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PELVIC FLOOR MUSCLE COMPLIANCE IN ELITE NULLIPAROUS ATHLETES.

<u>Hypothesis / aims of study</u>

Skeletal muscle is highly plastic and hypertrophy or atrophy occurs in response to both exercise and disuse, respectively (1). Women who have competed in high impact, long term, sport (HIFIT women) show differences in function and morphology of their pelvic floor muscles when compared to normal controls (2). 3/4D ultrasound and Magnetic Resonance Imaging have demonstrated hypertrophy of the puborectalis muscle, as well as an increased ability to distend the levator ani muscle during a voluntary valsalva in these HIFIT women.

The ability of the levator ani muscle to stretch is crucial during second stage labour to facilitate normal vaginal delivery. Changes within the muscle would influence the passive mechanics and therefore its ability to stretch. The aim of this study was to use a purpose built device to assess 'stiffness' of the puborectalis part of levator ani. However, as 'stiffness' or 'compliance' are strictly material properties measured with respect to force per cross sectional area (Pa), this study used the terms 'passive or active force' with 'stiffness' being interpreted as force per linear displacement.

<u>Study design, materials and methods</u>

Using a new, purpose built device we investigated passive force development in 15 HIFIT nulliparous women and 15 age-matched controls. Validation of the device had been undertaken by applying forces produced by known weights and measuring the corresponding voltage output which produced a linear Force N/ Voltage V relationship. A Hall-effect sensor was similarly calibrated using callipers to measure speculum displacement. Ten subjects were tested in a test-retest series 2-4 days apart to assess reliability. The reliability was assessed by calculating the coefficient of variation (CV%) at each diameter for the two different test days, and plotting the difference between the two measures against their mean (Bland Altman analysis). Passive force development was measured in the transverse diameter, between the lateral borders of the urogenital hiatus. The device consisted of a rounded speculum attached to two hollow aluminium rods, the dimensions of which are shown in the Figure 1. The ends of the device consisted of a rounded plastic speculum, very similar to a small 'Sims speculum'. The two 'arms' of the speculum were constructed such that when inserted into the vagina the tip of the speculum would be at a distance of 3.5cm from the introitus, where the puborectalis muscle is commonly situated. A force transducer was located inside the bottom arm, onto which a long screw acted. The ends of the speculum exerted a force against the muscle, with the screw transmitting that force to the load cell. Passive force of the muscle was determined by the displacement of the speculum and the reaction force from the muscle. The central unit consisted of a laptop computer and a National Instruments data acquisition card. A LabView V.8 application enabled the data to be visualised in real time via a custom user interface. This allowed the user to see a display of force to displacement in written and graphic form.

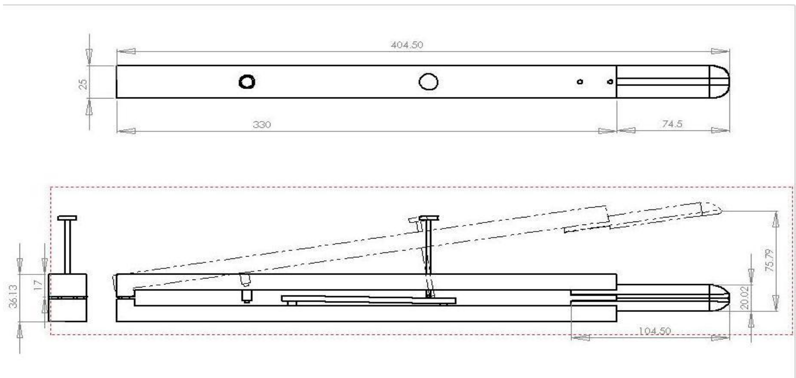

Figure 1: Illustration of the compliance device showing dimensions for the aluminium rods (A), the plastic speculum (B) and (C) the long screw acting on the force transducer.

Each participant was tested for passive force at five different diameters in increasing order, from 20mm to 40mm in 5mm steps. To account for reflex contraction on introduction of the device and the visco-elastic properties of the pelvic floor muscles, there was a time gap of 30seconds before recording started. This was repeated after each change in diameter of the device. All participants were tested supine, after voiding. The arms of the speculum were covered with disposable latex covers and hypoallergenic gel applied. The mean value of the passive force during this time was taken to be the force at that diameter. At a diameter of 40mm, the participants were instructed to perform a maximal voluntary pelvic floor contraction, twice. The most effective of these was used for analysis.

<u>Results</u>

The CV% for the reliability of the device, ranged between 4.42%-14.04% with an overall group CV% of 7.08%. Bland & Altman analysis did not show any systematic bias with mean differences close to zero at all diameters. The limits of agreement were most narrow at 25mm diameter of the device.

The demographic details of the two groups were similar in age, and body mass index. The age of the control group was 26.4 years (range 20-28) and the HIFIT 29.2years (range 19-37). BMI's for the control and the HIFIT were 23.5 (range 18.2-29.5) and 21.8 (range 18.1-25.6) respectively. Table 1 shows the results with significant increased passive force in the HIFIT group evident at 35mm and 40mm. Active force development was also significantly greater in the HIFIT group.

Diameter of device (mm)	HIFIT Mean passive force N (±SD)	Controls Mean passive force N (±SD)	p	95% CI
25	4.80(0.77)	4.26(0.90)	0.093	-1.16-.09

30	6.06(1.17)	5.33(1.23)	0.106	-1.6-0.16
35	8.18(1.73)	6.92(1.51)	0.043*	-2.24- -0.04
40	11.69(2.57)	9.61(2.17)	0.024*	-3.86- -0.29
PFMC	26.16(9.19)	16.52(4.60)	0.005*	-15.82 - -3.46

Table 1: Mean passive force in Newton of the pelvic floor muscle at each diameter in HIFIT women and Control group.

Interpretation of results

This preliminary study has demonstrated significant differences in stiffness, as previously defined, in HIFIT women, with an increased ability to generate greater active force during a maximum voluntary pelvic floor contraction. Increased 'stiffness' may be partly influenced by the naturally higher inherent tone of the pelvic floor muscles in the HIFIT group, due to an increased neural drive to pelvic floor muscle as a result of the long term high impact sport, and/or changes within the connective tissue component of the muscle. The muscle hypertrophy, previously demonstrated, would account for the increase in active force development. These preliminary findings may have implications both for vaginal delivery and the use of pelvic floor muscle exercise as a first line of treatment for urogenital disorders.

Concluding message

We have developed an intravaginal device for measuring stiffness/ compliance of the puborectalis muscle. This device was used in normal controls and athletes, showing significantly higher muscle stiffness and force generation in the athletes. Further prospective studies of pelvic floor muscle compliance are warranted.

References

1. Journal of Applied Physiology (1998) 64 (3) p 1114-1120
2. Ultrasound in Obstetrics and Gynecology (2007) 30 (1) p 81-85

Specify source of funding or grant	**University of Auckland**
Is this a clinical trial?	**No**
What were the subjects in the study?	**HUMAN**
Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**University of Auckland Human Participants Ethics committee**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**