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ORIGINAL ARTICLE

Effects of age on levator function and morphometry of the levator hiatus in women with pelvic floor disorders

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Abstract
Introduction and hypothesis Epidemiological data supports the hypothesis that ageing is a risk factor for pelvic organ prolapse. In this study, we intended to determine the effect of age on levator function and morphometry in women with pelvic floor disorders.
Methods Three hundred seventy-five patients underwent an interview, physical examination and transperineal ultrasound. Clinical assessment included palpation using the Modified Oxford Scale. Ultrasonography was performed to diagnose levator defects and assess levator hiatal morphometry.
Results Pelvic floor muscle strength was weakly associated with patient age ($r=-0.25$, $p<0.01$). This remained true after accounting for the confounders parity and levator defects. Morphometry of the levator hiatus was weakly positively correlated with age.
Conclusions Ageing seems to have a limited effect on contractility and distensibility of the pelvic floor muscle. The small effect of ageing results in reduced contraction strength and increased hiatal diameters. This effect is partly confounded by parity and levator defects.

Keywords Age · Pelvic floor · Prolapse · Ultrasonography

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Introduction

Epidemiological data support the hypothesis that ageing is a risk factor for female pelvic organ prolapse [1]. It is generally accepted that anatomical integrity and function of the levator ani muscle are likely to play an important role in pelvic organ support [2, 3]. However, several studies describing a relation between ageing and prolapse did not take into account parity, and parity is likely to be a confounder of this relationship [4].

There is a strong correlation between vaginal delivery and prolapse in epidemiological studies [1]. With MR imaging and transperineal ultrasound major levator defects (‘avulsions’) are diagnosed in 15–30% of vaginally parous women, with no such defects seen in nulliparous women [5, 6]. Women with prolapse are more likely to have major levator defects than controls (odds ratio [OR] 7.3, 95% confidence interval [CI] 3.9–13.6), and women with avulsion have an increased risk of prolapse, especially cystocele and uterine prolapse (relative risk [RR] 2.3 (CI, 2.0–2.7) for cystocele, and 4.0 (CI 2.5–6.5) for uterine prolapse) [3]. The genital hiatus was 50% longer in women with prolapse than controls [2]. An avulsion of the puborectalis muscle has a marked effect on levator function measured by the Modified Oxford grading [7] and on hiatal biometry [8]. Recent studies have shown a correlation between levator biometric indices and pelvic organ support [9, 10], and so it seems reasonable to assume that any age-related effect on pelvic organ support may be mediated by changes in pelvic floor function due to ageing However, Trowbridge et al. showed no association between age and levator function among healthy nulliparous women [11].

In this retrospective study, we therefore intended to determine the effect of age on levator function and morphometry of the levator hiatus in a series of patients

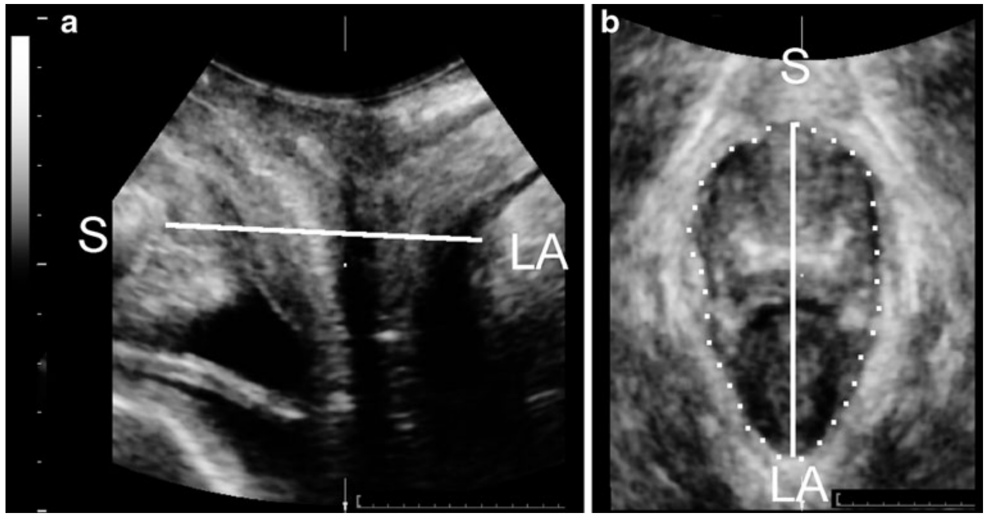

Fig. 1 Determination of hiatal dimensions by transperineal ultrasound. The left figure (**a**) shows a midsagittal view on maximal Valsalva. The white line defines the plane of minimal hiatal dimensions which is shown in the axial plane image on the right (**b**). The vertical white line on the right is the midsagittal hiatal diameter; the dotted line demonstrates measurement of the hiatal area on Valsalva. *S* symphysis pubis, *LA* levator ani muscle

presenting for urogynaecological evaluation, in order to determine whether the effect of age on pelvic organ support might be mediated by the levator ani muscle.

The hypothesis to be tested in this study is as follows: age has no effect on levator function and morphometry of the levator hiatus in patients presenting with symptoms of pelvic floor dysfunction.

Methods

In a retrospective study, we reviewed the records of 375 patients who had attended a tertiary urogynaecological unit for the investigation of lower urinary tract or pelvic floor disorders. A physical examination was performed to stage pelvic organ prolapse according to the international POP-Q classification. Clinical assessment of the pelvic floor muscles (PFM) was performed by digital palpation for contractility using the Modified Oxford Scale (MOS) system [12] (Grade 0, nothing; 1, flicker; 2, weak squeeze; 3, moderate squeeze and lift; 4, good squeeze and lift; 5, strong squeeze and lift). MOS grading was undertaken for both sides separately. The use of half grades was allowed. The mean of both sides was determined, resulting in a 21-point scale. For ultrasound imaging, Volume cine loops were obtained by 4D transperineal pelvic floor ultrasound. A GE Kretz Voluson 730 expert system (GE Medical Ultrasound) was used with an 8- to 4-MHz RAB volume transducer with 85° acquisition angle. Imaging was performed with the patient supine and after bladder emptying. All datasets were processed offline by a third investigator (MW), blinded for all clinical data, using the software GE Kretz 4D View 5.0 for hiatal area and diameters in rest, on PFM contraction and Valsalva (Fig. 1). Hiatal biometry obtained by this method has been shown to be reproducible, both by the authors and others [9, 13, 14]. Biomechanical properties of the levator ani muscle were measured by strain on valsalva and contraction as previously described [15]. Levator avulsion was diagnosed at the time of the clinical assessment, using tomographic ultrasound as previously described [16].

Statistical analysis was performed with SPSS version 15.0 for Windows. Pearson's correlation, *t* test and stepwise

Table 1 Patient characteristics

Mean age (range)	55 years (18–89)
History:	
Prior surgery for incontinence or prolapse	50/375 (13%)
Prior hysterectomy (any indication)	106/375 (28%)
Nulliparous	26/375 (7%)
No vaginal deliveries	50/375 (13%)
Prolapse	
Subjective: feeling of lump/dragging sensation	160/375 (43%)
Physical examination: POP-Q grade II or higher	155/375 (41%)
Urinary Incontinence:	
Stress	118/375 (31%)
Urge	119/375 (32%)
Levator defects (avulsion)	78/375 (21%)

Table 2 Effect on pelvic floor muscle strength by mean modified Oxford grading

	Standardised *b*	*p* value
Simple linear regression analysis		
Age	−0.25	<0.01
Menopausal status	0.03	0.52
At least one vaginal delivery	−0.17	<0.01
Levator defect (avulsion)	−0.29	<0.01
Multiple linear regression analysis		
Model: Age, at least 1 vaginal delivery, levator defects (avulsion)		
Age	−0.21	<0.01
At least 1 vaginal delivery	−0.11	0.04
Levator defect (avulsion)	−0.25	<0.01

regression were used. A p value<0.05 was considered statistically significant.

Results

The datasets of 375 women were available for analysis. Patient characteristics are summarised in Table 1. The mean age was 55 years (range 18–89). Of 375 patients, 26 (7%) were nulliparous, and a total of 50 (13%) were vaginally nulliparous. In 80 women (21% overall and 24% of the vaginally parous), an avulsion of the levator muscle was diagnosed by 4D perineal ultrasound.

Pelvic floor muscle strength as measured by the Oxford grading system was related to patient age on simple linear regression with standardised b=−0.25 (p<0.01; Table 2). Simple linear regression identified vaginal delivery and levator defects as possible confounders whereas menopausal status was not a confounder. In multiple linear regression, vaginal delivery (standardised b=−0.11, p 0.04) and levator defects (standardised b = −0.25, p<0.01) appear to be independent confounders, but even after accounting for these factors there was still a weak but significant association between age and the Oxford grading system (standardised b=−0.21, p<0.01; Table 2.)

Morphometry of the levator ani by 4D transperineal ultrasound included levator hiatal diameters and hiatal area at rest, on PFM contraction and on Valsalva. Table 3 shows the mean and the range of all biometric measurements.

The coronal diameters showed no significant relationship with age as shown in Table 4. All AP-diameters and area-measurements were weakly positively correlated with age. Strain as a measure of the biomechanical properties of the levator muscle showed no correlation between age and strain on contraction (standardised b −0.07, p=0.19) or on Valsalva (standardised b −0.03, p=0.57).

Multivariate regression analysis showed the confounding effect of vaginal delivery and levator defects, but there was still a weak association between age and morphometry of the levator hiatus. (Table 5) On performing subgroup analysis, correlations between age and hiatal dimensions were consistently strongest in nulliparous or vaginally nulliparous women confirming a weak relationship between age and morphometry irrespective of parity.

Discussion

Age is generally believed to be an important factor in the aetiology of female pelvic organ prolapse [1]. As morphology and function of the levator ani muscle is clearly associated with prolapse [2, 3, 10], we designed this retrospective observational study to determine whether there is a significant relationship between age and levator morphometry and function, as such a relationship might potentially explain the epidemiological link between age and prolapse.

We have demonstrated a weak relationship between age on the one hand and ultrasound morphometry of the levator hiatus as well as muscle strength as quantified by the Modified Oxford Grading system on the other hand. This relationship remained significant even after controlling for the confounding effect of parity and levator defects. This is in contradiction to Trowbridge et al. who showed no age-related effect at all with levator function among healthy nulliparous women [11], but Trowbridge assessed a smaller

Table 3 Mean (SD) and range of the biometric measurements of the levator hiatus

		Rest	Valsalva	Contraction
AP-diameter	Mean (SD)	5.87 (0.84)	6.80 (1.14)	5.00 (0.84)
	Min–max	3.38–9.40	2.66–10.49	2.86–7.34
Coronary diameter	Mean (SD)	4.46 (0.64)	5.32 (0.96)	4.17 (0.66)
	Min–max	2.54–6.65	2.72–8.58	2.63–6.41
Area	Mean (SD)	18.75 (4.72)	27.37 (8.72)	15.35 (4.27)
	Min–max	9.13–37.94	6.12–58.07	6.54–33.39
Strain	Mean (SD)		1.27 (0.23)	0.83 (0.11)
	Min–max		0.67–2.33	0.53–1.16

SD standard deviation

Table 4 Effect on morphometry levator hiatus and strain

Simple linear regression analysis: standardised *b* (*p* value)			
	Rest	Valsalva	Contraction
AP-diameter			
Age	0.22 (<0.01)	0.19 (<0.01)	0.21 (<0.01)
Menopausal status	−0.02 (0.66)	−0.16 (0.76)	−0.06 (0.25)
At least 1 vaginal delivery	0.17 (<0.01)	0.13 (0.01)	0.16 (<0.01)
Levator defect (avulsion)	0.05 (0.36)	0.23 (<0.01)	0.15 (<0.01)
Coronary diameter			
Age	0.03 (0.57)	0.09 (0.11)	0.04 (0.41)
Menopausal status	0.03 (0.60)	0.01 (0.81)	−0.04 (0.45)
At least 1 vaginal delivery	0.21 (<0.01)	0.19 (<0.01)	0.24 (<0.01)
Levator defect (avulsion)	0.30 (<0.01)	0.43 (<0.01)	0.34 (<0.01)
Area			
Age	0.19 (<0.01)	0.14 (0.01)	0.16 (<0.01)
Menopausal status	−0.01 (0.80)	−0.01 (0.83)	−0.80 (0.13)
At least 1 vaginal delivery	0.20 (<0.01)	0.17 (<0.01)	0.22 (<0.01)
Levator defect (avulsion)	0.18 (<0.01)	0.33 (<0.01)	0.27 (<0.01)
Strain			
Age		−0.03 (0.57)	−0.07 (0.19)
Menopausal status		0.20 (0.72)	−0.11 (0.40)
At least 1 vaginal delivery		0.02 (0.68)	0.07 (0.21)
Levator defect (avulsion)		0.21 (<0.01)	0.16 (<0.01)

sample of healthy nulliparous women and used vaginal closure force as the only measure of levator function.

The role of ageing in the pathogenesis of female pelvic organ prolapse is poorly defined. Increasing stages of prolapse were described with advancing age, but parity and number of vaginal deliveries are potential confounders [17, 18] that may be difficult to control. Lawrence et al. described a large community-based study among 4,103 women using questionnaires on the prevalence of pelvic floor dysfunction. They concluded that the unadjusted prevalence of several forms of pelvic floor dysfunction increased with increasing age, but this association was no longer significant after adjusting for confounders as parity, vaginal deliveries, obesity and menopause [19].

A longitudinal study followed 471 women from the general population for 5 years. Of women with stage II prolapse 10% of women showed progression and 9% showed regression of their prolapse [20], and much of the observed change may well have been due to false-positive or -negative assessments. The generally accepted idea that prolapse will worsen over time probably is not always true. A prevalence study among 285 climacteric women showed no increasing prevalence of anterior, apical or posterior prolapse with advancing age, although they noted a non

Table 5 Effect on morphometry of the levator hiatus

Multiple linear regression analysis Model: age, at least 1 vaginal delivery, levator defect, standardised *b* (*p* value)			
	Rest	Valsalva	Contraction
AP-diameter			
Age	0.19 (<0.01)	0.15 (<0.01)	0.19 (<0.01)
At least 1 vaginal delivery	0.14 (0.01)	0.08 (0.12)	0.11 (0.03)
Levator defect (avulsion)	0.01 (0.91)	0.20 (<0.01)	0.12 (0.03)
Area			
Age	0.15 (<0.01)	0.08 (0.11)	0.12 (0.02)
At least 1 vaginal delivery	0.16 (<0.01)	0.11 (0.03)	0.17 (<0.01)
Levator defect (avulsion)	0.14 (<0.01)	0.30 (<0.01)	0.24 (<0.01)

significant increase comparing premenopausal and postmenopausal subjects [21].

In a study among 5,489 women of whom 454 were symptomatic for prolapse the self reported prevalence of pelvic organ prolapse rose with age, but levelled off after the age of 60. In logistic regression analysis parity emerged as a considerably stronger risk factor than age [22]. The same conclusion was drawn by one of the authors of this paper in a recent study showing rectocele and cystocele to be positively associated with age up to the age of 60, but over the age of 60 the prolapse was negatively associated with age, suggesting improvement may be more likely than further deterioration in women over 60 [23].

The issue of age always raises the issue of oestrogen deprivation, i.e., the role of menopause. Goh et al. compared vaginal tissue from postmenopausal and premenopausal women and showed that oestrogen deprivation results in increased tissue stiffness [24]. Lei et al. confirmed this difference between pre- and postmenopausal women as described by Goh et al., and also compared patients of the same age with and without prolapse [25]. Lei et al. concluded that in women with prolapse connective tissue is even less elastic and stiffness is increased, but this may be effect rather than cause. In our study, we found no relation between menopausal status and levator function or morphometry of the levator hiatus.

Other authors suggest there may be other changes due to ageing, superimposed on oestrogen deficiency, which could be responsible for decreased integrity of the pelvic floor, for example changes in the ratio of different types of collagen or in the proportion of different muscle fibre types with advancing age [26].

Since studies focusing on age are seldom longitudinal, we do not only assess differences in age, but also the result of changing obstetric practice, changing obstetric demographics and changes in general health status over time. Comparing the prevalence of pelvic floor dysfunction among women of 40 years of age with 70 year old women means comparing two different generations. It is conceivable that differences now attributed to age are in reality differences in obstetrical practice concerning assisted and operative deliveries, difference in mean parity, of the quality of daily physical work, nutritional status, general health, etc. These differences illustrate possible reasons for a higher prevalence of pelvic organ prolapse in elderly women in our society other than as a biological consequence of growing older. To further elucidate the association between age and pelvic organ prolapse and pelvic floor function a longitudinal study design may be necessary. At the very least, prevalence studies should take into account obstetric history in as much detail as feasible.

There are several weaknesses to this study that have to be acknowledged. We present data obtained through a retrospective review of patient files, combined with offline analysis of ultrasound datasets obtained during routine clinical practice. This is not a cross-sectional study. The nature of this tertiary urogynaecology referral practice clearly limits conclusions regarding the overall population. The fact that these women are all symptomatic and a substantial minority has overt levator trauma, could lessen the range of variation seen with age. In addition, our patients were mostly Caucasian, and our results may not apply to other ethnic groups. Due to the absence of data we were unable to control for body mass index, a potential confounder, and we are intending to examine the issue of obesity in the future.

Our ability to assess levator function is limited. Pelvic floor muscle strength is assessed by modified Oxford grading, and it is recognised that palpated contraction strength is only one aspect of muscle function.

Palpation was performed with the operator aware of the patient's age, potentially introducing bias. On the other hand, the ultrasound analysis was performed blinded against all clinical data, suggesting that our conclusions are likely to be valid, and the confounding role of parity as identified in this study should be independent of the above-mentioned confounders, at least as regards ultrasound data.

Conclusion

Pelvic floor muscle strength as quantified by the Modified Oxford Grading system and morphometric measurements of the levator hiatus in a population of women with pelvic floor dysfunction are weakly associated with patient age. This small effect of ageing manifests in reduced contraction strength and increased hiatal diameters. These weak associations were still significant even after accounting for confounding factors such as parity and levator defects.

Conflicts of interest Prof. H.P. Dietz has received honoraria as a speaker from GE, Astellas and AMS and has acted as consultant for CCS and AMS. He has also received equipment loans from GE, Toshiba and Bruel and Kjaer.

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