type of UI. Thus, four studies [15–18] assessed the relationship between physical activity and SUI specifically in relation to muscle fatigue, while the study by Townsend et al. [14] analyzed the risk of developing UI in general, including SUI, UUI and MUI.

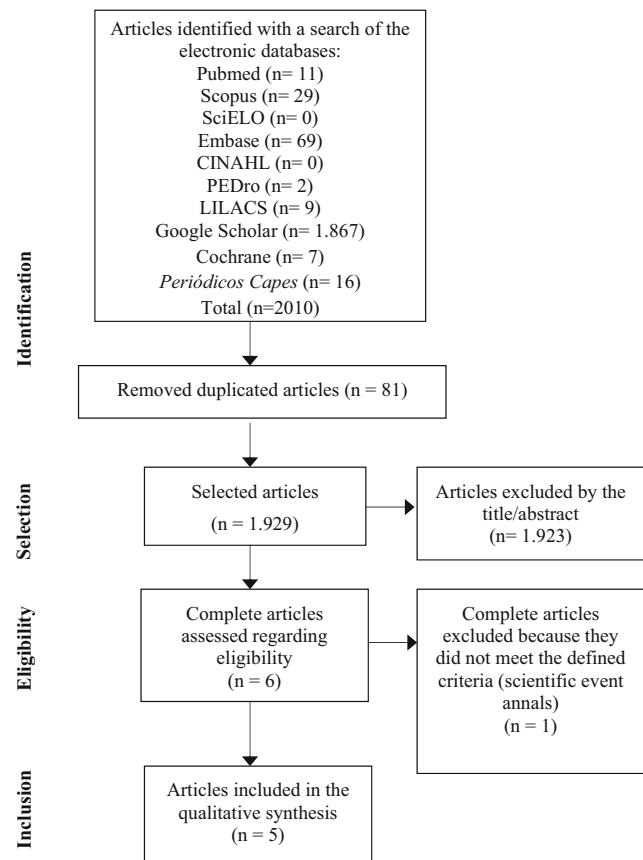


Fig. 1 Flow chart of the study selection

Regarding instruments and strategies for assessing outcomes, two studies [14, 18] used questionnaires to identify the risk of developing UI related to physical activity/PFM fatigue. Townsend et al. [14] investigated the relationship between physical activity and the risk of UI and the frequency and type of urinary loss using the Nurses' Health Study II questionnaire. Deffieux et al. [18] assessed urinary loss related to physical fatigue using a specific questionnaire, and the impact of UI symptoms on the patients' quality of life using the Bristol Female Lower Urinary Tract Symptoms questionnaire, and also determined maximum urethral closure pressures. In the other three studies electromyography was used for evaluation: Verelst et al. [15] assessed PFM fatigue and preactivation times between the PFM and abdominal muscles on coughing; Ree et al. [16] determined maximum voluntary contraction (MVC), resting vaginal pressure and sustained contraction time of the PFM; and Burti et al. [17] assessed MVC using electromyography, the level of effort in terms of the Borg exertion scale, and heart rate.

### Assessment of the quality of the studies

Regarding the methodological quality of the studies, as assessed using the Downs and Black scale [10], the five included studies [14–18] were considered of high quality, with

**Table 1** Characteristics of the studies

Reference	Country	Type of study	Objective of the study	Population	Sample size	Average age (years)	Study variables	Assessment tools	Observation methods	Outcomes	Quality score (Downs and Black)
[14]	USA	Prospective	To analyze the association between moderate physical activity and the risk of UI in middle-aged women.	Nurses (with SUI)	523	45.9	Frequency and type of urge UI; risk of UI related to physical activity	Questionnaire (Nurses' Health Study II questionnaire)	Analysis of the questionnaire answers	Risk of urinary loss decreased with an increase in moderate physical activity. Lower levels of physical activity may not lead to PFM fatigue and do not cause detrimental effects on pelvic function	10
[15]	Norway	Not stated	To investigate whether there is a difference between women without UI and women with SUI in relation to: (1) PFM fatigue, and (2) preactivation times between the PFM and the abdominal muscle when coughing	Women with and without UI	20 with SUI; 26 without UI	Without SUI: 41; with SUI: 45	Fatigue in the PFM; time of preactivation of the PFM and the abdominal muscles during cough	Electromyography	Subjects seated on a gynecological chair (semilithotomy position). Protocol for all measurements: (1) sensor manually inserted into the vagina by a gynecologist; diameter of the device adjusted to 40 mm; recordings made 60 s after insertion; (2) subjects performed three MVCs; (3) 60 s after the MVC, subjects instructed to contract the PFM as much as possible and to maintain the contraction as long as possible; and (4) 60 s after the fatigue test, subjects asked to cough three times while the temporal activity of the PFM and external oblique muscle recorded	No significant difference in the time of fatigue between groups (10.5 without UI/11.5 with UI); muscle fatigue does not seem to be associated with SUI	10
[16]	Norway	Crossover	To investigate whether strenuous physical activity causes PFM fatigue	Nulliparous women with mild SUI	12	24	Pressure of the MVC; resting vaginal	Electromyography	Intervention group: high impact training program – 90 min resistance activities; Control	In nulliparous young women with SUI, strenuous physical activity causes a	19

**Table 1** (continued)

Reference	Country	Type of study	Objective of the study	Population	Sample size	Average age (years)	Study variables	Assessment tools	Observation methods	Outcomes	Quality score (Downs and Black)
[17]	Brazil	Clinical trial case-control prospective	To compare PFM performance in women with and without SUI during resistance testing	symptoms during strenuous physical activity Women with and without SUI	30 with SUI; 26 without SUI	Without SUI; 50.73; with SUI 53.63	pressure; time of sustained contraction	Electromyography; Borg exertion scale	group: sitting for 90 min. Assessment of MVC, resting vaginal pressure and time of sustained contraction before and after intervention MVC measurement; resistance test (consecutive fast contractions of 1 s reaching MVC, with 1 s relaxation); assessment of the level of effort every minute (test interrupted when effort reached 10 = fatigue), recording of the time to reach Borg exertion scale scores of 5 and 10 in all women; heart rate when they reached Borg exertion scale scores of 5 and 10	decrease in MVC, indicating muscle fatigue. Women with SUI had worse performance in the endurance test (shorter time to fatigue), compared with women without SUI (with SUI 9 s to fatigue, without SUI 14 s)	10
[18]	France	Observational descriptive prospective	To evaluate urine loss frequency related to physical fatigue in women with SUI using a more specific questionnaire and to evaluate the association between the results of this questionnaire and the urodynamic findings	Women with and without SUI	61 with SUI; 10 without SUI	Without SUI; 51.9; With SUI 50.9	Severity of UI; UI related to physical fatigue; maximum urethral closure pressure	Bristol Female Lower Urinary Tract Symptoms questionnaire; fatigue-specific UI questionnaire; urodynamic examination	Completion of 2 questionnaires (assessment of UI severity and impact on QoL and another one specific for fatigue-related urine loss); cystometry and urethral pressure measurement in the supine position with bladder filled with 400 ml of saline solution	37% of the SUI group reported having UI related to physical fatigue frequently. Positive correlation between the results of the questionnaire and reduction of urethral pressure after repeated coughs.	10

MVC maximum voluntary contraction, PFM pelvic floor muscle, SUI stress urinary incontinence, UI urinary incontinence

scores equal to or greater than 70%. The only RCT [16] had a total score of 19 (70%), while the other observational studies [14, 15, 17, 18] had scores of 10 (71.42%).

### Relationship between the risk of UI and PFM fatigue

Townsend et al. [14] demonstrated that in middle-aged women moderate physical activity does not increase the risk of UI development in general, since it does not have a detrimental effect on PFM function. They also found a significant decrease in the risk of SUI in the most active women, and attributed this result to the fact that exercise plays an important role in maintaining body weight. Verelst et al. [15] concluded that muscle fatigue does not appear to be associated with SUI. The authors found no significant difference in time to PFM fatigue among women with and without SUI, but in those with SUI PFM strength was lower than in those without.

Ree et al. [16] found a 20% decrease in MVC after strenuous physical activity, and suggested that PFM fatigue from strenuous physical activity may increase the risk of developing SUI. Burti et al. [17] found that women with SUI had worse performance in the endurance test, with shorter time to fatigue. In addition, during and after the PFM resistance test, women with SUI had worse performance and functional status of the muscles. Deffieux et al. [18] found a strong association between the symptom of fatigue-related loss of urine reported in the questionnaires and a marked decrease in maximal urethral closure pressure after repeated coughs.

### Discussion

Overall, this systematic review shows that PFM fatigue may be associated with SUI, although the included studies were quite heterogeneous, making it difficult to compare the outcomes analyzed. Deffieux et al. [8], in a previous systematic review, also concluded that PFM fatigue may play an important role in the pathophysiology of SUI in women. The population of these studies was very diverse, in terms of both the number of participants, that ranged from 12 women in one study [16] to approximately 30,000 (523 with SUI) in another [14], and the profile of the participants, who included nulliparous, multiparous and premenopausal and postmenopausal women, which may have influenced the development or not of fatigue. Therefore, the heterogeneity and the difference in the number of participants may be a bias of the studies analyzed.

Three studies [15–17] used electromyography to assess muscle fatigue, while the other two [14, 18] used questionnaires to assess muscle fatigue and the risk of developing UI related to fatigue. According to Cifrek et al. [19], electromyography is the most commonly used technique to investigate the effects of localized muscle fatigue, since it produces

information about both the quantity and the quality of the electrical activation of the muscle. The protocols used to generate fatigue were diverse, and some studies did not report this aspect clearly. This is the case for Ree et al. [16], who used high-impact physical exercises without specifying the number of sets and repetitions, or the time between sets and exercises, and is also the case for Burti et al. [17], who determined the time to fatigue (level 10 on the Borg scale), but did not report the average fast contractions required to cause fatigue in women with and without SUI, data that are important for clinical practice.

Of the five studies analyzed [14–18], two [14, 15] showed no association between PFM fatigue and SUI, and three [16–18] did show such a relationship. Townsend et al. [14] found that moderate physical activity does not increase the risk of UI, but they assessed average activity, where the participants were asked to report the average time spent exercising during the week; thus, they did not assess loss of urine at the time of physical activity, which may be related to fatigue. In addition, they specifically investigated women who performed low to moderate impact activities, excluding those who performed high-impact activities, which, according to some authors [20, 21], increases the risk of UI by up to nine times due to increased abdominal pressure and consequent pelvic floor overload.

Verelst et al. [15] also found no association between fatigue and SUI, but the fatigue test demanded only three MVCs and a long relaxation time, which may have influenced the results. According to Yeung et al. [22], fatigue is common in endurance sports and daily activities. However, the test in this study [15] was performed in a laboratory environment with the subjects in the semilithotomy position, and the results may not reflect the PFM overload that occurs during daily activities. Ree et al. [16] found an association between SUI and fatigue after strenuous activity in nulliparous women, corroborating the findings of a study by Soares et al. [23], who found that activities that led to the greatest urinary loss included jumps, high-impact landings and running. According to Da Roza et al. [24], UI is generally found in women in the climacteric period and in multiparous women, but pelvic floor dysfunction may also occur in young nulliparous women during physical activity [16]. An explanation for UI in nulliparous and physically active young women who do not have any potential risk factors may be the type of physical activity they perform, which can cause a repeatedly high intra-abdominal pressure on the pelvic floor [24].

According to Reis et al. [4], the increase in intra-abdominal pressure is not the only risk factor for the development of SUI in athletes, since PFM fatigue caused by long periods of training, with high weekly frequency and no time for the muscles to recover may increase the predisposition to such dysfunction. According to Araujo et al. [25], UI may occur during resistance exercises due to muscle fatigue, since the majority

of PFM fibers, which are type I and resistant to fatigue, have their contractile capacity diminished in situations of oxygen compromise (when activated repeatedly) and are replaced by type II fibers, which are fast-twitch fibers and are not as efficient in maintaining PFM tone, and thus the continence mechanism is compromised. This corroborates the findings of Burti et al. [17], who found that women with SUI had worse performance in the endurance test, with shorter time to fatigue than women without SUI. According to Hodges et al. [13], PFM are more rapidly fatigued than limb muscles due to central fatigue, which can be demonstrated as a reduction in the ability to fully activate a muscle during MVC. This is important for physiotherapists and patients since it may help prevent PFM fatigue and thus preserve the PFM for continence control.

The results of this study indicate that, although PFM are considered fatigue-resistant muscles because they are largely composed of slow fibers, the majority of women suffering from SUI show loss of urine after repetitive efforts, which may suggest, among other things, that PFM fatigue affects UI.

### Limitations of the study

The small number of articles identified on the topic which met the eligibility criteria stipulated for the present study limited the number of articles selected. This factor, together with the methodological differences found, such as the large differences in sample numbers, made it impossible to carry out a meta-analysis and, therefore, there is uncertainty in the degree to which PFM fatigue affects UI.

### Conclusions

This systematic review confirmed that PFM fatigue can influence the development and/or worsening of SUI. However, due to the scarcity and heterogeneity of the studies on the subject, the conclusions are limited. Therefore, we suggest that new studies be performed to provide data to guide the clinical practice of professionals based on evidence.

### Compliance with ethical standards

**Conflicts of interest** None.

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