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Are Transversus Abdominis/Oblique Internal and Pelvic Floor Muscles Coactivated During Pregnancy and Postpartum?

Larissa Carvalho Pereira,[1] Simone Botelho,[1,2]* Joseane Marques,[1] Cesar Ferreira Amorim,[3] Ana Helena Lanza,[1] Paulo Palma,[1] and Cassio Riccetto[1]

[1]*Faculty of Medical Sciences of the State University of Campinas (UNICAMP), Campinas, Sao Paulo, Brazil*
[2]*Federal University of Alfenas (UNIFAL-MG), Alfenas, Minas Gerais, Brazil*
[3]*Master's program in Physical Therapy/University of City of Sao Paulo (UNICID), Tatuape, Sao Paulo, Brazil*

Aim: The aim of this study was to simultaneously evaluate both transversus abdominis/internal oblique (Tra/IO) and pelvic floor muscles (PFM) during isometric exercises in nulliparous, pregnant, and postpartum women. **Methods:** The study included 81 women divided into four groups: (G1) nulliparous women without urinary symptoms ($n = 20$); (G2) primigravid pregnant women with gestational age $\geq$24 weeks ($n = 25$); (G3) primiparous postpartum women after vaginal delivery with right mediolateral episiotomy ($n = 19$); (G4) primiparous postpartum women after cesarean section delivery, with 40 to 60 days of postpartum ($n = 17$). The assessment consisted of simultaneous surface electromyography (EMGs) of the PFM and Tra/IO, during three isometric maximum voluntary contractions. **Results:** Only nulliparous women presented significant simultaneous Tra/IO and PFM co-activation when asked to contract PFM ($P = 0.0007$) or Tra/IO ($P = 0.00001$). **Conclusions:** There is co-activation of the transversus abdominis/internal oblique and the pelvic floor muscles in young, asymptomatic nulliparous women. This pattern was modified in primigravid pregnant and primiparous postpartum women regardless of the delivery mode. *Neurourol. Urodynam. 32:416–419, 2013.* © 2012 Wiley Periodicals, Inc.

Key words: co-activation; electromyography; pelvic floor

INTRODUCTION

The musculoskeletal capsule that surrounds the abdominal and pelvic organs is formed by the pelvic floor, lumbar vertebrae, the deeper layers of multifídius muscle, respiratory diaphragm and the transversus abdominis.[1] The co-activation of the trunk muscles as a whole promotes its balance[2] and maintains the stability of the spine and pelvis.[3] Kegel[4] was the first to suggest the existence of simultaneous contractions of the abdominal and pelvic floor muscles (PFM). Other authors have also investigated the functional relationship between the pelvic floor and the abdomen.[5–8]

However, biomechanical and functional changes of the pelvic floor muscles during pregnancy can result in temporary or permanent urinary incontinence. It has been considered that pregnancy, as well as delivery mode, can be the cause of many of the lower urinary tract symptoms.[9–14] Pelvic floor muscle training (PFMT) can prevent or even treat the urinary symptoms triggered during pregnancy.[15,16]

It is important to understand the behavior of the abdominal and pelvic muscles at different circumstances, such as during pregnancy and postpartum.[17] Previous studies described the co-activation between the PFM and transverse abdominis/internal oblique muscles (Tra/IO) in nulliparous women.[1,5–8] However, there is little information about its pattern during pregnancy and postpartum and its impact on the pelvic floor function.

The aim of this study is to evaluate the co-activation between PFM and Tra/IO in nulliparous, primigravid pregnant, and primiparous postpartum women (vaginal delivery and cesarean section), using surface electromyography.

PATIENTS AND METHODS

Design

A clinical, controlled, prospective and study was conducted. Eighty-one women, with a mean age of 23.56 years (SD = 4.82) were included. The study was approved by the regional Ethics Review Board (protocol: CAEE 0307.0.213.213-07). All participants gave their informed and written consent according to the Helsinki declaration.

The women were recruited from January 2008 to April 2009 from a public health service center in the city of Pocos de Caldas in Brazil (City of Pocos de Caldas's Maternal Program).

There were included nulliparous women without urinary symptoms, primigravid pregnant, and primiparous postpartum women without urinary symptoms before pregnancy as described in Figure 1. All patients were evaluated with digital

Abbreviations: EMGs, surface electromyography; PFM, pelvic floor muscles; RMS, root mean square; Tra/IO, transverse abdominis/internal oblique.

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*Correspondence to: Simone Botelho, Physical Therapist, Physiotherapy Course, Nursing School, Federal University of Alfenas, UNIFAL/MG Street, Av. Jovino Fernandes Sales, 2600 Santa Clara, Alfenas/MG, Brazil Building A, Room 107-D CEP 37130-000, Brazil. E-mail: simone.botelho@unifal-mg.edu.br
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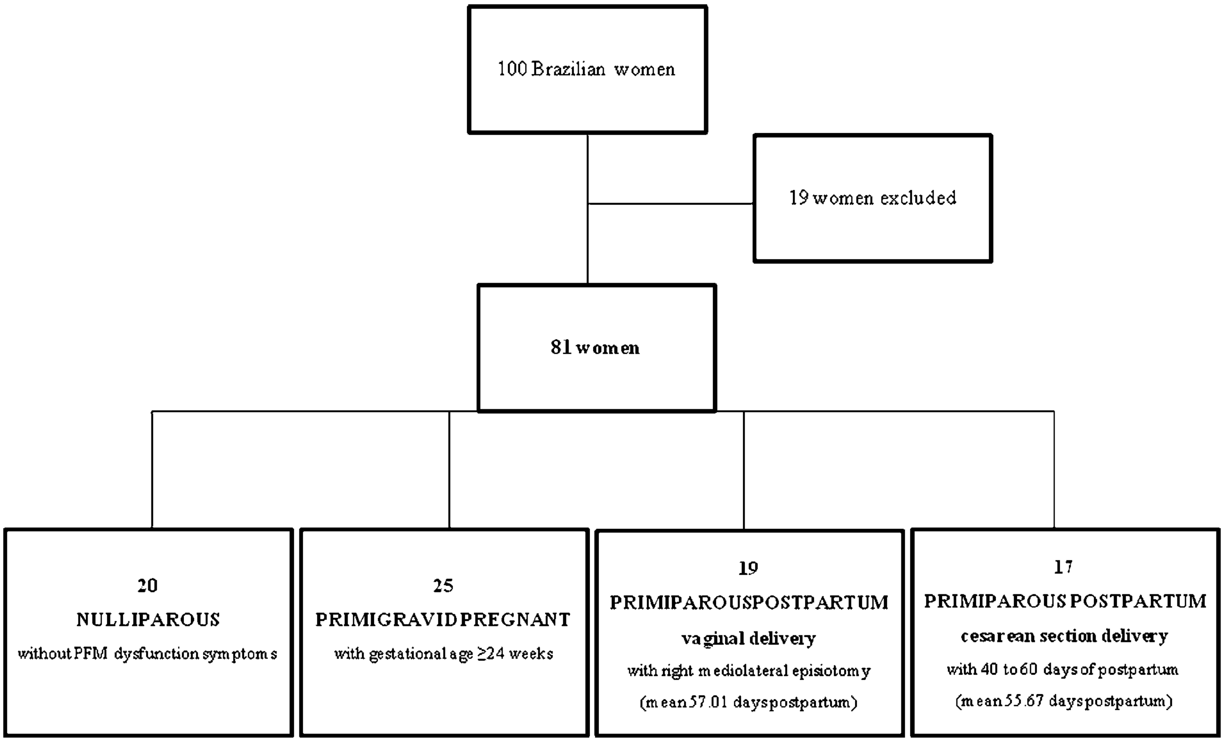

Fig. 1. Study population.

palpation prior to the inclusion. Only patients who were able to contract the PFM were included in the study.

Exclusion criteria were women who had prior abdominal or pelvic surgery, pelvic organ prolapse, diabetes, hypertension, neurological abnormalities, myopathy, chronic lung diseases, presence of urinary tract infection, body mass index (BMI) $\geq$30 kg/m^2, regular physically active and PFM, and/or abdominal muscles training.

Pelvic Floor and Transversus Abdominis/Internal Oblique Electromyography

PFM and Tra/IO contractility was registered using a surface electromyography equipment (EMG System do Brasil®, 400C model), which consisted of a signal conditioner with a band pass filter with cut-off frequencies at 20–500 Hz, an amplifier gain of 1,000 and a common mode rejection ratio of >120 dB. All data were processed using specific software for acquisition and analysis (AqData). Additionally, a 12-bit A/D signal converting plate, for the conversion of analog signals to digital ones with a 2.0 kHz anti-aliasing filter sampling frequency, with an input range of 5 mν, was used.

The volunteer was positioned in standing position and the abdominal region was cleaned with 70% alcohol. To test for the correct Tra/IO contraction, electrical activity generated with contraction was evaluated using surface sensors (disposable, 3M®) placed on the muscles' area, two centimeters away from the anterior iliac crest, in the direction of the pubic area[6–8] and by palpating the inward movement of the abdominal wall without moving the pelvis or the lower lumbar spine. Breathing was standardized by giving the following instructions: take a moderate breath in, let the breath out, and then contract the TrA.

The contraction of the PFM has been previously taught to the volunteer, requesting her to press the probe in cranial direction and observe its contraction on the computer screen. Each requested contraction, was performed with a rest period of twice the time of the performed contraction, in order to avoid muscle fatigue.

Pelvic floor EMG was recorded using a vaginal probe (Physio-Med Services®), which has two opposing metal sensors. The probe was inserted and manually positioned, by the researcher, with the aid of KY's hypoallergenic gel (Johnsońs & Johnsońs®), with the metallic sensors placed laterally in the vagina.[18,19] The reference surface electrode was positioned on the right wrist.

PFM and Tra/IO evaluation was performed putting the subjects in supine position, lower limbs flexed with the feet on the stretcher.[18–20]

Both sensors were connected to the EMG equipment, that transmitted the electrical signals in microvolt (μV) to a notebook (HP Pavilion® TX2000), making sure that all electrical equipments were unplugged from the electrical power line, though working with their own batteries, in order to avoid any kind of interference.

EMG evaluation protocol consisted of three, maximal, voluntary PFM contractions, recorded by the vaginal probe (channel 1). The contraction of the PFM has been previously taught to the volunteer, requesting her to press the probe in cranial direction and observe its contraction on the computer screen. Each requested contraction, was performed with a rest period of twice the time of the performed contraction, in order to avoid muscle fatigue.

Later, three, maximal, voluntary Tra/IO contractions were requested (channel 2). The volunteer was then instructed to perform an isometric contraction of the lower abdomen, during expiration.

PFM and Tra/IO electrical activities were simultaneously registered. All activities were supervised by the same researcher.

TABLE I. Medical and Demographic Data

	Nulliparous (n = 20)	Pregnant (n = 25)	Vaginal delivery (n = 19)	Cesarean section (n = 17)	Hc
Skin color n (%)					
White	16 (80%)	18 (72%)	14 (73.7%)	12 (70.5%)	
Black	0 (0%)	2 (8%)	2 (10.6%)	2 (11.8%)	
Other	4 (20%)	5 (20%)	3 (15.7%)	3 (17.6%)	
Occupation n (%)					
Employed	13 (65%)	11 (44%)	8 (42.1%)	10 (58.8%)	
Unemployed	6 (30%)	8 (32%)	7 (36.8%)	4 (23.5%)	
Other	1 (5%)	6 (24%)	4 (21.1%)	3 (17.6%)	
Marital status n (%)					
Single	15 (75%)	5 (20%)	8 (42.1%)	5 (29.4%)	
Married/living together	5 (20%)	25 (80%)	10 (52.7%)	12 (70.5%)	
Other	0 (0%)	0 (0%)	1 (5.2%)	0 (0%)	
Educational degree n (%)					
Illiterate	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Elementary school	1 (5%)	1 (4%)	3 (15.7%)	3 (17.6%)	
High school	5 (25%)	15 (60%)	15 (80.1%)	11 (64.7%)	
Higher education	14 (70%)	9 (36%)	1 (5.2%)	3 (17.6%)	
Age (years)					
Mean (SD)[a]	24.42 (3.6)	24.62 (5.6)	21.78 (3.1)	23.06 (5.9)	3.47
BMI (kg/m)					
Mean (SD)[a]	24.16 (2.8)	25.09 (2.1)	24.32 (3.6)	24.57 (2.5)	2.14
Weight gain (kg)[b]					
Mean (SD)[a]	—	—	14.92 (5.0)	13.84 (3.7)	1.24
Newborn weight (kg)					
Mean (SD)[a]	—	—	2.825 (1.0)	3.290 (303.4)	1.21

Hc, Hartley coefficient; kg, kilogram.
Data are given as mean ± standard deviation (SD) and percentage.
[a]The data were homogeneous according to Hartley test.
[b]During the pregnancy.

Each contraction was recorded for 5 sec, in microvolt and analyzed by root-mean-square (RMS). The arithmetic mean of three RMSs was considered per analysis.[18]

Statistical Analysis

A pilot study was performed to find the sample size using the Statistical Analysis System for Windows program (SAS 9.1.3). Data was calculated through the difference of the averages, as well as the variability, among the groups. A 5% level of significance was fixed for each studied parameter (PFM and Tra/OI EMG). A sample size of 15 women per group was indicated, which represented a power analysis of more than 0.80.

Homogeneity was checked based on: women age; BMI; gestational weight gain; and newborn weight. Data were analyzed using the Test of Homogeneity Hartley, with a significance level of 5%.

Electromyographic data were analyzed with the ANOVA and orthogonal contrasts test (significance level of 1%), in order to compare a specific group to the others, regarding to the influence of pregnancy and delivery mode on the PFM and Tra/IO co-activation.

RESULTS

The groups are considered homogeneous according to the Hartley Test. The medical and demographic aspects as well as personal data are presented in Table I.

The average of the three RMS, in microvolt was presented in Table II.

Nulliparous women presented significant simultaneous Tra/IO and PFM co-activation when were asked to contract PFM ($P = 0.0007$) or Tra/IO ($P = 0.00001$). However, it was not observed Tra/IO and PFM co-activation during pregnancy and postpartum (Table III).

DISCUSSION

Sapsford et al.[1,6] suggested that there was co-activation between Tra/IO and PFM, in normal physiological conditions. Likewise, the co-activation between the same muscles in the nulliparous women group was observed in the present study.

Neumann and Gill[7] have also observed the recruitment of Tra/IO during PFM contractions. These authors also add that one cannot perform an effective pelvic floor contraction while relaxing the deep abdominal muscles, which suggests that abdominal muscles have a strong influence on the pelvic floor performance.[7]

Our findings also corroborate with those of Bø[21] evaluating abdominal and pelvic floor muscles, showing that co-activation of Tra/IO muscles typically occurs during the contraction of the PFM.

Such findings can be explained by the anatomical and biomechanical relationship between these muscles. The transversus abdominis muscle has its fibers prolonged by the Transverse Perineal Muscle. Studies about postural biomechanical analysis showed that those muscles have a static function of containment of the viscera within the abdominal cavity and have biomechanical interactions with the PFM,

TABLE II. Electromyography Data

Groups	Pelvic floor muscle, mean EMG (μV; SD)[a]	Abdominal muscle, mean EMG (μV; SD)[a]
Nulliparous	48.78 (16.30)	32.06 (15.45)
Pregnant	30.62 (14.46)	17.37 (7.89)
Vaginal postpartum	28.67 (12.21)	23.23 (5.82)
Cesarean postpartum	29.58 (10.28)	20.00 (9.75)

[a]Data are given as mean ± standard deviation (SD).

TABLE III. Co-activation Between Abdominal and Pelvic Floor Muscle

Contrast	Groups	Abdominal muscles co-activation during maximal voluntary pelvic floor contraction (P-value)	Pelvic floor muscles co-activation during the isometric abdominal contraction (P-value)
1	Nulliparous compared to		
	Pregnant	**0.0007**	**0.00001**
	Vaginal postpartum		
	Cesarean postpartum		
2	Pregnant compared to		
	Vaginal postpartum	0.4509	0.7949
	Cesarean postpartum		
3	Vaginal postpartum compated to		
	Cesarean postpartum	0.2786	0.9633

Orthogonal contrast test $P \leq 0.001$.

because they belong to the same muscle chain, which also supports the theory that the Transversus abdominis muscle acts together with the PFM.

However, Bø et al.[22] reported that there is not enough scientific evidence to show that transversus abdominis muscle training is efficient in the treatment of urinary incontinence. According to them further research is needed to reach to this conclusion.

As shown above, the relationship between the co-activation of Tra/OI and PFM in asymptomatic young women has been demonstrated by several other studies.[1,6,7,23]

However, we have not found any studies concerning the behavior of these muscles in the pregnancy and postpartum stages until now.

In the present study, electromyographic simultaneous recording of the Tra/IO and PFM activity, in primiparous women (mean gestational age of 30.49 weeks), did not present any significant co-activation. Thus, one can infer that maternal adaptations can trigger changes in the motor behavior of those muscles. However, it is not established if such changes can be temporary or permanent.

Likewise, this study did not find any significant co-activation in the postpartum women's group, regardless of delivery mode. These findings allow us to infer that pregnancy and postpartum influence muscle physiology, blocking abdominal pelvic synergy.

This study shows a change in the function and relationship of the pelvic floor and abdominal wall muscle during pregnancy and postpartum.

CONCLUSION

There is co-activation of the transversus abdominis/internal oblique and the pelvic floor muscles in young, asymptomatic nulliparous women. This pattern was modified in primigravid pregnant and primiparous postpartum women regardless of the delivery mode.

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