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CHARACTERIZATION OF THE MECHANICAL PARAMETERS ASSOCIATED WITH PELVIC FLOOR MUSCLES CONTRACTIONS

Aims of study

To characterize the mechanical parameters associated with Pelvic Floor Muscles (PFM) contractions using a vaginal palpation probe and a transperineal ultrasound imaging system, in establishing the differences between continent and Stress Urinary Incontinent (SUI) females.

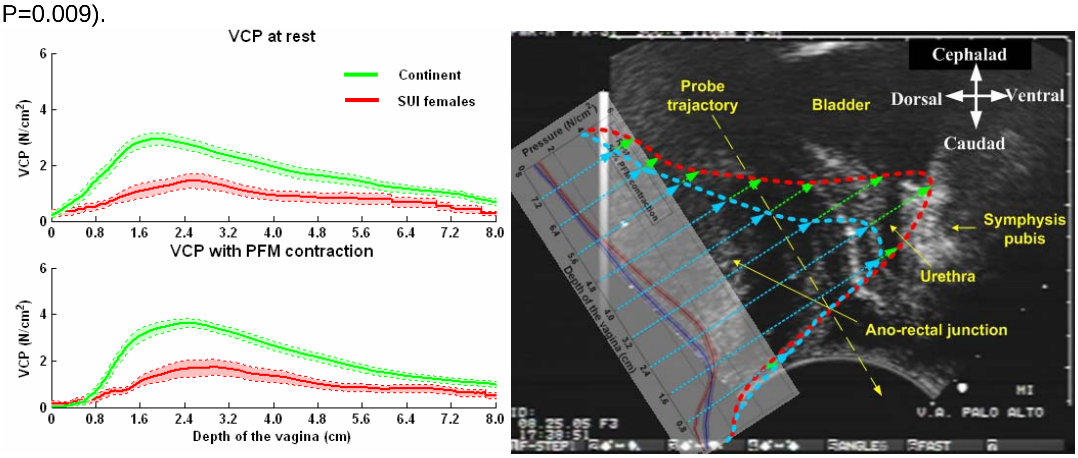
Study design, materials and methods

Studies were performed on 25 continent and 9 SUI females with a broad age distribution (continent: 38.95±2.3, SUI: 51.50±5.3) and parity (continent: 0.45±0.19, SUI: 1.5±0.22). The Vaginal Contact Pressure (VCP) on the posterior side (PFM side) of the vaginal wall was first assessed in supine position using the vaginal palpation probe. The VCP measurement was performed both at rest and during a sustained PFM contraction.

Perineal ultrasound imaging was then performed using a Hitatshi EUB-52 ultrasound system. Participants were asked to contract their PFM and hold the contraction for 5 seconds. The same perineal ultrasound imaging of PFM contraction was repeated in standing. A digital image processing approach, based on motion tracking algorithms, was then applied to the recorded ultrasound video to quantitatively analyze the kinematic parameters of PFM, in terms of displacement, velocity and acceleration, of the Ano-Rectal Angle (ARA). The positions of the ultrasound probe and the vaginal probe were both recorded by a six degrees-of-freedom positioning device. The VCP were geometrically matched with the ultrasound images according to the relative positions of the vaginal probe and ultrasound probe. Values are given as (Mean±SE) and level of significance was evaluated using the T-Test.

Results

Figure 1 (a) compares the VCP of continent and SUI subjects showing that the average VCP of the continent subjects is 1.67±0.13N/cm^2 at rest and 2.05±0.13 N/cm^2 during PFM contraction. These values are significantly higher than those of SUI patients both at rest (1.15±0.18N/cm^2, P=0.048) and with PFM contraction (1.35±0.20N/cm^2, P=0.009).



(a) (b)

Figure 1 (a) VCP of continent and SUI subjects. (b) The VCP matched with ultrasound image. The VCP at rest and with PFM contraction are shown in blue and red respectively. The VCP produced by the PFM contraction were derived by subtracting the VCP at rest from the VCP with PFM contraction (green arrows).

The kinematic measurements of the ARA movement are summarized in Table 1 and Table 2 showing that ARA displacements standing are significant higher supine. Maximum ARA velocities and accelerations (Table 2) shows: (1) the continent subjects have significantly higher ARA velocities in standing. By contrast, the SUI patients' ARA velocities didn't increase significant while standing. (2) The accelerations of the ARA are significantly higher in the standing position.

Table 1: Ventral-dorsal and cephalad-caudad displacement of the ARA (Unit: cm)

	Continent Subjects		SUI patients	
Directions	Ventral-dorsal	Cephalad-caudad	Ventral-dorsal	Cephalad-caudad
Supine	0.58±0.05	0.64±0.05	0.49±0.08	0.43±0.05
Standing	0.93±0.07	0.84±0.07	0.88±0.10	0.65±0.09
P value	P<0.0001	P=0.0167	P=0.0155	P=0.0608

Table 2: The ventral-dorsal and cephalad-caudad components of the maximum velocity and acceleration of the ARA.

	Velocity (cm/s)				Acceleration (absolute value, cm/s^2)			
	Ventral-dorsal		Cephalad-caudad		Ventral-dorsal		Cephalad-caudad	
	Healthy	SUI	Healthy	SUI	Healthy	SUI	Healthy	SUI
Supine	1.31±0.11	1.25±0.21	1.42±0.12	1.15±0.15	10.15±0.74	8.49±1.10	10.03±0.70	9.37±0.90
Standing	2.08±0.21	1.87±0.34	2.34±0.30	1.63±0.29	14.19±1.46	13.15±1.74	14.32±1.68	12.95±1.23
P value	**P=0.0008**	P=0.1441	**P=0.0009**	P=0.1283	**P=0.0077**	**P=0.0402**	**P=0.0076**	**P=0.0473**

Interpretation of results

As demonstrated in Figure 1 (b), the VCP measured along the posterior vaginal wall have maximum value at a position between the Urethro-Vesical Junction (UVJ) and symphysis pubis. It is suggested that VCP may produce a valve effect in the urethra: (1) cause L-shape deformations of urethra and therefore (2) increase closure pressure in the urethra. The statistical analysis shows the SUI patients had lower VCP both at rest and in standing. That implies the valve effects of the SUI patient are weaker than those of the continent subjects.

The ARA has become the target of our present analysis because the central sling component of the PFM, puborectalis and pubococcygeus, wrap around the anorectal junction, and its displacement is closely associated with a PFM contraction. The statistical analysis shows the continent subjects have greater ARA displacement than the SUI patients.

Analysis of ARA velocity suggests the continent subjects can contract their PFM faster in standing than supine. By contrast, PFM contractions of SUI patients are not significantly higher in standing implying that SUI patients' ability to control PFM contraction didn't significantly increase while standing, which is of higher possibility of urinary leaking than supine.

The ARA accelerations in PFM contraction were determined by the material properties of the pelvic floor tissues and the force produced by PFM contraction. The analysis shows ARA accelerations are higher in standing implying that a greater force is produced by PFM contraction and there is a lower resistance of pelvic floor tissues while standing compared to supine.

Concluding message

The continent subjects' PFM contractions produce higher VCP and more ARA displacement than SUI patients. In standing, the continent subjects' ARA velocities and accelerations are greater than in the supine position.

FUNDING: **NIH, grant 1R21 EB001654-1**
DISCLOSURES: NONE
HUMAN SUBJECTS: This study was approved by the Stanford University IRB committee and followed the Declaration of Helsinki Informed consent was obtained from the patients.