

EFFECT OF AGE ON LEVATOR ANI MUSCLE VOLUME AND CROSS-SECTIONAL AREA IN NULLIPAROUS WOMEN

Hypothesis / aims of study

It is not known how age, uninfluenced by parity, prolapse or incontinence, affects the volume and cross-sectional area (CSA) of the levator ani muscles in women. Ageing is associated with an increase in prevalence of pelvic organ prolapse, urinary incontinence and decreased muscle strength and bulk throughout the body. It is likely, therefore, that similar processes affect the pelvic floor musculature. We tested the null hypothesis that advancing age would neither affect the volume nor CSA of the levator ani, when compared to the adjacent striated muscle, obturator internus, visible in the pelvic MR images, which served as a control for the effect of age.

Study design, materials and methods

MR images of a sample of 15 healthy younger (aged between 21 and 25 years) and 12 healthy older nulliparous women (aged 63 years and over) were selected from more than 1,000 women recruited for pelvic floor research with images in an MR database. Our study was powered to detect an expected 30% difference in the volume and CSA of levator ani based on published studies of appendicular muscle. Outlines of the levator ani muscle were traced in the coronal plane (Fig 1), and obturator internus in the axial plane (not shown) in 3D Slicer version 3.4 (Slicer.org) and then lofted into 3D models. Two of the 12 older women's MRI scans had incomplete levator ani images and were only used for the obturator internus tracings. Models were then compared against original scans to detect artefacts from model creation and errors corrected iteratively. Volumes were calculated within Slicer and then models imported into ImagewareTM for calculation of muscle cross sectional area. For the levator ani, a fibre direction line was created based on superimposing a published fibre architecture plot (Fig 2). For the obturator internus, a fibre line was created from the midpoint of a line marking the ischium between its spine and tuberosity, to a midpoint at the dorsal aspect of the muscle. For each muscle, nine equidistant points were then marked along the fibre line from an anterior to posterior position and the anatomical CSAs were calculated at those points in planes perpendicular to the fibre line for the levator ani (Fig 2). The hypotheses were tested using repeated measures analysis of variance (mixed model procedures in SAS, v. 9.1; SAS, Inc.Cary, NC) with $p < 0.05$ being considered significant.



Figure 1. Sample traced outlines of coronal MR images from a young subject showing levator ani outlined in yellow.



Figure 2. The levator ani fibre line-of-action (thick line) superimposed upon the Shobieri fibre architecture and an aligned 3D model. The parallel lines show the measured CSAs

Results

Obturator internus (control) muscle volume was reduced by 28.2% in older (mean [SD]: 63.99[10.37] cm³) compared with younger (89.13[12.24] cm³) women ($p < 0.001$). CSA in older women (Figure 3) was statistically significantly reduced ($P < 0.001$), compared to younger women; especially in the more dorsal regions that lie near the muscle tendon (locations 5 to 8). The 10.9% degree of muscle loss between younger (mean [SD]: 29.59 [4.24] cm³) and older (26.37 [5.35] cm³) women in the levator ani muscle did not reach statistical significance ($p = 0.13$) and there was a non significant trend to differences in the CSA (Figure 3, right, $p = 0.12$). In terms of levator CSA, there was a non-significant trend to an age difference (Figure 3, right, $p = 0.12$). Only in the most dorsal aspect of the iliococcygeal portion of the levator was a significant difference found (location 9, Figure 3, $p = 0.006$).

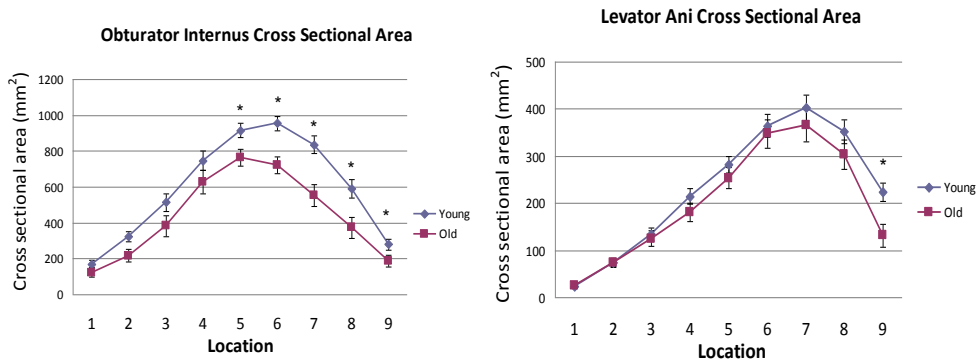


Figure 3. The mean (SE, vertical bars) anatomical CSAs in the two striated muscles from young (n=15) and old (n=12 for obturator internus, n=10 for levator ani). Location 1 is nearest the pubic symphysis and location 9 is closest to the ischial spine. * p<0.05

Interpretation of results

The differential findings depending on muscle type are most likely accounted for by the different fibre type composition of the two muscles. Many published studies have shown that the CSA of Type II fibres atrophy with age, whereas Type I fibres are relatively spared. Because the levator ani muscle is only comprised of 5-33% Type II fibres (1, 2), CSA may be less affected by age than the obturator muscle which has a 50/50 composition. The lack of deterioration in the volume and CSA of the levator muscle found in this study is consistent with the finding that levator ani function, as measured by resting vaginal closure force and augmentation of vaginal closure force, is not adversely affected by increasing age (3). We postulate therefore that parity plays a much more significant role in levator ani failure and the development of prolapse than ageing process itself.

Concluding message

In healthy nullipara, neither volume nor CSA of the intact levator ani decrease with age to the same degree as the adjacent striated appendicular muscle in the same individual. The question remains why age is a factor in prolapse development. It is likely that age related changes in connective tissue interact with prior birth-related injury and that this modest muscle loss due to age may be a small part of the story.

References

1. Gosling JA, Dixon JS, Critchley HO, Thompson SA. A comparative study of the human external sphincter and periurethral levator ani muscles. Br J Urol. 1981 Feb;53(1):35-41.
2. Gilpin SA, Gosling JA, Smith AR, Warrell DW. The pathogenesis of genitourinary prolapse and stress incontinence of urine. A histological and histochemical study. British journal of obstetrics and gynaecology. 1989;96(1):15-23.
3. Trowbridge ER, Wei JT, Fenner DE, Ashton-Miller JA, DeLancey JO. Effects of aging on lower urinary tract and pelvic floor function in nulliparous women. Obstet Gynecol. 2007 Mar;109(3):715-20.

<i>Specify source of funding or grant</i>	We gratefully acknowledge the financial support of U.S. Public Health Service grants P50 HD44406 and R01 HD38665.
<i>Is this a clinical trial?</i>	No
<i>What were the subjects in the study?</i>	HUMAN
<i>Was this study approved by an ethics committee?</i>	No
<i>This study did not require ethics committee approval because</i>	this study was a post hoc analysis of a previous study which did have the appropriate ethics approval
<i>Was the Declaration of Helsinki followed?</i>	Yes
<i>Was informed consent obtained from the patients?</i>	Yes