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Proprioception in stress urinary incontinence: A narrative review

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Abstract

Background: Urinary incontinence (UI) is more common than any other chronic disease. Stress urinary incontinence (SUI), among the various forms of urinary incontinence, is the most prevalent (50%) type of this condition. Female urinary continence is maintained through an integrated function of pelvic floor muscles (PFMs), fascial structures, nerves, supporting ligaments, and the vagina. In women with SUI, the postural activity of the PFMs is delayed and the balance ability is decreased. Many women, by learning the correct timing of a pelvic floor contraction during a cough, are able to eliminate consequent SUI. Timing is an important function of motor coordination and could be affected by proprioception. This study was conducted to review and outline the literature on proprioception as a contributory factor in SUI.

Methods: PubMed, Scopus, and Google Scholar databases were systematically searched from 1998 to 2017 for articles on the topic of pathophysiology, motor control alterations, and proprioception role in women with SUI.

Results: A total of 6 articles addressed the importance of proprioception in motor control and its alterations in women with SUI. There were also publications on postural control, balance, and timing alterations in women with SUI in the literature. However, there was no research on measuring proprioception in the pelvic floor in this group.

Conclusion: Both the strength of the PFMs and the contraction timing and proprioception are important factors in maintaining continence. Thus, conducting research on PFMs proprioception in women with SUI, as a cause of incontinence, is encouraged.

Keywords: Stress urinary incontinence, Pelvic floor muscles, Proprioception, Balance, Postural activity

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Introduction

The prevalence of urinary incontinence (UI) is about 38.4 in women older than 40 to 50 years in Iran (2), and it is more common than any other chronic disease (1). In addition, the prevalence of UI in women (27.6 %) is more than in men (10.5 %) (3). The 3 most common types of UI are as follow: (1) stress urinary incontinence (SUI), characterized by an unintentional loss of urine occurring as a result of an increase in intraabdominal pressure due to effort or exertion or on sneezing or coughing; (2) urge urinary incontinence (UUI), denoting involuntary leakage arising for no apparent reason and associated with urgency; and (3) mixed urinary incontinence (MUI), denoting the combination of both SUI and UUI. Also, SUI is the most prevalent (50%) form of UI, with the UUI and MUI representing 11% and 36% (3% not classified), respectively (1).

SUI imposes substantial costs both on the individual and

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↑What is "already known" in this topic:
SUI is the most prevalent form of UI. Women with SUI have balance and postural activity alterations. Also, the timing of muscle activation is altered in women with SUI.

→What this article adds:
Considering the balance and postural activity alterations and lack of appropriate timing of muscle activation in women with SUI and the role of proprioception in motor control, the proprioception of PFMs in women with SUI should be examined. Also, further research should be done on this subject.

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the society in the USA and worldwide (4-6). The treatment costs are estimated up to $16 billion annually in the USA (7). In developed countries, aging results in increasing the problems associated with SUI. While the etiology of SUI in women seems to be multifactorial, vaginal childbirth and pelvic trauma have been shown to have major impacts on the incidence of SUI (8, 9).

The possible pathophysiology aspect of the continence system leading to SUI includes the anatomical (pathologic support of the anterior vaginal wall) (10-12), functional (the intrinsic sphincter deficiency) (13), and neurophysiologic (neurocircuitry of the urethral continence mechanism damage and proprioception deficiency), which is a bridge between the anatomical and functional aspects. Understanding these mechanisms may help to achieve a comprehensive and integral theory which considers all anatomical, functional, and neurophysiological aspects (14).

Sherrington, by presenting the term proprioception, stated that the body acts as a stimulus for its own receptors(15). Proprioception communicates the sense of force, sense of effort, sense of balance, and sense of position and movement (kinesthesia) in the musculoskeletal system (16). Receptors that involve in proprioception are located in skin, joints, and muscles. Tendon organs and muscle spindles, are the 2 main mechanoreceptive receptors. Following disuse or muscle damage, the sensitivity of Golgi tendon organs and muscle spindle decreases. The pelvic floor muscles in women with SUI are weaker than continent women. Hence, the mechanoreceptor sensitivity linked to these muscles may be influenced and result in proprioception deficiencies. This poor proprioceptive deficiency could be enhanced due to the absence of skin mechanoreceptors and visual inputs (17).

Muscle activity timing, coordination, balance, and postural activity are influenced by proprioceptive input (18, 19), which may be impaired as a result of neural deficits. Recent studies have shown that neural deficits may lead to SUI (20). However, the neurocircuitry of SUI deficiency is still unknown. The timing of muscle contraction, which is conveyed by the neural system is an important factor in maintaining continence (21). While having strong enough pelvic muscles to contract properly is necessary, a timely contraction is essential to prevent SUI. Therefore, women need to be told when to contract their pelvic floor muscles (PFMs) during strengthening exercises.

The postural activity of the PFMs reported to be delayed during rapid arm movements in women with SUI, and these women have decreased balance ability compared to continent women. The increased activity of the pelvic floor and trunk muscles in women with SUI may impair balance, as they have a reduced contribution of trunk movement to postural correction or compromised proprioceptive acuity (22, 23).

Considering the importance of the proprioception role of PFMs, the timing of muscle activation in these muscles and their consequent influence on balance and postural activity in women with SUI, in this study, it was aimed to review and outline the literature on proprioception as a contributory factor in SUI.

Methods

A thorough review was done on 3 topics: (1) pathophysiology of SUI and factors that lead to SUI (2); postural control, balance, and motor control alterations; and (3) the role of proprioception in motor control in women with SUI. Inclusion criteria were (1) studies with explanatory or RCT design (2); trials that reported exclusive results on women with SUI; and (3) outcome measures relevant to motor control and proprioception. Studies in languages other than English were excluded from this review. PubMed was searched for human-study articles registered from 1998 to 2017. The keywords include stress urinary incontinence, pelvic floor muscles, proprioception, balance, and postural activity.

Results

A total of 6 relevant articles were selected and critically evaluated for their potential support (or lack of support) for the study hypothesis (The proprioception could be an effective factor for SUI along with other factors.) (Table 1). Included articles directly or indirectly indicated that proprioception deficiency may be associated with SUI mechanism. However, no study was found on proprioception measurement in women with SUI.

Table 1. Studies that remark the role of proprioception in SUI

Study	Study design	Methodological quality	Remarks
James et al, 2001 [21]	Overview commentary		A stronger muscle that is not activated during the time of a cough cannot prevent stress incontinence. Therefore, teaching the proper timing of muscle activation is critical.
Smith et al, 2007 [22]	-RCT -16 women with SUI and14 continent women -Measurement: EMG of PF, deltoid, ES, RA, OE, and OI	-Power: 15 subjects in each group is required -There are limitations in EMG normalization in symptomatic populations	-Incontinence is associated with ineffective control of the PF muscles. -Women with incontinence have increased PF and abdominal muscle activity associated with postural perturbations.
Smith et al, 2008 [23]	-RCT -16 women with SUI and 13 continent women -EMG and force plate measurements	-SUI was not confirmed with urodynamic testing -SUI ranged from moderate to severe (wide range) -Underestimate the differences with bladder fullness because of the improvement of the ability to perform the balance tasks after 20min -Limitations to EMG normalization	-Women with SUI have decreased balance ability compared to continent women. -Increased activity of the PF and trunk muscles in women with SUI may impair balance as a result of compromised proprioceptive acuity

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Table 1. Ctd

J.LaRue et al, 1995 [18]	-Experimental -1 deafferented patient and 4 controls -IRI variability was measured in two conditions: feedback and no- feedback tapping task -Comparing timing behaviors		-Timing is generally known as an important function of motor coordination. -It appears that proprioception is involved in the timing of motor activity.
A.K. Wise et al, 1998 [24]	-Experimental -6 healthy males and 5 healthy females -EMG measurement -Observing the effect of biceps and triceps contraction on movement detection threshold.		-During a cocontraction there seemed to be more 'noise in the system' which made it more difficult for them to detect the direction of the movement
Azizeh Farzinmehr et al, 2015 [25]	Clinical trial 43 women with SUI two groups: WBV and PFMT strength, QoL, incontinence intensity was evaluated.	-Power: a sample size of 15 per group was required -intra-tester reliability of objective tests -Test-retest reliability of pelvic floor muscle strength by the modified Oxford grading system	-WBVT protocol was effective in PFM strength similar to PFMT. -WBVT is a somatosensory stimulus for proprioception

PF: Pelvic floor. SUI: Stress urinary incontinence. WBVT: Whole body vibration training. PFM: Pelvic floor muscle. PFMT: Pelvic floor muscle training. ES: Erector spinae. RA: Rectus abdominus. OE: Obliquus externus. OI: Obliquus internus. QoL: Quality of life, RCT: Randomized clinical trial.

Discussion

This review identified limited evidence on proprioceptive deficiency associated with incontinence.

Various theories are presented about the pathophysiology of SUI. Over the years, the focus of theories from anatomical aspects, which brought up the dynamic interaction between the bladder and urethra, have been shifted toward both functional and anatomical aspects which emphasize urethral sphincter deficiency. Thus, SUI has come to be known as a multifactorial problem in the recent years (14). Neural components are the connector of the functional and anatomical theories. The lavatorani muscles, endopelvic fascia, and urethral muscle structures, as an integrated system, are coordinated by the central nervous system. Studies have shown that neural dysfunctions can lead to SUI. Leakage prevention through the contraction of the PFMs at the right time in women with SUI could be considered as evidence for the involvement of neural factors in the etiology of SUI. These neural factors have not yet been known, but clinical observations have shown that if the patient is trained to contract the PFMs at the right time, the urine will not leak. Thus, the strength of the PFMs is not the only case to consider, and also the timing of muscle contraction is an important factor (21). Proprioception plays an important role in the timing and motor control (16, 18), so the proprioception may also be a factor that results in SUI. Other studies that confirm the possibility of proprioception deficiency on SUI mainly investigated the balance and postural activities in women with SUI. Smith (2007) has studied the postural activities of the PFMs during rapid arm movements in women with SUI (22). In their study, the electromyographic (EMG) activity of pelvic floor, abdominal, erector spinae, and deltoid muscles were recorded. In women with SUI, the PFMs contraction occured after the contraction of deltoid muscle while doing shoulder flexion and extension. However, in continent women, PFMs were activated before the deltoid contraction, but in incontinent women, the activity of PFMs decreased. Despite the delay, the activity amplitude of the PFMs increased after the activation of the deltoid in women with SUI. Many studies have shown that the strength (26, 27), endurance (28, 29), and muscle mass (27, 30) of the PFMs decrease in women with SUI, however, some studies reported the PFMs amplitude increase both during the rest (29, 31, 32) and coughing (33). This could be regarded as a strategy to maintain continence and overcome the delayed or decreased initial activity of the PFMs. The authors of this study believe that the timing of the urethral closure and PFMs contraction should be considered in SUI. Studies reported that low-level muscle activity increases proprioception acuity (24), and the increased activity of PFMs can decrease proprioception acuity.

A study that compared the balance between women with and without SUI (23), reported impaired balance ability in women with SUI due to the increase COP displacement and trunk muscle EMG activity during static balance tasks. The increased trunk muscles activity leads to a reduction of trunk movement during postural correction (34) and an increase in the COP displacement. The increased trunk muscle activity increases the trunk stiffness that can alter the segmental spinal movement in women with and without SUI. The increased trunk muscle activity can reduce the proprioception acuity in women with SUI.

The study of the whole body vibration training (WBVT) with PFMs training has shown similar effects for both WBVT and PFMs training on the strength, endurance, severity of incontinence, and quality of life (25). WBVT is a novel intervention which can effect strength, endurance, and neuromuscular system (35, 36). WBVT acts as a somatosensory stimulation, so it can improve proprioception and postural control. Ia and II afferents are stimulated by the length changes due to vibration, so they stimulate proprioceptors and cause stretch and cutaneous

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reflexes (37). All the included studies express the role of proprioception in continence, however, none of them have measured the proprioception acuity in women with SUI. This paper provides a standpoint for further research into the role of proprioception in SUI. The insufficient evidence on pelvic floor proprioception may be explained by the anatomical and functional differences of the pelvic floor region compared to other parts of the body. To the best of the authors' knowledge, no study has measured the proprioception of the pelvic floor muscles or examined the proprioception differences between women with SUI and control group. Thus, future studies should find a way to measure the proprioception of PFMs and also evaluate the effect of proprioception training on SUI.

Conclusion

Preliminary evidence has focused on anatomical or functional factors to explain the pathophysiology of SUI. However, progressively, the point of view tended toward an integrated theory which combines both anatomical and functional factors (14). In fact, there may be many aspects of the continence mechanisms that may be damaged. Considering the timing alterations (21) and also the balance and postural deficits in women with SUI (22, 23), proprioception, as a key factor in motor control, seems to be important in SUI. The present inadequate insight of neurophysiologic aspects of SUI requires a profound measurement of proprioception in the pelvic floor area and the neurocircuitry of the continence mechanisms. There is a need for further studies on the role of proprioception in SUI and interventions that can improve proprioception in the pelvic floor.

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Conflict of Interests

The authors declare that they have no competing interests.

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