

## Evaluation of abdomino-pelvic synergy during functional activities in nulliparous women: case series

### Avaliação da sinergia abdomino-pélvica durante atividades funcionais em mulheres nulíparas: série de caso

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**RESUMO | INTRODUÇÃO:** É relevante compreender que as disfunções do assoalho pélvico (DAP) feminino são condições clínicas que acometem um número crescente de mulheres a cada ano, constituindo um problema de saúde pública. DAP podem ter relação com o desequilíbrio entre a sobrecarga tensional dessa musculatura e a diminuição da capacidade desses músculos em suportar o aumento da pressão nessa região, uma vez que essa musculatura deve se contrair durante qualquer atividade que promova o aumento da pressão intra-abdominal favorecendo a manutenção da continência. **OBJETIVO:** analisar a presença desta sinergia em três voluntárias descrevendo o comportamento da atividade eletromiográfica de músculos localizados no assoalho pélvico e no abdome durante as atividades funcionais: andar, sentar/levantar, segurar peso, agachar, pular e tossir. **MATERIAIS E MÉTODOS:** Série de três casos, envolvendo voluntárias jovens universitárias nulíparas, sem queixas miccionais. Foi mensurado o registro da atividade eletromiográfica dos músculos do assoalho pélvico e o grupo muscular formado pelo transverso abdominal e oblíquo interno durante as atividades funcionais, utilizando a eletromiografia de superfície. **RESULTADOS:** O sinal eletromiográfico aumentou em relação ao repouso durante as atividades funcionais de tossir, pular, agachar, sentar/levantar, segurar peso e andar em ambas as musculaturas analisadas. As maiores atividades eletromiográficas foram observadas durante as atividades de pular e agachar, e as menores ao segurar peso, andar e sentar/levantar. **CONCLUSÕES:** A partir da coleta eletromiográfica dos músculos transverso abdominal/oblíquo interno e esfíncter anal externo em três voluntárias nulíparas foi possível observar sinergia destas musculaturas durante as atividades funcionais propostas. Estudos que envolvam grupos maiores de voluntárias, são necessários para podermos afirmar as respostas sobre a sinergia entre esses grupos musculares durante as atividades funcionais.

**PALAVRAS-CHAVE:** Disfunção pélvica. Atividades funcionais. Eletromiografia.

**ABSTRACT | INTRODUCTION:** It is relevant to understand that female pelvic floor dysfunctions (PFD) are clinical conditions that affect an increasing number of women each year, constituting a public health problem. PFD may be related to the imbalance between the tensional overload of this musculature and the decreased ability of these muscles to withstand increased pressure in this region, since this musculature must contract during any activity that promotes an increase in intra-abdominal pressure favoring the maintenance of continence. **OBJECTIVE:** The present study aims to analyze the presence of this synergy in three volunteers describing the behavior of electromyographic activity of muscles located in the pelvic floor and abdomen during functional activities: walking, sitting rising, holding weight, crouching, jumping and coughing. **MATERIALS AND METHODS:** A series of three cases, involving volunteer nulliparous university students, with no voiding complaints. The recording of electromyographic activity of pelvic floor muscles and muscular group formed by the transverse abdominal and oblique internal muscles during functional activities was measured using surface electromyography. **RESULTS:** The electromyographic signal increased in relation to rest during functional activities of coughing, jumping, squatting, sitting rising, holding weight and walking in both musculature analyzed. The largest electromyographic activities were observed during jumping and crouching activities, and the lowest ones when holding weight, walking and sitting rising. **CONCLUSION:** From the electromyographic data collection of the transverse abdominal/internal oblique muscles and external anal sphincter in three nulliparous volunteers, it was possible to observe synergy of these muscles during the proposed functional activities. Studies involving larger groups of volunteers are needed to be able to state important details about the synergy between these muscle groups.

**KEYWORDS:** Pelvic dysfunction. Functional activities. Electromyography.

## Introduction

Female pelvic floor dysfunctions (PFD) are clinical conditions that affect an increasing number of women each year, and constitute a public health problem<sup>1</sup>. These dysfunctions generate direct effects on daily life activities, interfering in social interaction, generating isolation, low self-esteem, sexual problems and depression, thus affecting the quality of life of these women and their relatives<sup>2</sup>.

Research has shown that many PFD may be related to the imbalance between the tensional overload of this musculature and the decrease in the capacity of these muscles to withstand increased pressure in this region<sup>3</sup>. By forming the base of the abdominal cavity, the pelvic floor muscles should contract during any activity that promotes increased intra-abdominal pressure (IAP), making an important contribution to maintaining continence<sup>5</sup>. It is relevant to observe how these musculatures behave during activities in which urinary losses usually occur to make use of this synergistic action and to optimize muscle training in order to treat and/or prevent such dysfunctions.

Electromyography (EMG) is the most accurate method to measure neuromuscular integrity, being a technique performed through the use of electrodes that are able to measure the spontaneous or voluntary activity of the motor units<sup>4</sup>. Surface electromyography (EMGs) is easy to handle and is very useful in assessing the behavior of the abdominal muscles and pelvic floor muscles and can be used during exercises in different postures<sup>6</sup>.

Knowing the importance of using this feature to demonstrate PFM activation and abdomino-pelvic synergism, during the performance of various functional activities in women, the present study aims to analyze the presence of this synergy in three volunteers describing the behavior of the electromyographic activity of muscles located in the pelvic floor and abdomen during the following functional activities: walking, sitting rising, holding weight, crouching, jumping and coughing.

## Materials and methods

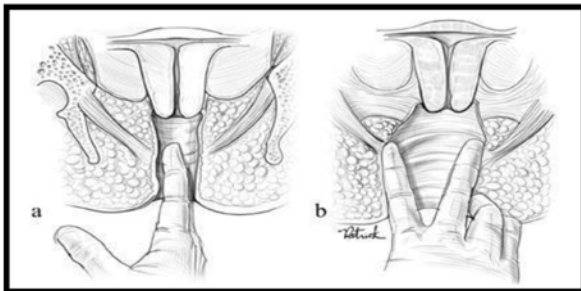
This is a series of cases, involving three voluntary young nulliparous university students, with no voiding complaints confirmed by the Physiotherapeutic Assessment Sheet, aged between 18 and 29 years, Body Mass Index (BMI) up to 26 kg/m<sup>2</sup> and who agreed to participate in this research by signing the Informed Consent Term. This study was approved by the Research Ethics Committee for Human Beings of the Health Sciences Institute of the Federal University of Bahia, under the protocol number 2.012.990 (CAAE 60943316.9.0000.5662) and the evaluation protocols were applied after approval, where all the participants were previously informed in detail about the evaluation to which they would be submitted.

Exclusion criteria were: virgin women with current urinary infection who had already undergone supervised pelvic floor muscle training (PFMT) and had neurological and/or cognitive abnormalities that made it impossible to participate in the study. University volunteers were recruited, through verbal invitation, on campus, classrooms and living space of a university, from May 2017, and sent to a Clinic School of Physiotherapy, where the collections were made.

The Evaluation Questionnaire was applied with the purpose of collecting in detail personal data, menstrual history, surgical history, complaints of urogynecological dysfunctions and use of drugs that could compromise the function of the lower urinary tract. In order to define the level of physical activity of the volunteers, the International Physical Activity Questionnaire (IPAQ), short version, was a practical instrument that describes levels of physical activity dividing and classifying the categories into sedentary, active and very active, has a coefficient of validity and reproducibility similar to that of other instruments, has the advantage not only of practicality, the possibility of comparing both large population groups and small groups, and is thus a good alternative for international comparisons<sup>7</sup>.

Visual inspection and palpation of the pelvic region were performed, including neurological tests to evaluate the integrity and function of the nerve that integrates the lumbosacral dermatomes that innervate the bladder and urethra. The vaginal touch was preferentially bidigital (Figure 1) or, in the presence of undercurrents (such as pain and/or discomfort), one patient was asked to contract the pelvic floor musculature by compressing the evaluator's fingers similarly to holding the examiner's fingers avoiding its removal. The capacity to contract or not was recorded, together with the calculation of the resistance and the maximum time in which the contraction was maintained, by assigning the corresponding values of P (power), E (endurance), R (repetitions) and F (fast)<sup>8</sup>.

**Figure 1.** Evaluation of pelvic floor muscles in manual bidigital touch (Etienne, Waitman, 2006).

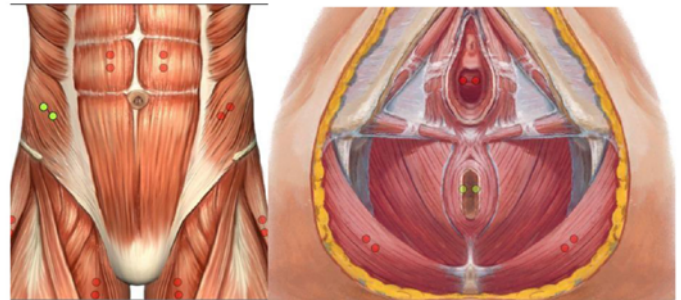


For the acquisition of for the biological signal was used the surface electromyograph Miotec® brand, model New Miotool Uro USB 08 channels. Structures evaluated by electromyography were the muscle group formed by the Transverse abdominal and Oblique internal muscles (TrA/IO) and external anal sphincter (EAS). Surface disposable electrodes (3M®) positioned in the TrA/IO muscles region on the right (two centimeters proximal, towards the pubic region, at the midpoint of the line between the anterior superior iliac spine and the pubic symphysis) were used<sup>9</sup>. The use of the TrA/IO muscle group is due to the impossibility of structurally differentiating the OI from the TrA by the anatomical proximity present in the region used for the acquisition of the signal<sup>10</sup> (Figure 2). To verify the electrical activity of the pelvic floor musculature, the electrodes were positioned in the EAS and, according to the device manufacturer's instructions (<http://www.miotec.com.br/uroginecologia/miograph/>), an electrode was

positioned at 3:00 p.m. and another at 9:00 p.m., making analogy with a clock (Figure 2).

The volunteers were informed about the placement of the electrode in the EAS muscle, being necessary the previous preparation of the skin of this region with simple cleaning and tricotomy whose procedures were clarified at the time of recruitment.

**Figure 2.** Location of surface electrodes



(Available in: <http://www.miotec.com.br/uroginecologia/miograph/>  
Accessed on: July 2017).

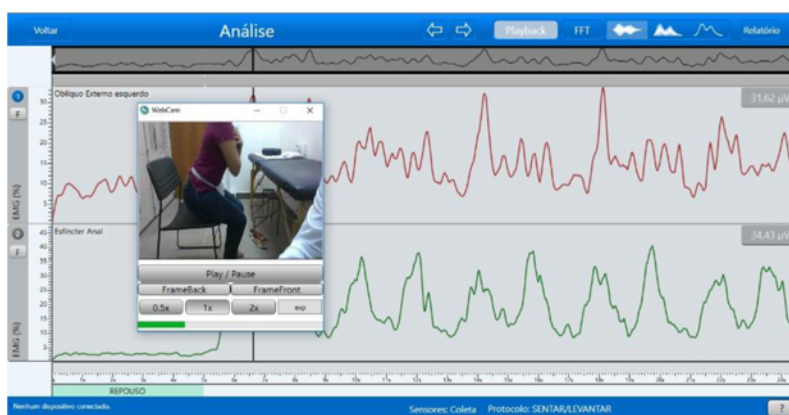
The parameters for the collection of the EMGs were adjusted as follows: 5Hz Pass-Through and Low-pass 500Hz, Notch 60Hz, automatic tuning gain per channel and 2KHz sample rate. The electromyographic activity of the maximal voluntary contraction (MVC) was performed with the volunteers in the dorsal decubitus position. Three MVC of the PFM were requested, followed by the Tra/IO, being checked the highest value of each region.

Then, the electromyographic activity of the PFM and Tra/IO was recorded during the following functional activities:

- Walk straight for 20 seconds;
- Sitting rising, of a chair, 05 times, with the upper limbs flexed making a "X" in the thorax;
- Coughing, 02 repeated coughs repeatedly, 05 times;
- Hold weight of 2kg in each hand for 20 seconds while keeping elbows flexed at 90°;
- Crouch up to 90°, 05 times, with the upper limbs flexed making an "x" in the thorax;
- Jump on the trampoline back and forth, 05 time also with the upper limbs flexed by making an "X" in the thorax.

Collections during the functional activities happened without request for any specific muscular contraction. All activities were recorded in video simultaneously with the collection of electromyographic activity.

**Figure 3.** Collection of simultaneous electromyographic activity during video recording during functional sitting rising activity.



The electromyographic data were later analyzed offline where the percentages of MVC were compared during each of the functional activities. Descriptive analysis of the quantitative data was done for each volunteer. The results are shown in the form of tables.

After the data collection, a report was issued, stating the results of the tests for each participant and a primer on the correct contraction, activating the synergy of the abdominal and pelvic muscles so that during its activities this synergic recruitment occurs, aiming at the prevention of pelvic floor dysfunctions.

## Results

According to data collected through the Physiotherapeutic Evaluation Sheet, International Questionnaire of Physical Activity, electromyographic capture of the maximum voluntary contraction of the analyzed muscle groups and vaginal palpation, the volunteers presented the characteristics listed in table 1.

**Table 1.** Sociodemographic, anthropometric and electromyographic data, referring to the three volunteers of the study.

DATA	CASE 1	CASE 2	CASE 3
AGE	25 years	22 years	24 years
WEIGHT	69 kg	62 kg	48 kg
HEIGHT	1,65 m	1,63 m	1,62 m
CIVIL STATUS	Married	Single	Single
PROFESSION	Student	Student	Student
RELIGION	Catholic	Catholic	Agnostic
BMI	25,34 kg/m <sup>2</sup>	23,34 kg/m <sup>2</sup>	18,29 kg/m <sup>2</sup>
TrA/IO (MVC)	57,92µV	120,36µV	126,11µV
EAS (MVC)	97,28µV	79,61µV	27,21µV
IPAQ	Very active	Very active	Insufficiently active
PERFECT	P= 4 R=1 E=10 F=10	P= 3 R=10 E=3 F=10	P= 2 R=2 E=2 F=4

BMI - Body Mass Index; MVC - Maximum Voluntary Contraction of the TrA/IO - muscular group formed by the transverse abdominal and internal oblique; EAS - external anal sphincter; IPAQ - International Questionnaire of Physical Activity; PERFECT - corresponding values of P (power), E (endurance), R (repetitions) and F (fast); kg - kilogram; m - meter; kg/m<sup>2</sup> -kilogram per square meter; µV - microvolt

### Case 1

During the proposed activities, it presented the following percentages of MVC in each functional activity (Table 2):

**Table 2.** Electromyographic evaluation of Voluntary 01, referring to the percentage of the maximum voluntary contraction of the transverse abdominal/internal oblique muscles and external anal sphincter at rest and during functional activities.

FUNCTIONAL ACTIVITY	EMG			
	TrA/IO		EAS	
	REST (%MVC)	FUNCTIONAL ACTIVITY (%MVC)	REST (%MVC)	FUNCTIONAL ACTIVITY (%MVC)
FLOOR	3,06%	10,45%	2,12%	11,87%
SITTING RISING	8,61%	15,46%	2,37%	20,54%
COUGH	2,54%	13,77%	4,16%	19,97%
CARRY WEIGHT	16,02%	18,69%	2,44%	11,26%
SQUAT	9,03%	38,79%	3,55%	21,3%
JUMP	3,89%	54,36%	2,28%	28,34%

EMG - electromyography; TrA/IO - muscular group formed by the transverse abdominus and internal oblique; EAS - external anal sphincter muscle; % MVC - percentage of maximum voluntary contraction

The volunteer had a higher mean, 54.36% of the MVC, in the Tra/IO muscles when she jumped, and a lower mean when walking, presenting 10.45%.

Regarding the activation of EAS, there was also greater electromyographic activity when jumping on the trampoline (28.34% of MVC) and less active when insuring weight (11.26% of MVC), followed by gait (11.87% of MVC).

It is possible to notice an increase in electromyographic activity of both muscles and in all functional activities when we compared the rest with the performance of the activity.

## Case 2

During the proposed activities, the patient presented the following percentages of MVC in each functional activity (Table 3):

**Table 3.** Electromyographic evaluation of the Voluntary 02, referring to the percentage of the maximum voluntary contraction of the transverse abdominal/internal oblique muscles and external anal sphincter at rest and during functional activities.

FUNCTIONAL ACTIVITY	EMG			
	TrA/IO		EAS	
	REST (%MVC)	FUNCTIONAL ACTIVITY (%MVC)	REST (%MVC)	ATIVIDADE FUNCIONAL (%MVC)
FLOOR	24,28%	23,11%	27,24%	18,76%
SITTING RISING	16,06%	15,76%	5,93%	28,27%
COUGH	14,24%	26,58%	4,26%	11,31%
CARRY WEIGHT	20,69%	20,81%	3,63%	4,43%
SQUAT	17,57%	24,95%	5,93%	38,35%
JUMP	21,49%	37,09%	4,88%	43,18%

EMG - electromyography; TrA/IO - muscular group formed by the transverse abdominal and internal oblique; EAS - external anal sphincter muscle; % MVC - percentage of maximum voluntary contraction.



The volunteer presented a higher mean, 37.09% of the MVC, in the TrA/IO muscles when she jumped, and a lower mean on sitting rising, presenting 15.76%.

Regarding the activation of the EAS, there was a greater electromyographic active when jumping on the trampoline (43.18% of the MVC) and less activity when insuring weight (4.43% of the MVC).

It is possible to notice that the electromyographic activity reduced in the functional activity of gait in

both musculatures and in the TrA/IO when sitting rising. In the other activities it is possible to notice an increase in electromyographic activity of both musculatures when we compared the rest with the performance of the activity.

### Case 3

During the proposed activities, the patient presented the following percentages of MVC in each functional activity (Table 4):

**Table 4.** Electromyographic evaluation of Voluntary 03, referring to the percentage of the maximum voluntary contraction of the transverse abdominal/internal oblique muscles and external anal sphincter at rest and during functional activities.

FUNCTIONAL ACTIVITY	EMG			
	TrA/IO		EAS	
	REST (%MVC)	FUNCTIONAL ACTIVITY (%MVC)	REST (%MVC)	FUNCTIONAL ACTIVITY (%MVC)
FLOOR	8,41%	9,79%	26,26%	43,94%
SITTING RISING	8,44%	10,13%	17,95%	51,82%
COUGH	13,08%	33,33%	22,54%	52,59%
CARRY WEIGHT	8,38%	11,49%	19,97%	20,55%
SQUAT	9,45%	16,01%	34,95%	59,74%
JUMP	8,42%	29,74%	28,43%	80,03%

EMG - electromyography; TrA/IO - muscular group formed by the transverse abdominal and internal oblique; EAS - external anal sphincter muscle; % MVC - percentage of maximum voluntary contraction.

The volunteer presented a higher mean, 33.33% of MVC, in the TrA/IO muscles in the cough, followed by jumping with 29.74% of the MVC and a lower average walking, presenting 9.79%.

Regarding the activation of the EAS, there is a greater electromyographic activity when jumping on the trampoline (80.03% of the MVC) and less active when insuring weight (20.55% of the MVC).

Is notice an increase in electromyographic activity of both muscles and in all functional activities when we compared the rest with the performance of the activity.

### Discussion

The pelvic floor musculature has become responsible for the support and contention of the abdominal and pelvic organs since the man assumed the erect posture<sup>11</sup>. Such muscles withstand the force of gravity and their activity increases reflexively in response to maneuvers that increase IAP<sup>12</sup>. Moreover, with increasing age, symptoms such as ligament laxity, urogenital dysfunctions and other types of pathologies may arise due to the imbalance between the tensional overload of this musculature and the diminution of the capacity of these muscles to support the increase of the pressure in that region<sup>13,3</sup>. Aukee et al.<sup>14</sup> observed that the higher the age of women, the lower the electrical activity of the PFM,

even in the continents, correlating the decrease in the electrical activity of the muscles with aging.

Authors such as McLean<sup>3</sup> and Sapsford<sup>5</sup> used EMGs in their studies to measure the electrical activity of PFM in various body postures and during the contraction of specific muscle groups, concluded that there were contractions of equally strong PFM in decubitus, sedation and orthostasis, however, the pattern of abdominal and PFM activation varies according to the position. A study conducted by Shafik et al.<sup>15</sup> with EMG of the anus elevator in the upright position, associated with variations of the IAP, showed a reduction in the electrical activity of this muscle, related to the reduction of the IAP, such results suggest that the PFM responds tonic to the increase of the IAP establishing the function of support of the pelvic viscera, especially in the position that was studied. These findings corroborate with what we observe in the electromyographic signal of the three volunteers during coughing, squatting and jumping. By promoting an increase in the IAP, these activities generated an increase in the electromyographic activity of the internal transverse abdominal/oblique and external anal sphincter in all volunteers studied. The percentage of MVC of the volunteer 02 to the floor was less than the percentage detected at rest in both musculatures. In this sense, there was synergy of these muscles both in cases where muscle activities increased and in cases where both muscles cut the percentage of MVC.

Sapsford et al.<sup>5</sup> evaluated the resting activity of PFM and abdominal muscles during different sitting positions and the results showed that pelvic floor muscle activity is significantly higher in the seated posture without back support, compared to sitting posture with support, emphasizing the importance of body posture during PFM rehabilitation. Following this same reasoning, when performing the sitting rising movement without support in the back, we observed an increase in electromyographic activity of the EAS in the three volunteers of the present study.

Madill and McLean<sup>3</sup> evaluated the maximal voluntary contraction of nulliparous women in the sitting, dorsal and orthostatic positions in an attempt to describe the synergy of PFM with the abdominal musculature. The activation of the abdominal, oblique, internal and external oblique

and abdominal transverse muscles was evaluated by means of surface electrodes and concluded that the electrical activity of the PFM during maximal voluntary contraction at the different positions was similar and that the abdominal muscles were synergistically activated at PFM. In accordance with the results of the present study, it is worth mentioning the synergy of the analyzed muscles, where we saw how the external anal sphincter muscle and the internal transverse abdominal/oblique muscle group behaved during the performance of the different functional activities. We observed greater muscle activation in the activities that generate a sudden increase in IAP, such as the jump in the three volunteers and during the cough in the volunteer 03, and minor muscle activations were recorded in the activities that request muscle contractions maintained for longer periods, as observed during walking and holding weight.

The pelvic floor has a very complex biomechanical activity, because in many movements it acts synergistically with the muscles of the abdomen due to its communication by the muscular fascias, which, when requested, help in the stabilization of the trunk in diverse movements<sup>5,16</sup>. Due to this, Junginger et al.<sup>17</sup> mentioned the importance of performing the training of the PFM associated with the abdominal muscles and that this muscular activation should be intensified in the orthostatic position, since the women had less electrical activity during the active contraction in this position<sup>18</sup>.

Researches (Junginger et al.<sup>17</sup>, Lemos and Feijó<sup>21</sup>) has indicated the importance of using the abdomino-pelvic synergy in rehabilitation programs and/or prevention of pelvic floor dysfunctions. Using PFM strengthening together with abdominal muscle training seems to be useful in clinical settings in which the functional loss associated with decreased PA muscle strength is observed, as in cases of urinary incontinence and pelvic organ prolapse. Although some studies show good reproducibility and reliability<sup>19,20</sup>, the literature still lacks standardization in relation to the electromyographic parameters to be used in the evaluation of the pelvic floor. No studies were found that analyzed this synergy during the performance of daily functional activities.

It is relevant to observe how these musculatures behave during activities in which urinary losses

usually occur, to make use of this synergistic action and to optimize muscle training in order to treat and/or prevent such dysfunctions.

## Conclusions

From the electromyographic collection of the transverse abdominal/internal oblique muscles and external anal sphincter in three nulliparous volunteers, two of them were classified as very active in IPAQ, it was possible to observe synergy of these muscles during the proposed functional activities. Studies involving larger groups of volunteers, separated by level of physical activity, are necessary to be able to state important details about the synergy between these muscle groups in order to make use of this information during the prevention and/or rehabilitation of pelvic floor dysfunctions.

## Author contributions

Pinto FR and Saraiva A participated in the study design conception, data collection, results interpretation, and paper writing. Camatti JR participated in the analysis and interpretation of the data. Luz CS participated in the results interpretation.

## Competing interests

No financial, legal or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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