Assessment of bioelectrical activity of pelvic floor muscles in female cross-training practitioners: A cross-sectional observational study

Avaliação da atividade bioelétrica dos músculos do assoalho pélvico em mulheres praticantes de cross-training*: um estudo observacional transversal*

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Abstract

Introduction: Stress urinary incontinence (SUI) during high-impact exercises is common in female cross-training practitioners and may be due to failure of the pelvic floor muscles (PFM) in supporting the bladder neck and urethra. **Objective:** To evaluate the functional and bioelectrical activity of PFM in female cross-training practitioners with and without symptoms of SUI during sports practice. **Methods:** Forty women practicing cross-train-ing for at least eight uninterrupted months, at least three times per week, over than 50 minutes were divided according to the presence or absence of SUI. The International Consultation on Incontinence Questionnaire – Short Form (ICIQ-SF), pelvic floor muscle assessment by PERFECT scheme, surface electromyography of PFM using the Glazer protocol, and tetrapolar bioimpedance for body composition evaluation were used for the assessments. Statistical analysis was performed using the Mann-Whitney test and Student t-test. A level of significance of 0.05 was adopted for all analyses. **Results:** The participants had a mean age of 37.25 ± 7.80 years and had practiced the modality for an average of 34.5 months. Women with SUI (n = 16) had lower number of fast and slow repetitions (p = 0.052), lower intensity of tonic contractions of PFM (p = 0.054), a longer time before peak phasic contractions (p = 0.041), a longer time before peak tonic contractions (p = 0.009), and a longer time after peak tonic contractions (p = 0.006) than women without SUI (n = 24). **Conclusion:** Women with SUI during physical activity exhibit deficits in the functioning of both fast and slow muscle fiber contractions, as well as reduced bioelectrical activity in the tonic and phasic fibers of the PFM. Additionally, these women frequently display a lack of abdominal-pelvic synergy. These findings indicate an important relationship between bioelectrical parameters and the presence of SUI, providing a foundation for the development of future interventions aimed at health prevention and rehabilitation.

Keywords: Physical exercise. Pelvic floor. Stress urinary incontinence. Women.

Resumo

Introdução: *A incontinência urinária de esforço (IUE) é comum em praticantes de* cross-training *durante exercícios de alto impacto e pode ser decorrente da falha dos músculos do assoalho pélvico (MAP) em sustentar o colo vesical e a uretra.* ***Objetivo:*** *Avaliar a atividade funcional e bioelétrica dos MAP em praticantes de* cross-training *com e sem sintomas de IUE durante a prática esportiva.* ***Métodos:*** *Quarenta mulheres praticantes de* cross-training *por pelo menos oito meses ininterruptos, pelo menos três vezes por semana, 50 minutos por dia, foram divididas de acordo com a presença ou ausência de IUE. Utilizaram-se o Questionário Internacional de Consulta sobre Incontinência – Versão Curta (ICIQ-SF), a avaliação dos músculos do assoalho pélvico pelo esquema PERFECT, a eletromiografia de superfície dos MAP através o protocolo de Glazer e a bioimpedância tetrapolar para avaliação da composição corporal. A análise estatística foi realizada utilizando os testes de Mann-Whitney e t de Student. Adotou-se um nível de significância de 0,05 para todas as análises.* ***Resultados:*** *As participantes tinham idade média de 37,25 ± 7,80 anos e praticavam a modalidade há 34,5 meses em média. Mulheres com IUE (n = 16) apresentaram menor número de repetições rápidas e lentas (p = 0,052), menor intensidade de contrações tônicas da MAP (p = 0,054), maior tempo antes do pico das contrações fásicas (p = 0,041), maior tempo antes do pico das contrações tônicas (p = 0,009) e maior tempo após o pico das contrações tônicas (p = 0,006) do que mulheres sem IUE (n = 24).* ***Conclusão:*** *Mulheres com IUE durante a atividade física apresentam déficits no funcionamento das contrações das fibras musculares rápidas e lentas, bem como atividade bioelétrica reduzida nas fibras tônicas e fásicas da MAP. Além disso, essas mulheres frequentemente apresentam falta de sinergia abdominal-pélvica. Esses achados indicam uma importante relação entre parâmetros bioelétricos e a presença de IUE, fornecendo uma base para o desenvolvimento de futuras intervenções voltadas à prevenção e reabilitação da saúde.*

Palavras-chave: *Exercício físico. Assoalho pélvico. Incontinência urinária de esforço. Mulheres.*

Introduction

Urinary incontinence (UI), defined by the International Continence Society (ICS) as any involuntary loss of urine, is a prevalent disorder among women.[1,2]

Common risk factors include menopause, obesity, and multiparity, with stress urinary incontinence (SUI) being the most frequent type, characterized by urine loss during physical exertion, coughing, or sneezing.[3] SUI may result from bladder neck hypermobility due to impaired support, intrinsic sphincter deficiency, or hormonal and surgical factors.[4] Additionally, pelvic floor muscle (PFM) spasms and fatigue can compromise contraction efficiency, especially of type I fibers, reducing oxygenation and muscle endurance. SUI occurs when bladder pressure – formed by detrusor and abdominal muscle contraction – exceeds urethral closing pressure.[5,6]

UI is a stigmatizing condition that impairs quality of life and may discourage physical activity. Prevalence increases with age, affecting 12.4% of young women, 45% of postmenopausal women, and 75% of older adults.[7] High-impact sports may increase the risk of UI by up to nine times.[8] Studies show that 40% of cross-training practitioners report at least one episode of urine leakage, particularly during jumping exercises.[9] Among female athletes, UI prevalence can reach 75.6% in volleyball, 72.7% in trampoline, and ranges from 20 to 50% in other modalities such as indoor soccer, skiing, running, basketball, and handball.[10,11]

The pelvic floor consists of muscles, ligaments, and fascia, responsible for supporting pelvic and abdominal organs, maintaining continence, and contributing to sexual function.[11] The PFM are composed predominantly of type I tonic fibers (70%), which maintain baseline tone and continence at rest, and type II phasic fibers (30%), activated during sudden increases in intra-abdominal pressure.[12] When this muscular support is compromised, and intra-abdominal pressure surpasses urethral closure force, urine leakage may occur.[13] High-intensity exercises further increase intra-abdominal pressure and may overload the PFM.

The aim of the present study was to evaluate the functional and bioelectrical activity of PFM in female cross-training practitioners with and without symptoms of SUI during sports practice.

Methods

This is a cross-sectional study that included female high-impact exercise practitioners who were divided into two groups: women with and without SUI. The study was approved by the Institutional Review Board of the

Federal University of Mato Grosso do Sul (UFMS), under approval number 5.834.048. All participants provided written consent prior to assessments.

The criteria for inclusion were a women aged between 18 and 50 years and participation in high-impact activity for at least 8 months at least three times per week, over than 50 minutes, based on the International Physical Activity Questionnaire (IPAQ).[14] Exclusion criteria were the use of antimuscarinic drugs, genital prolapse in physical exam, urinary tract infection, nocturia, enuresis, a history of pelvic floor exercises, and abdominal or pelvic surgery. Women who were virgins, pregnant, puerperal, or post-menopausal were also excluded.

The sample was calculated in the Bioestat 5.3 program, through a pilot study in which group 1 (women without SUI) obtained an average of tonic contractions of 40.99 ± 16.19 μV and group 2 (women with SUI) an average of tonic contractions of 27.95 ± 10.95 μV, assuming a 1:1 relationship between groups, a statistical power of 80% and an alpha (type I error) of 0.05, reaching the minimum need of 17 members in each group in order to control type I and type II statistical errors.

To minimize selection bias, participants were selected from gyms in three different regions of the city of Campo Grande, Mato Grosso do Sul, Brazil, with the aim of representing different socioeconomic profiles and levels of sports practice during the period from March 2021 to March 2022 (Figure 1). Recruitment took place through an email invitation and those who accepted were scheduled for an interview and physical evaluation at Women's Health Laboratory of the "Integrated Clinic School", at UFMS. The initial assessment consisted of the application of a sociodemographic and clinical ques-tionnaire and physical examination of PFM. To reduce confounding bias, all assessments were performed by a physiotherapist with clinical experience in pelvic dys-functions, previously trained in the standardization of procedures. In addition, instruments validated for the Brazilian population were used. To minimize response bias in sensitive questions, questionnaire responses were collected confidentially and anonymously, through self-reporting and guaranteeing anonymity/confidentiality.

The International Consultation on Incontinence Questionnaire – Short Form (ICIQ-SF) was used to assess and classify UI in the participants. This questionnaire is composed of four questions that assess the frequency, severity and impact of UI, in addition to a set of eight self-diagnosis items related to UI situations experienced by the participants.[15] The sample was divided into groups with and without SUI based on item 3: "How often do you leak urine?" Women who responded never (score 0) were classified as continent and the others as incontinent. Next, item 6 was analyzed: "When do you leak urine?" Women who answered that they leak urine during physical activity were classified as having SUI.

After this step, the participants were submitted to a functional assessment of the pelvic floor. First, anatomical and functional information about the pelvic floor was provided. The participants were asked to empty their bladder and were placed in dorsal decubitus, with the hips and knees semi-flexed. A physical therapist specialized in pelvic disorders performed the examinations. PERFECT scheme was used to assess the strength measured by palpation with one-two fingers, and the PFM function was evaluated according to the power, endurance, number of repetitions, and number of fast contractions. The power was graded from 0 to 5, according to the Oxford grading system. It is noteworthy that all the instruments used had been validated for the Portuguese language and had been adapted for the population in question.[16,17]

Next, the participants were prepared for the electromyographic evaluation. Surface electromyography (sEMG) was used to assess the PFM using the New Miotool Wireless Version with 8 channels (Miotec®, Porto Alegre/RS, Brazil). The MIO Graph software (Miotec®, Porto Alegre, RS, Brazil) was used for data acquisition. The data were stored on a laptop computer (ASPIRE-ACER-A51454G, Intel Inside Core i5, 8GB memory and 64-bit system). The subcostal region 12 to 15 cm lateral to the umbilical scar was cleaned with cotton moistened with alcohol for placement of the double electrode (Maxicor® Ag/Agcl). The electrodes were used to capture possible simultaneous activity of the left transversus abdominis muscle (TrA) to monitor the use of this muscle during PFM contraction. The reference electrode (Maxicor® Ag/Agcl) was placed on the knee in the region of the left lateral edge of the patella. The surface electrode (Maxicor® Ag/Agcl) was placed in the region of the perineum, just below the vaginal introitus (tendinous center of the perineum) and perianal region (9 and 3 o'clock direction).[18,19] The participants were asked to perform three maximum voluntary contractions, and the best contraction was selected for subsequent normalization of the signal.

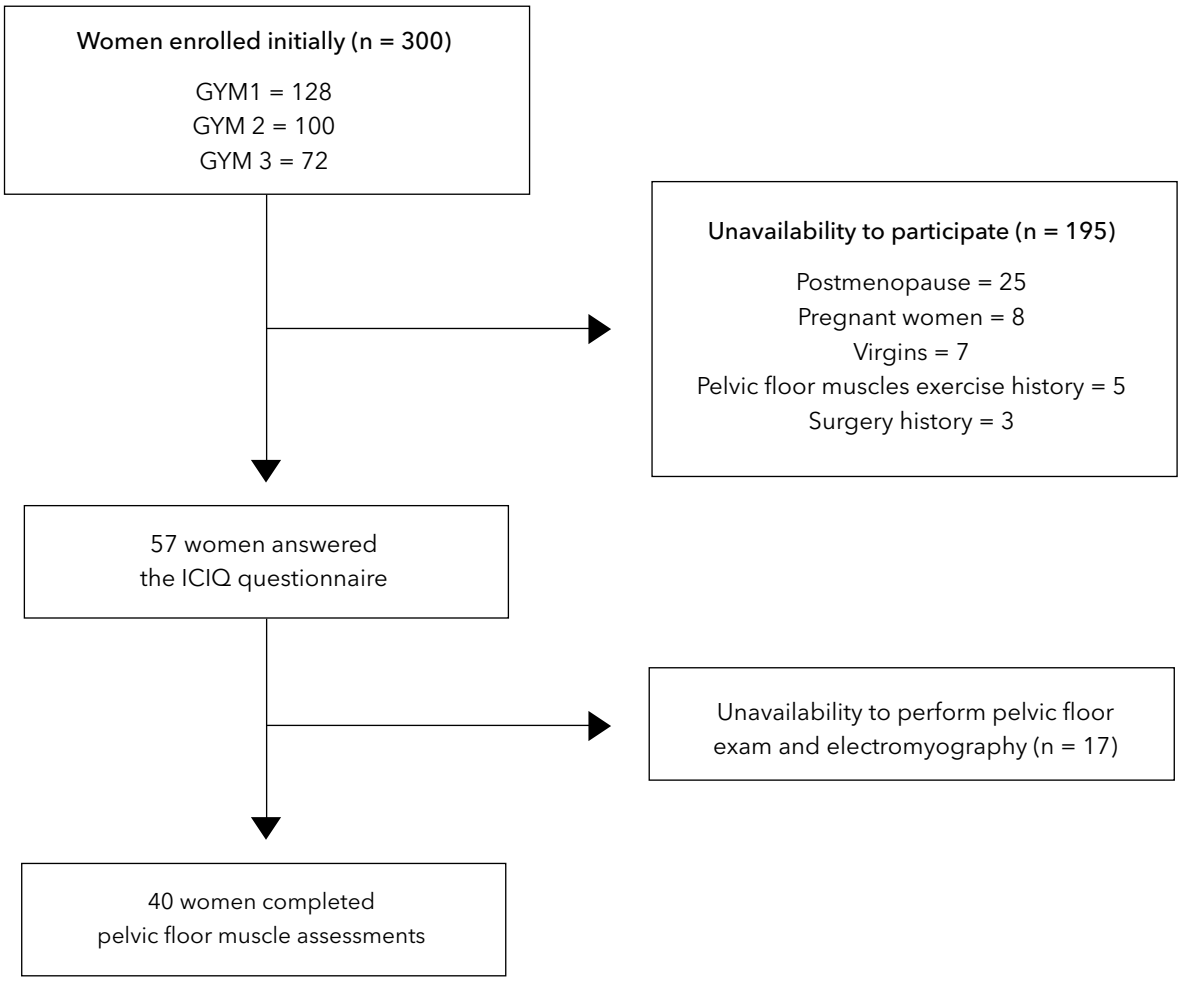

Figure 1 - Flowchart of recruitment and exclusion participants of the study.

Note: ICIQ = The International Consultation on Incontinence Questionnaire.

The Glazer protocol [20] consists of five activities:

1) 60-second rest (pre-baseline) – the women were asked to feel the pelvic floor in a resting position.

2) Five 2-second phasic contractions with 2 seconds of rest between contractions – the women were asked to contract the PFM as quickly as possible and then to rapidly and completely relax the muscles immediately after contraction.

3) Five 10-second tonic contractions with 10 seconds of rest between contractions - the women were asked to contract the PFM as hardly as possible, sustaining the contraction for 10 seconds, and then to relax the muscles completely after contraction, remaining relaxed for 10 seconds.

4) 60-second endurance contraction – the women were asked to contract the PFM to an extent that they could sustain for 60 seconds.

5) 60-second rest (post-baseline) – the women were asked to feel the pelvic floor in a resting position.

The root mean square values and mean and median frequency normalized by the maximum voluntary contractions were used for signal analysis. The Notch filter was only applied in the case of interference at 60 Hz in the Fast Fourier Transform graph. Each contraction was visually windowed considering the beginning and end of the contraction and points of greater signal stability. The values of the variables analyzed were obtained as the mean of the three contractions at each time point.[20,21]

For tetrapolar bioimpedance analysis, the participants were instructed to fast for four hours, not to exercise, to empty their bladder before the test, and to remove metal objects such as rings and earrings. The participants were evaluated in the supine position, wearing only light clothing and no shoes or socks; the upper limbs were extended and parallel to the body, with the hands open and resting on the gurney and the lower limbs apart and relaxed. The electrodes were placed as follows: the distal electrode was placed on the middle finger and on the proximal finger (thumb); on the lower limb, the electrode was placed between the lateral and medial malleoli. The participants were asked not to move during the test. The relevance of the analysis of body bioimpedance consists in characterizing the sample, demonstrating that the studied sample actually consists of women who effectively practice high-intensity activities.

The following body composition parameters were obtained: body mass index (BMI), skeletal muscle mass, fat mass, fat percentage, segmental lean mass analysis, and segmental water analysis. The Biodynamics 450 bioimpedance analyzer (Biodynamics, Seattle, WA) was used.

Statistical analysis

The data were reported as the mean and standard deviation and were analyzed using the Statistical Package for the Social Sciences (SPSS, version 20.0). The Mann-Whitney U test was used for the analysis of homogeneity and of differences between groups. Inferential analysis was performed using the Student t-test to determine the existence of any difference between means of the two groups. A level of significance of 0.05 was adopted for all analyses. No missing data was observed in the variables analyzed. All participants included presented complete responses in the instruments used and in the physical assessments performed.

Results

The sample of the pilot study consisted of 40 women with a mean age of 37.25 ± 7.80 years, including 16 participants with SUI and 24 without SUI. The sample sizes of the two groups were different; however, the groups were similar in terms of age, BMI, fat percentage, and trunk muscle mass.

Table 1 shows the body composition parameters of the sample obtained by bioimpedance. There was no statistically significant difference in the body composition variables between participants with and without SUI.

Table 2 shows the variables of the PERFECT scheme obtained by digital vaginal palpation of the PFM. There was a statistically significant difference between participants with and without SUI regarding the number of slow and fast contractions of the pelvic floor muscles.

Table 1 - Clinical characteristics and body composition of female cross-training practitioners with and without stress urinary incontinence (SUI), Campo Grande, Brazil

Characteristics	Without SUI (n = 24)	With SUI (n = 16)	p-value
Age (years)	37.80 ± 6.10	36.30 ± 10.10	0.693
BMI (kg/m²)	24.57 ± 4.04	23.86 ± 2.75	0.674
TMM (kg)	20.71 ± 2.40	21.68 ± 2.52	0.408
Fat percentage	24.49 ± 6.89	22.96 ± 4.36	0.590
TLM (%)	102.89 ± 7.58	106.93 ± 7.82	0.271

Note: BMI = body mass index; TMM = trunk muscle mass; TLM = trunk lean mass.

Table 2 - Analysis of the PERFECT scheme of female cross-training practitioners with and without stress urinary incontinence (SUI), Campo Grande, Brazil (n = 40)

PERFECT variables	Without SUI (n = 24)	With SUI (n = 16)	p-value
Power	4.0 ± 2.0	3.0 ± 1.0	0.699
Endurance (s)	5.0 ± 4.0	4.0 ± 4.0	0.109
Slow repetitions (n)	8.0 ± 1.5	5.0 ± 2.0	0.052*
Fast repetitions (n)	8.0 ± 3.5	4.5 ± 5.0	0.052*

Note: Data areexpressed as mean ± standard deviation. Inferential analysis was performed using the Student t-test. *Significant at $p < 0.05$. s = seconds.

The electromyographic variations are presented in Table 3. Among the 40 women submitted to pelvic floor assessment, most women without SUI (91.6%) and 62.5% of the women with SUI had good coordination of the PFM and TrA (abdominal-pelvic synergism). Regarding baseline muscle tone, most women had normal baseline tone, while three women without SUI and nine with SUI exhibited hyperactive baseline tone.

Table 3 - Surface electromyography of the pelvic floor and transversus abdominis muscles in female cross-training practitioners with and without stress urinary incontinence (SUI), Campo Grande, Brazil

Electromyographic parameter	Without SUI (n = 24)	With SUI (n = 16)	p-value
Pre-baseline rest	9.70 ± 9.06	17.80 ± 24.00	1.000
Phasic contractions – average mean (μV)	42.40 ± 16.00	35.70 ± 16.10	0.247
Phasic contractions – time before peak (s)	0.31 ± 0.15	0.64 ± 0.49	0.041*
Phasic contractions – time after peak (s)	0.36 ± 0.42	0.71 ± 0.44	0.063
Tonic contractions – average mean (μV)	42.30 ± 16.10	27.50 ± 10.90	0.054*
Tonic contractions – time before peak (s)	0.67 ± 0.92	1.76 ± 1.33	0.009*
Tonic contractions – time after peak (s)	0.28 ± 0.29	4.91 ± 3.37	0.006*
Endurance contractions – median frequency (Hz)	135.40 ± 52.90	137.40 ± 27.50	0.440
Endurance contractions – mean frequency (Hz)	158.00 ± 24.10	416.80 ± 696.50	0.217
Endurance contractions – average peak (μV)	26.40 ± 22.70	27.90 ± 26.70	0.939
Post-baseline rest	9.79 ± 10.53	18.20 ± 23.90	0.643
Time to endurance contractions	39.70 ± 19.85	23.00 ± 18.90	0.101
Transversus – peak phasic contractions	43.75 ± 28.93	38.20 ± 15.30	0.817
Transversus – peak tonic contractions	54.58 ± 40.61	43.11 ± 15.20	0.817

Note: Data are expressed as mean ± standard deviation. Mann-Whitney U test for independent samples and for the determination of differences between groups. Mann-Whitney U test p-value for quantitative variables. *Significant at $p < 0.05$.

No significant interactions between participants with and without SUI were found for the following variables: pre-baseline rest, time after peak phasic contractions, median and mean frequency during endurance contractions, peak endurance contraction of PFM, or maximum voluntary contraction of phasic and tonic fibers of the TrA.

There was a statistically significant difference in the following electromyographic parameters between participants without and with SUI, respectively: average mean of tonic contractions (42.3 ± 16.1 versus 27.5 ± 10.9 μV, $p = 0.054$), time before peak phasic contractions (0.31 ± 0.15 versus 0.64 ± 0.49 s, $p = 0.041$), time before peak tonic contractions (0.67 ± 0.92 versus 1.76 ± 1.33 s, $p= 0.009$), and time after peak tonic contractions (0.28 ± 0.29 versus 4.91 ± 3.37 s, $p = 0.006$).

Discussion

This study aimed to analyze the function and bioelectrical activity of the PFM in female cross-training practitioners with and without symptoms of SUI. Instruments such as bioelectrical impedance analysis and the IPAQ were used solely to characterize the sample. In terms of body composition, 45% of participants had a BMI, segmental water content, and skeletal muscle mass – especially in the upper limbs and trunk (80%) – above reference values.[22] Beside this, body fat percentage was within normal limits in 80% of the sample. These results reflect a group of regular practitioners (average of 29 uninterrupted months), with evident muscular development in the trunk and upper limbs relative to their weight and age.

This muscular profile can be attributed to the demands of cross-training, which involves high-intensity strength training with rapid execution of compound movements such as squats, deadlifts, cleans, snatches, and overhead presses. Both Olympic lifts and gymnastic elements require substantial upper limb recruitment for lifting progressive loads or supporting body weight on bars or rings, leading to hypertrophy and increased intracellular water in these regions.[23]

The results in Table 2 show a statistically significant difference in the PERFECT scheme variables between participants with and without SUI. Women with SUI presented reduced capacity for both slow and fast PFM contractions, as assessed by digital vaginal palpation. These findings indicate altered pelvic floor muscle function in this group, reinforcing the relevance of evaluating both contraction types in clinical assessments of SUI.

EMG is a consistent and specific method for assessing PFM activity, particularly through the Glazer protocol in women with SUI. Despite its limitations – such as inability to isolate deep muscles and potential interference from adjacent musculature – these factors were minimized through standardized procedures. Assessments were performed by a trained physiotherapist in a controlled setting, following SENIAM (Surface EMG for non-invasive assessment of muscles) guidelines and ICS standards for pelvic floor evaluation.

Electromyographic analysis, based on Glazer protocol values, showed that women without SUI exhibited phasic EMG amplitudes comparable to those of young nulliparous women. In contrast, women with SUI demonstrated lower bioelectrical activity in both phasic and tonic fiber amplitudes, indicating impaired neuromuscular performance.[19,20]

The analysis of the time before peak revealed that only women with SUI showed a delay in the onset of both phasic and tonic PFM contractions. This delay was not observed in continent women, who demonstrated more efficient activation within the expected time frame. The analysis of time after peak revealed that only women with SUI showed reduced ability to sustain contraction over time of tonic fibers. Additionally, the SUI group presented lower amplitude during tonic contractions, indicating impaired neuromuscular performance. These findings underscore the importance of assessing muscle response time in the functional evaluation of SUI. Supporting this, Chen et al.[24] demonstrated reduced pelvic floor contractility in women with SUI, with tonic contraction amplitude being associated with the presence of the condition. Furthermore, Falah-Hassani et al.[1] reported morphofunctional alterations such as decreased maximum urethral closing pressure and inadequate support of the bladder neck, reinforcing the contribution of neuromuscular deficits to the pathophysiology of SUI.

Although no significant differences were observed in the intensity or duration of TrA contraction between women with and without SUI, the present study identified impaired abdominal-pelvic coordination in the SUI group. Nearly half of these women failed to demonstrate effective synergy between the TrA and PFM, suggesting that neuromuscular coordination, rather than isolated abdominal strength, plays a central role in continence maintenance. This lack of coordination becomes especially relevant in high-impact physical activities, where increased intra-abdominal pressure should ideally trigger simultaneous PFM activation to maintain continence.[25] However, many female athletes do not perform – or are unaware of – the need for voluntary or reflexive PFM en-gagement during such efforts. The absence of this coactivation, combined with repetitive high loads, may lead to pelvic floor fatigue, overstretching, and dysfunction. Over time, these factors compromise the support provided by key muscles such as the levator ani, increasing the risk of SUI.[26] Supporting this, recent studies have shown a higher prevalence of UI among female athletes – especially in jump-based sports and CrossFit – highlighting the role of factors such as age, BMI, and parity in increasing risk.[27-29] These findings align with the neuromuscular dysfunctions observed in the SUI group of the present study.

While recent studies have primarily focused on the prevalence of SUI among female athletes engaged in high-impact or strength-based sports,[29,30] few have investigated the neuromuscular function of the pelvic floor in this population. These studies rely mainly on self-reported data and do not offer objective assessments of PFM function. One exception is a study that compared vaginal pressure-based PFM strength between elite female athletes, suggesting that general athletic training may not sufficiently strengthen the PFM and that specific exercises are required.[31]

The reduced ability to generate and sustain tonic contractions, along with delayed muscular responses observed in the incontinent group, highlights a neuromuscular dysfunction that may compromise the continence mechanism during high-impact physical activities. These findings underscore the importance of early identification of functional impairments through clinical evaluation tools, which provide objective parameters to guide individualized physiotherapeutic planning.

From a clinical perspective, the results support the inclusion of targeted pelvic floor rehabilitation strategies, which should address the velocity of muscle activation, the ability to sustain each contraction, and especially the coordination between the abdominal and PFM. These strategies are particularly relevant for physically active women, especially those involved in high-impact modalities such as cross-training.

The frequent occurrence of SUI in cross-training practitioners, as observed in previous studies,[31-33] further reinforces the need for preventive programs focused on pelvic floor awareness, functional training, and early

identification of dysfunctions. Educational campaigns led by health professionals can contribute to demystifying the condition, encoura-ging open dialogue, and guiding women toward evidence-based interventions that may enhance both their athletic performance and quality of life.

Limitations

This study has two main limitations. The first is the small sample size, which limited the statistical power and prevented adjustments for potential confounding variables such as age, BMI, and parity. As a result, it was not possible to perform subgroup or interaction analyses, which could have revealed relevant differences among groups. Dividing the sample into smaller strata could introduce bias and compromise the robustness of the findings. Future studies with larger samples are essential to support more reliable multivariate analyses and subgroup comparisons.

The second limitation relates to the timing of data collection, which occurred during the COVID-19 pandemic. Social distancing measures and restricted access to gyms made participant recruitment more challenging and may have limited sample diversity. This context should be considered when interpreting the results and their generalizability.

Conclusion

This study demonstrated that women with SUI during physical activity exhibit a delay in the onset of both phasic and tonic muscle contractions, as well as reduced time of activity in the tonic contractions of the PFM. Additionally, these women frequently display a lack of abdominal-pelvic coordination. These findings indicate an important relationship between bioelectrical parameters and the presence of SUI, providing a foundation for the development of future interventions aimed at health prevention and rehabilitation.

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Authors' contributions

SSPCF, FRBS and YTCP were responsible for data acquisition, and HAPS and GC for the analysis and interpretation of data. SSPCF wrote and edited the manuscript, while ABGSP critically reviewed the article. All authors approved the final version

References

1. Falah-Hassani K, Reeves J, Shiri R, Hickling D, McLean L. The pathophysiology of stress urinary incontinence: a systematic review and meta-analysis. Int Urogynecol J. 2021;32(3):501-52. https://doi.org/10.1007/s00192-020-04622-9

2. Araújo MP, Brito LGO, Rossi F, Garbiere ML, Vilela ME, Bittencourt VF; Cross Continence Brazil Collaboration Group. Prevalence of female urinary incontinence in Crossfit practitioners and associated factors: an internet population - Based survey. Female Pelvic Med Reconstr Surg. 2020;26(2):97-100. https://doi.org/10.1097/spv.0000000000000823

3. Bø K, Nygaard IE. Is physical activity good or bad for the female pelvic floor? A narrative review. Sports Med. 2000;50 (3):471-484. https://doi.org/10.1007/s40279-019-01243-1

4. Haylen BT, Ridder D, Freeman RM, Swift SE, Berghmans B, Lee J, et al. An International Urogynecological Association (IUGA/International Continence Society (ICS) joint report on the terminology for female pelvic floor dysfunction. Neurourol Urodyn. 2010;29(1):4-20. https://doi.org/10.1002/nau.20798

5. Brennand E, Ruiz-Mirazo E, Tang S, Kim-Fine S; Calgary Women's Pelvic Health Research Group. Urinary leakage during exercise: problematic activities, adaptive behaviors, and interest in treatment for physically active Canadian women. Int Urogynecol J. 2018;29(4):497-503. https://doi.org/10.1007/s00192-017-3409-1

6. Araujo MP, Parmigiano TR, Della Negra LG, Torelli L, Carvalho CG, Wo L, et al. Avaliação do assoalho pélvico de atletas: existe relação com a incontinência urinária? Rev Bras Med Esporte. 2015;21(6):442-6. https://doi.org/10.1590/1517-869220152106140065

7. Elks W, Jaramillo-Huff A, Barnes KL, Petersen TR, Komesu YM. The Stress Urinary Incontinence in CrossFit (SUCCeSS) Study.

Female Pelvic Med Reconstr Surg. 2020;26(2):101-6. https://doi.org/10.1097/spv.0000000000000815

8. Yang J, Cheng JW, Wagner H, Lohman E, Yang SH, Krishingner GA, et al. The effect of high impact crossfit exercises on stress urinary incontinence in physically active women. Neurourol Urodyn. 2019;38(2):749-56. https://doi.org/10.1002/nau.23912

9. Simeone C, Moroni A, Pettenò A, Antonelli A, Zani D, Orizio C, et al. Occurrence rates and predictors of lower urinary tract symptoms and incontinence in female athletes. Urology. 2010; 77(2):139-46. https://doi.org/10.1177/039156031007700210

10. Bø K. Exercise and pelvic floor dysfunction in female elite athletes. In: Muntjoy ML, editor. Handbook of Sports Medicine and Science: The Female Athlete. Hoboken, New Jersey: Wiley Blackwell; Sports Med. 2015;34(7):451-64. https://doi.org/10.1002/9781118862254.ch8

11. Reis AO, Câmara CNS, Santos SG, Dias TS. Comparative study of the capacity of pelvic floor contraction in volleyball and basketball athletes. Rev Bras Med Esporte. 2011;17(2):97-101. https://doi.org/10.1590/S1517-86922011000200005

12. Veiga PB, Furlanetto MP. Perfil eletromiográfico do assoalho pélvico de bailarinas de dança do ventre. Fisioter Bras. 2020; 21(6):592-600. https://doi.org/10.33233/fb.v21i6.4207

13. Casey EK, Temme K. Pelvic floor muscle function and urinary incontinence in the female athlete. Phys Sportsmed. 2017; 45(4):399-407. https://doi.org/10.1080/00913847.2017.1372677

14. Pardini R, Matsudo S, Araújo T, Matsudo V, Andrade E, Braggion G, et al. Validação do questionário internacional de nível de atividade física (IPAQ - versão 6): estudo piloto em adultos jovens brasileiros. Rev Bras Cien Mov. 2001;9(3):45-51. https://portalrevistas.ucb.br/index.php/rbcm/article/view/393

15. Tamanini JTN, Dambros M, D'Ancona CAL, Palma PCR, Netto Jr NR. Validation of the "International Consultation on Incontinence Questionnaire - Short Form" (ICIQ-SF) for Portuguese. Rev Saude Publica. 2004;38(3):1-6. https://doi.org/10.1590/S0034-89102004000300015

16. Laycook J, Jerwood D. Pelvic floor muscle assessment: The PERFECT scheme. Physiotherapy. 2001;87(12):631-42. https://doi.org/10.1016/S0031-9406(05)61108-X

17. Pereira VS, Correia GN, Driusso P. Individual and group pelvic floor muscle training versus no treatment in female stress urinary incontinence: A randomized controlled pilot study. Eur J Obstet Gynecol Reprod Biol. 2011;159(2):465-71. https://doi.org/10.1016/j.ejogrb.2011.09.003

18. Ferreira AS, Guimarães FS, Silva JG. Aspectos metodológicos da eletromiografia de superfície: considerações sobre os sinais e processamentos para estudo da função neuromuscular. Rev Bras Cienc Esporte. 2010;31(2):11-30. http://revista.cbce.org.br/index.php/RBCE/article/view/300

19. Bertotto A, Schvartzman R, Uchôa S, Wender MCO. Effect of electromyographic biofeedback as an add-on to pelvic floor muscle exercises on neuromuscular outcomes and quality of life in postmenopausal women with stress urinary incontinence: A randomized controlled trial. Neurourol Urodyn. 2017;36(8):2142-7. https://doi.org/10.1002/nau.23258

20. Oleksy Ł, Wojciechowska M, Mika A, Antos E, Bylina D, Kielnar R, et al. Normative values for Glazer Protocol in the evaluation of pelvic floor muscle bioelectrical activity. Medicine (Baltimore). 2020;99(5):e19060. https://doi.org/10.1097/md.0000000000019060

21. Resende APM, Nakamura MU, Ferreira EAG, Petricelli CD, Alexandre SM, Zanetti MRD. Eletromiografia de superfície para avaliação dos músculos do assoalho pélvico feminino: revisão de literatura. Fisioter Pesqui. 2011;18(3):292-7. https://doi.org/10.1590/S1809-29502011000300016

22. Barbão KEG, Pavanello A, Oliveira FM, Santos NQ, Valdés-Badilla P, Marchiori LLM, Franchini E, Branco BHM. Variation in body composition components across different age groups and proposal of age-specific normative aables: A cross-sectional study. Nutrients. 2025; 17(9):1435. https://doi.org/10.3390/nu17091435

23. Chacao M, Dominski FH, Steclan C, Fuentes Filho AR, Petreça DR. Perfil de composição corporal e de somatotipos de praticantes de Crossfit®. Rev Bras Presc Fisiol Exerc. 2019; 13(82):212-20. https://www.rbpfex.com.br/index.php/rbpfex/article/view/1661

24. Chen J, Ren Y, Zhu L. Correlation between modified Oxford grading scale and pelvic floor surface electromyography in assessment of pelvic floor muscle function in female patients with stress urinary incontinence. Zhonghua Yi Xue Za Zhi. 2020; 100(37):2908-12. https://doi.org/10.3760/cma.j.cn112137-20200301-00525

25. Madill SJ, Harvey MA, McLean L. Women with SUI demonstrate motor control differences during voluntary pelvic floor muscle contractions. Int Urogynecol J Pelvic Floor Dysfunct. 2009;20(4):447-59. https://doi.org/10.1007/s00192-008-0800-y

26. Joseph C, Srivastava K, Ochuba O, Ruo SW, Alkayyali T, Sandhu JK, et al. Stress urinary incontinence among young nulliparous female athletes. Cureus. 2021;13(9):e17986. https://doi.org/10.7759/cureus.17986

27. Bø K, Borgen JS. Prevalence of stress and urge urinary incontinence in elite athletes and controls. Med Sci Sports Exerc. 2001;33(11):1797-802. https://doi.org/10.1097/00005768-200111000-00001

28. Caetano AS, Tavares MCGCF, Lopes MHBM. Urinary incontinence and physical activity practice. Rev Bras Med Esporte. 2007;13(4):245-8e. https://doi.org/10.1590/S1517-86922007000400012

29. Dominguez-Antuña E, Diz JC, Suárez-Iglesias D, Ayán C. Prevalence of urinary incontinence in female CrossFit athletes: a systematic review with meta-analysis. Int Urogynecol J. 2023;34(3):621-34. https://doi.org/10.1007/s00192-022-05244-z

30. Dominguez-Antuña E, Diz JC, Ayán C, Suárez-Iglesias D, Rodríguez-Marroyo JA. Prevalence and severity of urinary incontinence among male and female competitors and recreational CrossFit® practitioners. Eur J Obstet Gynecol Reprod Biol. 2022;276:144-7. https://doi.org/10.1016/j.ejogrb.2022.07.014

31. Skaug KL, Engh ME, Frawley H, Bø K. Prevalence of pelvic floor dysfunction, bother, and risk factors and knowledge of the pelvic floor muscles in Norwegian male and female powerlifters and Olympic weightlifters. J Strength Cond Res. 2022;36(10):2800-7. https://doi.org/10.1519/jsc.0000000000003919

32. George R. 'If you wee yourself, you just rock on': is incontinence inevitable for women who lift heavy? [Internet]. The Guardian; 2025 Jan 21 [cited 2025 May 11]. Available from: https://tinyurl.com/bdaryxzn

33. Ludviksdottir I, Hardardottir H, Sigurdardottir T, Ulfarsson GF. Comparison of pelvic floor muscle strength in competition-level athletes and untrained women. Laeknabladid. 2018;104(3):133-8. https://doi.org/10.17992/lbl.2018.03.177

Data Availability Statement

Research data is not available.