PELVIC FLOOR MUSCLE SIMULATION FOR STRENGHT TESTS

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Abstract. *The pelvic floor is a complex muscular structure. The urogyneacological clutters of this muscle structure are innumerable and the urinary incontinence is one of the most frequent complications. For the physioterapical treatment of this dysfunction it is necessary trustworthy devices in obtaining relevant data. The available instruments in the market as biofeedback and perinemetry present imperfections as: to measure muscular response and pressures of all the skeleton muscle groups instead of specifically the pelvic floor. The aim of this work is to simulate "in vitro" the levator anis muscle to train futures examiners the sensibility of vaginal digital palpation. For this experiment, five springs were inserted in a plastic resin pelvis to simulate this specific muscle. Therefore, it was possible to establish a relation between the elastic force of the springs with an adaptation of the subjective Oxford scale used in evaluation of vaginal palpation. The results found are preliminary for this kind of bioengineering study and they should be used with some criteria once they were collected in a "in vitro" experiment and not in a "in vivo" patients.*

***Keywords**: pelvic floor, digital vaginal palpation, levator anis, strength, modified Oxford scale.*

1. Introduction

The pelvis is located in an intermediate position between the lower limb and the trunk, (Sampaio, 1999). It articulates with the trunk by the lombosacral joint and with the inferior members by the hip joint. The bone structure has unique characteristics that protect the pelvic as well as making possible the function of feminine copula and childbirth, (Rezende, 1995). The pelvis also participates in the static and dynamic balance of the body, transmitting the inferior forces between the vertebral column and the limb (Woerman, 2001).

The bony parts are the two ileums, which are symmetrical pairs; the sacrum, being uneven and symmetrical, (vertebral block consisting by the union of five sacra's vertebrae) and coccyx. Kapandji (2000) states that the pelvic girdle is an osteo- articular ring, stable and closed composed of four bone parts and three joints. The sacra iliac joint, that has reduced mobility, links the sacral bone to each one of the ileum bones and they are anteriorly articulated through the pubic symphysis, (Kapandji, 2000). A muscular layer coats the ileum bones and the walls of the pelvic cavity are set in inferior direction, like a funnel. The bone and muscle mass that occupies the base of this ring has the format of a basin, (Blandine, 1989).

The inferior cavity of the pelvis is linked to the pelvic floor through muscles, connected to the bone accidents that exist in the pelvic walls, (Blandine, 1991). Strottbehn (1998) divided the structures of the pelvic floor in: active - neuromuscles (muscles and nerves) and passive - bones and connective structures. Alterations and disequilibrium in the passive structure can intervene with the performance of the perineis muscles. This leads to the miccional dysfunctions (urinary incontinence and prolapses), pubic symphysis dysfunctions (sinfisites), and dispareunya (pain during the sexual act) (Woerman, 2001).

The pelvic floor muscles are divided into three layers, (Sapsford, 2004):

Superficial: the external anal sphincter and the bulbospongiosus, isquiocavernousous and superficial transverse perinei muscles.

Intermediate: intrinsic urethral sphincter, deep transverse perinei, and in the female, compressor urethra and the urethrovaginal sphincter.

Deep: levator anis comprising puborectalis, pubococcygeus, iliococcygeus and ischiococygeus, also know as coccygeus.

The levator ani is composed of two types of muscular fibers, type I, corresponding to 70% of staple fibers (slow contraction) and type II, which appears in 30% of the fibers (fast contraction). This composition allows the maintenance of the tonus for a long period, as well as the attainment of a sudden increase of the tonus to compensate sudden increases of the intra-abdominal pressure that occurs during coughing, sneezing and other types of physical effort, (Moreira and Amaro, 1999). The different muscles have fibbers in different directions, and if each muscle could contract in isolation, they would have different functions, (Bo, 2004). There are no primary motor muscles to put into motion the sacroiliac joint. The pelvic ring responds to a massive contraction of the pelvic floor muscles, (Greenman, 1999).

However, the only known voluntary function of the pelvic floor is the massive contraction that results in the rise and closing of the urethral, vaginal and anal meatos, (Bump, 1991). This inward movement of the muscles shows the capability of the maximum tension generated, and this force reflects the power, the resistance and the functional status of the same (Shull, 2002).

When the patient produces the maximum contraction of the skeletal muscles, he/she increases strength through a combination of factors as: an increase in the efficiency of motor units activation, an increase of the frequency of detonation of the same ones, an improvement in muscle tonus, and finally by the activation and hypertrophy of type I and of type II fibers visualized by the sectional area in the ultrasound (Di Nubile, 1991). The strengthen of the pelvic floor and the increase of the muscular stiffness, help the improvement of the support of the pelvis through a superior displacement of these muscles promoting a higher stability of the pelvic complex (Bo, 2004; Janda, 2003).

In the present study it was measured the strength of the levator anis muscular simulated "in vitro" through five springs attached in a plastic resin pelvis. Therefore, once we have simulated this muscle, a relation was established between the force applied in the springs with an adaptation of the Oxford (Brinck; 1994) subjective scale, used in evaluation of vaginal palpation.

2. Materials and methods

Tests were performed using a Plastic resin pelvis model with 9.5 cm of anterior-posterior diameter (imaginary line from the superior point of the pubis symphysis to the superior point of the promontory) and an 11.5 cm transverse diameter (imaginary line that superiorly cuts the pelvis cavity).

In order to simulate the levator anis musculature, five springs were used:

- One of the ends of the two springs was attached to a rope fixed in the pelvis at the height of the pubic symphysis and the other end was fixed to the coccyx by a steel handle, simulating tension in the pubococcygeus muscle. Those springs were disposed parallel to each other (Fig. 1 – Spring B1 and B2).
- One of the ends of two other springs was attached to a lower rope fixed in the pelvis at the height of the ileum and the other extremity was fixed to the coccyx by a steel handle, simulating tension in the iliococcygeus muscle. These springs were disposed parallel to each other (Fig.1 – Spring A1 and A2).
- The last spring was fixed to both ischyatic extremities, simulating tension in the ischiococygeus muscle and the upward movement of the levator anis muscle during a maximum contraction (Fig.1 – Spring C).

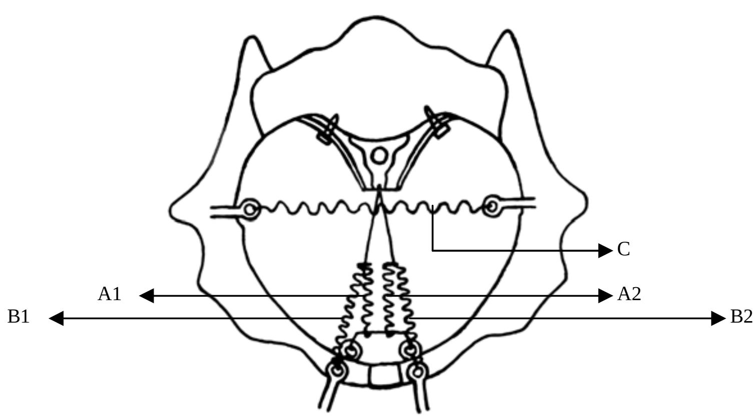

Figure 1. Schematical representation of the simulation of the levator anis with five springs.

The steel handles attached to the springs were inserted in to a mechanism of traction as indicated in the Figure 2. This mechanism of traction consists in an extensor of steel handle connected in a sixth spring (spring D) which actuates as a dynamometer to calibrate the system of springs. The four steel handle from the springs A1, A2, B1 and B2 were attached to this sixth after passing through a sheave system simulating the proper angulation of this musculature contraction.

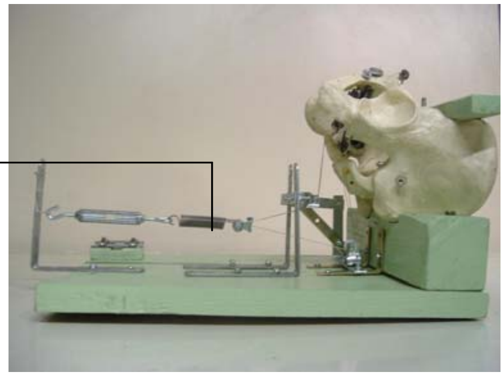

Figure 2. Lateral view of traction mechanism.

The digital assessment was performed with the pelvis fixed in anatomical position (Fig. 3 and Fig. 4). A well trained physiotherapist executed the palpation between the 4 springs to simulate the vaginal meatus. The movement and function of the levator anis contraction done by the springs was evaluated according to an Oxford modified scale (See Tab. 1.).

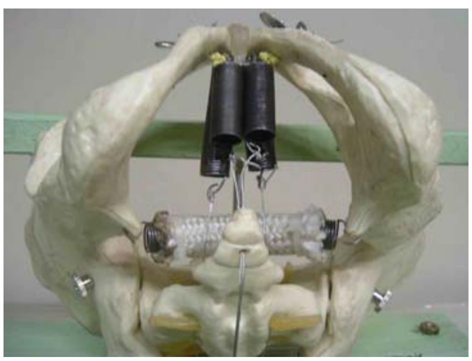

Figure 3. Springs in a relaxed position.

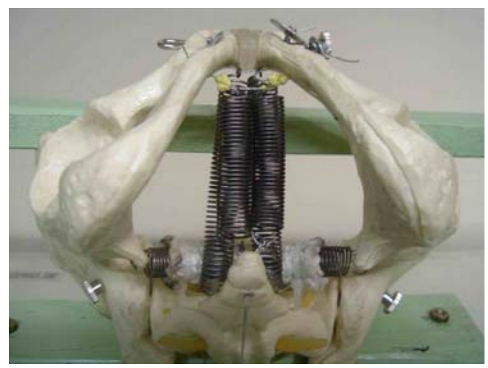

Figure 4. Springs in a contracted position.

Table 1. Modified Oxford Scale for digital evaluation of levator anis contraction strength.

Findings	Score
Null	0
Flicker of muscles	1
Weak contraction	2
Medium: Slight lift of examiners fingers	3
Strong: Elevation of examiners fingers	4
Very Strong: Elevation of examiners fingers	5

It was decided to use a modified scale because in this study there was no intention to simulate neither resistance nor fatigue from the levator anis muscles.

As the traction mechanism was strechted, the physiotherapist identified the six scores of the modified scale. At each score identified, the elongation of the spring D (dynamometer) was registred by a calliper. The score 0 was considered the inicial elongation of the spring when this was fixed in extensor of steel handle.

3. Results

Twelve series of vaginal digital palpation were performed by the physiotherapist in order to establish a relation between the score conferred by the modified Oxford scale and the force produced in the sixth spring. The results are presented in Fig. 5. It shows that score 0 represents the null force obtained by a null elongation of this spring.

Digital assessments of contraction strength, from scores 1-5, result in the following average values of force, respectively: 1(55.5 N), 2(56 N), 3(56.8 N), 4(59.5 N), 5(65.2 N).

The range of results for each score varied from: 1(55.3-55.8) N, 2(55.7-56.4) N, 3(56.4-57.2) N, 4(57.6-61.3) N, 5(62.6-67.9) N. The maximum value of standard deviation was 2.6 N, corresponding to score 5. Figure 5 shows the medium value and it standard deviation in each score of the subjective scale (1-5).

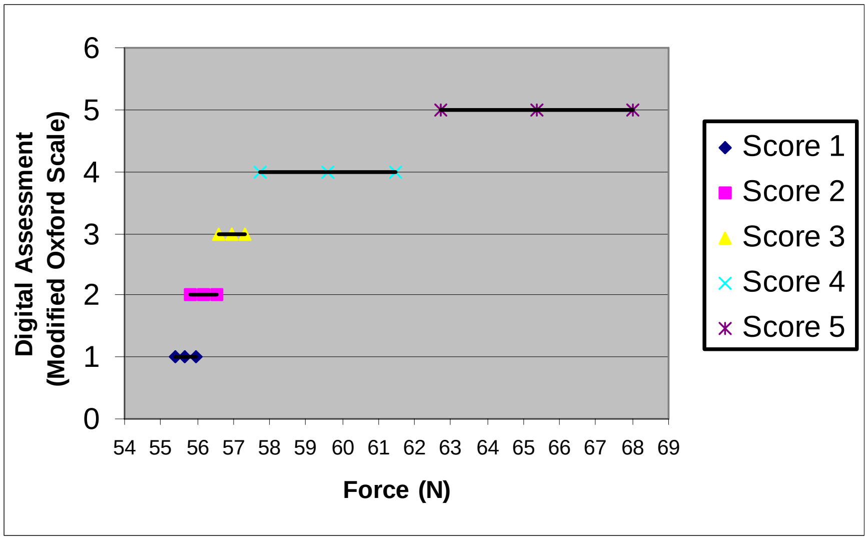

Figure 5. Distribution of results obtained when assessing digital palpation. In each score we represented the value of the average force ± its standard deviation value.

4. Discussion

This preliminary model developed at the Bioengineering Laboratory, after future improvements, has the intention to give the physiotherapist students a knowledge about the measures forces sensed by the clinician's fingers through digital palpation of vaginal meatus.

Vaginal digital palpation is a simple and subjective method to assess pelvic floor muscle function. It is employed a modified Oxford scale (6 points) to assess the contraction strength and movement of levator anis muscle simulated by five springs.

There are innumerable references about the position and numbers of examiners fingers (Hanh, 1996; Isherwood, 2000). In the present study two-finger palpation was used and the same investigator performed all the assessments. There was a break of fifteen minutes between each assessment so the sensibility and vascularization of the physiotherapist fingers could be re-established.

When performing the evaluation of the fourth and fifth grades, the physiotherapist examiner had difficulties in distinguish those points in the scale. According to Bo, K. (2001), palpation-categorizing scale does not have sufficient sensitivity (responsiveness) to differentiate between these scores. This goes in according to our data that shows a considerable increase in the standard deviation of the fourth and fifth grades (1.9 N and 2.6 N, respectively) when comparing with the others grades.

The general literature presents a pelvic floor results that are expressed in cmH_2O or mmHg (BO, 1999; Isherwood, 2000; Bo, 2001; Hahn, 1996). Only Dumoulin (2003) presented her results in N using a dynamometer calibrated applying increasingly greater loads from 0 to 15N. In a following paper, Morin and Dumoulin (2004) compared vaginal digital assessment with dynamometric measurements for determining the maximal strength of the pelvic floor muscles. They found that the dynamometric mean forces of pelvic floor muscle increased across subsequent categories of digital assessment, but the force values between two adjacent categories do not differ. Even in a different range of values, the data obtained in the present work agree with Morin's conclusion (See Fig. 4).

There is no standard recommendation for the minimum desirable forces when assessing pelvic floor muscle strength (Isherwood, 2000). It was identified errors during the data collection process, which are referred as follows: imperfect spring fixation, the procedures for the attainment of the springs Hook's module, procedures for calliper's reading, sheave attrition and the most significant, the examiner assessment.

In this study, some materials had been searched to simulate the levator anis muscles. However, the springs had been the mechanism that comprehends two important characteristics: to develop similar pressures and volumes at the examiners fingers and to distend/ compress by itself.

Although the subjective nature of this type of evaluation limits its use in scientific pelvic floor function, it can improve the quality of the measures developed by the examiners fingers. It was possible to establish a relation between springs force and the Oxford scale. Vaginal palpation is of utmost importance when teaching a patient how to perform a correct pelvic floor muscle contraction. It is well used by all clinicians to give the patient feedback about the quality of the contraction.

5. Acknowledgements

Authors wish to thank physiotherapist Thais Andrade for her expertise aid during the test rig evaluations. Financial support of CNPq and CAPES are kindly acknowledged.

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