ORIGINAL ARTICLE

DIFFERENT TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION PATHWAYS IN THE TREATMENT OF MIXED URINARY INCONTINENCE IN WOMEN: AN EXPERIMENTAL STUDY

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Highlights: (1) Combined TENS and PFMT improved MUI. (2) TTNS and TPES showed similar effectiveness for MUI treatment. (3) PFMT improved pelvic floor muscle function.

PRE-PROOF
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ABSTRACT

Objective: To verify and compare the effects of transcutaneous tibial nerve electrical stimulation (TTNS) combined with Pelvic Floor Muscle Training (PFMT) versus parasacral transcutaneous electrical stimulation (PTES) combined with PFMT in women with mixed urinary incontinence (MUI). **Method:** A longitudinal experimental study was performed, with pre- and post-treatment assessments. Forty women with MUI were divided into a Tibial Group: TTNS + PFMT and a Parasacral Group: PTES + PFMT. The treatment was performed twice a week, totaling 12 sessions. The electrical stimulation parameters used were: frequency: 10Hz, pulse duration: 700μs, intensity: according to sensitivity, and duration: 20 minutes. PFMT was performed in four positions (sitting, lying down, standing, and on all fours) immediately after the electrical stimulation. Pre- and post-treatment evaluations were conducted using a clinical history form, the Pelvic Floor Distress Inventory-20 (PFDI-20), which investigates pelvic floor discomfort, the King's Health Questionnaire (KHQ), which assesses quality of life related to urinary incontinence, and the PERFECT scheme, which assesses pelvic floor muscle (PFM) function. In the statistical analysis, ANOVA for repeated measures was applied to verify the effects of treatments, time points, and interactions on the investigated variables, with a significance level of 5%. **Results:** The groups demonstrated significant improvements in PFDI 20, KHQ, and PERFECT when comparing pre- and post-treatment time points, with no significant difference between treatments. **Conclusion:** Treatment with electrical stimulation combined with PFMT promotes improvement in MUI regardless of the application site, leading to enhanced quality of life and PFM function.

Keywords: urinary incontinence; transcutaneous electrical nerve stimulation; quality of life; physiotherapy; women; electric stimulation therapy.

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INTRODUCTION

The *International Continence Society* (ICS) defines urinary incontinence (UI) as any complaint, reported by the patient, related to involuntary loss of urine[1]. UI can be classified into three types: Stress UI (SUI), in which urinary leakage occurs during exertion such as coughing, running, jumping, and laughing; Urge UI (UUI), in which urine leakage occurs associated with urinary urgency; and Mixed UI (MUI), characterized by a combination of SUI and UUI, where leakage occurs both during exertion and urgency[1].

UI is a common health problem, affecting approximately 300 million people worldwide[2]. Although it occurs in both men and women, the prevalence is higher in females and with increasing age[3]. An epidemiological study conducted in the United States indicates a prevalence of 53% for any type of UI, with a distribution of 26% for SUI, 16% for MUI, and 10% for UUI [4]. Epidemiological data in Brazil paint a different picture, with UI (87.2%) being the most prevalent, followed by SUI (7.5%) and UUI (5.3%)[5].

UI can affect multiple aspects of a patient's life, including psychological, professional, sexual[6], and social aspects. This last aspect, in some situations, results in restrictions[7], leading to isolation and withdrawal from friends and family. There are also reports that UI presents negative psychological and physical burdens[8], harming quality of life (QoL), and contributing to a significant social and economic burden[4].

For treatment, the type of UI must be considered. Possible interventions include electrostimulation, lifestyle changes, bladder training, pelvic floor muscle training (PFMT), and biofeedback[9]. PFMT is considered the gold standard in the treatment of UI, especially SUI, with Level 1 evidence (recommendation A), and is considered the first-line treatment in these cases[10]. PFMT is defined as exercise to improve the strength, endurance, power, and relaxation of the pelvic floor muscles (PFM), or a combination of these[1], thus promoting improved PFM function and resulting in improved urinary symptoms.

Another resource used in the treatment of UI, especially UUI, is transcutaneous

electrical nerve stimulation (TENS). The TENS application methods include Transcutaneous Tibial Nerve Stimulation (TTNS) and Parasacral Transcutaneous Electrical Stimulation (PTES)[11]. Electrostimulation is used as a treatment to modulate detrusor muscle contraction, with the aim of reducing frequent and excessive contractions during the bladder filling phase[12]. The evidence for TENS is still debated, with TTNS reported as the 2nd [13] and 3rd [14] line of treatment guidelines for UUI, with evidence levels of B[13] and C[14] respectively. PTES, however, lacks scientific evidence and further studies are required with adult female populations [15].

Since MUI is the association of the two types of UI, the combination of different resources for its treatment is suggested. In this context, the current study is relevant as it investigates the combination of two resources for the treatment of MUI in adult women. Thus, the objective of the current study was to verify and compare the effects of TTNS associated with PFMT, and of PTES associated with PFMT, in women with MUI.

METHODS

Type of Study and Collection Location

This is a longitudinal experimental study with pre- and post-treatment, conducted with adult women with self-reported MUI. Data collection took place in the Physiotherapy block of the Urogynecological Physiotherapy Laboratory (LABUROGIN) at the Federal University of Amapá (UNIFAP), from July 2023 to June 2024. The recruitment of participants took place through the distribution of pamphlets and posters in community groups in the city of Macapá/AP, as well as through social media.

Sample Size

Sample size calculation was performed using G*Power 3.1.9.2 software, considering the comparison of two groups, F-test, Analysis of Variance (ANOVA) - repeated measures, intra-group interaction, effect size of 0.25, significance level of 5%,

and test power of 85%, resulting in a minimum total of 38 participants. However, considering possible sample losses, a total of 40 participants were recruited (20 per group).

The participants were allocated to the groups through a simple draw (1:1 allocation ratio), conducted by a collaborator not involved in the physical assessment and treatment of the participants. Forty rectangular pieces of paper in two different colors were placed Inside a brown envelope, with each color corresponding to a treatment group. The color orange corresponded to TTNS combined with PFMT (tibial group) and the color blue corresponded to PTES combined with PFMT (parasacral group). The participant drew one piece of paper of one color from the envelope and then attached it to their monitoring sheet. Thus, the researcher responsible for the treatment visualized the color of the piece of paper and applied the corresponding technique throughout the 12 sessions. The researcher administering the treatment was blinded to the participants' evaluations and re-evaluations.

Inclusion and Exclusion Criteria

The inclusion criteria were women over 18 years of age; with self-reported MUI, confirmed by an affirmative answer to both questions of the King's Health Questionnaire (KHQ): "Urgency Urinary Incontinence: Do you leak urine when you have a strong urge to urinate?" and "Stress Urinary Incontinence: Do you leak urine with physical activities such as coughing, sneezing, running?"[16]. The exclusion criteria were: having only SUI or only UUI; absence of pelvic floor muscle contraction (grade 0 on the Modified Oxford Scale (MOS)); having a urinary tract infection at the time of collection; having a history of smoking or drug addiction; lesions and altered skin sensitivity at the site where the procedure would be applied; cognitive impairment; dementia; currently undergoing drug and physiotherapy treatment for urinary incontinence; having suffered a stroke; being pregnant or postpartum; having any neurological disease (e.g., multiple sclerosis; Parkinson's disease); and spinal cord injuries or trauma.

Assessment Instruments

The assessments were conducted before and after treatments by a researcher not involved in the treatment performed.

Anamnesis Form

An anamnesis form developed by the researchers was used, containing questions related to the sociodemographic, anthropometric, urogynecological, and obstetric information of the women.

King's Health Questionnaire (KHQ)

The KHQ was applied to investigate QoL in relation to UI. This tool was translated and validated[16] for the Portuguese language. The KHQ consists of 30 questions, divided into eight domains: general perception of health, impact of UI, limitations in daily activities, physical limitations, social limitations, personal relationships, emotions, sleep/energy. There are also two other independent scales: one assesses the severity of UI (severity measures) and the other the presence and intensity of urinary symptoms (urinary symptom scale). The KHQ is scored for each domain, therefore there is no overall score. Scores range from 0 to 100, and the higher the score, the worse the QoL related to that domain[16].

Pelvic Floor Distress Inventory – 20 (PFDI-20)

The PFDI-20 was applied to investigate the degree of discomfort related to symptoms of pelvic floor disorders. This questionnaire was translated and validated[17] into Portuguese, and is composed of questions from three different questionnaires: (Pelvic the Organ Prolapse Distress Inventory (POPDI-6); Colorectal-Anal Distress Inventory (CRADI-8); and Urinary Distress Inventory (UDI-6)), which assess 20 symptoms of disorders of the urinary tract, bowel, and vagina. Six items on the questionnaire assess prolapse symptoms, 8 questions are related to anorectal symptoms, and 6 questions are for urinary symptoms. When the answer to the questions was affirmative, participants responded based on a scale of 1 to 4 (1=no discomfort; 2=somewhat; 3=moderately;

4=quite a lot). Each sub-questionnaire has a score from 0 to 100, and the highest score indicates the greatest discomfort related to the symptoms. The final score is obtained by summing the scores of the sub-questionnaires and ranges from 0 to 300, with the highest score indicating the greatest discomfort[17].

Assessment of the Pelvic Floor Muscles

This evaluation consisted of visual inspection and bimanual vaginal palpation. To perform the physical examination, the participant remained in the supine position with her hips and knees flexed at 45º and her feet supported on the examination table[18]. Pelvic floor muscle function was assessed using the PERFECT Scheme[19], which grades maximal voluntary contraction (Power), quantifies the duration of maximal voluntary contraction (Endurance), as well as repetitions of sustained contractions (Repetitions) and fast contractions (Fast). Initially, maximum voluntary contraction was graded according to the MOS, on a scale ranging from 0 to 5, where 0 represents no contraction and 5 represents a strong contraction. Next, endurance was assessed by recording the maximum time the contraction could be maintained, limited to 10 seconds. The Repetitions and Fast items were obtained by counting the number of sustained repetitions and the number of fast contractions performed until fatigue, respectively[18,19].

Treatments

The treatments were conducted by a researcher not involved in the randomization and evaluation of the participants. The intervention groups were the Tibial Group: TTNS and PFMT, and the Parasacral Group: PTES and PFMT. The treatments consisted of Transcutaneous Electrical Nerve Stimulation (TENS) and Pelvic Floor Muscle Training (PFMT), with PFMT performed according to a protocol adapted from Bø, Talseth, and Holme (1999)[20] and the TENS performed based on the protocol adapted from Padilha et al., (2020)[21]. The treatment protocol consisted of an initial application of the randomized TENS modality, followed by pelvic floor muscle training (PFMT). Both treatments were performed for a total of 12 sessions, occurring twice a week on alternate days, with a minimum interval of 1 day between sessions, lasting a total of 6 weeks.

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Transcutaneous Electrical Stimulation

The interventions consisted of TTNS and PTES, using the Quark® Dualpex Uro device, P04 program, with a frequency of 10 Hz, pulse duration of 700 µs, and duration of 20 minutes. The intensity was adjusted according to the patient's sensitivity.

For TTNS, the electrodes were positioned along the tibial nerve pathway, one electrode was placed next to the medial malleolus and the other electrode approximately 10 cm above the first (Image 1A). For PTES, the electrodes were positioned at the level of the 3rd sacral vertebra (S3) with a 4 cm distance between each electrode (Image 1B).

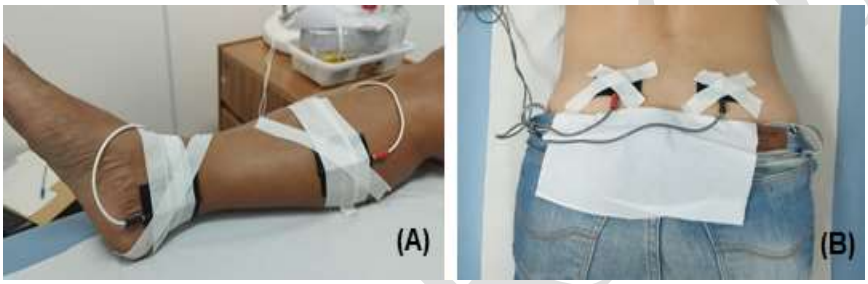

Image 1. Positioning of the TTNS (A) and PTES (B) electrodes. **Source**: Authors.

The participants were previously informed that the electrostimulation modalities used in this study are considered low-risk, with adverse effects generally limited to mild discomfort, transient tingling, or skin irritation at the electrode sites[22]. Regarding the benefits, the potential effectiveness in modulating urgency symptoms and reducing urinary frequency was highlighted. Participants were instructed to report any discomfort during the sessions, and no adverse effects were observed during the protocol.

Pelvic Floor Muscle Training

For the execution of the PFMT, the participant adopted 4 different positions: supine; quadruped; seated; standing. In each position, a series of slow contractions was performed with appropriate progression per week, varying from 8 to 12 repetitions of 6 to 8 seconds of hold. In addition, at the end of each slow contraction, 1 series of fast contractions was added (4 fast contractions of 1 second each)[20]. All positions were supervised by the researcher responsible for the treatment, who provided guidance on the

participant's body awareness and proper breathing associated with the exercises.

The verbal commands that the researcher gave to the participants were: 1. “Inhale and during exhalation, contract the pelvic floor muscles as if you were holding back urine”; 2. “Make an upward and inward movement with the muscles and maintain the contraction”; 3. "Try not to contract your abdomen, glutes, and leg muscles while performing the pelvic floor muscle contraction." It is emphasized that all participants were encouraged to perform the exercises at home at least once a day, according to their daily routine.

Statistical analysis

The data were tabulated using Microsoft Excel version 365, and all analyses were performed using R program (R version 4.2.2). Qualitative variables are described using frequency distributions and percentages, while quantitative variables are described using the mean, standard deviation, and median. The normality of the data was tested using the Shapiro-Wilk test. A repeated measures ANOVA, intra-group interaction, was applied to verify the effect of treatments, time points, and interactions on the total PFDI-20 scores, including the UDI-6 sub-questionnaire and PFDI-20 questions, KHQ domains, and PERFECT. If the residuals in the ANOVA model were normal, the parametric approach of the F-test with post-hoc Tukey's test was used. Otherwise, the non-parametric approach using ANOVA-Type Statistics (ATS test) was employed. A significance level of 5% was considered.

Ethical Aspects

The execution of this study was approved by the Ethics and Research Committee (CEP) of the Federal University of Amapá (UNIFAP) under CAAE: 65181022.2.0000.0003 and opinion number: 5.802.938. This study respected the ethical

precepts of Resolution 466/2012, which advocates ethical care in research involving human beings.

RESULTS

The current study included 40 women with self-reported MUI, with a mean age of 46.86 ± 6.58 years. Sociodemographic, anthropometric, obstetric, and urinary characteristics, divided by group, are presented in Table 1.

Table 1. Sample characterization.

VARIABLES	Tibial Group (n=20)	Parasacral Group (n=20)
SOCIODEMOGRAPHIC AND ANTHROPOMETRIC CHARACTERISTICS		
Age (years), (mean ± SD)	47.10±4.52	46.55±8.26
Race, n (%)		
Brown	14 (70)	17 (85)
White	3 (15)	1 (5)
Black	2 (10)	1 (5)
Yellow	1 (5)	-
Did not declare	-	1 (5)
Marital status, n (%)		
Married/Common-law partner	12 (60)	9 (45)
Single	6 (30)	6 (30)
Divorced/Separated	2 (10)	5 (25)
Monthly income, n (%)		
Up to 1 minimum wage	14 (70)	8 (40)
From 2 to 4 minimum wages	3 (15)	10 (50)

Did not declare	3 (15)	2 (10)
Schooling, n (%)		
Completed elementary education	1 (5)	-
Incomplete elementary education	4 (20)	3 (15)
Completed high school education	9 (45)	8 (40)
Completed higher education	1 (5)	-
Incomplete higher education	5 (25)	9 (45)
Height (m), (mean ± SD)	1.56±0.06	1.57±0.07
Body Mass (kg), (mean ± SD)	72.97±14.04	70.85±14.60
Body Mass Index (kg/m^2), (mean ± SD))	29.98±6.13	28.67±4.86
OBSTETRIC CHARACTERISTICS		
Number of pregnancies, (mean ± SD)	4.5±1.85	3.20±1.51
Number of births, (mean ± SD)	3.95±1.54	2.95±1.36
Type of birth, n (%)#		
Vaginal	67 (84.81)	45 (76.27)
Cesarean	12 (15.19)	14 (23.73)
Weight of the largest newborn (Kg), (mean ± SD)	3.785±0.73	3.544±0.70
URINARY CHARACTERISTICS		
Number of urinations during the day (mean ± SD)	8.65±3.98	9.35±2.83
Number of urinations during the night (mean ± SD)	3.10±3.19	2.85±1.60
Pad use, n (%)		
Yes	15 (75)	9 (45)
No	5 (25)	11 (55)

SD: Standard Deviation; m: meter; Kg: kilogram; # Calculation based on the total number of births in the Tibial Group: 79 and the total number of births in the Parasacral Group: 59.

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Regarding the symptoms presented, no significant interactions were observed between group and time point for any of the variables analyzed ($p > 0.05$), indicating that the evolution of scores over time was similar between the groups. Both groups showed improvement in pelvic floor discomfort, assessed using the PFDI-20. The same occurred with the specific questions regarding urinary issues in the PFDI-20 (urinary frequency, UUI, and SUI, questions 15, 16, and 17 respectively) and the UDI-6 questionnaire, which investigates lower urinary tract symptoms, that showed significant improvement in symptoms after treatment in both groups (Table 2).

Regarding QoL and pelvic floor function, there was a decrease in the scores of all KHQ domains, demonstrating a smaller impact of UI on the different domains. In pelvic floor muscle function, measured by the PERFECT scheme, an increase in muscle function was observed, which went from weak to moderate, assessed by the median of the MOS in the P (power) phase, as well as an improvement in endurance (E), repetitions (R), and speed of contractions (F), after both treatments. Table 2 presents further information on the comparisons between the groups and assessment times.

Table 2 – Mean, Standard Deviation, Median, and multiple comparisons (parametric and non-parametric) between treatments (tibial and parasacral) and time points (pre and post) for the total PFDI-20 score, Questions 15, 16, and 17 of the PFDI-20, UDI-6, KHQ domains, and PERFECT scores.

Variables	Assessment	Tibial Group (n=20)	Parasacral Group (n=20)	$F^{\$}$ / $ATS^{\&}$ (p-value of the Interaction)	$F^{\$}$ / $ATS^{\&}$ (p value of the Treatment)	$F^{\#}$ / $ATS^{\&}$ (p value of the Moment)
PFDI-20 Mean (SD)						
PFDI-20$^{\&}$	**Pre**	155.83^{a} (54.51)	117.81^{a} (61.21)	2.36$^{\&}$ (0.1244)	2.56$^{\&}$ (0.1097)	47.75$^{\&}$ (<0.0001)
	Post	88.27^{b} (66.37)	73.80^{b} (54.90)			
Question 15$^{\&}$	**Pre**	3.05^{a} (1.23)	2.60^{a} (1.67)	0.64$^{\&}$ (0.4221)	0.22$^{\&}$ (0.6403)	25.53$^{\&}$ (<0.0001)
	Post	1.30^{b} (1.63)	1.40^{b} (1.82)			
Question 16$^{\&}$	**Pre**	3.50^{a} (0.76)	3.05^{a} (1.10)	0.04$^{\&}$ (0.8470)	1.41$^{\&}$ (0.2281)	40.90$^{\&}$ (<0.0001)

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	Post	1.60[b] (1.76)	1.25[b] (1.59)			
Question 17[&]	**Pre**	3.70 [a] (0.66)	3.65[a] (0.88)	0.29[&] (0.5921)	0.11[&] (0.7389)	42.16[&] (<0.0001)
	Post	2.10[b] (1.74)	1.80[b] (1.67)			
UDI-6[$]	**Pre**	73.33[a] (19.75)	61.46[a] (22.41)	0.21[$] (0.6461)	2.18[$] (0.1482)	54.49[#] (<0.0001)
	Post	39.79[b] (31.08)	31.88[b] (25.91)			
KHQ Domains Mean (SD)						
General Perception of Health[&]	**Pre**	46.25[a] (20.32)	57.50[a] (21.61)	0.01[&] (0.9156)	3.57[&] (0.0587)	8.67[&] (0.0040)
	Post	35.00[b] (18.85)	46.25[b] (23.33)			
Impact of Incontinence[&]	**Pre**	76.67[a] (26.71)	75.00[a] (33.98)	0.64[&] (0.4233)	0.16[&] (0.6928)	26.97[&] (<0.0001)
	Post	43.33[b] (39.14)	53.33[b] (29.42)			
Task Limitations[&]	**Pre**	55.83[a] (34.32)	53.33[a] (40.32)	0.30[&] (0.5843)	0.01[&] (0.9412)	12.85[&] (0.0003)
	Post	30.00[b] (27.89)	32.50[b] (28.85)			
Physical Limitations[$#]	**Pre**	67.50[a] (27.29)	52.50[a] (32.57)	6.18[$] (0.0175)	0.05[$] (0.8285)	26.27[$] (<0.0001)
	Post	26.67[b](29.81)	38.33[a] (28.15)			
Social Limitations[&]	**Pre**	27.78[a] (23.22)	31.67[a] (22.01)	0.31[&] (0.5756)	1.62[&] (0.2024)	14.97[&] (0.0001)
	Post	13.33[b] (23.80)	19.17[b] (22.47)			
Personal Relationships[&]	**Pre**	44.17[a] (36.38)	35.83[a] (40.20)	2.91[&] (0.0881)	0.01[&] (0.9089)	5.65[&] (0.0175)
	Post	24.17[b] (33.97)	30.83[b] (34.74)			
Emotions[&]	**Pre**	41.67[a] (31.40)	54.44[a] (31.82)	0.38[&] (0.5385)	2.94[&] (0.0863)	12.54[&] (0.0004)
	Post	25.56[b] (29.75)	41.67[b] (33.98)			
Sleep/Energy[&]	**Pre**	45.00[a] (36.31)	44.17[a] (30.72)	2.52[&] (0.1122)	1.51[&] (0.2189)	10.68[&] (0.0011)
	Post	18.33[b] (19.42)	35.00[b] (28.56)			
Severity Measure[$]	**Pre**	48.33[a] (33.73)	49.17[a] (23.86)	2.67[$] (0.1106)	0.94[$] (0.3375)	17.85[$] (0.0001)
	Post	26.67[b] (20.52)	39.58[b] (20.57)			
PERFECT (median)						
P[&] (power)	**Pre**	2.00[a]	2.00[a]	0.49[&] (0.4824)	0.26[&] (0.6088)	24.18[&] (<0.0001)
	Post	3.00[b]	3.00[b]			
E[&] (endurance)	**Pre**	3.00[a]	4.00[a]	1.83[&] (0.1764)	0.57[&] (0.4495)	33.92[&] (<0.0001)
	Post	6.00[b]	5.00[b]			

R[&] (repetition)	**Pre**	3.00[a]	3.00[a]	0.28[&] (0.5998)	0.24[&] (0.6206)	26.59[&] (<0.0001)
	Post	4.00[b]	4.50[b]			
F[&] (speed)	**Pre**	6.50[a]	7.50[a]	0.89[&] (0.3442)	0.45[&] (0.5013)	23.48[&] (<0.0001)
	Post	10,00[b]	10,00[b]			

Means followed by the same letter in the columns do not differ statistically from each other. [&]: Non-parametric ATS test. [$]: F-test. [#]: Interaction analysis using Tukey's test. PFDI-20: Pelvic Floor Distress Inventory-20; KHQ: King Health Questionnaire. SD: Standard Deviation.

DISCUSSION

Considering the clinical challenges in treating MUI, the aim of the current study was to compare the effects of TTNS combined with PFMT, and of PTES combined with PFMT in women with this condition. The main findings of the study were that both treatments improved discomfort related to the pelvic floor, urinary symptoms, QoL related to urinary symptoms, and PFM function, with no significant differences between the groups.

These results suggest that, regardless of the application site (tibial or parasacral nerve), the association of TENS with PFMT positively influences the outcome of MUI. This equivalence is clinically relevant because it offers greater flexibility in treatment choice, taking into account patient preference and possible contraindications of the application site, thus providing two options for TENS application sites. The findings are important due to the complex nature of MUI, which, according to the International Urogynecological Association (IUGA), causes greater clinical severity than isolated SUI or UUI[23]. This complexity creates clinical dilemmas regarding which component of the UI should be prioritized in treatment[23], although some guidelines recommend focusing on the predominant symptom [24]. However, the present research suggests that combining resources such as TTNS and PFMT can be an effective strategy, as it allows the simultaneous treatment of both stress and urgency components, highlighting the positive effects of combined treatment for MUI, regardless of the TENS site recommended.

The overall improvement observed in both groups can be analyzed according to

the role of each intervention. On the one hand, PFMT is considered the gold standard in the treatment of SUI[10] and is crucial in MUI. Given that the participants presented weak PFM strength in the initial assessment, the significant improvement in PFM function observed in both groups demonstrates the effectiveness of PFMT in strengthening these muscles. The consequent reduction in urinary incontinence and improvement in QoL can be attributed, in part, to the improved urethral and pelvic organ support achieved by PFMT[25,26].

Regarding the questions related to the urgency component, such as symptoms of increased urinary frequency (Question 15 of the PFDI-20) and urgency-related leakage (Question 16 of the PFDI-20), an improvement was observed in the present study, with a decrease in the scores of these questions after the treatments. It is known that contraction of the pelvic floor muscles leads to a decrease in detrusor pressure, an increase in urethral pressure, and suppression of the micturition reflex, which also supports the use of PFMT for the treatment of urinary urgency symptoms[27]. Therefore, the PFMT used in the current study may have contributed to the improvement in these symptoms. However, the benefit of PFMT alone in urinary urgency symptoms is still debated[27], and the importance of combining electrostimulation and PFMT is supported by previous literature. A study [28] demonstrated that treatment satisfaction in patients with MUI was higher when TTNS was combined with PFMT compared to PFMT alone. Thus, it is believed that in our results, the combination of resources was responsible for the overall improvement. The findings also highlight the importance of electrostimulation in the treatment, and in our research, at both application sites. These data are important because, when considering urinary incontinence, data on the effectiveness of electrical stimulation are less consistent in the literature for the two techniques applied herein.

Regarding electrostimulation, TTNS is widely indicated for the treatment of overactive bladder symptoms due to its effects on improving urgency, and decreasing urinary frequency and nocturia, with the advantage of having no side effects when compared to drug treatments for these conditions[29]. Despite this, the evidence for MUI remains controversial [13,14], and it is relevant to analyze how these findings relate to the

results of the present study.

In our sample, TTNS combined with PFMT contributed to the improvement in MUI symptoms, which is consistent with previous investigations that indicate clinical benefits in different manifestations of urinary dysfunction[29], Although the outcomes of isolated MUI have received less attention in the literature, for MUI specifically there is limited evidence that TTNS combined with surgical sling treatment is superior to surgical intervention alone[23]. This reflects that the therapeutic response to MUI may depend on the type of associated intervention and the mechanism involved. Similarly, a previous study[30] study showed that when comparing three strategies: PFMT with biofeedback and intravaginal electrostimulation to promote PFM contraction; isolated TTNS; and intravaginal TENS for pudendal nerve neuromodulation with parameters equivalent to TTNS, there were no differences between the groups regarding the reduction in leakage and improvement in scores on the International Consultation on Incontinence Questionnaire – Short Form (ICIQ-SF), Questionnaire for the Diagnosis of Urinary Incontinence (QUID), and Pelvic Floor Questionnaire (PFQ). This pattern of equivalence between different electrotherapy modalities was also observed in the current study, although with the caveat that, while study[30] included a group with isolated PFMT, herein we evaluated the association of PFMT with TTNS or PTES. Thus, although the designs are not identical, both investigations converge in indicating that TTNS has positive effects on MUI symptoms, but that its superiority over other stimulation options or over PFMT is not evident.

In the case of PTES, the available literature does not clearly distinguish its effects in women exclusively with MUI. Existing studies have evaluated urinary urgency in populations with urinary incontinence and urinary urgency allocated to the same group, which limits direct comparisons. However, the existing data help contextualize our findings. A clinical trial[11] that investigated the effects of TTNS and PTES in treating urinary urgency in adult women showed that both the PTES and TTNS groups experienced fewer urgency episodes post-treatment than the placebo group. Furthermore, they had a similar positive effect in reducing urinary urgency[11]. The same occurred in a

study[31] in which 50 women with overactive bladder syndrome were divided into two groups and received either TTNS or PTES for 6 weeks, with the same parameters, and showed similar improvements: the PTES group demonstrated a greater improvement in the Overactive Bladder-Validated 8-question Awareness Tool (OAB-V8) than the TTNS group, but both groups showed improvement in the KHQ and Incontinence Severity Index (ISI), demonstrating that, in general, both treatments were effective and safe for improving symptoms. These findings corroborate the results of the present study, indicating that both TTNS and PTES can be effective and safe strategies in the management of MUI.

Therefore, these convergences between our study and the literature suggest that, when electrostimulation is used as an adjunct to PFMT, the benefits appear to stem from the overall conservative approach, and not from the specific superiority of one of the treatment modalities. Furthermore, by demonstrating positive effects with two distinct TENS modalities, we reinforce that the clinical choice can consider relevant practical factors, such as patient preference, anatomical characteristics, contraindications of the application site, and equipment availability.

A limitation of the study was the absence of a control or placebo group that did not receive any treatments, or that received only PFMT, to assess the isolated impact of TENS on the treatment. However, since the objective of the study was to observe whether there is superiority between TTNS and PTES, the comparisons between the two proposed groups demonstrated that there was no difference between them. Therefore, future studies should include the addition of different control groups in the study design. Furthermore, it is suggested that when recommending home exercises in future studies, their execution should be monitored in order to verify possible effects of greater adherence in a given group.

CONCLUSION

Treatments with transcutaneous electrical nerve stimulation, either via the tibial nerve or in the parasacral region, combined with pelvic floor muscle training, improved mixed urinary incontinence, pelvic floor muscle function, and quality of life in relation to urinary incontinence. Thus, both treatments applied were beneficial, providing improvement in MUI symptoms. This research contributes to the advancement of knowledge regarding MUI, highlighting the importance of conservative treatments applied in combination to improve symptoms and the quality of life of women affected by this condition.

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DIFFERENT TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION PATHWAYS IN THE TREATMENT OF MIXED URINARY INCONTINENCE IN WOMEN: AN EXPERIMENTAL STUDY

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