DETERMINATION OF PELVIC FLOOR MUSCLE OSCILATION FREQUENCY IN A HEALTHY WOMAN

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Abstract. *The pelvic floor is a complex muscular structure and the urogynaecological dysfunctions of this muscular structure are innumerable. Physical therapy treatment to the urogynaecological dysfunctions involves pelvic floor muscles (PFM) exercises. The inner surface of the pelvis basin is cover by the PFM that maintains continence by actively supporting the pelvic organs and closing the pelvic openings when contracting. A voluntary contraction is a simultaneous contraction of all PFM and can be described as an inward movement and closure around the urethral, vaginal and anal meatus. The inward movement can represent those muscles capability to generate tension, power, resistance and functional status. Pelvic floor muscles training aims to change all these muscle performance components (impairments), in a way that the patient can develop urogynaecological function adequately and enhance quality of life. To better understand the biomechanics of pelvic floor muscle contraction, it is necessary knowledge about pelvic floor muscle oscillation frequency. The frequency in witch the PFM oscillate can contribute to the prescription of different physiotherapy modalities of treatment, such as electrical stimulation and kinesiotherapy. So the aim of this article is to determine the frequency in with the pelvic floor muscle of healthy women oscillates, using a vaginal sensor probe developed at Labbio. The probe is connected to a National Instruments© USB data acquisition system in order to acquire the oscillation frequency of pelvic floor muscle in a healthy woman volunteer. The system sample was of 1.0 kHz and the data were processed with mathematical software (MATLAB®). The analyses of the oscillation frequency showed a range of 0 to 0.5 Hz during slower sustained pelvic floor muscles contraction and from 0.5 to 1.0 Hz during fast pelvic floor muscle contractions. This was the first study developed at Labbio to analyze pelvic floor muscle oscillation in healthy women. The data showed a small oscillation range that could be attributed to the fact that 30% of all women do not know how to contract their pelvic floor muscles in the first attempt. More researches are necessary to confirm if different modalities of physical therapy would interfere in this oscillation frequency.*

Keywords: *Pelvic floor muscles, Oscillatory frequency, Vaginal sensor probe*

1. INTRODUCTION

The pelvic floor is a complex muscular structure and the urogynaecological dysfunctions of this muscular structure are innumerable (Bo et al., 2004). Physical therapy treatment to the urogynaecological dysfunctions involves pelvic floor muscles (PFM) exercises (Bump *et al.*, 1991). The inner surface of the pelvis basin is covered by the PFM, which maintain continence by actively supporting the pelvic organs and closing the pelvic openings when contracting (Netter, 2001). A voluntary contraction is a simultaneous contraction of all PFM and can be described as an inward movement and closure around the urethral, vaginal and anal *meatus*. The inward movement can represent those muscles capability to generate tension, power, resistance and functional status (Bump *et al*, 1991). Pelvic floor muscles training aims to change all these muscle performance components (impairments), and so the patient can perform urogynaecological function adequately and enhance quality of life (Bo and Sherburn, 2005).

To better understand the biomechanics of pelvic floor muscle contraction, it is necessary knowledge about pelvic floor muscle oscillation frequency. The frequency in which the PFM oscillate can contribute to the prescription of different physiotherapy modalities of treatment, such as pelvic floor electrical stimulation (Bo, 2004). Electrical stimulation (ES) may be considered an initial or an adjuvant therapy to pelvic floor muscle training exercises.

It is minimally invasive, with little side effects and well accepted by most women. ES has become an attractive therapy, particularly when combined with motivation and discipline, conditions essential to the achievement and maintenance of good pelvic floor muscle strengthen results (Polden and Mantle, 1997). However, few studies evaluated long-term electrical stimulation therapeutic effects, in the treatment of pelvic floor dysfunctions.

Eriksen and Eik-Nes (1989) reported cure or improvement in 68% of women submitted to pelvic floor ES, maintaining the success rate of 56% two years after therapy. Appel (1998) performed a study with six years follow-up, showing that only 40% of women showed improvement after the electrical stimulation. However, the combination of regular pelvic floor exercises to strengthen the perineal muscles associated to ES may interfere, positively in results maintenance.

In order to better understand pelvic floor muscles oscillation, and prescribe adequate parameters to ES, the aim of this article is to determine the frequency in which pelvic floor muscles of a healthy woman oscillate during pelvic floor maximal and endurance contraction.

2. METHODOLOGY

2.1. Measurement system

A measurement system composed of a vaginal sensor probe, a data acquisition system and analysis software was developed. The vaginal probe consists of three parts: the dome, the sensitive element and the handle. The dome has an anatomical, rounded shape in order to allow the insertion of the device into the patient's vaginal canal with a minimum level of discomfort. The sensitive portion is formed by eight force-resistive sensors (8.0 mm in diameter and 0.1 mm in height, model SENM-08A, China) assembled in pairs in a hollow cylinder with four longitudinal flat orthogonal faces (Saleme *et al,* 2007). The vaginal sensor probe was connected to a USB data acquisition system of the National Instruments©, model NI Compact DAQ, NI Cdaq-9172, with two modules of 4 channels each, 100.0 kS/s and 16.0 bits resolution (model NI 9215), for simultaneous acquisition. "Figure 1" shows the connection scheme used and "Fig. 2" illustrates a diagram block of the used module internal components.

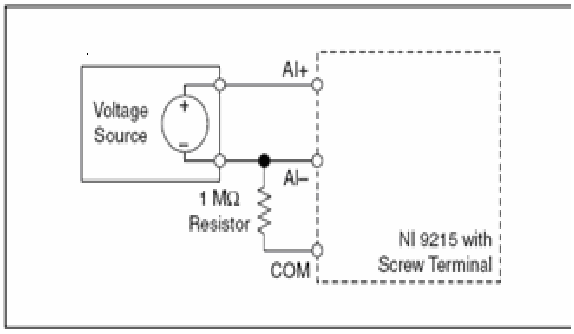

Figure 1. Connection of a floating differential voltage signal to the NI 9215 with Screw terminal

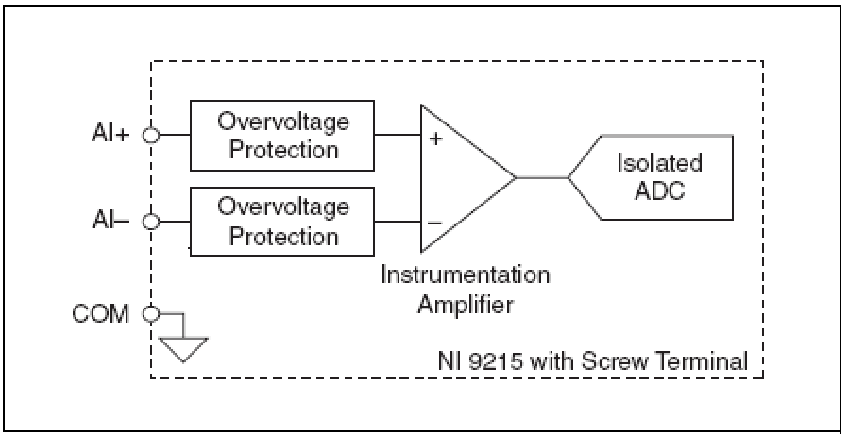

Figure 2. Input circuit for one channel on the NI 9215 with Screw terminal

I was used the software LabVeiw 8.5 of National Instruments© to make only the data acquisition. The software was configured to have a sampling frequency of 1.0 kHz, reference voltage of ± 1.0 V and the data were storage in a text file, with one thousand samples per second, which was later processed by MATLAB® 2008.

2.2. Clinical procedure

A clinical protocol was developed and has the authorization to be conducted with human beings (COEP-UFMG n. 289/06). One woman with 29 years old was submitted for the pelvic floor muscle assessment. She adopted a supine position, hips and knees flexed and supported by a pillow. The vaginal probe was prepared for insertion by covering it with a latex condom and lubricating it with a hypo-allergen gel. The probe was inserted into the vaginal canal by a physical therapist; contractions were asked to the woman so that could be visualized where the maximal force points were located. The probe was then stabilized by the therapist to prevent the movement of it inside the vaginal canal. In this position, it was possible to measure the passive and active force of pelvic floor muscle. After that, a protocol of PFM contraction was performed:

- One maximal pelvic floor six seconds contraction;
- An endurance pelvic floor contraction
- Cyclical pelvic floor contractions.

The signal collected by the system was stored in a computer and subsequently processed using the mathematical tool MATLAB® 2008. Firstly, the signal went through a 60.0 Hz Notch filter of 6th order, so that the interference of the power grid could be filtered. After that, the signal was split up in order to separate the signal with contractions and signal with no contraction. To eliminate the interference of the frequency of the exercise, only the signal with contraction was analysed. This signal was then processed by Fast Fourier Transform (FFT). The continuous components of the signal were cut off and only the frequencies over than 40% of the frequency with biggest amplitude were considered.

3. RESULTS

The presented results have their units expressed in Volts because the objective of this work was only to analyse the data in the frequency domain, and not to describe the force measurement.

The signal generated in the first test is shown in “Fig. 3”. An offset can be seen in the sensor 2 (anterior wall), created by ± 10% the resistors error inconsistency due to the no application of an initial set point. There is a good consistency of the collected signal with the well captured and defined contractions in the four sensors.

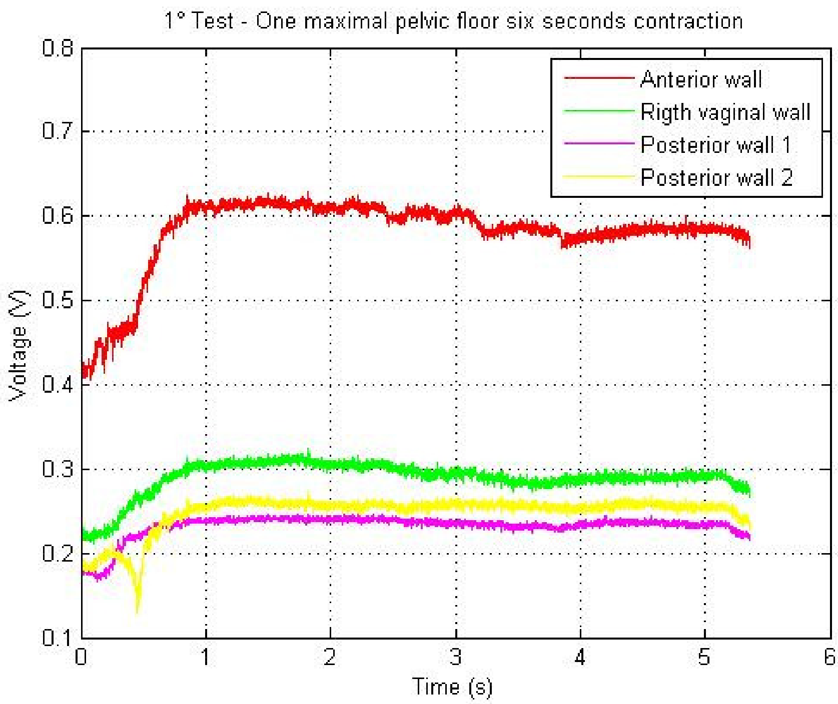

Figure 3. The signal generated in the first test

“Figure 4” presents a zoom of the Fourier Transform. In this figure, it can be observed the absence of signal interference from the power grid frequency (60.0 Hz). The fundamental frequency of the system was 0.0 Hz, which means the continuous signal, already expected because the whole measurement system is powered by continuous voltage.

The calculated values of amplitude and frequency for each vaginal wall are represented in "Tab. 1". The entire value of fraction is correlated with the first obtained frequency (0.244 Hz). The other fraction values were digitally calculated until the criteria were reached. To summarise the frequency and amplitude values presented in "Tab. 1" were evaluated until the fraction value had achieved a value less than 40%.

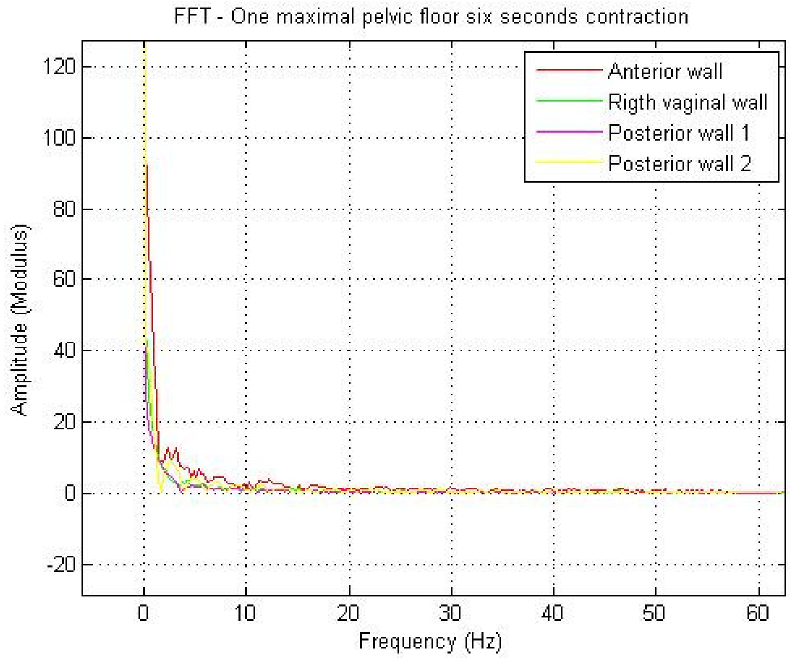

Figure 4. A zoom of the Fourier Transform of signal generated in the first test

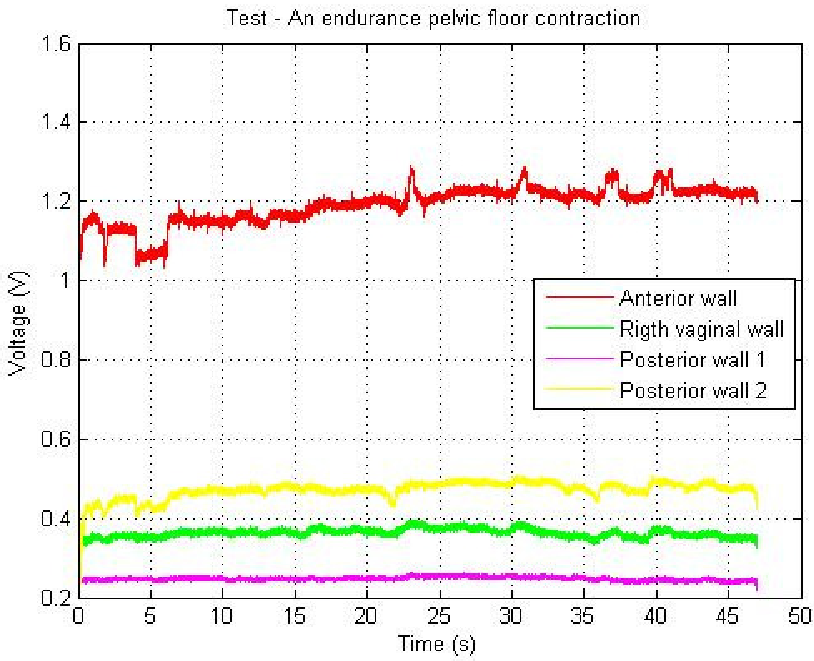

Figure 5. Generated signal in the endurance test

"Figure 6" shows a zoom of the Fourier Transform for the second test. As explained for the first test, in this figure can be observed the absence of signal interference from the grid. Once again, the system frequency is more active in the frequency of 0.0 Hz or continuous signal, which was expected because the whole measurement system is powered by continuous voltage.

Table 1. Obtained results for each vaginal wall of the FFT processing

Anterior Wall	**1°**	**2°**	**3°**	**4°**
Frequency(Hz)	0.244	0.488	0.733	0.977
Amplitude (Module)	99800	70.180	52.070	38.940
Fraction (%)	100.000	70.320	52.170	39.020
Right Lateral Wall	**1°**	**2°**	**3°**	**4°**
Frequency (Hz)	0.244	0.488	0.733	0.977
Amplitude (Module)	48.340	26.950	19.900	15.170
Fraction (%)	100.000	55.750	41.170	31.380
Posterior Wall 1	**1°**	**2°**	**3°**	**4°**
Frequency (Hz)	0.244	0.488	0.733	0.977
Amplitude (Module)	27.990	18.190	15.600	12.850
Fraction (%)	100.000	64.990	55.730	45.910
Posterior Wall 2	**1°**	**2°**	**3°**	**4°**
Frequency (Hz)	0.244	0.488	0.733	0.977
Amplitude (Module)	42.520	18.190	15.600	12.850
Fraction (%)	100.000	42.780	36.690	30.220

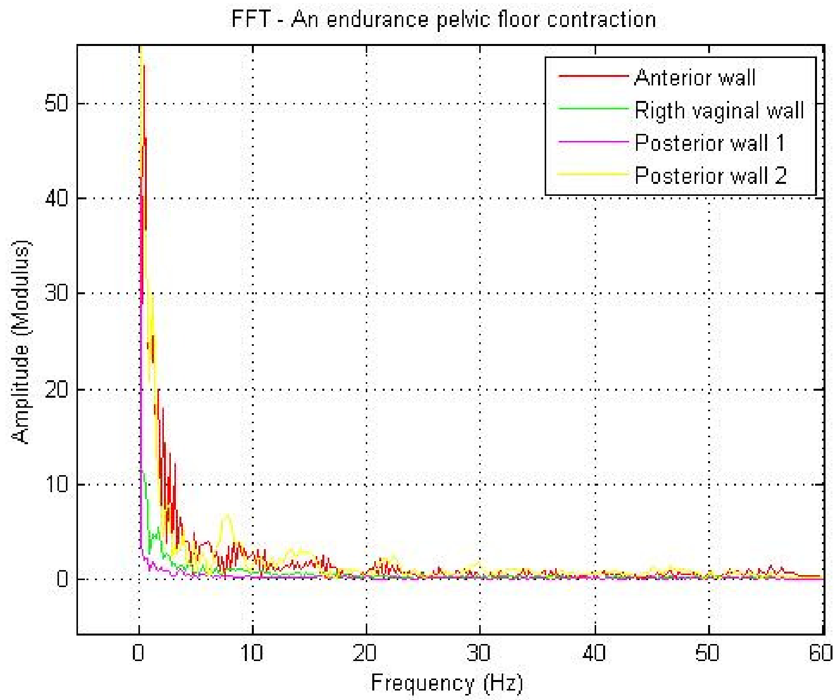

Figure 6. A zoom of the Fourier Transform of signal in the endurance test

Moreover, it was demonstrated that 0.244 Hz is the most prevalent frequency after Fourier Transformation. "Figure 7" shows the collected signal during cyclical pelvic floor contraction, with a determinate time of contraction and relaxation. The frequency estimated visually in the diagram is about 0.8 Hz to 1.0 Hz.

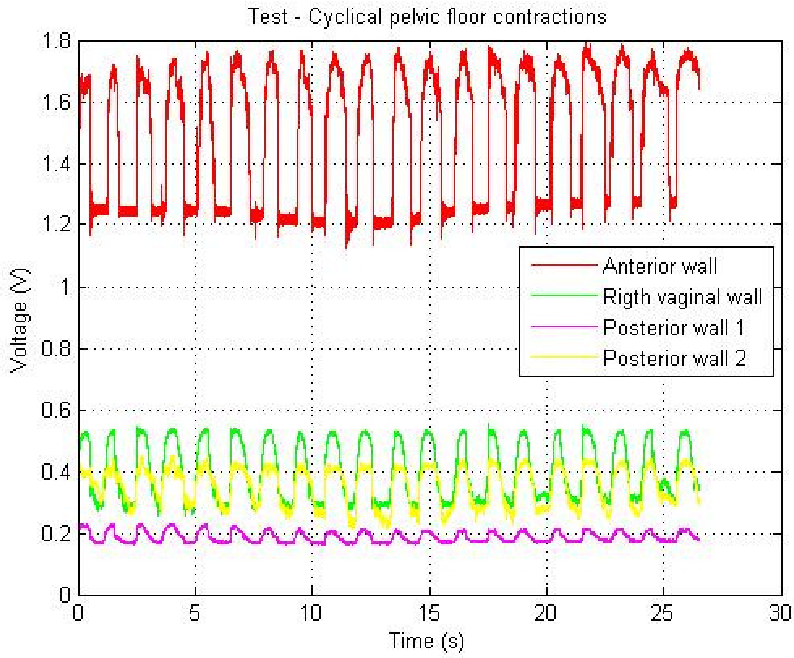

Figure 7. The signal during cyclical pelvic floor contraction

"Figure 8" shows the Fourier Transformation of the cyclical pelvic floor contraction. In this test, two principal frequencies were found; one caused by the exercises 0.977 Hz and another by muscle oscillation (0.488 Hz). It is important to elucidate that the frequency of 0.488 Hz is a harmonic frequency of 0.244 Hz. So, once more, the principal frequency obtained from the cyclical pelvic floor contraction was 0.244 Hz.

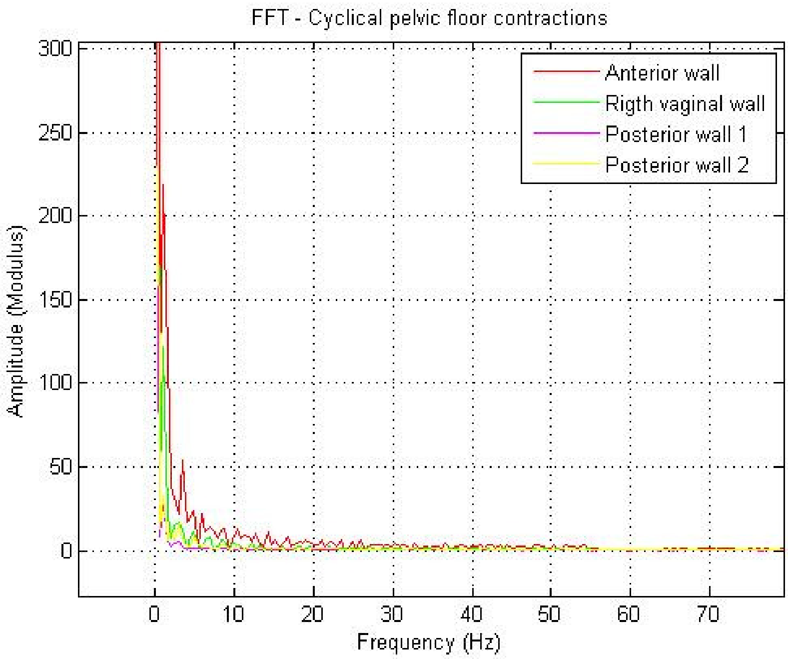

Figure 8. The Fourier Transformation of the cyclical pelvic floor contraction

Constantinou and Omata (2007) presented the design of a directionally sensitive multi-sensor probe, which had circumferential spatial resolution. The probe was constructed to identify the distribution of anisotropic forces that acted on the vagina following voluntary and reflex pelvic floor contractions. The results obtained from their time-frequency distribution of the force and displacement data in the anterior direction of the vaginal wall, indicated that the dynamic response of this probe configuration is sufficiently high to show that enough pelvic floor muscle contraction, contains significantly higher-frequency components (0.5– 4.4 Hz) compared to voluntary pelvic floor muscle contraction, whose range was 0.25–0.5 Hz. In this paper, similar oscillation frequencies to the work of Constantinou and Omata (2007) were found for voluntary pelvic floor contraction.

3. CONCLUSIONS

The frequency in which the PFM oscillate can contribute to the prescription of different physiotherapy modalities of treatment. So, the study of the pelvic floor muscle oscillation frequency is really important to be known. This was the first study developed at Labbio to analyze pelvic floor muscle oscillation in a healthy woman during different types of contractions. The data showed a small oscillation frequency, 0.244 Hz, which could be compared to the results found in the literature. This low frequency value could be attributed to the fact that 30% of all women do not know how to contract adequately their pelvic floor muscle in the first attempt, generating a fatigue condition. However, future works are necessary, with a great number of samples, in a way not only to confirm the population frequency oscillation of their pelvic floor but also perform a statistical analysis of the results.

4. ACKNOWLEDGEMENTS

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