Pelvic Floor Muscle Function, Pelvic Floor Dysfunction, and Diastasis Recti Abdominis: Prospective Cohort Study

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Aims: Compare vaginal resting pressure (VRP), pelvic floor muscle (PFM) strength, and endurance in women with and without diastasis recti abdominis at gestational week 21 and at 6 weeks, 6 months, and 12 months postpartum. Furthermore, to compare prevalence of urinary incontinence (UI) and pelvic organ prolapse (POP) in the two groups at the same assessment points. **Methods:** This is a prospective cohort study following 300 nulliparous pregnant women giving birth at a public university hospital. VRP, PFM strength, and endurance were measured with vaginal manometry. ICIQ-UI-SF questionnaire and POP-Q were used to assess UI and POP. Diastasis recti abdominis was diagnosed with palpation of ≥ 2 fingerbreadths 4.5 cm above, at, or 4.5 cm below the umbilicus. **Results:** At gestational week 21 women with diastasis recti abdominis had statistically significant greater VRP (mean difference 3.06 cm H_2O [95%CI: 0.70; 5.42]), PFM strength (mean difference 5.09 cm H_2O [95%CI: 0.76; 9.42]) and PFM muscle endurance (mean difference 47.08 cm H_2O sec [95%CI: 15.18; 78.99]) than women with no diastasis. There were no statistically significant differences between women with and without diastasis in any PFM variables at 6 weeks, 6 months, and 12 months postpartum. No significant difference was found in prevalence of UI in women with and without diastasis at any assessment points. Six weeks postpartum 15.9% of women without diastasis had POP versus 4.1% in the group with diastasis ($P = 0.001$). **Conclusions:** Women with diastasis were not more likely to have weaker PFM or more UI or POP. *Neurourol. Urodynam.*

Key words: diastasis recti abdominis; pelvic floor muscles; pelvic organ prolapse; postpartum; pregnancy; urinary incontinence

INTRODUCTION

The relationship between abdominal muscles and pelvic floor muscle (PFM) function is controversial and much debated.[1] Diastasis recti abdominis is defined as an impairment with midline separation of the two rectus abdominis muscles along the linea alba.[2] It is a common condition with prevalence rates between 27% and 100% in the second and third trimesters of pregnancy[3,4] and 30–68% in the postpartum period.[5,6] The condition is also found to be high in middle-aged women [7] and may also be present in men.[8]

The etiology of diastasis recti abdominis is not yet clear, but a common cause of both diastasis and pelvic floor dysfunction may be weak connective tissue. In addition, it has been hypothesized that if the abdominal muscles are weak or damaged as seen in diastasis recti abdominis, the abdominal wall cannot co-contract effectively during the PFM contraction and the PFM contraction will therefore be less effective.[7]

In a study of middle aged women, it was found that women with diastasis recti abdominis were more likely to report urinary (UI)—and fecal incontinence and pelvic organ prolapse (POP) than women without the condition.[7] The authors also concluded that a larger percentage of women with diastasis recti abdominis had lower grades of PFM strength assessed by vaginal palpation than women without diastasis.[7] In general, the research on diastasis recti abdominis is sparse and a recently published systematic review concluded that there is an urgent need for more research both on prevalence, risk factors, prevention, and treatment of the condition.[9]

The aim of the present study was therefore to compare vaginal resting pressure (VRP), PFM strength, and endurance between women with and without diastasis recti abdominis in primiparous women participating in a prospective cohort study from gestational week 21 till 12 months postpartum. Furthermore, we wanted to compare prevalence of UI and POP in the two groups, at the same assessment points.

MATERIALS AND METHODS

Three hundred nulliparous pregnant women giving birth at the same public hospital and able to understand the native language were included in this prospective cohort study.[10] Data from four different time points were analyzed: gestational week 21, 6 weeks, 6 months, and 12 months postpartum. For the purpose of this analysis, an inclusion criterion was that all participants had to have data registered on both rectus diastasis and pelvic floor muscle function. Exclusion criteria

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Ethical approval: All women gave written informed consent to participate, and the study was approved by the Regional Medical Ethics Committee (2009/170), date: 13.10.09 and the Norwegian Social Science Data Services (2799026)/Local Data Protection Officer Akershus University Hospital, date: 30.09.09.

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were previous miscarriage after gestational week 16. Ongoing exclusion criteria were premature birth <32 weeks, stillbirth, or serious illness to mother or child.

Figure 1 shows the flow of participants in the study. All women gave written informed consent to participate, and the study was approved by the Regional Medical Ethics Committee (2009/170) and the Data Protect Officer (2799026).

Diastasis recti abdominis was evaluated with fingerbreadth and cut off point for diagnosis of diastasis was set to two fingers assessed by palpation 4.5 cm above, at, or 4.5 cm below the umbilicus.[3] Assessment with fingerbreadth has been found to have an intra- and inter-observer ICC value of 0.7 and 0.5, respectively.[11] The participating women were assessed by two trained physiotherapists at gestational week 21, and 6 weeks, 6 months, and 12 months postpartum.

Correct PFM contraction was defined as a squeeze around the pelvic openings and a lift of the perineum.[12–14] A trained physiotherapist taught the participants how to contract the PFM, and ability to perform correct contractions was controlled by observation of inward perineal movement and vaginal palpation.[13]

VRP, PFM strength (assessed as mean of three maximum voluntary contractions [MVC]) and PFM endurance were measured using a high precision pressure transducer connected to a vaginal balloon catheter (Camtech AS, Sandvika, Norway). The method has demonstrated very good intra-observer reliability for strength.[15] Only contractions with simultaneous visible inward movement of the catheter/perineum were considered correct.[13] Strength was estimated as the difference between MVC and resting pressure. Muscle endurance was assessed during attempt to hold the contraction for 10 sec and quantified as the area under the measurement curve.[16] The participants performed three MVCs followed by a short resting period and one holding period. All measurements were done in supine position with bent knees and hips, feet flat on the bench.

PFM dysfunction was defined as stress urinary incontinence (SUI), urgency urinary incontinence (UUI), mixed urinary

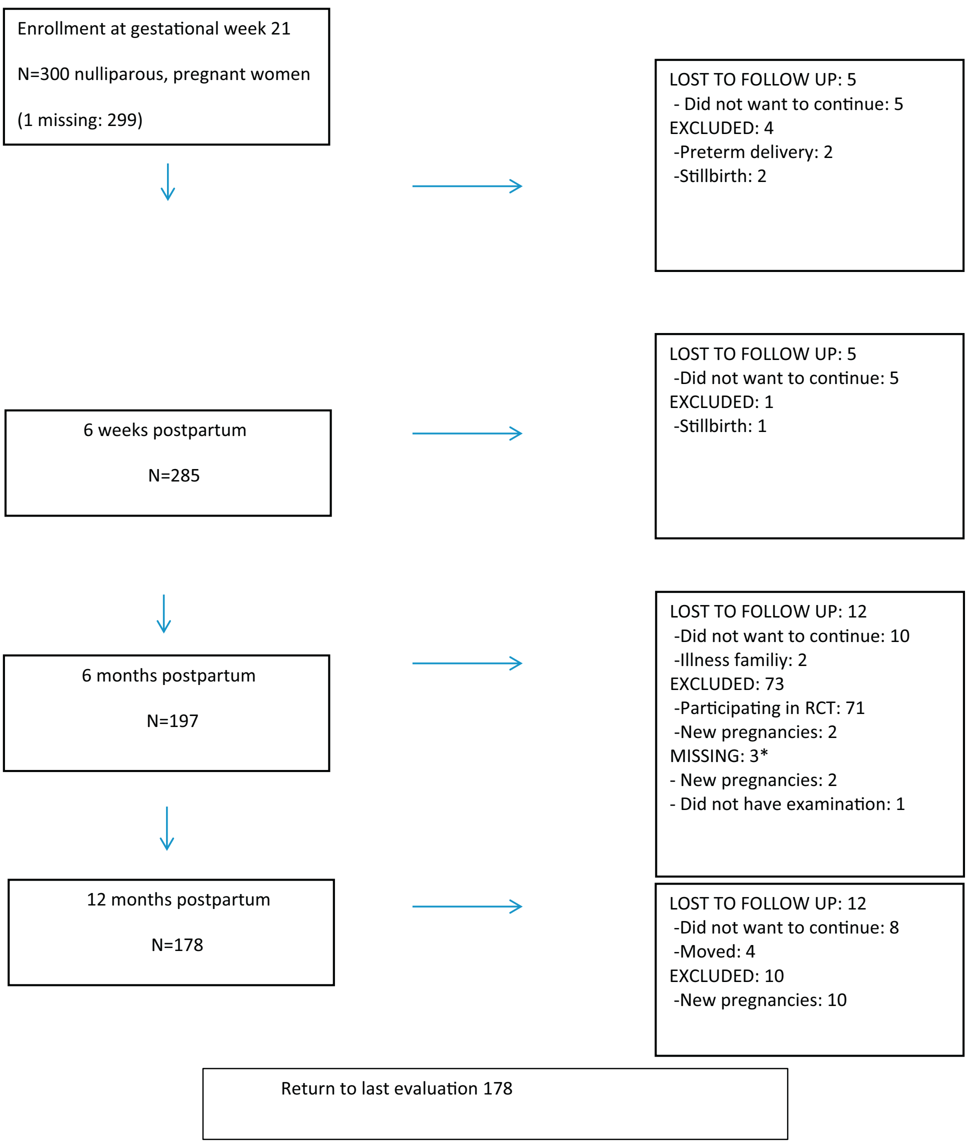

Fig. 1. Flow chart.

incontinence (MUI), and POP. Urinary incontinence (UI) was assessed by electronic questionnaire by use of International Consultation of Urinary Incontinence Short Form (ICIQ-UI-SF).[17] Prevalence of UI was based on question 3; how often do you leak urine? Type of UI was based on question 6; when does urine leak? Avery et al.[17] found that ICIQ-UI-SF had good reliability, good construct validity, and acceptable convergent validity. POP was assessed by two experienced gynecologists using Pelvic Organ Prolapse Quantification System (POP-Q) in a half sitting lithotomy position.[18] POP was defined as POP-Q $\geq$2 of any compartments and no POP as POP-Q stage 0 or 1. The physical therapists evaluating PFM function and the gynecologists evaluating POP were blinded to symptoms registered by the electronic questionnaires.

Statistical Analysis

Background variables are shown as means with standard deviations (SD) or numbers and percentages. The results are presented as means with 95%CI. Comparison between women with and without diastasis recti abdominis and PFM function was analyzed with Student *t*-test and comparison between women with and without diastasis recti abdominis and number of women with PFM dysfunction with χ^2 or Fischer's test. Any findings revealing significant differences in PFM dysfunction were controlled for possible covariates by Binary logistic regression. *P*-value was set to 0.05. The selection of possible covariates was based on existing literature, clinical reasoning, and between group differences on potential risk factors with $P < 0.05$.

RESULTS

Background variables for the whole study group are shown in Table I. Table II shows that women with diastasis recti abdominis at mean gestational week 21 had significantly lower BMI pre-pregnancy and at gestational week 21. Significantly more women with diastasis had participated in general physical activity $\geq$3 times/week pre-pregnancy and at gestational week 21. Age and numbers doing abdominal training did not differ between those with and without diastasis.

Table III shows mean VRP, PFM strength, and endurance in women with and without diastasis recti abdominis at mean gestational week 21 and 6 weeks, 6 months, and 12 months postpartum. At mean gestational week 21 women with diastasis recti abdominis had statistically significant better PFM function than women without diastasis: VRP: mean difference 3.06 cm H_2O (95%CI: 0.70; 5.42), PFM strength: mean difference 5.09 cm H_2O (95%CI: 0.76; 9.42) and PFM muscle endurance: mean difference 47.08 cm H_2O sec (95%CI: 15.18; 78.99). There were no statistically significant differences between women with and without diastasis recti abdominis in any PFM variables 6 weeks, 6 months, and 12 months postpartum.

Table IV shows women with and without diastasis recti abdominis and prevalence of SUI, UUI, MUI, and POP at the different assessment points. No significant difference was found in prevalence of UI in women with and without diastasis recti abdominis at any assessment points. Six weeks postpartum 15.9% of women without diastasis had POP versus 4.1% in the group with diastasis ($P = 0.001$). The significant difference in POP 6 weeks postpartum remained after adjustments for pre-pregnancy BMI and general physical activity $\geq$3 times/week ($P = 0.002$). Eighty-six percent of women with no diastasis recti abdominis had vaginal delivery versus 84.2% among those with diastasis. The percentage with caesarean section was 14.0% versus 15.8%, respectively ($P = 0.738$). There was no significant between group differences in prevalence of POP at any other assessment points.

TABLE I. Demographics

	Pre-pregnancy N = 300
Mean age (years)	28.7 (SD 4.3)
Mean BMI (kg/m^2) (SD)	23.9 (SD 3.9)
	N (%)
Civil status	
Married/cohabitant	287 (95.7)
Living alone	13 (4.3)
Educational level	
College/university	226 (75.3)
Primary/high school/other	74 (24.7)
Smoking	77 (25.7)
Physical active >3 times per week	136 (44.9)

DISCUSSION

Contradictory to the hypothesis, VRP, PFM strength, and endurance were better in women with diastasis recti abdominis than in women without diastasis at mean gestational week 21. Further, no significant differences in PFM function were found between women with or without diastasis at 6 weeks, 6 months, and 12 months postpartum. Six weeks postpartum more women without diastasis were diagnosed with POP $\geq$ stage 2. Hence,

TABLE II. Difference in Background Variables Between Women With and Without Diastasis Recti Abdominis (DRA) at Gestational Week 21 (n = 299)

	With DRA (n = 99)	Without DRA (200)	*P*-value
Age	28.4 (4.1)	28.8 (4.4)	0.49
Pre-pregnancy BMI	22.5 (2.8)	24.5 (4.0)	<0.001
BMI at gestational week 21	24.9 (3.2)	26.4 (4.1)	<0.001
Pre-pregnancy abdominal exercise			
Never	13 (13%)	38 (19%)	
≥3 times/week	12 (12.1%)	22 (11%)	0.54
Abdominal training at gestational week 21			
Never	51 (51.5%)	112 (56.0%)	
≥3 times/week	4 (4%)	4 (2%)	0.71
Pre-pregnancy physical activity ≥3 times/week	55 (55.6%)	80 (40.0%)	0.02
Physical activity at gestational week 21 ≥3 times/week	22 (22.2%)	31 (15.5%)	0.20

TABLE III. Vaginal Resting Pressure (VRP) (cm H_2O), Pelvic Floor Muscle (PFM) Strength (cm H_2O) and PFM Endurance (cm H_2O sec) in Women Without and With Diastasis Recti Abdominis (DRA) at Mean Gestational Week 21 and 6 Weeks, 6 Months, and 12 Months Postpartum in First Time Pregnant Women

	With DRA	Without DRA	*P*-value
Gestational week 21	N = 99	N = 200	
VRP	45.1 (SD 9.9)	42.0 (SD 9.7)	0.01
PFM strength	38.9 (SD 18.3)	33.8 (SD 17.7)	0.02
PFM endurance	277.3 (SD 139.8)	230.2 (SD 127.9)	0.004
6 weeks postpartum	N = 171	N = 114	
VRP	31.9 (SD 8.6)	31.4 (SD 9.4)	0.64
PFM strength	18.1 (SD 13.4)	19.2 (SD 15.1)	0.52
PFM endurance	128.4 (SD 106.1)	135.3 (SD 104.1)	0.59
6 months postpartum	N = 90	N = 107	
VRP	34.3 (SD 8.7)	35.6 (SD 9.0)	0.29
PFM strength	31.9 (SD 18.5)	31.5 (SD 19.1)	0.90
PFM endurance	245.9 (SD 151.2)	248.8 (SD 163.1)	0.90
12 months postpartum	N = 58	N = 120	
VRP	34.2 (SD 8.6)	35.7 (SD 8.9)	0.27
PFM strength	32.5 (SD 19.2)	35.8 (SD 19.3)	0.29
PFM endurance	255.3 (SD 156.9)	287.8 (SD 170.3)	0.22

Means with standard deviations (SD).

women with diastasis recti abdominis were not found to be more likely to have UI or POP than their counterparts with no diastasis neither during pregnancy nor during the first postpartum year.

Strengths and Limitations

Strengths of the present study were use of a prospective design and use of responsive, reliable, and valid methods to assess VRP, PFM strength, and endurance, [13,15,19] UI[17] and POP.[18] Two trained physiotherapists assessed both PFM function and diastasis recti abdominis and they were blinded to whether the participants had pelvic floor dysfunctions or not.

Limitations of the study are that diastasis recti abdominis was assessed by palpation using fingerbreaths, which can be considered a less reliable method than ultrasonography.[11] At the time when our cohort study was planned there were no reliability studies on the use of ultrasound to measure diastasis and we chose the method most commonly used in clinical physiotherapy practice worldwide. Palpation using finger breaths has shown to have an intra- and interrater reliability of 0.7 and 0.5, respectively.[11] Van de Water and Benjamin[20] concluded that although fingerbreadths is widely used in clinical practice, it has been under-evaluated with regards to measurement properties. However, they suggested that it may be a valuable method for screening women for presence of diastasis. In our study, the method was only used to screen whether the women had diastasis or not. Palpation was also used in the other published study on the relationship between PFM function and diastasis recti abdominis.[7] However, in addition to including a multiparous middle aged group, they used a location 2.5 cm above and below the umbilicus and also applied another cut-off point. Hence, the results between the two studies are not directly comparable. Our study examined a cohort of first time pregnant women where already at 21 weeks of gestation estrogen levels are high and the pregnant uterus is considerably enlarged. At 6 weeks postpartum the women are close in time to delivery. Hence, there may be a true difference in both PFM and abdominal function between the two study populations.

The hypothesis that women with diastasis recti abdominis may have less PFM strength and endurance is based on the assumption that the abdominals and the PFM are both part of the abdominal canister and therefore the two muscle groups are closely related through the intra-abdominal pressure.[21] Spitznagle et al.[7] hypothesized that if the abdominal muscles are weak or damaged as in diastasis recti abdominis, the abdominal wall cannot co-contract effectively during the PFM contraction and the PFM contraction may therefore be less effective. Our results did not support this hypothesis and our results were opposite of those reported by Spitznagle et al.[7] However, as elaborated above, the two studies are not directly comparable. Spitznagle et al.[7] point to methodological weaknesses of their study, such as a retrospective design and use of vaginal palpation to assess PFM function. In addition to use of different assessment methods for PFM variables, our participants were younger and in the peripartum period.

We also found contradictory results regarding diastasis recti abdominis and UI and POP compared to Spitznagle et al.[7] At most of our assessment points there were no difference between women with and without diastasis and prevalence of UI or POP. However, at 6 weeks postpartum we found that the prevalence of POP was higher in women with no diastasis. With multiple testing this may be a coincidence, but the *P*-value was 0.001 and therefore also holds a Bonferroni correction. In addition, controlling for possible confounders, such as BMI and exercise level, did not change the findings. The result is contra-intuitive as both POP and diastasis recti abdominis may be associated with weak connective tissue. The prevalence of POP in our study population was lower than in a middle aged population and highest 6 weeks postpartum where a significant difference was found. None of the participants in our study had stages 3 or 4 assessed with POP-Q, and there was a natural remission of POP from 6 weeks to 12 months postpartum. Hence, although vaginal birth is a risk factor for POP,[22] the condition may not be as manifested at this early age and may explain the differences between our results and those of Spitznagle et al.[7] Controlling for vaginal delivery and caesarean section did not change the results. This corresponds with the results of Sancho et al.[23]

Diastasis recti abdominis, weakness of the PFM and pelvic floor dysfunctions are all common conditions in women during pregnancy and after delivery.[4,24] The results of the present study challenge the belief that diastasis recti abdominis negatively affects the function of the PFM and is associated with UI and POP. There is scant knowledge and research on diastasis recti abdominis in general and especially on the relationship between the condition and the PFM. There is an urgent need for more studies on the diastasis recti abdominis.[9] Until more research is available, clinicians should use caution when postulating associations between PFM, pelvic floor dysfunctions, and the abdominal muscles.

CONCLUSIONS

Contradictory to the hypothesis women with diastasis recti abdominis had higher VRP, PFM strength and endurance at gestational week 21. There were no differences between groups in any of the PFM variables at any time-points in the postpartum period. At 6 weeks postpartum more women without diastasis had POP. Women with diastasis recti abdominis did not have higher prevalence of UI or POP. The results of this study does not support recommendations to include clinical assessment of diastasis or restoration of diastasis in treatment of women with pelvic floor dysfunctions.

TABLE IV. Difference in Urinary Incontinence (UI), Stress Urinary Incontinence (SUI), Urgency Incontinence (UUI), Mixed Urinary Incontinence (MUI), and Pelvic Organ Prolapse Quantification (POP-Q) Stage ≥ II in Women With and Without Diastasis Recti Abdominis (DRA) at Gestational Week 21, 6 Weeks Postpartum, 6 Months, and 12 Months Postpartum

Gestational week 21			
Variables	**With DRA (n = 99) (%)**	**Without DRA (n = 200) (%)**	***P*-value**
UI	34 (34.3)	70 (35.0)	1.000
SUI	32 (32.3)	65 (32.5)	1.000
UUI	9 (9.1)	24 (12.0)	0.576
MUI	8 (8.1)	13 (6.5)	0.793
POP-Q stage II	3 (3.0)	10 (5)	0.628
6 weeks postpartum			
Variables	**With DRA (n = 171) (%)[a]**	**Without DRA (n = 114) (%)[b]**	***P*-value**
UI	64 (37.9)	47 (42.0)	0.574
SUI	46 (27.2)	33 (29.5)	0.784
UUI	29 (17.2)	18 (16.1)	0.939
MUI	15 (8.9)	9 (8.0)	0.977
POP-Q stage II	7 (4.1)	18 (15.9)	0.001
6 months postpartum			
Variables	**With DRA (n = 90) (%)**	**Without DRA (n = 107) (%)[c]**	***P*-value**
UI	31 (34.4)	38 (36.2)	0.917
SUI	20 (22.2)	26 (24.8)	0.805
UUI	14 (15.6)	15 (14.3)	0.963
MUI	3 (3.3)	5 (4.8)	0.728
POP-Q stage II	2 (2.2)	3 (2.8)	1.000
12 months postpartum			
Variables	**With DRA (n = 58) (%)[d]**	**Without DRA (n = 120) (%)[e]**	***P*-value**
UI	21 (36.8)	50 (41.7)	0.654
SUI	13 (22.8)	44 (36.7)	0.095
UUI	10 (17.5)	11 (9.2)	0.173
MUI	3 (5.3)	8 (6.7)	0.977
POP-Q stage II	1 (1.7)	3 (2.5)	1.000

Data given as numbers with percentages (absolute percent).
[a]Missing data on ICIQ UI SF for two women with DRA.
[b]Missing data on ICIQ UI SF for two women without DRA; missing data on POP-Q stage for one woman without DRA.
[c]Missing data on ICIQ UI SF for two women without DRA; missing data on POP-Q stage for one woman without DRA.
[d]Missing data on ICIQ UI SF for one woman with DRA.
[e]Missing data on POP-Q stage for one woman without DRA.

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AUTHORS' CONTRIBUTIONS

KB performed conception and planning of the study, main investigator and supervisor, analyzing data, and writing up the paper. Planning of the study, carrying out the study, analyzing data, and writing up the paper were done by GH. Planning of the study, analyzing, and writing up the paper were done by MKT. Planning of the study, analyzing, and writing up the paper were done by JBS. MEE performed conception and planning of the study, anlyzing data, and writing up the paper.

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