

FUNCTIONAL ASPECTS OF PELVIC FLOOR MUSCLE CONTRACTION USING 4D REAL TIME ULTRASOUND. A TEST-RETEST STUDY

Hypothesis / aims of study

During a pelvic floor muscle (PFM) contraction, mainly the lift of the bladder neck has been investigated. To our knowledge only one study has quantified pubovisceral muscle length reduction (1), and no studies have quantified narrowing of levator hiatus (LH) area and transverse distance during contraction. Neither has the magnitude and the direction of the displacement of rectal ampulla been investigated. The aims of the present study were to evaluate test-retest measurements of functional aspects of PFM contraction using 4D real time ultrasound by:

1. Measuring LH area, antero-posterior distance (LHap), transverse distance (Lhrl) and pubovisceral muscle length rest and maximal contraction (axial plane) (Fig 1).
2. Measuring lift (displacement) of the bladder neck, cervix uteri, rectal ampulla and back sling of the pubovisceral muscle (sagittal plane)

Study design, materials and methods

The study was designed as a test-retest intra-tester study. Two test series were performed with an interval of 7 to 35 days. The assessor was blinded to the results of test 1 during test 2.

A convenience sample of 17 healthy female volunteers performed three maximal PFM contractions in standing, recorded by 4D real time ultrasound. A GE Voluson 730 expert ultrasound system with 4-8 MHz curved array 3D/4D ultrasound transducer (RAB 4-8 l/obstetric) was used. The field of view angle was set to its maximum of 70 ° in the sagittal plane and volume acquisition angle to 85 ° in the coronal plane (frame rate was 3 Hz). Only a minor part of the PS was scanned in order to include the back sling of the pubovisceral muscle. Analyses of 4D real time volumes were conducted offline using the software "4D View v 5.0". Measurements were performed in the axial plane of minimal hiatal dimensions, and in the sagittal plane. Positions of all the structures in the sagittal plane were analysed using two different systems, a horizontal reference line (2) and an on-screen vector-based method (3). Test-retest intra-tester reliability was analysed using intra-class correlation coefficient (ICC, repeated measures) with 95% confidence interval (CI). Results are given as mean values with 95% CI for test 1 values. Wilcoxon's nonparametric test was used to test the hypothesis that the two variables have the same distribution, analysed from test 1. P values <0.05 were considered significant. ICC values under 0.20 were considered poor, 0.21- 0.40 fair, 0.41-0.60 moderate, 0.61-0.80 good, and 0.81-1.00 very good.

Results

Very good and good reliability was found for measurement of: LH area, LH antero-posterior dimension, LH transverse dimension, pubovisceral muscle length at rest and at maximum constriction and LH narrowing (Table 1). Shortening of LH transverse distance and muscle length during contraction showed poor and fair reliability, respectively. During contraction the LH area was reduced 25%. The muscle length shortened 21%. Test-retest values from measurements in the sagittal plane showed good and very good reliability, using the on-screen method (3), and showed more variable results using the method with A horizontal reference line (2). The position of the cervix uteri was only detected in three pairs of 17 volumes, and therefore was not analyzed. The back sling of the pubovisceral muscle and the rectal ampulla had a greater displacement than the bladder neck ($p > .004$). The displacement of the pelvic organs was two times, or more, greater in the cranial versus anterior direction. The mid urethra moved 1.1mm (95% CI= 0.1-2.2) towards the pubic bone during contraction.

Table 1. Test-retest analyses for measurement during pelvic floor contraction. Measurement of displacement of the pelvic organs in the sagittal plane is conducted using on-screen vector method. Mean values with 95% confidence interval (CI) and ICC with 95% CI.

	Test 1	Test 2	ICC
LH area narrowing (%)	24.91 (18.13-31.70) (n=11)	28.66 (20.71-36.59) (n=13)	0.92 (0.68-0.98) (n=8)
LH anterior posterior reduction (%)	21.14 (17.00-25.28) (n=15)	26.97 (19.97-33.96) (n=13)	0.63 (0.09-0.89) (n=11)
LH transverse reduction (%)	6.34 (2.94-9.74) (n=16)	4.05 (1.22-6.89) (n=17)	0 (0-0.34) (n=16)
Muscle length during contraction (cm)	9.70 (8.73-10.67) (n=16)	9.57 (8.54-10.60) (n=16)	0.79 (0.50-0.93) (n=15)
Muscle length shortening (%)	20.62 (15.29-25.95) (n=15)	27.41 (21.59-33.23) (n=14)	0.40 (0-0.78) (n=12)
Bladder neck displacement (cm)	1.13 (0.83-1.43) (n=16)	1.17 (0.92-1.41) (n=17)	0.81 (0.54-0.93) (n=16)
Rectal ampulla displacement (cm)	2.04 (1.46-2.61) (n=13)	2.09 (1.60 -2.57) (n=12)	0.80 (0.44-0.94) (n=11)
Pubovisceralis back sling displacement (cm)	1.98 (1.59-2.39) (n=13)	1.94 (1.32-2.56) (n=11)	0.75 (0.25-0.94) (n=9)

Interpretation of results

4D ultrasound can reliably assess muscle length, narrowing of LH area, reduction of LH antero-posterior dimension and lift of bladder neck, rectal ampulla and back sling of the pubovisceral muscle. Thus, both squeeze and lift can be quantified during PFM contraction. Shortening of LH transverse distance and muscle length during contraction showed poor and fair reliability, respectively. Hence, measurement of hiatal dimensions and displacement of bladder neck, rectal ampulla and back sling of the pubovisceral muscle can be used in clinical practice and in scientific research.

Concluding message

Very good and good reliability was found for measurement of: LH area, LH antero-posterior dimension, LH transverse dimension, pubovisceral muscle length and LH narrowing. During contraction the LH area was reduced 25% and the muscle length shortened 21%. The back sling of the muscle and the rectal ampulla moved more than the bladder neck and the displacement of the pelvic organs was two times, or more, greater in the cranial versus anterior direction. There is still a need for further investigation of how to quantify displacement of cervix uteri and muscle length shortening. Based on the present study perineal 4D ultrasound is recommended to measure constriction of hiatal dimensions and displacement of bladder neck, rectal ampulla and back sling of the pubovisceral muscle.

References

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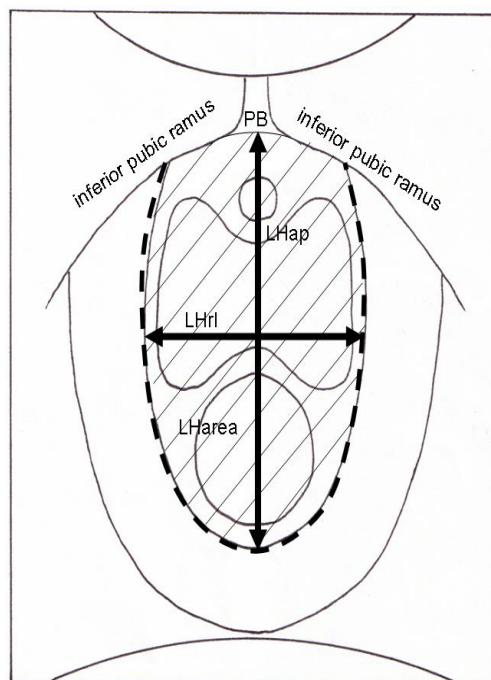


Figure 1: Measurements in the axial plane of minimal hiatal dimensions. Levator hiatus area (LH area) is marked with lines. LH ap= levator hiatus antero-posterior diameter. LH rl= Levator hiatus transverse diameter right-left. PB= pubic bone.

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Is this a clinical trial?	Yes
Is this study registered in a public clinical trials registry?	Yes
Specify Name of Public Registry, Registration Number	Clinical Trials gov Identifier: NCT00271297, and the Data Inspectorate of Norway (200501371 SM/RH).
What were the subjects in the study?	HUMAN
Was this study approved by an ethics committee?	Yes
Specify Name of Ethics Committee	The study was approved by the Regional Medical Ethics Committee (s-05146-2)
Was the Declaration of Helsinki followed?	Yes
Was informed consent obtained from the patients?	Yes