

Is there a difference in balance between continent and incontinent women?

Existe diferença no equilíbrio entre mulheres continentes e incontinentes?

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Abstract

Introduction: Urinary incontinence is defined as any involuntary loss of urine. An imbalance in the transmission of forces between the bladder and urethra, associated with deficient support of the pelvic floor muscles, contributes to an alteration in balance in women. **Objective:** To compare balance between continent and incontinent women. **Methods:** This was a cross-sectional study with 13 women divided into incontinent (age: 41.50 ± 9.13 years) and continent (age: 35.29 ± 4.99 years) groups. Balance assessments were performed using a force platform and electromyography: standing, with eyes open (BI_OA); standing, with eyes closed (BI_OF); standing on foam, with eyes open (ESP_OA) and closed (ESP_OF); and standing with unipedal support, with eyes open (UNI_OA). Statistical analysis was initiated after resampling of the original data using the bootstrap technique, with the α value set at 5% ($p < 0.05$). **Results:** In the BI_OA task, no significant differences were found between the groups. In the BI_OF task, incontinent women showed greater displacement in the anteroposterior axis ($p < 0.001$), and continent women showed greater displacement in the mediolateral axis ($p = 0.008$). In the ESP_OA task, incontinent women showed greater displacement in both the COP_X ($p = 0.003$) and COP_Y ($p = 0.001$) axes; in the ESP_OF task, continent women showed greater displacement in the COP_X ($p < 0.001$) axis. In the UNI_OA task, greater anteroposterior displacement was observed among incontinent women ($p = 0.008$). **Conclusion:** Continent women showed greater displacement in the mediolateral axis in the tasks with eyes closed, and incontinent women showed greater displacement in the anteroposterior axis in the BI_OF, ESP_OA, and UNI_OA tasks.

Keywords: Electromyography. Postural balance. Urinary incontinence.

Resumo

Introdução: *A incontinência urinária é definida como qualquer perda involuntária de urina. Um desequilíbrio na transmissão de forças entre bexiga e uretra, associado a um suporte deficitário dos músculos do assoalho pélvico, contribui para uma alteração no equilíbrio de mulheres.* ***Objetivo:*** *Comparar o equilíbrio entre mu-lheres continentes e incontinentes.* ***Métodos:*** *Trata-se de um estudo transversal, com 13 mulheres divididas em incontinentes (idade: 41,50 ± 9,13 anos) e continentes (idade: 35,29 ± 4,99 anos). A avaliação do equilíbrio foi realizada na plataforma de força associada à eletromiografia: em pé, com olhos abertos (BI_OA); em pé, com olhos fechados (BI_OF); em pé sobre uma espuma, com olhos abertos (ESP_OA) e fechados (ESP_OF); e em pé com apoio unipodal, com olhos abertos (UNI_OA). A análise estatística foi iniciada após a reamostragem dos dados originais pela técnica Bootstrap, com valor de α fixado em 5% (p < 0,05).* ***Resultados:*** *Na avaliação do equilíbrio BI_OA, não foram encontradas diferenças significativas entre os grupos. No BI_OF, as mulheres incontinentes apresentaram maior deslocamento no eixo anteroposterior (p < 0,001), enquanto as continen-tes, no médio-lateral (p = 0,008). Na tarefa ESP_OA, as incontinentes apresentaram maior deslocamento em ambos os eixos COP_X (p = 0,003) e COP_Y (p = 0,001); já na ESP_OF, as continentes apresentaram maior deslocamento no COP_X (p < 0,001). Na tarefa UNI_OA, observou-se maior deslocamento anteroposterior entre as incontinentes (p = 0,008).* ***Conclusão:*** *Mulheres continentes apresentaram maiores deslocamentos no eixo médio-lateral nas tarefas de olhos fechados, enquanto as incontinentes, no eixo anteroposterior nas tarefas BI_OF, ESP_OA, UNI_OA.*

Palavras-chave: *Eletromiografia. Equilíbrio Postural. Inconti-nência urinária.*

Introduction

The International Continence Society (ICS) defines urinary incontinence (UI) as any involuntary loss of urine. It is a pathology that results in deleterious effects on daily activities, leading to sexual issues, social embarrassment, low self-esteem and depression.[1]

UI can be caused by bladder abnormalities, neurological diseases, and changes in pelvic muscle strength or by increased pressure on the pelvic floor muscles (PFMs), ligaments and connective tissue.[2] Due to their anatomical structure, PFMs are intimately involved in the function of the lower urinary tract and anorectal and sexual function.[2] The normal function of these muscles is an important predictor of the continence mechanism during increased intra-abdominal pressure generated by functional tasks, indirectly contributing to lumbopelvic stabilization and postural control.[3,4]

Postural control is defined as a process by which the central nervous system (CNS) generates patterns of muscle activity necessary to regulate the relationship between the body's centre of mass and the base of support. Postural control is the balance that is achieved when all external and internal forces are controlled, allowing the body to remain in a desired position (static balance) or to move in a controlled manner (dynamic balance).[5] Recent evidence suggests that women with stress urinary incontinence (SUI) exhibit an increase in trunk muscle activity when subjected to changes in postural control.[6]

The increase in PFM activity in relation to postural disturbances is important for both continence and lumbopelvic stability. An imbalance in the transmission of forces between the bladder and urethra, associated with deficient PFM support, was identified in women with UI in situations of increased intra-abdominal pressure.[4,5]

In view of the biomechanical function of the pelvic muscles in stabilizing the pelvis and their synergistic action with the PFMs in maintaining urinary continence and postural control, women with UI may have a deficit in these functions due to muscle imbalance. The objective of this study was to evaluate the difference in static and dynamic balance in five different positions between continent and incontinent women.

Methods

This was a cross-sectional study with a quantitative approach conducted at the Laboratory of Biomechanics of the Federal University of Uberlândia (UFU), located at the Center of Sports Excellence (CENESP), Physical Education Campus. This study was approved by the Research Ethics Committee of UFU under protocol 2,088,840 and CAAE 65933017.5.0000.5152. All volunteers who participated in the study read and signed a free and informed consent form (ICF) prior to data collection, evidencing that they agreed to participate in the study.

Regarding the sample, referencing the proposal by Madill and McLean,[7] thirteen women were included in this study and divided into two groups: an incontinent group (IG), with six women with a mean age of 41.5 ± 9.13 years, and a continent group (CG), with seven women with a mean age of 35.29 ± 4.99 years (p = 0.32). The IG comprised six women diagnosed with mild to moderate SUI,[8] confirmed by the medical report of a urodynamic exam. The CG comprised seven women without signs and symptoms of UI who were selected through convenience sampling, i.e., recruited through social media and personal contacts of the researchers.

The inclusion criteria for both groups were primiparous or multiparous women, regardless of the type of delivery, without self-reported signs and symptoms of menopause and a body mass index (BMI) between 19 and 25 kg/m². The exclusion criteria for both groups were as follows: nulliparous; urge incontinence, characterized by the triad urgency to urinate, nocturia and increased urinary frequency;[9] presence of respiratory diseases; diabetes; history of pelvic or abdominal surgery to correct any urogynaecological dysfunction; any type of treatment for UI, constipation or smoking (as these are risk factors for UI and PFM[10] injury). In addition, women with neurological and vestibular diseases, severe changes in the lower limbs and a history of falls were excluded, as these conditions affect body balance. Figure 1 shows the framework of the study.

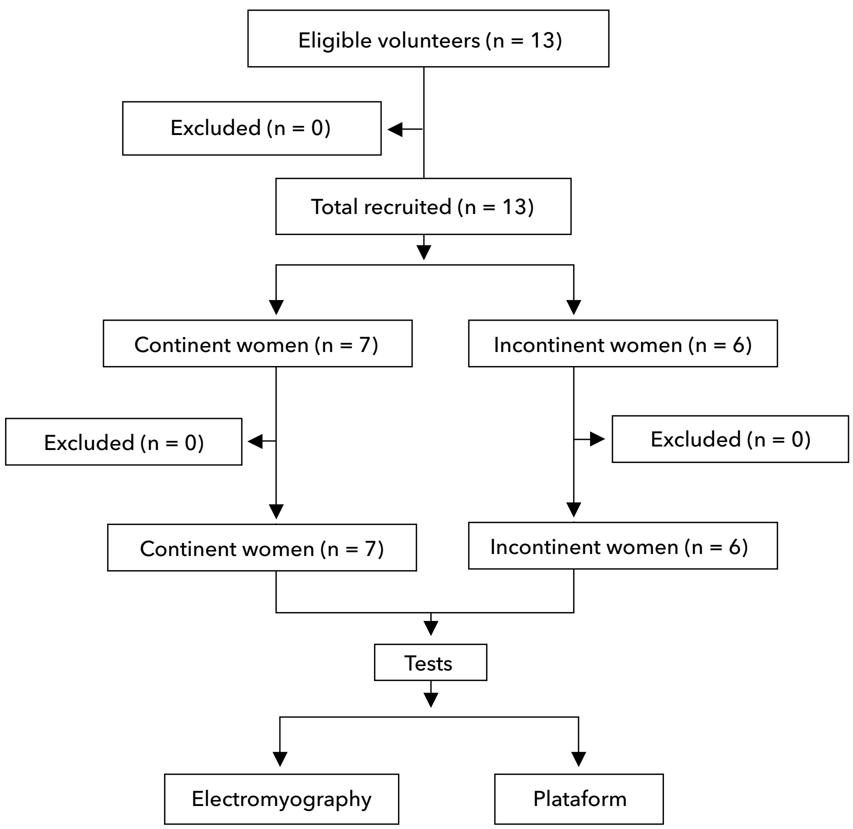

Figure 1 - Study framework.

A 16-channel electromyograph (EMG System®) was used to perform electromyography (EMG) at a sampling rate of 2000 Hz. This equipment was connected to a battery that was not connected to the electrical network so that there was no electrical interference at the time of the exam. The electrical activity data generated by muscle contractions were collected through software installed on a computer. Prior to EMG, local areas were shaved and conductive gel was applied to improve the contact between the electrode and the skin at the time of

EMG data collection. Disposable 3M® surface electrodes were positioned along the line of action of the muscle fibres of the dominant side of the participant,[11] and the reference electrode was placed on the fibular head of the dominant leg. The following muscles were evaluated:

• Rectus abdominis (RA): 2 cm lateral and caudal to the umbilicus;

• External obliques (EO): over the body of the eighth rib towards the muscle fibres;

• Internal obliques (IO): at the midpoint between the anterior superior iliac spine and the pubic symphysis towards the muscle fibres;

• Gluteus medius (GM): 50% on the line from the iliac crest to the femoral trochanter;

• Rectus femoris (RF): 50% on the anterior superior iliac spine line to the superior surface of the patella;

• Semitendinosus (ST): 50% on the line between the ischial tuberosity and the medial condyle of the tibia;

• Tibialis anterior (TA): 1/3 proximal to the fibular head on the lateral edge of the tibia;

• Lateral gastrocnemius of the dominant leg (GL): 1/3 proximal between the fibular head and the calcaneus;

• Ipsilateral erector spinae (EE): 1 cm medial to the posterosuperior iliac spine at the L2 level.

The measurements on the force platform were performed under static and dynamic conditions using the EMG System® do Brasil, model SAC-2000. For the dynamic position, each participant was placed on a 15-cm-thick high-density foam (D33). The force platform measures and records, using load cells and software, the three components of the ground reaction force (GRF) applied in the mediolateral (X), anteroposterior (Y) and vertical (Z) directions. Using the GRF components, the centre of pressure (COP) in the anteroposterior (Y) and midlateral (X) directions under static and dynamic conditions were obtained. The signals collected from the force platform were synchronized with the signals collected from electromyography using a device provided by EMG System® (Brazil).

All data collection was performed by a specialized physical therapist. First, through telephone contact made by the researchers, volunteers were screened using the inclusion and exclusion criteria.

In the electromyographic evaluation, baseline mean muscle tone (BT) at rest for 30 seconds and maximum voluntary contraction (MVIC) for 6 seconds were captured, with a 1-minute interval between each contraction. The highest value of three consecutive replicates was recorded.[12] Subsequently, the women were positioned on the platform with bare feet aligned hip-width apart, arms along the body, head directed forwards and eyes focused on a fixed point on the wall two meters away.

To evaluate which muscles were most activated during the tasks and the strategies used by the volunteers to maintain balance, five different positions were used: bipedal support with the feet directly on the platform, with the eyes open (BI_OA); bipedal support with the feet directly on the platform, with eyes closed (BI_OF); bipedal support with the feet on foam, keeping the eyes open (ESP_OA); bipedal support with the feet on foam, keeping the eyes closed (ESP_OF); and unipedal support with the feet directly on the platform, with eyes open (UNI_OA). For the safety of the participants, the unipedal stance position with eyes closed (UNI_OF) was not tested because it is considered a posture of greater instability.

Each condition was tested for 40 seconds, and the first 10 seconds were discarded due to adaptation conditions. At each change in test condition, the participant was asked to step down from the platform to avoid postural adjustments. In addition, no previous training was performed because learning can improve postural control.[13] For each task, the participants were instructed to keep their feet positioned at specific points, remaining as still as possible. As soon as the participant established her equilibrium point, the timer was started. If she lost balance during the task and/or moved her feet from the specific point, the test was restarted until the volunteer was able to remain balanced until completion.[11]

Twenty minutes before beginning data collection, each participant ingested an average amount of 600 ml of water to activate PFM reflexes; the tonic activity of the PFMs is greater when the bladder is full.[12]

The processing of the electromyographic and force platform data was performed in MATLAB, and the data were initially filtered with different frequencies using a Butterworth digital bandpass filter. The electromyographic signal data were filtered at a cut-off frequency of 20 Hz to 500 Hz and zero phase delay, and those from the force platform were filtered at a frequency of 10 Hz.

After data collection and preprocessing, the following electromyographic and stabilometric signal variables were calculated from the force platform data:

COP_X – root mean square (RMS) of displacement in the mediolateral direction;

COP_Y – root mean square (RMS) of displacement in the anteroposterior direction;

TD – root mean square (RMS) of total displacement;

VMT – root mean square (RMS) of the average velocity of the trajectory of the centre of pressure, an indicator of how fast the COP shifts.

For the statistical analysis, Statistical Package for Social Sciences was used, the original data were resampled twenty times using the bootstrap technique. In each resampling, the mean was calculated to compose the final dataset. This technique can be applied when studies are conducted with only one data sample that is used to estimate a population parameter. Another option for using the technique is for small samples, for which the estimates of the statistical methods used may be unsatisfactory due to the bias related to significance.[14,15]

Descriptive statistics were applied to characterize the sample. Categorical variables are presented as frequency distributions, and numerical variables are presented as measures of central tendency and variability. R software was used for the statistical analysis. After the application of the Shapiro-Wilk test to verify a normal distribution of the data, the hypothesis that the data were distributed normally was rejected for the following electromyographic and stabilometric signal variables:

- Bipedal support, with eyes closed: COP_X, DT;
- Bipedal support on foam, with eyes closed: COP_X, COP_Y;
- Single leg support, with eyes open: COP_X, COP_Y, DT.

The Mann-Whitney test was used for these variables, and Student's t test was used for the others. The α value was set at 0.05 or 5% ($p < 0.05$).

Results

In the characterization of the sample, 85.7% of continent women and 50% of incontinent women had completed higher education. When investigating individual income, most incontinent women (66.6%) had an income greater than three times the minimum wage, and only 28.6% of continent women had the same income. Regarding marital status, 50% of incontinent women were married or lived with a partner, and 57.1% of continent women were divorced or single. Regarding the obstetric history of the sample, both the continent women (55.6%) and the incontinent women (80%) had the majority of their deliveries by caesarean section.

When comparing the means of the RMS values for the normalized electromyographic signal of the muscles in bipedal stance with eyes open (BI_OA), continent women had greater muscle activity in the rectus abdominis ($p < 0.001$) and rectus femoris ($p < 0.001$) muscles, and incontinent women had greater muscle activity in the external oblique ($p = 0.006$), internal oblique ($p = 0.029$), tibialis anterior ($p = 0.001$), semitendinosus ($p = 0.007$) and lateral gastrocnemius ($p = 0.021$) muscles (Table 1). In the analysis of the stabilometric variables, no significant differences were found in COP_X ($p = 0.108$), COP_Y ($p = 0.351$), TD ($p = 0.190$) and VMT ($p = 0.310$) between the CG and IG groups (Table 1).

When comparing the means of the normalized RMS values for the electromyographic signal of the same task with eyes closed (BI_OF), continent women presented greater muscle activation of the rectus abdominis ($p < 0.001$), rectus femoris ($p = 0.003$), gluteus medius ($p = 0.015$) and lateral gastrocnemius ($p = 0.027$), and incontinent women demonstrated greater activation of the tibialis anterior ($p < 0.001$) and erector spinae ($p < 0.001$) (Table 2).

In the assessment of the BI_OF task, the stabilometric evaluation showed that compared with continent women, incontinent women had greater displacement in the anteroposterior axis ($p < 0.001$) and greater total displacement ($p < 0.001$) and mean centre of pressure velocity ($p < 0.001$) (Table 2).

The comparison of the means of the RMS values for the normalized electromyographic signal in bipedal support on foam with eyes open (ESP_OA) showed greater electromyographic activity only in the rectus abdominis ($p < 0.001$), rectus femoris ($p < 0.001$) and lateral gastrocnemius ($p < 0.001$) muscles among continent women and greater electromyographic activity only in the erector spinae ($p < 0.001$) and semitendinosus ($p < 0.001$) muscles among incontinent women (Table 3). For this same task (ESP_OA), when analysing the stabilometric variables, incontinent women showed greater displacement in both axes (COP_X ($p = 0.003$) and COP_Y ($p = 0.001$)), but continent women showed greater total displacement ($p = 0.002$) and mean centre of pressure velocity ($p < 0.001$) (Table 3).

Table 1 - Root mean square (RMS) resampling values for the electromyographic and stabilometric signals in bipedal stance with eyes open

Variables	Incontinent women	Continent women	p-value
External obliques	0.11408 ± 0.025591	0.09262 ± 0.01769	**0.006**
Rectus abdominis	0.06063 ± 0.00633	0.09164 ± 0.01789	**<0.001**
Internal obliques	0.09118 ± 0.02860	0.07618 ± 0.01275	**0.029**
Rectus femoris	0.02957 ± 0.01184	0.11423 ± 0.04106	**<0.001**
Tibialis anterior	0.04406 ± 0.01659	0.02769 ± 0.00540	**0.001**
Ipsilateral erector spinae	0.07482 ± 0.01102	0.06542 ± 0.02009	0.053
Gluteus medius	0.08634 ± 0.02418	0.08677 ± 0.03630	0.818
Semitendinosus	0.04989 ± 0.03136	0.02946 ± 0.00654	**0.007**
Lateral gastrocnemius	0.08158 ± 0.00834	0.07204 ± 0.01326	**0.021**
Mean lateral centre of pressure	1.30711 ± 0.28153	1.14572 ± 0.22572	0.108
Anteroposterior centre of pressure	3.18800 ± 0.51429	2.61063 ± 0.47718	0.351
Total displacement	21.99873 ± 1.14187	22.49523 ± 1.96901	0.190
MVT of the centre of pressure	0.561043 ± 0.02564	0.54464 ± 0.05538	0.310

Note: MVT = mean velocity of the trajectory. Data are expressed as the mean ± standard deviation. Bold text indicates a statistically significant difference.

Table 2 - Root mean square (RMS) resampling values for the electromyographic and stabilometric signals in bipedal stance with eyes closed

Variables	Incontinent women	Continent women	p-value
External obliques	0.098 ± 0.015	0.100 ± 0.010	0.925
Rectus abdominis	0.055 ± 0.007	0.080 ± 0.010	**<0.001**
Internal obliques	0.081 ± 0.023	0.080 ± 0.010	0.797
Rectus femoris	0.042 ± 0.015	0.080 ± 0.040	**0.003**
Tibialis anterior	0.053 ± 0.018	0.030 ± 0.000	**<0.001**
Ipsilateral erector spinae	0.339 ± 0.275	0.060 ± 0.010	**<0.001**
Gluteus medius	0.068 ± 0.012	0.100 ± 0.040	**0.015**
Semitendinosus	0.045 ± 0.026	0.040 ± 0.010	0.310
Lateral gastrocnemius	0.081 ± 0.006	0.090 ± 0.010	**0.027**
Mean lateral centre of pressure	3.564 ± 0.531	3.720 ± 0.600	**0.008**
Anteroposterior centre of pressure	2.336 ± 0.532	1.590 ± 0.230	**<0.001**
Total displacement	29.106 ± 3.680	24.460 ± 1.530	**<0.001**
MVT of the centre of pressure	0.771 ± 0.099	0.650 ± 0.050	**<0.001**

Note: MVT = mean velocity of the trajectory. Data are expressed as the mean ± standard deviation. Bold text indicates a statistically significant difference.

The comparison of the means of the RMS values for the electromyographic signal in bipedal support on foam with eyes closed (ESP_OF) indicated that continent women had greater muscle activity in the external oblique ($p < 0.001$), rectus abdominis ($p < 0.001$), internal oblique (0.004), rectus femoris ($p < 0.001$) and gluteus medius ($p = 0.006$) and that incontinent women showed greater activation of only the semitendinosus muscle ($p = 0.036$) (Table 4).

In this same task, when analysing the stabilometric variables, continent women showed greater displacement in the COP_X axis ($p < 0.001$), total displacement ($p < 0.001$) and mean centre of pressure velocity ($p < 0.001$) (Table 4).

Table 3 - Root mean square (RMS) resampling values for the electromyographic and stabilometric signals in bipedal support on foam with eyes open

Variables	Incontinent women	Continent women	p-value
External obliques	0.096 ± 0.016	0.110 ± 0.020	0.218
Rectus abdominis	0.062 ± 0.010	0.090 ± 0.010	**<0.001**
Internal obliques	0.081 ± 0.025	0.090 ± 0.020	0.064
Rectus femoris	0.062 ± 0.018	0.130 ± 0.040	**<0.001**
Tibialis anterior	0.060 ± 0.023	0.050 ± 0.010	0.133
Ipsilateral erector spinae	2.874 ± 2.130	0.080 ± 0.010	**<0.001**
Gluteus medius	0.063 ± 0.016	0.070 ± 0.020	0.172
Semitendinosus	0.214 ± 0.138	0.060 ± 0.010	**<0.001**
Lateral gastrocnemius	0.114 ± 0.015	0.140 ± 0.010	**<0.001**
Mean lateral centre of pressure	1.486 ± 0.311	1.260 ± 0.160	**0.003**
Anteroposterior centre of pressure	3.356 ± 0.691	3.350 ± 0.500	**0.001**
Total displacement	51.346 ± 3.662	56.170 ± 4.340	**0.002**
MVT of the centre of pressure	1.345 ± 0.087	1.490 ± 0.100	**<0.001**

Note: MVT = mean velocity of the trajectory. Data are expressed as the mean ± standard deviation. Bold text indicates a statistically significant difference.

Table 4 - Root mean square (RMS) resampling values for the electromyographic and stabilometric signals in bipedal support on foam with eyes closed

Variables	Incontinent women	Continent women	p-value
External obliques	0.101 ± 0.019	0.140 ± 0.020	**<0.001**
Rectus abdominis	0.065 ± 0.012	0.100 ± 0.020	**<0.001**
Internal obliques	0.074 ± 0.022	0.090 ± 0.010	**0.004**
Rectus femoris	0.083 ± 0.021	0.260 ± 0.090	**<0.001**
Tibialis anterior	0.145 ± 0.051	0.140 ± 0.030	0.579
Ipsilateral erector spinae	0.125 ± 0.042	0.110 ± 0.030	0.199
Gluteus medius	0.070 ± 0.017	0.100 ± 0.030	**0.006**
Semitendinosus	0.349 ± 0.259	0.100 ± 0.040	**0.036**
Lateral gastrocnemius	0.171 ± 0.028	0.190 ± 0.020	0.091
Mean lateral centre of pressure	2.653 ± 0.498	4.290 ± 0.600	**<0.001**
Anteroposterior centre of pressure	7.898 ± 1.440	7.800 ± 0.940	0.797
Total displacement	108.327 ± 10.068	137.830 ± 14.660	**<0.001**
MVT of the centre of pressure	2.830 ± 0.291	3.350 ± 0.400	**<0.001**

Note: MVT = mean velocity of the trajectory. Data are expressed as the mean ± standard deviation. Bold text indicates a statistically significant difference.

Finally, the comparison of the means of the RMS values for the electromyographic signal in the unipedal stance with eyes open (UNI_OA) showed that continent women had greater activity in the rectus abdominis ($p < 0.001$) and internal oblique ($p = 0.001$) muscles. However, the continent women showed greater activity in the tibialis anterior ($p < 0.001$) and semitendinosus ($p = 0.047$) (Table 5). In the analysis of the stabilometric variables in the same task (UNI_OA), there was greater total displacement ($p = 0.006$) and average velocity of the centre of pressure ($p < 0.001$) among continent women and greater total displacement ($p < 0.001$) and average velocity of the centre of pressure ($p = 0.008$) in the anteroposterior axis among incontinent women.

Table 5 - Root mean square (RMS) resampling values for the electromyographic and stabilometric signals in a single leg stance with eyes open

Variables	Incontinent women	Continent women	p-value
External obliques	0.157 ± 0.020	0.150 ± 0.020	0.675
Rectus abdominis	0.101 ± 0.013	0.150 ± 0.040	**<0.001**
Internal obliques	0.106 ± 0.021	0.130 ± 0.020	**0.001**
Rectus femoris	0.208 ± 0.050	0.230 ± 0.110	0.882
Tibialis anterior	0.427 ± 0.165	1.930 ± 1.190	**<0.001**
Ipsilateral erector spinae	0.635 ± 0.858	0.140 ± 0.020	0.579
Gluteus medius	0.160 ± 0.025	0.180 ± 0.040	0.239
Semitendinosus	0.243 ± 0.087	0.190 ± 0.040	**0.047**
Lateral gastrocnemius	0.673 ± 0.164	0.670 ± 0.190	0.968
Mean lateral centre of pressure	1.784 ± 0.329	1.450 ± 0.310	0.695
Anteroposterior centre of pressure	3.193 ± 0.718	2.590 ± 0.630	**0.008**
Total displacement	104.605 ± 4.498	110.540 ± 7.370	**0.006**
MVT of the centre of pressure	2.665 ± 0.097	2.900 ± 0.180	**<0.001**

Note: MVT = mean velocity of the trajectory. Data are expressed as the mean ± standard deviation. Bold text indicates a statistically significant difference.

Discussion

The influence of UI on balance can be demonstrated by the contribution of the pelvic floor to postural stability in simultaneous, bilateral and synergistic contractions between the pelvic diaphragm and fascia with other muscles through neuronal connections, indicating the synergy of the abdominal muscles with the PFMs. In the investigation of the effects of hypopressive gymnastics on the pelvic muscles in women with UI, activation of the transversus abdominis muscle was proportional to the increase in the pressure of contraction of the PF, and in an attempt to maintain posture, activation of the abdominal muscles occurred before activation of the PFMs.[16]

Improvements in urinary loss were presented by sedentary and incontinent women after performing three months of resistance exercises with the isometric activation of the abdominals.[17] The pelvic floor muscles are activated simultaneously with the activation of the transversus abdominis,[18] and maintaining a relaxed abdomen during contractions of perineal muscles can negatively affect their performance.[19]

Abdominal contractions associated with perineal contractions may promote an increase in PFM strength and function due to the synergistic action of the transversus abdominis muscle.[20] The synergy between the abdominal muscles and the PFMs has been demonstrated in the supine, sitting and orthostatic positions in healthy women.[21] In the orthostatic position, the rectus abdominis and external oblique muscles are activated before the PFMs, and the transversus abdominis and internal oblique muscles are activated later.[22]

The electromyographic data in this study showed that continent women had higher RMS values for the rectus abdominis in all tasks, both with eyes open and with eyes closed. A deficiency in the activation of the PFMs and the rectus abdominis was shown in patients with SUI in activities in which intra-abdominal pressure was increased,[23] a finding that corroborates the results in this study, in which incontinent women, compared with continent women, had lower RMS values for abdominal muscles.

Another important muscle group in the maintenance of posture and in synergistic action with the PFMs is the quadriceps; studies have emphasized resistance training of this muscle in women with urinary loss.[17,22] Improvement in urinary leakage was demonstrated after resistance exercise training of the quadriceps without PF contraction in incontinent women,[17] furthermore, improvements in PFM strength and endurance associated with concentric and eccentric quadriceps strengthening during squatting have been observed for runners with UI.[22] Contradictory results were found in a study with incontinent women over 70 years of age, in whom there was no significant difference between the prevalence of SUI and quadriceps strength measured during concentric torque in an isokinetic device.[24] This result is explained by the age of the participants and the change in body composition with an increased percentage of fat and decreased skeletal muscle mass in this age group.

Thus, considering that the continence mechanism is related to the tonicity of the PFMs and synergistic muscles, coactivation of the rectus abdominis and rectus femoris muscles is inferred, both in urinary control and in the maintenance of postural balance. Additionally, electromyographic data for incontinent women showed that the semitendinosus and tibialis anterior muscles were active in most tasks. A correlation between the action of the tibialis anterior muscle and UI[25] was observed through preactivation of the PFMs before heel strike as an important strategy for neural PFM control in female runners with and without UI, suggesting an anticipated activation of the PFMs during limb movement.[26] In addition, greater electromyographic activity in the PFMs occurred in the horizontal position and in the standing position with the ankles in dorsiflexion, when the pelvis tilts anteriorly, suggesting coactivation between the tibialis anterior and the PFMs.[27]

The influence of UI on balance can be explained by the contribution of the pelvic floor in maintaining correct position and posture. Balance can be determined by the ability of the PFMs to maintain a stable body position through contractions between the pelvic diaphragm and fascia with other muscles initiated through neuronal connections. This reflex correlation between the activity of the pelvic floor and other functions in the maintenance of vertical posture[6] suggests high tonic activity in the PFMs in the orthostatic position.[28] In this context, changes in lumbopelvic posture influence PFM contractility and the amount of vaginal pressure generated during static and dynamic tasks because the greatest PFM strength at rest is observed in the standing posture.[28] In addition, reduced strength and flexibility of the lumbopelvic region suggest a reduction in postural control.[29] Furthermore, activation of the transversus abdominis, multifidus and pelvic floor has been indicated in lumbopelvic stabilization to maintain postural control systems.[30]

In the evaluation of balance in the present study, incontinent women showed greater displacement in the anteroposterior direction in all tasks and thus used the ankle strategy to maintain balance, as demonstrated by the activation of the tibialis anterior muscle in most tasks. Among the continent women, the greatest displacement was observed in the mediolateral axis only in tasks with eyes closed, justifying the greater activation of the rectus abdominis in tasks such as hip strategy in postural control.

The support of each body segment, which is performed through postural control, occurs by the action of passive structures (bones, joints and tendons) and active structures (muscles). Thus, an anteroposterior sway is indicative of the ankle strategy for maintaining balance, and a mediolateral sway is indicative of the hip strategy.[31] Corroborating the results of this study, women with incontinence, compared with continent women, have been shown to have greater difficulty controlling their postural balance while standing with a full bladder[32] and to have greater displacement in both axes in static posture.[13] These findings justify the hypothesis of the present study by suggesting that insufficient strength of the abdominal muscles to maintain balance among incontinent women leads to compensatory activation of the tibialis anterior and semitendinosus for postural control.

Conclusion

In conclusion, continent women, compared to incontinent women, had higher RMS values for the rectus abdominis muscle in all tasks. It is suggested that the abdominal muscles, in addition to being an important postural and pelvic stabilizer, act synergistically with the PFMs to maintain the mechanism of urinary continence. In addition, the electromyographic data for incontinent women showed greater activity in the semitendinosus and tibialis anterior in most tasks, and in the evaluation of balance, incontinent women presented greater postural instability, evidenced in anteroposterior displacement in the tasks (BI_OF, ESP_OA, and UNI_OA).

In this context, knowing that PFM weakness is a predictive factor for UI and considering its synergy in postural control, incontinent women activated the muscles of the lower limbs as an ankle strategy for maintaining balance and consequently postural control. We emphasize the need for studies with larger samples that relate improvements in PFM strength with improvements in postural control.

Authors' contribution

KCF was responsible for preparing the manuscript and, together with AAP, for writing and reviewing it. IMO and LAJV were responsible for data collection. All authors elaborated on the intellectual concept and approved the final version of the article.

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