World Journal of Urology (2019) 37:1421–1427
https://doi.org/10.1007/s00345-018-2521-2

ORIGINAL ARTICLE

Electroacupuncture for postmenopausal women with stress urinary incontinence: secondary analysis of a randomized controlled trial

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Received: 17 July 2018 / Accepted: 6 October 2018 / Published online: 13 October 2018

Abstract

Purpose The efficacy and safety of electroacupuncture was compared to those of sham electroacupuncture for the treatment of postmenopausal women with stress urinary incontinence (SUI).

Methods This study was a secondary analysis of a multicenter, randomized controlled trial that recruited 504 women with SUI and randomized 349 postmenopausal women to receive 18 treatment sessions of electroacupuncture or sham electroacupuncture over 6 weeks, with a 24-week follow-up assessment. Treatment response was defined as a 50% or greater reduction in urine leakage, as measured by a 1-h pad test at week 6.

Results Of the 349 randomized women, 332 completed the study. The response rate was 61.0% in the electroacupuncture group compared to 18.9% in the sham electroacupuncture group (difference 42.5%; 95% confidence interval, 33.3–51.7; $p < 0.001$). After 6 weeks of treatment, the mean 72-h urinary incontinence episode frequency, proportion of participants with at least a 50% decrease in mean 72-h incontinence episode frequency, participant-reported SUI severity, International Consultation on Incontinence Questionnaire-Short Form scores, and participants' self-evaluation of therapeutic effects improved in both groups, with significant between-group differences. Treatment-related adverse events occurred in 2.1% of women during the 6-week treatment.

Conclusion Electroacupuncture may effectively and safely relieve urinary incontinence symptoms and improve quality of life in postmenopausal women with SUI.

Keywords Acupuncture · Urinary incontinence · Stress · Postmenopause · Woman · Randomized controlled trial · Electroacupuncture

Introduction

Stress urinary incontinence (SUI) is a common medical condition characterized by the inadvertent loss of urine during episodes of increased intra-abdominal pressure related to effort or exertion or upon sneezing or coughing [1]. SUI prevalence generally varies by age, race and ethnicity, with 4.6–28% of Europeans [2] and 18.9 [3]–46% [4] of Asians being affected. SUI may negatively impact social and work life and contribute to poor mental health [5]. Studies by Capobianco et al. [1] show that SUI prevalence among postmenopausal women can reach nearly 40%. Potential causes for the higher prevalence, development or progress of SUI among postmenopausal women are unknown, but may be related to hormonal changes [1, 6, 7]. Though numerous therapeutic options such as pelvic floor muscle training and local administration of estrogens exist, these conventional treatments might face a major challenge because of anatomic

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Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00345-018-2521-2) contains supplementary material, which is available to authorized users.

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and physiologic changes, such as thinning of the urethral mucosa, loss of urethral closure pressure, and decreased sensory threshold of the lower urinary tract [8]. In addition, surgical therapy (e.g., midurethral synthetic sling, autologous fascia pubovaginal sling, colposuspension) could be the preferred option for patients who have failed conservative management strategies [9, 10], the potential risk and a higher cost cannot be ignored. There is still a need to identify new non-surgical therapeutic strategies to achieve a better balance between efficacy and adverse events [1].

Acupuncture is a complementary and alternative medical therapy that appears promising for the treatment of SUI. In 2017, we reported results from a randomized clinical trial of electroacupuncture (EA) compared to sham electroacupuncture (SA) to treat SUI which showed that 6-week lumbosacral EA treatment was associated with decreased urine leakage compared to SA treatment [11]. Because that study focused on the general female population, the efficacy of acupuncture among postmenopausal women with SUI was not specifically reported among the primary study findings.

To address the limitations of previous research, a post hoc analysis was performed using strict outcome measures to assess the effectiveness and safety of EA compared to SA among postmenopausal women with SUI.

Methods

Data source

This study is a secondary analysis of a multicenter, randomized, parallel, sham-controlled trial of 504 participants at 12 hospitals in China from October 8, 2013 to May 15, 2015. Of 504 original participants, 349 (69.3%) were included in the secondary analysis based on postmenopausal status, which is defined by the absence of vaginal bleeding for at least 12 months [12].

Study design details have been published previously [13]. Briefly, Chinese women with SUI were eligible if they had a pad weight gain of greater than 1 g, as measured by the 1-h pad test. SUI was defined based on the International Consultation on Urological Diseases clinical diagnosis recommendations [14]. Women were excluded for a history of urge, mixed, or other type of urinary incontinence; symptomatic urinary tract infection with specific treatment; or use of medication that may affect bladder function. Participants ranged in age from 40 to 75 years and were enrolled in the EA and SA groups according to a 1:1 ratio. Randomization was stratified by enrolment site in a block size of six via a central randomization system. Participants, outcome assessors, and statisticians were blinded to intervention group. Following a 1-week baseline assessment, participants underwent 30-min EA or SA treatment sessions three times per week (ideally every other day) for a total of 18 sessions over 6 consecutive weeks. Participants were then examined at a 24-week follow-up. During the trial, nine participants in the EA group and 13 participants in the SA group dropped out.

The original trial was registered at ClinicalTrials.gov (NCT01784172), and the study protocol was approved by independent ethics committees at all participating sites (see Supplement 2). The study was conducted in accordance with the tenets of the Declaration of Helsinki and the Good Clinical Practice guidelines. All participants provided written informed consent prior to the start of the study.

Outcome measures

Treatment response was defined as a 50% or greater reduction in urine leakage, as measured by the 1-h pad test at week 6 compared to baseline. Secondary outcomes included the mean change in 72-h urinary incontinence episode frequency (IEF), as measured by a 72-h bladder diary (from baseline to weeks 1–6, weeks 15–18, and weeks 27–30); change in amount of urine leakage (AUL) (from baseline to week 2 and week 6); proportion of participants with a 50% or greater decrease in the mean 72-h IEF (from baseline to weeks 1–6, weeks 15–18, and weeks 27–30); change in score on the validated Chinese version International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF) [15] (from baseline to week 6, week 18, and week 30); participant-reported SUI severity and self-evaluation of therapeutic effects at week 6, week 18, and week 30; and the number of urine pads used. All adverse events were recorded throughout the trial.

Statistical analysis

SAS version 9.4 (SAS Institute, Cary, NC, USA) was used for all statistical analyses following the intention-to-treat principle. Descriptive statistics were used for demographics, baseline characteristics, and safety variables. Treatment response was analyzed by fitting a generalized linear model with a binomial distribution that was adjusted for sites. Participants who did not continue with follow-up and did not provide a post-baseline measure for urine leakage were considered non-responders at week 6. The same approach was used for the participants with at least a 50% reduction from baseline in the mean 72-h IEF. Secondary continuous outcomes were assessed using a mixed-effect model with a repeated measures approach. The model included change from baseline as the response variable. Baseline value, treatment, visit, treatment × visit interaction as a fixed effect, site, and interaction between site and treatment as random effects were also included. For participants using urine pads, comparisons between treatment groups were assessed using the Wilcoxon rank-sum test. Participants' missing data on

the primary outcome were considered non-responders. All statistical tests were two sided, and a p value of less than 0.05 was considered statistically significant.

Results

In total, 349 postmenopausal women with SUI (mean age, 58.8 years) were included in the secondary analysis (169 in the EA group and 180 in the SA group). Of these, 332 completed the follow-up assessment, and 17 patients (five in the EA group and 12 in the SA group) were classified as non-responders because no post-baseline 1-h AUL data were available. No baseline differences were evident between groups (Table 1). There were 103 responders among 169 participants in the EA group and 34 responders among 180 participants in the SA group. The response rate was 61% in the EA group compared to 18.9% in the SA group [difference 42.5%; 95% confidence interval (CI), 33.3–51.7; $p < 0.001$; Table 2].

Table 1 Baseline patient characteristics

Characteristics	EA ($n = 169$)	SA ($n = 180$)
Age, mean (SD), year	58.2 (6.90)	59.4 (7.06)
Race, no. (%)		
Han	162 (95.9)	177 (98.3)
Minorities	7 (4.1)	3 (1.7)
Educational level, no. (%)		
Primary education or less	43 (25.4)	51 (28.3)
Secondary education	114 (67.5)	115 (63.9)
Tertiary education	12 (7.1)	14 (7.8)
Manner of child delivery, no. (%)[a]		
Vaginal delivery	156 (92.3)	165 (92.7)
Cesarean section	11 (6.5)	11 (6.2)
Both	2 (1.2)	2 (1.1)
BMI, mean (SD), kg/m^2	24.2 (2.89)	23.9 (2.59)
SUI duration, median (IQR), months	60 (36–120)	63 (40–120)
Co-morbidities, no. (%)	18 (10.7)	23 (12.8)
Severity of SUI (objective), no. (%)[b]		
Mild	87 (51.5)	89 (49.4)
Moderate	62 (36.7)	73 (40.6)
Severe	20 (11.8)	18 (10.0)
1-h AUL, mean (SD)	20.4 (26.6)	20.6 (30.0)
72-h IEF, mean (SD)	8.3 (9.43)	8.3 (7.97)
ICIQ-SF score, mean (SD)[c]	9.9 (3.52)	9.9 (3.20)
Severity of SUI (subjective), no. (%)[d]		
None	3 (1.8)	3 (1.7)
Mild	77 (45.6)	90 (50.3)
Moderate	71 (42.0)	72 (40.2)
Severe	18 (10.7)	14 (7.8)
24-h volume of liquid intake, median (IQR), ml	1067 (766.0–1450)	1017 (700.0–1500)
Patients using urine pads, no.(%)	80 (47.3)	78 (43.3)
Weekly mean consumption of urine pads used, median (IQR)[e]	7.0 (3.0–10.5)	7.0 (4.0–9.0)
Previous treatments for SUI within 2 weeks, no (%)[f]	10 (5.9)	10 (5.6)

[a]Two participants in the SA group had no history of childbirth

[b]Severity of SUI (objective) was rated by the AUL, as measured by the 1-h pad test (minimal/continent, ≤ 1 g; mild, 1.1–9.9 g; moderate, 10–49.9 g; severe, ≥ 50 g)

[c]ICIQ-SF scoring was additive (range 0–21), with higher values indicating worse outcomes

[d]Severity of SUI (subjective) was rated by patients using a 72-h bladder diary (none; mild, leaking several drops; moderate, soaking underwear; severe, soaking outerwear)

[e]Weekly use of urine pads was assessed in patients who used them

[f]Previous SUI treatment mainly included pelvic floor muscle training (EA, $n = 3$; SA, $n = 1$), medicine and acupuncture (EA, $n = 7$; SA, $n = 7$), and lifestyle intervention (SA, $n = 2$)

Table 2 Primary and secondary outcomes

Variable	EA ($n=169$)	SA ($n=180$)	Difference (95% CI)	p value
Primary outcome				
Reduction ≥ 50% in the 1-h AUL from baseline, n (%)				
Week 6	103/169 (61.0)	34/180 (18.9)	42.5 (33.3–51.7)	< 0.001
Secondary outcomes				
Change in the mean 72-h IEF, adjusted mean (95% CI)[b]				
Weeks 1–6	− 3.0 (− 3.9 to− 2.1)	− 2.3 (− 3.1 to− 1.4)	− 0.7 (− 1.7 to 0.3)	0.15
Weeks 15–18	− 5.1 (– 6.0 to − 4.3)	− 3.1 (− 4.0 to− 2.3)	− 2.0 (− 2.9 to − 1.1)	< 0.001
Weeks 27–30	− 5.5 (− 6.3 to − 4.6)	− 3.2 (− 4.0 to − 2.4)	− 2.3 (− 3.2 to − 1.3)	< 0.001
Change in the 1-h AUL, adjusted mean (95% CI), g[a]				
Week 2	− 7.5 (− 10.3 to − 4.8)	− 2.5 (− 5.2 to 0.2)	− 5.1 (−7.4 to − 2.7)	< 0.001
Week 6	− 11.5 (− 14.3 to − 8.7)	− 3.4 (− 6.2 to − 0.6)	− 8.1 (− 10.5 to − 5.6)	< 0.001
Reduction ≥ 50% in the mean 72-h IEF from baseline				
Weeks 1–6	57/161 (35.4)	45/171 (26.3)	10.0 (0.4–19.7)	0.04
Weeks 15–18	102/160 (63.8)	68/164 (41.5)	21.9 (11.7–32.2)	< 0.001
Weeks 27–30	110/160 (68.8)	69/164 (42.1)	26.2 (16.0–36.3)	< 0.001
Change in the ICIQ-SF score, adjusted mean (95% CI)[b,c]				
Week 6	− 2.5 (− 3.2 to − 1.8)	− 1.0 (− 1.7 to – 0.2)	− 1.6 (− 2.5 to – 0.6)	< 0.001
Week 18	− 3.8 (− 4.6 to − 3.0)	− 1.5 (− 2.3 to – 0.7)	− 2.3 (− 3.4 to − 1.3)	< 0.001
Week 30	− 4.6 (− 5.4 to − 3.7)	− 1.7 (− 2.5 to – 0.9)	− 2.8 (− 4.0 to − 1.7)	< 0.001
Patients using urine pads				
Weeks 1–6	72/163 (44.2)	80/173 (46.2)	NA	0.70
Weeks 7–18	46/163 (28.2)	60/165 (36.4)	NA	0.12
Weeks 19–30	48/163 (29.4)	63/165 (38.2)	NA	0.10
Weekly mean consumption of urine pads used, median (IQR)[d]				
Weeks 1–6	3.3 (2.0–6.5)	4.5 (2.0–7.0)	–	0.25
Weeks 7–18	3.5 (1.5–6.3)	3.9 (1.4–7.1)	–	0.55
Weeks 19–30	2.9 (1.4–6.3)	4.0 (2.0–7.8)	–	0.07

Data are expressed as number/total number of patients (%), unless otherwise indicated

[a]Multiple imputations for missing data were used for the primary outcome only. All other results presented in the table and in the manuscript are based on consistent use of data for completers, without imputation

[b]Repeated measures analysis of variance model was used for the 72-h IEF and ICIQ-SF score

[c]ICIQ-SF scoring was additive (0–21), with higher scores indicating worse outcomes

[d]The weekly use of urine pads was assessed in patients who used them. The Wilcoxon rank-sum test was used, and the differences between two groups are not provided

With respect to secondary outcomes, change in the mean decrease in the 72-h IEF from baseline was greater for the EA group compared to the SA group during weeks 15–18 and weeks 27–30 but not weeks 1–6 [between-group differences of − 2.0 (95% CI, − 2.9 to − 1.1; $p<0.001$) and − 2.3 (95% CI, − 3.2 to − 1.3; $p<0.001$), respectively]. The difference in 1-h AUL decreases from baseline in the EA group compared to the SA group was greatest at weeks 2 and 6, with between-group differences of − 5.1 (95% CI, − 7.4 to − 2.7; $p<0.001$) and − 8.1 (95% CI, − 10.5 to − 5.6; $p<0.001$). The EA group had a higher proportion of women who experienced greater than 50% reduction in the mean 72-h IEF from baseline to weeks 1–6, weeks 15–18, and weeks 27–30, with between-group differences of 10% (95% CI, 0.4–19.7; $p=0.04$), 21.9% (95% CI, 11.7–32.2; $p<0.001$), and 26.2% (95% CI, 16.0–36.3; $p<0.001$), respectively. Furthermore, ICIQ-SF scores showed the greatest change from baseline at weeks 6, 18, and 30 in the EA compared to the SA group, with between-group differences of − 1.6 (95% CI, − 2.5 to – 0.6; $p<0.001$), − 2.3 (95% CI, − 3.4 to − 1.3; $p<0.001$), and -2.8 (95% CI, − 4.0 to − 1.7; $p<0.001$), respectively. There were no between-group differences with respect to urine pad use during weeks 1–6, weeks 7–18, or weeks 19–30 ($p>0.05$ for all) or mean weekly use of urine pads during weeks 1–6 or weeks 7–18 ($p>0.05$ for both; Table 2). The EA group experienced a greater improvement in participant-reported SUI severity improvement during weeks 1–6 ($p=0.03$), weeks 15–18 ($p<0.001$), and weeks 27–30 ($p<0.001$), as well as a marked improvement

in self-evaluated therapeutic effects at weeks 6, 18, and 30 ($p < 0.001$ for all; Table 3).

Adverse events related to treatment affected 2.1% of participants during the 6-week treatment period; however, all adverse events were mild and transient (Table 4).

Table 4 Treatment-related adverse events

AE	EA ($n = 164$)[a] Patient, no. (%)	SA ($n = 177$)[a] Patient, no. (%)	Total[b] Patient, no. (%)
Total	3 (1.8)	4 (2.3)	7 (2.1)
SAE	0	0	0
Subcutaneous hematoma	0	3 (1.7)	3 (0.9)
Fatigue	2 (1.2)	1 (0.6)	3 (0.9)
Sharp pain	1 (0.6)	0	1 (0.3)

AEs were analyzed for all patients who received treatment and were counted by type rather than frequency for the same patient. AEs of different types occurring in a single patient were defined as independent AEs. A single AE type with multiple occurrences in a single patient was defined as one AE

[a]Five patients in the EA group and three patients in the SA group did not receive treatment

[b]$p > 0.99$ for the between-group comparison using Fisher's exact test

Discussion

Main findings

This secondary analysis is the first, to our knowledge, to report treatment outcomes of EA compared to SA for postmenopausal women with SUI symptoms. Over 6 weeks, a higher proportion of patients receiving EA compared to SA experienced symptom improvement.

The 1-h pad test is a reliable measurement of SUI for quantifying urine leakage. A decrease of 50% or more from baseline in the amount of urine leakage, as measured by the 1-h pad test, was considered evidence of clinical improvement [16] and defined as treatment response in this secondary analysis. In this study, the response rates for postmenopausal patients with SUI were 61% in the EA group and 18.9% in the SA group (difference, 42.5%). Results show that EA produced a clinically meaningful decrease in urine leakage among postmenopausal women with SUI. The 61% response rate in the EA group was similar to the 65.2% of patients who experienced improved 1-h pad test results (< 1 g) when treated with 12 weeks' circular muscle exercises and higher than the 50% of patients treated with 12 weeks' pelvic floor muscle training [17]. However, that study did not focus on postmenopausal women. Quantification of urine leakage using change in the 1-h AUL showed that EA decreased urine leakage among postmenopausal women at a rate similar to pelvic floor muscle exercises, vaginal cones, and intravaginal estriol for postmenopausal women with SUI [18, 19].

Our findings also showed that EA improved IEF over a 6-week treatment period and 24-week follow-up period, as measured by the mean change in 72-h IEF and the proportion of women experiencing a 50% or greater reduction in mean 72-h IEF from baseline. However, a between-group difference in the decrease from baseline for the 72-h IEF

Table 3 Participant-reported symptom severity and participant self-evaluation of therapeutic effects

	Week 6			Week 18			Week 30		
	EA ($n = 169$)	SA ($n = 180$)	p value	EA ($n = 169$)	SA ($n = 180$)	p value	EA ($n = 169$)	SA ($n = 180$)	p value
Severity of SUI, no. (%)[a]									
No	8 (4.9)	4 (2.3)	0.03	29 (17.9)	12 (7.2)	< 0.001	35 (21.6)	16 (9.6)	< 0.001
Mild	93 (56.7)	82 (47.1)		112 (69.1)	93 (55.7)		100 (61.7)	95 (56.9)	
Medium	59 (36.0)	74 (42.5)		18 (11.1)	51 (30.5)		23 (14.2)	47 (28.1)	
Severe	4 (2.4)	14 (8.0)		3 (1.9)	11 (6.6)		4 (2.5)	9 (5.4)	
Missing	5	6		7	13		7	13	
PSTE, no. (%)									
No help	2 (1.2)	58 (33.3)	< 0.001	4 (2.5)	57 (34.1)	< 0.001	7 (4.3)	61 (36.5)	< 0.001
Little help	19 (11.6)	63 (36.2)		35 (21.5)	64 (38.3)		32 (19.6)	61 (36.5)	
Medium help	78 (47.6)	31 (17.8)		63 (38.7)	22 (13.2)		61 (37.4)	24 (14.4)	
Great help	65 (39.6)	22 (12.6)		61 (37.4)	24 (14.4)		63 (38.7)	21 (12.6)	
Missing	5	6		6	13		6	13	

P was per Wilcoxon rank-sum test

[a]SUI severity was rated per participant using the 72-h bladder diary (none; mild, leaking several drops; moderate, soaking underwear; severe, soaking outerwear). The worst degree of urine incontinence during each period (weeks 1–6, weeks 15–18, and weeks 27–30) was used as the SUI severity for each corresponding time period

was only observed during follow-up, not during treatment. The finding that the mean 72-h IEF changed by 5.5 episodes from baseline to weeks 27–30 in the EA group, compared with 3.2 in the SA group ($p < 0.001$), was consistent with previous research in a sample that included premenopausal and postmenopausal women with SUI [20]. Compared to the SA group, the EA group had a higher percentage of participants with a 50% or greater reduction in the mean 72-h IEF at 24 weeks. A 50% reduction in IEF can be considered as a threshold for clinically relevant SUI in outcome research [21]. Thus, our results suggest that patients treated with EA may have sustained post-treatment reductions in urinary incontinence episodes among postmenopausal women with SUI.

In this secondary analysis, EA was also superior to SA based on secondary outcome measures of change in ICIQ-SF score, participant-reported symptom severity, and participant self-evaluation of therapeutic effects. These subjective outcome measures closely correlate with quality of life for patients with SUI. The improvements reported by patients in this study after EA treatment are consistent with previous results for studies of EA and pelvic floor muscle exercise [11, 20, 22].

Though estrogen deficiency may be an etiological factor in the development of urinary incontinence in women [23], and local administration of estrogens improves incontinence symptoms [24], there is inadequate evidence that systemic estrogen improves symptoms of incontinence among menopausal women [25]. Pelvic floor muscle exercises are commonly recommended as first-line, conservative management for women with SUI [26]. This secondary analysis showed that EA may also play a role in conservative management of SUI among postmenopausal women.

The mechanisms by which acupuncture affects SUI among postmenopausal women remain unclear. Stimulation of pelvic floor muscle contraction and simulated pelvic floor muscle training by stimulating S3 via BL33 and the pudendal nerve via BL35 have been described as a plausible mechanism by which acupuncture treats SUI [27].

The main strengths of this study were the multicenter RCT design involving a large sample size, high adherence to the treatment protocol, and the use of strict outcome measures. Meanwhile, this secondary analysis addresses a current knowledge gap about the effect of EA in postmenopausal women with SUI. This study could provide some evidence to support the acupuncture in the management of postmenopausal women with SUI.

Our study also has several limitations. First, we do not know the actual treatment response for those patients who did not complete follow-up. Likewise, it is unknown whether treatment effects would have been maintained over an extended follow-up. Second, the secondary analysis was not predefined during the original study design; thus, potential bias influencing the outcomes cannot be ruled out due to the limitations of any post hoc analysis. Third, study participation was limited to Chinese women; therefore, generalizability to other groups is unknown. Fourth, the collection of cost-related data was not required in the design of the original research though the assessment of costs has practical significance in SUI treatment. Taking medical insurance coverage for acupuncture in Beijing as an example, the total costs for 18 acupuncture sessions came to around 1440 CNY (≈$ 210) with about 80 CNY (including treatment fee and material fee) per acupuncture treatment.

Conclusion

Electroacupuncture may decrease urine leakage and urinary incontinence episodes while improving quality of life among postmenopausal women with SUI. This treatment may be a favorable, conservative treatment alternative. Further high-quality research is necessary to evaluate acupuncture's efficacy as well as the mechanism of action of this intervention.

Acknowledgements We acknowledge the volunteers for their participation. We thank *Medjaden* Bioscience Limited for editorial assistance.

Author contributions WW: project development, data collection, and manuscript writing. YL: data analysis, data management, and manuscript writing. SS: project development, data collection and management. BL: data management and manuscript revision. TS: project development, data collection and management. JZ: project development and data collection. ZL: project development, data analysis, and critical review of the manuscript. All authors approve the final version of this manuscript to be published and agree to be accountable for all aspects of the work.

Funding This study was supported by the program of the "12th Five-year" National Science and Technology Pillar Program (2012BAI24B01) by the Ministry of Science and Technology of the People's Republic of China.

Compliance with ethical standards

Conflict of interest The authors declare that no competing interests exist.

Research involving human/animal participants The study protocol was approved by independent ethics committees at all participating sites.

Informed consent The participants' informed consent was obtained from each patient before the performance of any study-specific procedures.

References

1. Capobianco G, Madonia M, Morelli S, Dessole F, De Vita D, Cherchi PL, Dessole S (2018) Management of female stress

urinary incontinence: a care pathway and update. Maturitas 109:32–38
2. Hampel C, Artibani W, Espuña Pons M, Haab F, Jackson S, Romero J, Gavart S, Papanicolaou S (2004) Understanding the burden of stress urinary incontinence in Europe: a qualitative review of the literature. Eur Urol 46(1):15–27
3. Zhu L, Lang J, Liu C, Han S, Huang J, Li X (2009) The epidemiological study of women with urinary incontinence and risk factors for stress urinary incontinence in China. Menopause 16(4):831–836
4. Onur R, Deveci SE, Rahman S, Sevindik F, Acik Y (2009) Prevalence and risk factors of female urinary incontinence in eastern Turkey. Int J Urol 16(6):566–569
5. Hunskaar S, Burgio K, Diokno A, Herzog AR, Hjälmås K, Lapitan Lapitan MC (2003) Epidemiology and natural history of urinary incontinence in women. Urology 62(Suppl. 1):16–23
6. El-Hefnawy AS, Wadie BS (2011) Severe stress urinary incontinence: objective analysis of risk factors. Maturitas 68(4):374–377
7. Nygaard CC, Betschart C, Hafez AA, Lewis E, Chasiotis I, Doumouchtsis SK (2013) Impact of menopausal status on the outcome of pelvic floor physiotherapy in women with urinary incontinence. Int Urogynecol J 24(12):2071–2076
8. Chen YC, Chen GD, Hu SW, Lin TL, Lin LY (2003) Is the occurrence of storage and voiding dysfunction affected by menopausal transition or associated with the normal aging process? Menopause 10(3):203–208
9. Kobashi KC, Albo ME, Dmochowski RR et al (2017) Surgical treatment of female stress urinary incontinence: guideline. J Urol 198(4):875–883
10. Fusco F, Abdel-Fattah M, Chapple CR et al (2017) Updated systematic review and meta-analysis of the comparative data on colposuspensions, pubovaginal slings, and midurethral tapes in the surgical treatment of female stress urinary incontinence. Eur Urol 72:567–591
11. Liu Z, Liu Y, Xu H et al (2017) Effect of electroacupuncture on urinary leakage among women with stress urinary incontinence: a randomized clinical trial. JAMA 317(24):2493–2501
12. Harlow SD, Gass M, Hall JE, Lobo R, Maki P, Rebar RW, Sherman S, Sluss PM, de Villiers TJ, STRAW + 10, Collaborative Group (2012) Executive summary of the stages of reproductive aging workshop +10: addressing the unfinished agenda of staging reproductive aging. Climacteric 15(2):105–114
13. Liu Z, Xu H, Chen Y, He L, Liu J, Yan S, Du R, Wu J, Liu B (2013) The efficacy and safety of electroacupuncture for women with pure stress urinary incontinence: study protocol for a multicenter randomized controlled trial. Trials 14:315
14. Abrams P, Khoury S, Cardozo L, Wein A (2013) Incontinence, 5th international consultation on incontinence, Paris February, 2012. ICUD-EAU, Arnhem
15. Huang L, Zhang SW, Wu SL, Ma L, Deng XH (2008) The Chinese version of ICIQ: a useful tool in clinical practice and research on urinary incontinence. Neurourol Urodyn 27(6):522–524
16. Aksac B, Aki S, Karan A, Yalcin O, Isikoglu M, Eskiyurt N (2003) Biofeedback and pelvic floor exercises for the rehabilitation of urinary stress incontinence. Gynecol Obstet Investig 56(1):23–27
17. Liebergall-Wischnitzer M, Lavy Y, Hochner-Celnikier D, Shveiky D, Manor O, Paltiel O (2009) Randomized trial of circular muscle versus pelvic floor training for stress urinary incontinence in women. J Womens Health (Larchmt) 18(3):377–385
18. Pereira VS, de Melo MV, Correia GN, Driusso P (2012) Vaginal cone for postmenopausal women with stress urinary incontinence: randomized, controlled trial. Climacteric 15(1):45–51
19. Castellani D, Saldutto P, Galica V, Pace G, Biferi D, Paradiso Galatioto G, Vicentini C (2015) Low-dose intravaginal estriol and pelvic floor rehabilitation in post-menopausal stress urinary incontinence. Urol Int 95(4):417–421
20. Xu H, Liu B, Wu J, Du R, Liu X, Yu J, Liu Z (2010) A pilot randomized placebo controlled trial of electroacupuncture for women with pure stress urinary incontinence. PLoS One 11(3):e0150821
21. Yalcin I, Peng G, Viktrup L, Bump RC (2010) Reductions in stress urinary incontinence episodes: what is clinically important for women? Neurourol Urodyn 29(3):344–347
22. Sjöström M, Umefjord G, Stenlund H, Carlbring P, Andersson G, Samuelsson E (2013) Internet-based treatment of stress urinary incontinence: a randomised controlled study with focus on pelvic floor muscle training. BJU Int 112(3):362–372
23. Gopal M, Sammel MD, Arya LA, Freeman EW, Lin H, Gracia C (2008) Association of change in estradiol to lower urinary tract symptoms during the menopausal transition. Obstet Gynecol 112(5):1045–1052
24. Ewies AA, Alfhaily F (2010) Topical vaginal estrogen therapy in managing postmenopausal urinary symptoms: a reality or a gimmick? Climacteric 13(5):405–418
25. Cody JD, Richardson K, Moehrer B, Hextall A, Glanzener CMA (2009) Oestrogens for urinary stress incontinence in women. Cochrane Database Syst Rev 10:CD001405
26. Dumoulin C, Hay-Smith EJ, Mac Habee-Seguin G (2014) Pelvic floor muscle training versus no treatment, or inactive control treatments, for urinary incontinence in women. Cochrane Database Syst Rev 5:CD005654
27. Wang S, Zhang S (2012) Simultaneous perineal ultrasound and vaginal pressure measurement prove the action of electrical pudendal nerve stimulation in treating female stress incontinence. BJU Int 110(9):1338–1343