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Women with diastasis recti abdominis might have weaker abdominal muscles and more abdominal pain, but no higher prevalence of pelvic floor disorders, low back and pelvic girdle pain than women without diastasis recti abdominis

Sandra Gluppe[a,*], Marie Ellström Engh[b,c], Kari Bø[a,b,c]

[a] Department of Sports Medicine, Norwegian School of Sports Sciences, Sognsveien 220, 0806 Oslo, Norway
[b] Department of Obstetrics and Gynaecology, Akershus University Hospital, Sykehusveien 25, 1478 Lørenskog, Norway
[c] Faculty of Medicine, University of Oslo, Oslo, Norway

Abstract

Objective To investigate whether women with diastasis recti abdominis (DRA) have weaker abdominal muscles and higher prevalence of pelvic floor disorders (PFD), low back, pelvic girdle and abdominal pain than women without DRA.
Design Cross sectional study of women with and without DRA.
Setting University study.
Participants Seventy-two parity and age matched women with and without DRA.
Main outcome measures Maximal abdominal muscle strength and endurance were assessed with a dynamometer and with a curl-up test. Women reported whether they experienced PFD, low back pain, pelvic girdle pain or abdominal pain. Those experiencing PFD or pain completed the Pelvic Floor Distress Inventory-short form 20 (PFDI-20), the Oswestry Disability Index (ODI), the Pelvic Girdle Questionnaire (PGQ) or questions about abdominal pain, respectively.
Results Maximal abdominal strength standing with 30° hip flexion was significantly lower in women with DRA (mean difference −12.9 Nm, 95%CI: −24.4 to −1.5; $P = 0.028$), but adjusted analyses showed no significant difference (mean difference −11.9 Nm, 95%CI: −26.5 to 2.6; $P = 0.106$). Adjusted analyses showed significant higher prevalence of abdominal pain in women with DRA (OR: 0.02, 95%CI: 0.00 to 0.61, $P = 0.026$). There was no difference between the groups in PFD, low back and pelvic girdle pain.
Conclusion Women with DRA tend to have weaker abdominal muscles and higher prevalence of abdominal pain, but no higher prevalence of PFD, low back or pelvic girdle pain than women without DRA.

Keywords: Abdominal muscle strength; Abdominal pain; Diastasis recti abdominis; Lumbo-pelvic pain; Pelvic floor dysfunctions

Introduction

Diastasis recti abdominis (DRA) is defined as an impairment with midline separation of the two rectus abdominis muscles along the linea alba [1]. Prevalence of DRA has been reported as 60%, 45% and 33%, 6 weeks, 6 months and 12 months postpartum, respectively [2]. To date there is no consensus on the cut-off point for diagnosing DRA, but two fingerbreadths on palpation is commonly used [3]. Candido et al. 2005 [4] classified severity of diastasis as: mild (25–35 mm or visible protrusion with diastasis less than 25 mm), moderate (35–50 mm) and severe (>50 mm). Most women present with mild diastasis postpartum. The prevalence of moderate and severe DRA has been reported to be just 1% and 0% at six months and 12 months postpartum

* Corresponding author.
E-mail addresses: s.l.gluppe@nih.no (S. Gluppe), m.e.engh@medisin.uio.no (M. Ellström Engh), kari.bo@nih.no (B. Kari).

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respectively [2]. DRA has also been found to be prevalent in middle-aged women, both parous (52%) and nulliparous (35%) [5].

The inter-recti distance (IRD) is the distance between the medial borders of the two rectus abdominis muscles, measured in palpation with finger widths, with calipers, or using ultrasound [3]. Ultrasound has the best intra- and inter-tester reliability with intraclass correlation coefficients (ICC) above 0.9 [6], and is the recommended measurement method [3].

Two studies [7,8] reported higher prevalence of pelvic girdle or low back pain in women with DRA and three [2,9,10] found no difference between women with or without DRA. A recent systematic review found only weak evidence that DRA severity may be associated with impaired abdominal muscle strength and low back pain severity [11].

The objective of this study was to investigate whether parous women with DRA have weaker abdominal muscles and higher prevalence of pelvic floor disorders (PFD), low back, pelvic girdle and abdominal pain than women without DRA. Further, to compare these variables in subgroups of women with moderate and severe DRA.

Material and methods

Design

This was a cross sectional study comparing abdominal muscle strength, PFD and low back, pelvic girdle and abdominal pain in women more than six weeks postpartum with and without DRA.

Setting

An equivalent number of controls were added in this study. The study was conducted at the laboratory of the Norwegian School of Sport Sciences between February and October 2019.

Participants

Thirty-six women diagnosed with DRA, recruited through women's health physiotherapists, personal trainers, midwives and gynecologists/obstetricians, friends and acquaintances and by advertising in social media were included in the study. In addition, 36 age and parity matched women without DRA were recruited from friends and acquaintances of women with DRA. There was a maximum age difference of ±3 years between the matched woman with and without DRA. All participants had a single visit for clinical assessment. Inclusion criteria were: Primi- and multiparous women more than 6 weeks postpartum (with no upper limit to time since birth), 18–70 years old and able to understand instructions in Norwegian. Exclusion criteria were any neurological, and systemic musculoskeletal diseases or psychiatric diagnoses.

Inter-recti distance measurement and cut-off point for DRA

An initial screening of participants using palpation to confirm or exclude DRA was done prior to ultrasound assessment. DRA was diagnosed initially if the assessor palpated two finger widths or more, or observed abdominal protrusion, during an abdominal curl-up. Study recruits were those with DRA > 25 mm, 2 cm above or, 2 cm below the umbilicus during a curl-up, measured with 2D real-time ultrasonography [4]. Women with an observable protrusion during a curl-up were included in the analyses, even if IRD was <25 mm above or below the umbilicus. To assess IRD in women with and without DRA the authors used a portable 2D ultrasound machine with a linear transducer (Logic e R7, GE Healthcare, Chalfont St Giles, United Kingdom). To standardize the measurement locations, two marks on the skin were made with the centre of the umbilicus as the point of reference [6,12,13]. The ultrasound imaging protocol used is described in detail in Gluppe et al. [14]. Measurements of the ultrasound images were coded and undertaken off-line with the physiotherapist blinded to the results of the clinical assessments and questionnaire data. One trained physiotherapist performed all assessments, in addition to the off-line measurements.

Main outcome measures

Differences in abdominal muscle strength, PFD and low back, pelvic girdle and abdominal pain in women with and without DRA.

Abdominal muscle strength

Isometric trunk flexion assessments with dynamometers in a sitting position has shown excellent test–retest reliability and strong correlation with IRD [7,15]. The authors used the Humac NORM isokinetic dynamometer (CSMi, Soughton, MA) to assess maximal isometric abdominal wall strength, limited to trunk flexion. The Humac software 2015 was installed on the computer and the dynamometer was calibrated prior to the study according to the operating manual. Trunk flexion assessments followed a standardized protocol and were conducted standing in two different positions; hip flexion of 10° and 30° from zero (Fig. 1). Testing in a standing position was considered functional and transferable to situations where postpartum women need abdominal strength, e.g. carrying and lifting the baby. After the participants were placed in the dynamometer, adjustments were made for body height. To avoid compensatory movements women were attached above and below their knees, over their thighs and at their chest level. Prior to the maximal strength tests, participants performed three submaximal attempts for familiarization of the test protocol. The highest maximal test of three was registered and results measured in Newton metre (Nm). The participants were instructed to take a deep breath, breathe out, bend forward and gradually increase to maximal force during a five second recording. Standardised verbal

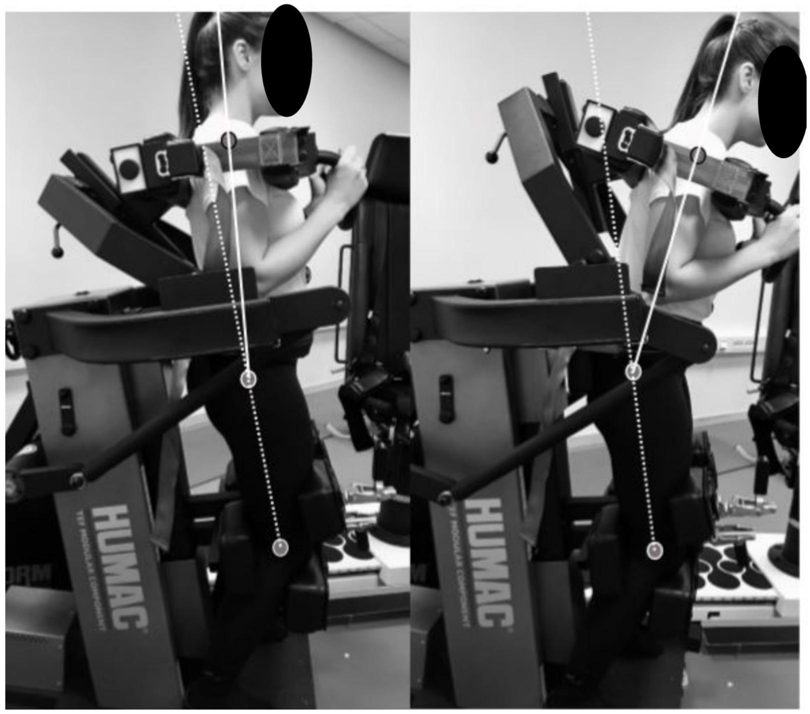

Fig. 1. Illustration of test positions (10° and 30°) in the Humac NORM. Reproduced with permission by Kristina L. Skaug.

encouragement was given to all participants during the test. A 60 second rest period was given between the maximal test repetitions. During the test participants could watch the screen for real time feedback on their effort.

Abdominal endurance was assessed as number of repetitions of a standardized abdominal curl-up to exhaustion following the protocol of the American College of Sports Medicine (ACSM) curl-up test [16,17] (Fig. 2). Participants were asked to lift their head and shoulder blades off the mat and slide their fingertips from one tape to another, 8 and 12 cm away, for women ≥45 years and <45 years, respectively. A metronome set to 40 beats per minutes regulated the speed of movement. There was no verbal encouragement during the test. The participants performed as many curl-ups as possible and the test was terminated if the participants could not reach the second tape, follow the speed of the metronome, or made compensatory movements. All participants were given three warm-up repetitions before commencing the test.

Electronic questionnaire

Prior to the clinical assessments, participants completed an electronic questionnaire which gathered information on background variables and asked; "Do you have symptoms in your bowel, bladder or pelvic region that bother you (e.g. urinary leakage, bowel leaks or feeling any bulge in the vagina)?", "Do you have low back pain?", "Do you have pelvic girdle pain?" and "Do you have pain in you abdomen?". If answering yes to these questions, participants were asked to respond to the following; The Pelvic Floor Distress Inventory-short form 20 (PFDI-20) [18], the Oswestry Disability Index (ODI) [19] and the Pelvic Girdle Questionnaire (PGQ) [20] as appropriate to their reported symptoms. The PFDI-20 consists of three scales: Pelvic Organ Prolapse Distress Inventory 6 (POPDI-6), Colorectal-Anal Distress Inventory 8 (CRADI-8) and Urinary Distress Inventory 6 (UDI-6) [18]. Each scale score in the PFDI-20 ranges from 0 to 100 and the summary score from the three scales together range from 0 to 300. The sum score in the ODI is calculated in percent from 0 (not disabled) to 100 (disabled) and PGQ is calculated in percent from 0 (not at all) to 100 (to a large extent). All three instruments have been validated and are recommended for assessment of symptoms of PFD, functional measure of disability due to low back pain, and limitation in activities/participation due to pelvic girdle pain [18–20]. If participants responded yes to having abdominal pain, they were asked to indicate the location, and to what degree (from zero = not at all, to ten = a lot) it affected their activities of daily living.

Physical activity level was self-reported. Participants reported their current level of participation in moderate or high intensity (short of breath and/or sweating) physical activity [21] (average number of minutes per week).

Joint hypermobility

The Beighton score was used to assess benign joint hypermobility [22]. Hypermobility was defined if five or more tests out of nine were positive. Intra- and intertester reliability has been found to be <0.7 [23].

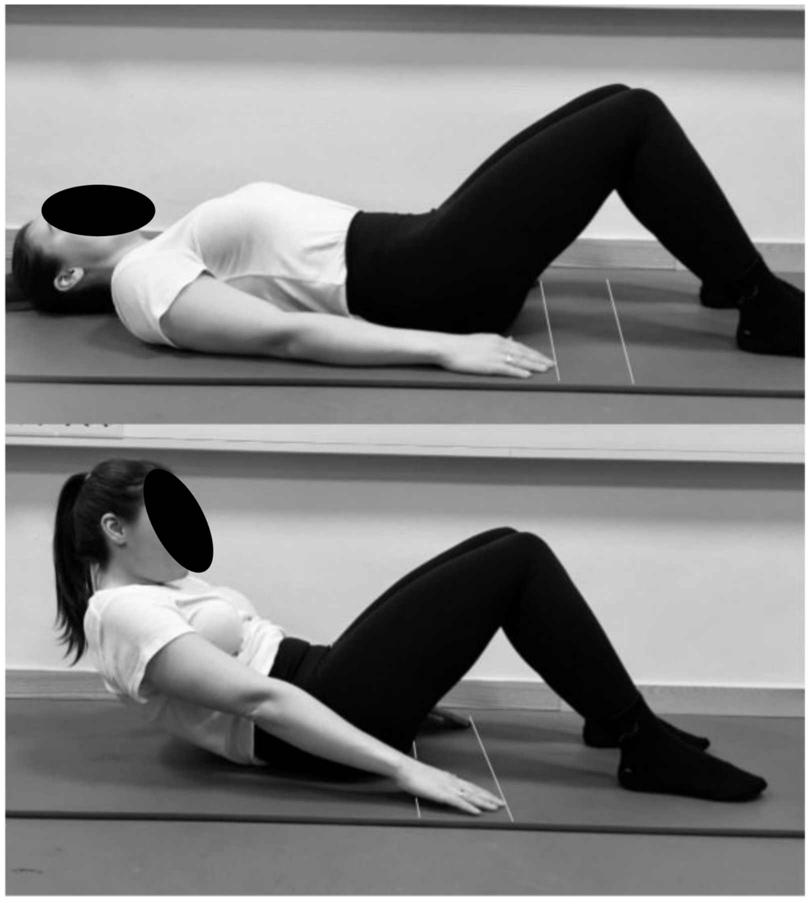

Fig. 2. Illustrations of start and ending postion during the ASCM curl-up test. Reproduced with permission by Kristina L. Skaug.

Data analysis

Background variables are presented as means with SD or numbers with percentages. All the IRD data were normally distributed. Differences in background variables were analyzed with an independent *t*-test for continuous data and with Chi Square of independence for the categorical data. If the expected count in a variable was less than five, the Exact Sig (two-sided) value was used. An independent *t*-test or Fisher's Exact Test was used to compare differences between groups in the main analyses. In addition, linear or logistic regression were used to adjust for possible confounders; age, height, physical activity level, BMI, parity, time since birth and DRA severity. For subgroup analyses the number for confounding factors was reduced according to the number of participants. Unadjusted and adjusted mean scores with 95% confidence intervals (CI) are presented for continuous data. For categorical data unadjusted and adjusted data with percentages are reported. Statistical significance was defined as $P < 0.05$.

Results

Seventy-two women were included in this study. Table 1 presents background variables for women with and without DRA. The oldest woman was 58 years old. There was no statistically significant difference in background variables between women with and without DRA.

Table 2 shows mean inter-recti distance (mm) with standard deviation (SD) at rest and during a curl-up in women with and without DRA. According to the classification of DRA severity [4] 18/35 (51%) women were classified with mild, 13/35 (37%) with moderate and 4/35 (11%) with severe DRA.

Table 3 presents mean numbers and scores (Nm) of abdominal muscle strength tests, unadjusted and adjusted for age, BMI, height, parity, DRA severity, time since last birth and physical activity. Subgroup analyses of women with severe and moderate DRA compared to women without DRA showed no differences in the abdominal muscle strength tests, neither adjusted nor unadjusted.

Table 4 presents women with and without DRA experiencing PFD, low back, pelvic girdle, and abdominal pain, unadjusted and adjusted for age, BMI, height, parity, DRA severity, time since last birth, and physical activity. There were no significant differences in numbers of women with and without DRA experiencing PFD, low back, pelvic girdle and abdominal pain in the unadjusted analyses. When adjusted for possible confounders, significantly more women with DRA reported abdominal pain than women without

Table 1
Difference in background variables between women with and without diastasis recti abdominis (DRA).

	Total sample (*n* = 72)	With DRA (*n* = 36)	Without DRA (*n* = 36)	*P*-value
Age, years, mean (SD)	36 (5.0)	36 (5.0)	35 (5.0)	0.59
Height, m, mean (SD)	1.68 (0.06)	1.68 (0.05)	1.67 (0.06)	0.67
BMI, kg/m^2, mean (SD)	24 (4.1)	23 (3.6)	24 (4.5)	0.25
Weight gain last pregnancy, kg, mean (SD)	14 (4.7)	14 (4.7)[a]	13 (4.6)[b]	0.21
Waist circumference, cm, mean (SD)	80 (8.7)	80 (8.8)	81 (8.7)	0.72
Parity				
1	8 (11.1)	4 (11.1)	4 (11.1)	1.0
2	54 (75.0)	27 (75.0)	27 (75.0)	1.0
3	8 (11.1)	4 (11.1)	4 (11.1)	1.0
4	2 (2.8)	1 (2.8)	1 (2.8)	1.0
Time since last birth				
<6 months	5 (6.9)	1 (2.8)	4 (11.1)	0.18*
6 to 11 months	18 (25.0)	12 (33.3)	6 (16.7)	
1 to 3 years	35 (48.6)	18 (50.0)	17 (47.2)	
<3 years	14 (19.4)	5 (13.9)	9 (25.0)	
Heavy lifting at work				
Perform heavy lifting	11 (19.9)	5 (17.2)[c]	6 (23.0)[d]	0.59
Rarely/never perform heavy lifting	44 (80.0)	24 (82.8)[c]	20 (76.9)[d]	
Menstruation postpartum				
Yes	40 (69.0)	21 (67.7)[e]	19 (70.4)[f]	0.83
No	18 (31.0)	10 (32.3)[e]	8 (29.6)[f]	
Mode of delivery				
Vaginal	53 (73.6)	27 (75.0)	26 (72.2)	0.86*
Cesarean	11 (15.3)	6 (16.7)	5 (13.9)	
Both vaginal and caesarean	8 (11.1)	3 (8.3)	5 (13.9)	
Birthweight, g				
<4500	3 (2.0)	1 (1.4)	2 (2.7)	
4000 to 4500	28 (18.9)	18 (24.3)	10 (13.5)	
3000 to 3999	96 (64.9)	45 (60.8)	51 (68.9)	
2500 to 2999	15 (10.1)	7 (9.5)	8 (10.8)	
1500 to 2499	4 (2.7)	3 (4.1)	1 (1.4)	
1000 to 1499	0 (0.0)	0	0	
<1000	2 (1.4)	0	2 (2.7)	
Use of contraceptives				
Yes	33 (45.9)	16 (44.4)	17 (47.2)	0.81
No	39 (54.2)	20 (55.6)	19 (52.8)	
Current breastfeeding				
≥1 times/day	25 (43.1)	14 (45.2)[e]	11 (40.7)[f]	0.74
Rarely/never	33 (56.9)	17 (54.8)[e]	16 (59.3)[f]	
Physical activity, minute/week	121.6 (111.8)	123.6 (118.3)	119.5 (106.5)	0.88
Total Beigthon score	0.6 (1.0)	0.6 (1.0)	0.6 (0.7)	1.0
Striae				
During teenage	31 (43.1)	16 (44.4)	15 (41.7)	0.81
During pregnancy	28 (38.9)	14 (38.9)	14 (38.9)	1.0
Postpartum	11 (15.3)	7 (19.4)	4 (11.1)	0.33

Values are presented as numbers (percentages) of women unless otherwise indicated. BMI = body mass index.
* Exact sig (2-sided) reported were expected cells are <5.
[a] Total *n* = 32; four women did not answer this question in the questionnaire.
[b] Total *n* = 35; one woman did not answer this question in the questionnaire.
[c] Total *n* = 29; this question was only given to women who were working (valid percentages are reported).
[d] Total *n* = 26; this question was only given to women who were working (valid percentages are reported).
[e] Total *n* = 31; this question was only given to women who were <3 years since last birth (valid percentages are reported).
[f] Total *n* = 27; this question was only given to women who were <3 years since last birth (valid percentages are reported).

DRA (OR: 0.02, 95%CI 0.00 to 0.61, $P = 0.026$). Subgroup analyses comparing women with moderate and severe DRA to women without DRA found no differences in numbers of women experiencing PFD, low back, pelvic girdle and abdominal pain (unadjusted and adjusted analyses for age, height, physical activity, BMI and parity). In women who experienced PFD, no statistically significant difference was found between women with and without DRA in the sum score for the PFDI-20, ODI, and PGQ. Mean sum score for women reporting abdominal pain that interfered with their activities of daily living was 3.9 (SD 2.5) and 2.5 (SD 1.3) in women with and without DRA, respectively. The most common location of abdominal pain was above the umbilicus ($n = 5$). None of the controls ($n = 4$) reported such pain.

Table 2
Mean inter-recti distance (mm) with standard deviation (SD) at rest and during a curl-up measured 2 cm above- and 2 cm below the umbilicus in women with DRA ($N = 36$) and without DRA ($N = 36$).

IRD		With DRA ($n = 36$)	Without DRA ($n = 36$)
Above umbilicus			
	Rest, mean (SD)	43.5 (13.1)	23.3 (7.1)
	Curl-up, mean (SD)	34.6 (10.7)[a]	17.2 (5.7)
Below umbilicus			
	Rest, mean (SD)	32.8 (13.4)	15.4 (7.8)
	Curl-up, mean (SD)	30.2 (10.2)[a]	12.6 (5.6)

DRA, diastasis recti abdominis.
[a] Total $n = 35$; one woman was not able to perform a curl-up.

In women classified with severe DRA ($n = 4$), two women experiencing PFD showed a PFDI-20 total sum score of 33.3 and 36.5 with the following scale score on POPDI-6; 8.33 and 25.0, CRADI-8; 3.13 and UDI-6; 25.0 and 8.33. One woman with severe DRA experienced low back pain and her score on the ODI was 12%. No women with severe DRA experienced pelvic girdle pain and one woman reported abdominal pain.

One woman was not able to perform a curl-up during the IRD assessments and classification of DRA severity was therefore not possible. Her IRD measurement during rest indicated a severe DRA. She experienced PFD, low back, pelvic girdle, and abdominal pain and her total score on the PFDI-20 was the highest reported with 212.5 (POPDI-6: 50, CRADI-8: 62, UDI-6: 100), the ODI was 10% and the PGQ was 34%. The reported abdominal pain was 9/10 on a VAS.

Discussion

This study found that women with DRA had no higher prevalence of PFD, low back and pelvic girdle pain than women without DRA. Adjusted analyses showed no difference between groups in abdominal muscle strength, but higher prevalence of abdominal pain in women with DRA. Subgroup analyses comparing women with severe and moderate DRA with women without DRA showed no difference in abdominal strength, report of PFD, low back, pelvic girdle and abdominal pain than women without DRA.

In agreement with others [7,24,25], this study found reduced abdominal strength in women with DRA. Benjamin et al. [11] concluded that there is weak evidence that DRA severity may be associated with impaired abdominal muscle strength. Similar to this study, Gunnarsson et al. [25] used a dynamometer to measure isometric strength, but in a sitting position. However, this position may activate the hip flexors and results are therefore not directly comparable to results measured in standing. A recently published case-control study including 18 women with, and 22 women without DRA, found that the former demonstrated significant lower trunk muscle rotation torque than the latter [7]. The authors have not found any other studies evaluating rotation, and our apparatus could only assess flexion and extension. So, although both Hills et al. [7] and our study found reduced

Table 3
Unadjusted and adjusted mean score with 95% confidence intervals (CI) for ACSM curl-up test and maximal isometric strength (Nm) in 10° and 30° position in women with DRA and no DRA.

Variable	With DRA ($n = 36$)	Without DRA ($n = 36$)	Mean difference (95% CI); P-value	Adjusted mean difference (95% CI); P-value
Numbers of ACSM curl-ups, mean (SD)	5.1 (10.6)[a]	4.5 (8.9)[b]	0.6 (−4.0, 5.2); 0.80	6.1 (−3.3, 15.6); 0.20
Maximal isometric strength 10°, mean Nm (SD)	73.9 (17.5)[c]	82.9 (22.4)	−9.0 (−18.8, 0.68); 0.07	−5.3 (−17.3, 6.7); 0.38
Maximal isometric strength 30°, mean Nm (SD)	96.1 (20.6)[d]	109 (26.7)	−12.9 (−24.4, −1.5); 0.028	−11.9 (−26.5, 2.6); 0.11

DRA = diastasis recti abdominis, Nm = Newton meter.
[a] Total $n = 11$; 25 women were not able to perform the test.
[b] Total $n = 9$; 27 women were not able to perform the test.
[c] Total $n = 35$; one woman was not able to perform the test.
[d] Total $n = 34$; two women were not able to perform the test.

Table 4
Women with DRA and without DRA experiencing pelvic floor disorders, low back, pelvic girdle and abdominal pain. Results presented as numbers and percentages (%).

Variable	With DRA ($N = 36$)	Without DRA ($N = 36$)	P value	Adjusted P value	OR (95% CI)
Pelvic floor disorders	17 (47)	13 (36)	0.47	0.59	1.78 (0.22 to 14.2)
Low back pain	16 (44)	10 (28)	0.22	0.28	0.31 (0.04 to 2.65)
Pelvic girdle pain	11 (31)	4 (11)	0.08	0.27	0.16 (0.01 to 4.00)
Abdominal pain	10 (28)	4 (11)	0.14	0.048	0.19 (0.38 to 0.99)[a]

DRA = diastasis recti abdominis.
[a] The confounder "DRA severity" was not included in the adjusted analysis.

strength, they are not directly comparable. In addition, the reported mean IRD in women with DRA (mean 26 mm, SD 4) in the study of Hills et al. [7] was almost equal to the mean IRD for women *without* DRA in the present study (mean 23.3 mm, SD 7.1). Hence, the populations in Hills et al. [7] and this study are very different, and any comparison of the results should be undertaken with caution. Another interesting finding of our study was that the unadjusted analysis demonstrated a difference in abdominal muscle strength for the 30° position between the women with and without DRA. However, this statistically significant difference disappeared with the adjusted analysis controlling for possible confounders. There is a need for further studies to verify whether these variables are risk factors for DRA.

This study found no difference in ACSM curl-up test between the two groups. This contrasts with others [7,24] who reported a significantly lower score on their sit-up test in women with DRA. All three studies used different curl-up tests and were conducted at different timepoints postpartum. The time factor may influence abdominal strength as a natural recovery after childbirth is expected [24]. The use of different tests might reflect the difficulty in finding tests that directly assess abdominal muscle strength and endurance. Interestingly, 72% of participants in our study were unable to perform a single curl-up according to the ACSM curl-up test protocol, and there was no difference between women with and without DRA. Although the test was not developed for women postpartum, the authors argue that this finding is interesting because it may reflect that postpartum women in general have been discouraged from doing sit-ups postpartum [26] and thus have lost this function of the abdominal muscles. It may also be that this test is too difficult for women with DRA postpartum, and therefore should only be used as a test for ability to perform a single curl-up in future studies. Porcari et al. [27] found that in a group of eight exercising women, mean age 40 (SD 6), the average number of repetitions of the ACSM curl-up test was 29 (SD 14). The authors were unable to find reliability data on the ACSM curl-up test, and the results should therefore be interpreted with caution.

There was no difference in prevalence and severity of PFD between women with and without DRA, neither in sum score nor the three scale scores, and when comparing the subgroup with more severe DRA. This is in line with the results of a systematic review [11] that found no significant association between DRA and urinary incontinence and only a small association between DRA and pelvic organ prolapse. Our results also concur with two recent studies that did not find an association between PFD and DRA [28,29]. Contrary to these findings, a study including women with different lumbo-pelvic diagnoses reported that 25/30, 83% of the women had DRA [8]. The same study found a relationship between pelvic pain and dysfunction (PFDI) and DRA. However, the mean sum score in the PFDI was only 5.5 out of 300.

The authors found no difference in prevalence of low back or pelvic girdle pain between women with and without DRA. This result is in line with the results of the systematic review by Benjamin et al. [11]. However, their included studies consisted mainly of women with mild or moderate DRA whereas our study included a higher proportion of women with moderate and severe DRA. Despite this, the results of our subgroup analyses were still in line with their conclusion [11]. Our study used the ODI to undertake a functional measure of disability due to low back pain. The same questionnaire was used by Parker et al. [9] and Dalal et al. [8]. In addition, a recent study by Hills et al. [7] used the Roland-Morris Disability Questionnaire Score and found no difference in disability due to low back pain between women with and without DRA. Reported lumbo-pelvic pain is expected to be high and may affect between 9% and 48% of women postpartum [9,30]. The prevalence of low back and pelvic girdle pain in our study was within this range, suggesting that there is no association between lumbo-pelvic pain and DRA.

This study found a higher prevalence of abdominal pain in women with, than those without, DRA when adjusted for possible confounders. A connection between DRA and abdominal pain and discomfort concur with anecdotal experience from clinical physiotherapy practice. However, as far as the authors have ascertained, only two previous studies have measured abdominal pain. Parker et al. [9] measured combined abdominal and pelvic pain using a visual analogue scale and found that women with DRA reported more pain than women without it. Hills et al. [7] found no difference in abdominal pain between women with and without DRA. As there were differences in assessment methods and populations within our and these studies, further research is warranted.

Strengths

The strengths of this study include the use of ultrasound to measure IRD, and that measurements were taken both at rest and during a curl-up. Measurements of the ultrasound images were performed off-line after the clinical assessments, and the physiotherapist was blinded to the women‘s IRD and any symptoms reported. One physiotherapist performed all the tests. The study used recommended and validated questionnaires to assess PFD, low back and pelvic girdle pain. In addition, compared to previous published studies, the authors have included a larger proportion of women classified with moderate and severe DRA.

Limitations

A limitation of this study is the absence of reliability studies for the Humac NORM and the ACSM curl up test. However, reliability studies with comparable dynamometers to measure maximal trunk flexion have showed good to excellent intra-tester reliability [15,31]. Another limitation is the absence of an a-priori power calculation. All women with DRA were part of an earlier study where the sample size was estimated with the purpose of detecting the immediate change in IRD during different abdominal and pelvic floor muscle exercises [14]. Hills et al. [7] estimated that 52 women (26 in each group) were needed to detect a difference in trunk flexion endurance time between women with and without DRA. A similar test was done in this study, and the authors therefore suggest that the inclusion of 36 women in each of our groups was enough to detect a difference for the strength measurements. The reported reduction in abdominal strength was only tested in two different positions for trunk flexion. Therefore, our results are limited to flexion and cannot tell the influence of DRA on other abdominal motions, e.g. trunk rotation. Due to low power in the sub-group analysis the possibility of a type II error should also be considered. In addition, our study sample consisted of highly educated Caucasian women, which limits generalization of our results to other populations.

Conclusion

The results of this study support a growing body of knowledge that DRA may be associated with impaired abdominal muscle strength and abdominal pain but cast some doubt on the common belief that DRA can cause PFD, low back and pelvic girdle pain. Physiotherapists working within an evidence-based paradigm should be cautious when addressing a causal inference between PFD, low back, and pelvic girdle pain in women with DRA. Further studies are warranted on the consequences of DRA, especially in the small subgroup of women with severe diastasis.

Key messages

- This study found that women with DRA tend to have weaker abdominal muscle strength and higher prevalence of abdominal pain than women without DRA.
- To the authors' knowledge, this is the first study to investigate possible consequences of DRA in a subgroup of women with moderate and severe diastasis.
- The results contradict the common belief that there is an association between DRA and PFD, low back and pelvic girdle pain and add important information to the existing body of knowledge.

[5pt]*Ethics approval*: The study was approved by the Regional Medical Ethics Committee (REK South East Ref. No. 2018/2312) and the Norwegian Centre for Research Data (Ref. No. 440860). Written informed consent was obtained from all participants.

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