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ASSOCIATION BETWEEN DIGITAL ASSESSMENT (FLEXIBILITY AND STRENGTH) AND ULTRASOUND MORPHOMETRIC PARAMETERS OF THE PELVIC FLOOR

Hypothesis / aims of study

Pelvic floor muscles (PFM) should have an adequate resting tone, symmetry and the ability to voluntarily and involuntarily contract with constriction and inward (ventro-cephalad) movement of the pelvic openings [1]. Decreases in muscle tone and strength are associated with either reduced contractile activity and/or passive stiffness, which are components of the mechanism related to pelvic organs descent and urinary incontinence (UI). PFM function is commonly assessed by digital palpation scales, with the disadvantage of being a subjective method with limited reproducibility. Transperineal ultrasound (TPUS) has been increasingly used as an objective and non-invasive method to assess both the constriction of the PFM muscle and the inward movement of the pelvic floor structure, however its relation to digital assessments of PFM function in UI women is still unclear. The aim of this study is to explore the relation between PFM digital assessment (flexibility and strength) and morphometric parameters measured by TPUS in women with UI.

Study design, materials and methods

This is a cohort study with 60 years or older women suffering from UI symptoms. Participants were recruited through community-based advertising. UI was defined as at least one weekly episode of involuntary urine loss during the preceding 3 months. The participants were asked to empty their bladders, and were positioned in supine. Digital and TPUS assessments of the PFM were conducted by an experienced physiotherapist. The flexibility of the vaginal opening-(passive vaginal opening~~)~~ was measured with the index and, if possible, the middle finger inserted into the distal vagina to the proximal interphalangeal joints and abducted in the 3 and 9 o'clock plane. It was scored from 0 (less than one finger insertion) to 4 (two finger insertion with fingers abducted horizontally ≥2cm) [2]. PFM strength was assessed intra-vaginally with one finger, using the Modified Oxford Scale (MOS) with scores ranging from 1 to 5. PFM morphometry was evaluated using TPUS imaging (Voluson E8 Expert BT10; GE Healthcare) with a 3-/4-dimensional transperineal probe (RM6C next-generation matrix). Images were recorded at rest, during maximum PFM contraction and during cough. Each maneuver was performed twice and the ultrasound volume with the most effective contraction (i.e., most reduced levator hiatus antero-posterior diameter) and cough (i.e., most caudal displacement of the bladder neck (BN)) were considered for analysis. TPUS data was analyzed offline (4D View, Version 10.2; GE Healthcare) by an observer blinded to the digital assessment. Morphometry was assessed by measuring the following parameters in the midsagittal and axial planes (at the level of minimal hiatal dimensions) planes: (1) anorectal height, distance from the apex of the anorectal angle to a horizontal reference line passing by the inferior-posterior margin of the symphysis pubis, BN (2) x-axis and (3) y-axis related to the inferior-posterior margin of the symphysis pubis, (4) levator hiatus area, (5) levator hiatal antero-posterior and (6) transverse diameters.
The shift between rest condition and both tasks (cough and contraction) were calculated (rest – task), as well as the percentage of change for each variable ((rest – task)/rest %). BN cranioventral displacement was also calculated for contraction and cough as the hypotenuse of a right-angled triangle (square root: ΔBN-x^2+ΔBN-y^2).
The relationships between digital and TPUS assessments of PFM function were investigated using Pearson correlation coefficient and hierarchical stepwise regression by assessment condition (rest, contraction/couch). This method was used to explore how well digital assessment variances are explained by morphometric parameters of the pelvic floor TPUS evaluation.

Results

204 incontinent women were evaluated. Participants were aged between 60 and 84 (68 ± 5.6) years, mean BMI was 27.1 ± 4.6 Kg/m^2, parity ranged from 0 to 8 (median 2, interquartile range from 1 to 3) and the mean ICIQ-UI SF score was 12.3 ± 3.3. For the digital assessment, flexibility score ranged from 0.75 to 4 (median 2, interquartile range from 2 to 2.5) and MOS ranged from 0 to 5 (median 3, interquartile range from 3 to 4). Ultrasound morphometric parameters are shown in Table 1.
Associations between flexibility and morphometric parameters of the PFM during rest and cough are shown in Table 2. Using hierarchical regression by assessment condition (rest, cough) levator hiatus area at rest explained 10.9% of the variance in flexibility (Beta coefficient in the final model is β= 0.327; p<0.01). When adding variables in the cough condition to the model, BN cranio-ventral shift (β = 0.028; p = 0.700) explained additionally 0.1% of the variance, for a total explained variance of 11%.

Table 1 Morphometric parameters measured by transperineal ultrasound

Ultrasound assessment	*Rest*	*Std Dev.*	*Contraction*	*Std Dev.*	*shift*	*(%)*	*Cough*	*Std Dev.*	*shift*	*(%)*
Anorectal height [mm]	18.8	6.4	21.7	6.0	-2.9	(-15%)	15.6	7.2	3.2	(17%)
Bladder neck x [mm]	2.0	5.4	-2.8	6.1	4.8	(246%)	8.2	6.9	-6.3	(-321%)
Bladder neck y [mm]	23.6	4.2	25.2	4.8	-1.6	(-7%)	19.2	6.5	4.4	(19%)
Levator hiatus area mm2]	1433.3	318.2	1184.2	262.1	249.1	(17%)	1622.5	403.8	-189.2	(-13%)
Levator anteroposterior [mm]	53.5	7.5	44.9	6.7	8.6	(16%)	54.1	8.0	-0.6	(-1%)
Levator transverse [mm]	38.2	4.8	37.0	4.8	1.2	(3%)	41.2	5.6	-3.0	(-8%)

Bladder neck cranio-ventral shift [mm]: contraction 6.7 ± 4.6 and cough 9.2 ± 6.0.

Table 2 Pearson correlation coefficients and *p* values (flexibility *versus* morphometry)

	Rest	*Cough*		
Ultrasound assessment	*raw data*	*raw data*	*shift*	*% of change*
Anorectal height	r= -0.036; p=0.62	r= -0.055; p=0.44	r= 0.078; p=0.28	r= 0.107; p=0.13
Bladder neck x	r= 0.127; p=0.08	r= 0.269; p<0.01	r= -0.233; p<0.01	r=-0.022; p=0.77
Bladder neck y	r= 0.069; p=0.33	r= -0.131; p=0.07	r= -0.183; p<0.01	r= -0.181; p=0.01
Levator hiatus area	r= 0.353; p<0.01	r= 0.349; p<0.01	r= -0.161; p=0.03	r= -0.120; p=0.11
Levator hiatus anteroposterior	r= 0.275; p<0.01	r= 0.280; p<0.01	r= -0.101; p=0.16	r= -0.091; p=0.21
Levator hiatus transverse	r= 0.254; p<0.01	r= 0.298; p<0.01	r= -0.151; p=0.04	r= -0.129; p=0.08

BN cranio-ventral shift (r= 267, p<0.01); Statistically significant results are highlighted, p<0.05

Associations between strength (MOS) and morphometric parameters of the PFM during rest and contraction are shown in Table 3. Using hierarchical regression by assessment condition (rest, contraction), the anorectal height at rest explained 1.6% of the variance in strength (Beta coefficient in the final model is β= 0.135; p=0.052). When adding variables in the contraction condition to the model, anorectal height percentages of change (β = -0.324; p<0.001), levator hiatus anteroposterior shift (β = -0.726; p = 0.002) and percentages of change (β = 1.198; p<0.001) explained additionally 33.8% of the variance (p<0.001) for a total explained variance of 35.4%.

Table 3 Pearson correlation coefficients and *p* values (strenght *versus* morphometry)

	Rest	*Contraction*		
Ultrasound assessment	*raw data*	*raw data*	*shift*	*% of change*
Anorectal height	r= -0.128; p=0.07	r= 0.070; p=0.32	r= -0.326; p<0.01	r= -0.290; p<0.01
Bladder neck x	r= 0.016; p=0.82	r= -0.239; p<0.01	r= 0.363; p<0.01	r= 0.095; p=0.21
Bladder neck y	r= 0.029; p=0.68	r= 0.203; p=0.01	r= 0.201; p=0.01	r= 0.174; p=0.02
Levator hiatus area	r= 0.007; p=0.92	r= -0.274; p<0.01	r= 0.346; p<0.01	r= 0.421; p<0.01
Levator hiatus anteroposterior	r= 0.065; p=0.36	r= -0.319; p<0.01	r= 0.461; p<0.01	r= 0.511; p<0.01
Levator hiatus transverse	r= -0.044; p=0.54	r= -0.112; p=0.12	r= 0.103; p=0.15	r= 0.125; p=0.08

BN cranio-ventral shift (r= 0.357, p<0.01); Statistically significant results are highlighted, *p*<0.05

Interpretation of results

Higher PFM flexibility (passive vaginal opening) was associated with larger levator hiatus at rest. For the cough task, higher flexibility was related to more dorsally positioned BN and larger displacements of BN and levator hiatus. Levator hiatus area at rest contributed more to predicting PFM flexibility than any other morphometric parameter assessed during rest or cough, although with poor agreement. PFM strength was associated with smaller hiatus area and anteroposterior dimension, with more cranial and ventrally positioned BN and with higher shifts and percentages of change of almost all measured variables during contraction. Anorectal height, levator hiatus dimension shift and percentages of change during contraction were the variables that better contributed to the prediction of PFM strength, with fair agreement.

Concluding message

In older women with UI, increased flexibility was poorly associated with PFM morphometry during rest and cough. Higher PFM strength was fairly associated with increased constriction of the PFM and inward movement of the PFM structure during contraction.

References

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