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The association between Diastasis recti abdominis and pelvic floor dysfunction, sacroiliac joint dysfunction, and quality of life among postpartum women after Cesarean delivery

Zusammenhang zwischen Rektusdiastase, Beckenbodendysfunktion, sakroiliakaler Dysfunktion und Lebensqualität bei Frauen nach Kaiserschnittentbindung

Authors
Enas Abu Saleh[1], Lori Walton[2], Sahar Said[3], Veena Raigangar[4], Meeyoung Kim[4]

Affiliations
1 Physiotherapy, University of Sharjah, Sharjah, United Arab Emirates
2 Department of Physical Therapy, University of Scranton, Scranton, United States
3 Physical medicine and rehabilitation, Dubai Hospital, Dubai, United Arab Emirates
4 Physiotherapy, University of Sharjah, Sharjah, United Arab Emirates

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70469 Stuttgart, Germany

Correspondence
Dr. Meeyoung Kim
University of Sharjah, Physiotherapy, College of Health Sciences, University of Sharjah
27272 Sharjah
United Arab Emirates
Tel.: +97165057367
mkim@sharjah.ac.ae

ABSTRACT

Purpose The goal of this study is to see if there's a predictive relationship between diastasis rectus abdominis and pelvic floor dysfunction, sacroiliac joint dysfunction, and postpartum women's health-related quality of life.

Method This cross-sectional, correlative study focused on 32 postpartum mothers aged 18 to 45 years old. Real Ultrasound Sonographic Imaging (RUSI) was used to determine DRA. The Pelvic Floor Disability Index was used to assess pelvic floor dysfunction (PFDI). The Active Straight Leg Raise Test (ASLR), the Long Dorsal Sacral Ligament Test (LDL), and the Posterior Pelvic Provocation Test (P4) were also investigated. The Short Form-12 (SF-12) Survey was used to assess health-related quality of life (HRQoL).

Results A negative correlation between DRA and postpartum period was recorded ($\rho = 0.0001$). The following categories showed a significant positive correlation between DRA and Pelvic floor dysfunction: Pelvic Organ Prolapse Distress Inventory-6 (POPDI-6) corelated positively with DRA ($\rho = 0.01$); Colorectal-Anal Distress Inventory-8 (CRAD-8) ($\rho = 0.02$); Urinary Distress Inventory-6 (UDI-6) ($\rho = 0.00$). There was no correlation between DRA and sacroiliac joint dysfunction ($\rho = 0.8$).

Conclusion DRA was discovered to be a strong predictor of pelvic floor dysfunction, such as prolapse, colorectal-anal dysfunction, and urine distress. There was no evidence of a link between DRA and sacroiliac joint dysfunction or HRQoL.

ZUSAMMENFASSUNG

Fragestellung Ziel der vorliegenden Studie ist es zu untersuchen, ob eine prädiktive Beziehung zwischen Rektusdiastase und Beckenbodendysfunktion, iliosakraler Dysfunktion und der gesundheitsbezogenen Lebensqualität von Frauen in der postpartalen Phase besteht.

Methode In die korrelative Querschnittsstudie wurden 32 Frauen im Alter von 18 bis 45 Jahren in der postpartalen Phase aufgenommen. Das Vorliegen einer Rektusdiastase wurde mittels RUSI (Real Ultrasound Sonographic Imaging) bestimmt. Mithilfe des PFDI (Pelvic Floor Disability Index) wurde das Vorliegen einer Dysfunktion des Beckenbodens ermittelt. Weiterhin wurden der funktionelle Beckentest ASLR (Active Straight Leg Raise Test), der LDL (Long Dorsal Sacral Ligament Test) und der P4-Provokationstest (Posterior Pelvic Provocation Test) durchgeführt. Für die Ermittlung der gesundheitsbezogenen Lebensqualität (HRQoL) wurde der SF-12-Fragebogen (Short Form 12) verwendet.

Ergebnisse Es fand sich eine negative Korrelation zwischen Rektusdiastase und postpartaler Phase ($\rho = 0{,}0001$). Die folgenden Kategorien zeigten eine signifikante positive Korrelation zwischen Rektusdiastase und Beckenbodendysfunktion: POPDI-6 (Pelvic Organ Prolapse Distress Inventory-6) zeigte eine positive Korrelation mit einer Rektusdiastase ($\rho = 0.01$); CRAD-8 (Colorectal-Anal Distress Inventory-8) ($\rho = 0.02$); UDI-6 (Urinary Distress Inventory-6) ($\rho = 0.00$). Hingegen fand sich keine Korrelation zwischen Rektusdiastase und sakroiliakaler Dysfunktion ($\rho = 0.8$).

Schlussfolgerung Die Rektusdiastase zeigte sich als starker Prädiktor einer Beckenbodendysfunktion, wie beispielsweise Prolaps, kolorektal-anale Dysfunktion und Harnwegsbeschwerden. Es fand sich kein Hinweis auf eine Beziehung zwischen Rektusdiastase und sakroiliakaler Dysfunktion oder gesundheitsbezogener Lebensqualität.

ABBREVIATIONS

DRA	Diastasis of rectus abdominis
PFDI	Pelvic Floor Disability Index
VBAC	Vaginal Birth after cesarean
IRD	Inter-rectus distance
BMI	Body Mass Index
SF-12	12-Item Short Form Survey

Introduction

The separation of two rectus abdominis bellies along the linea alba is known as rectus abdominis diastasis (DRA). DRA is most common during and after pregnancy, with rates ranging from 66 to 100 percent in the third trimester, 53 percent within 24 hours of delivery, and up to 36 percent up to 12 months [1]. Non-obstetric cohorts with DRA have been reported, including uro-gynecological, menopausal, elderly populations, and those with abdominal aortic aneurysms [1]. The average population has inter-recti distances (IRD) ranging from 1.3 to 2.1 cm at the umbilicus at rest, according to radiological and cadaveric investigations. A clinically significant difference is defined as an inter-recti widening of greater than 2.2–2.3 cm as seen by ultrasonography, Mota found that the greater widening in primiparous women is at 2 cm above umbilicus [2]. There was a debate if this enlargement is linked to negative health outcomes such as lumbo-pelvic instability, low back pain, and incontinence [3, 4].

The stretching of the linea alba causes DRA. The rectus abdominis, transversus abdominis, and oblique muscles all insert into the linea alba's connective tissue. This lattice of collagen fibers runs from the xiphoid to the pubic symphysis, and various studies have shown that the most dramatic widening occurs at the umbilicus level [2, 4, 5]. Stretching of the linea alba occurs during pregnancy as a result of hormonal changes in elastic connective tissue as well as the mechanical strain placed on the abdomen wall by a developing fetus, rising weight, and shifting abdominal organs. The core muscles and fascia's capacity to operate is harmed as a result of this. The linea alba must be kept taut to keep the rectus bellies close together and the transversus abdominis, rectus abdominis, and oblique muscles torqued [4, 5]. The imbalance of strength and length in these abdominal wall muscles, as well as the ensuing altered fascial tension, has been linked to changed movement patterns, resulting in pain and dysfunction [1, 2, 4]. Multiple pregnancies, maternal age, childcare obligations, strenuous lifting, and a higher BMI have all been connected to the prevalence of DRA [5]. Force closure mechanism that is affected by the presence of DRA compromises the control of the surrounding joints like the sacroiliac joint, pelvic floor muscles, and, as a sequence, health quality of life in various functional tasks. DRA has been linked to low back pain, lumbopelvic pain, incontinence, pelvic organ prolapses, and abdominal muscle strength in some studies, but not in others [5–7]. Postpartum pain and perceived health status were the most during four to six postpartum weeks [8].

DRA is linked to a variety of health problems, including lumbo-pelvic instability, low back pain, and incontinence [5]., little evidence supports the postulated associations. To date, there has been no study done investigating associations across DRA, dysfunction in SIJ and pelvic floor, and HRQoL by utilizing the ultrasound measurement of IRD among multi-nationality postpartum women within the United Arab Emirates. It was found that cesarean section is one of the major risk factors for DRA [1]. Therefore, in this study only C-section women were selected. In addition, postpartum women with a maximum of two C-sections were included to avoid chronic secondary factors affecting the results. The purpose of the study is to examine the ability of diastasis recti abdominis to predict outcomes of Sacroiliac joint dysfunction and pelvic floor dysfunction. This study examined the association between IRD and pelvic floor dysfunction, sacroiliac joint dysfunction and health-related quality of life for postpartum women in UAE as it is an underdiagnosed condition in this area.

Subjects and Methods

Purposive sampling was used to acquire data from 32 participants in this cross-sectional study. The Dubai Scientific Research Ethics Committee (DSREC) of the Dubai Health Authority granted ethical permission (the certificate number was DSREC-SR-08/2020 01), as well as the University of Sharjah's Research Ethics Committee (The certificate number was REC-20–06–11–03-S).After obtaining ethical approval and informed consent, data were collected from postpartum women at the Physical Medicine and Rehabilitation department at Dubai Hospital based on inclusion criteria between August 2020 and March 2021.

Sonography imaging was done by an experienced physical medicine physician [10]. The researcher, an experienced women's health physiotherapist, interviewed the participants and performed the pain provocation tests for the assessment of SIJ [11].

Participants were included in the study between 12–48 weeks postpartum and between 18–45 years of age. Inclusion criteria were one to two Cesarean section deliveries with no vaginal deliveries and women who had elective and emergency Cesarean section deliveries. However, the exclusion criteria were women who had any type of vaginal delivery, Vaginal Birth after cesarean (VBAC), Normal Vaginal Birth Deliveries or assisted vaginal deliveries. Women with a history of traumatic injury to the lumbar-pelvic region, hip, or lower extremities, or history of systemic disease affecting the musculoskeletal, neuromuscular, or cardiopulmonary systems, or cardiovascular disease affecting lung function were all excluded.

Measurements

Inter-recti distance (IRD) was measured in three test conditions; from supine at rest, curl up and standing. All participants were examined by (Acuson P300 portable ultrasound system, Siemens, Germany) with linear probe to confirm if they have DRA or not [10]. DRA was considered as the distance between two bellies of rectus abdominis >20 mm [2]. Participants who scored IRD > 50 mm were considered severe DRA following the recent Swedish National Guidelines [21].

The active straight leg raise test (ASLR), the long dorsal sacral ligament test (pain provoking test) (LDL), and the posterior pelvic pain provocation test (P4) were used to assess sacroiliac joint dysfunction in postpartum women [11–13]. The ASLR test is thought to evaluate the capacity to shift weight from the legs to the trunk [15]. Subject laid supine and was instructed to alternately lift each leg to a height of ~20 cm and return it to the bench after a 1–2 second hold in the elevated position. ASLR was done with compression and without compression on the pelvic girdle. The test is positive, if impairment in raising one leg with and without compression on the pelvic girdle [15, 17, 18].

To trigger pain in the sacroiliac area, the posterior pelvic pain provocation test (P4 test) was used [8]. With the patient supine, the hip was flexed to 90 ° (with bended knee) to stretch the posterior structures. By applying axial pressure along the length of the femur, the femur was used as a lever to push the ilium posteriorly. One hand was placed beneath the sacrum to fixate its position while the other hand was used to apply a downward force to the femur [16]. The test is positive for pelvic girdle pain if the axial pressure provokes pain over the sacroiliac joint that is familiar to the patient.

Palpation of the Long dorsal sacral ligament (LDL) causes pain in the ligament [8, 14]. The patient laid prone, palpation of the LDL directly under the caudal part of the posterior superior iliac spine and checked for tenderness. The pain was measured on a 4-point scale:

0: no pain 1: mild pain 2: moderate pain 3: unbearable pain

The sum score can be between 0–6 because the scores on both sides are added [8, 14].

If any of the previous tests were positive, it was considered as positive pelvic girdle involvement.

The pelvic floor disability index (PFDI) was used to measure the strength and function of the pelvic floor muscles. The 46-item PFDI assesses symptom distress in women with pelvic floor disorders and is divided into three categories: the Urinary Distress Inventory (UDI; range 0–300), the Pelvic Organ Prolapse Distress Inventory (POPDI: range 0–300), and the Colorectal-Anal Distress Inventory (CRADI; range 0–400) [19]. The SF-12, a self-reported outcome form that assesses the impact of health on an individual's daily life, was used to assess participants' quality of life. This form consists of two main sections: physical and mental. It is used as health-related quality of life measure. Participants were explained the questionnaire, PFDI, and SF12 by an experienced physiotherapist [20]. All the questionnaires were self-reported and filled online by the participants

Statistical analysis

IBM SPSS statistical software, version 25, was used to analyze the data. Continuous variables are reported as mean ± standard deviations (SDs) if the data is normally distributed, whereas categorical variables are numbers and percentages. The correlation between inter-rectus distance and outcome measures was analyzed with Spearman Correlation Coefficient (r_s). In data analysis, medians (interquartile ranges) were derived if the data was not normally distributed. Nonparametric test: The Kruskal Wallis test was used to examine the relationship between IRD and the postpartum period, as well as the prevalence of various clinical symptoms related to DRA. Under the conditions of normally distributed data, an independent samples t-test was employed to examine variations in background characteristics between women with and without DRA. The significance level was set at $P<0.05$.

Informed consent: Informed consent has been collected from all participants included in this study.

Ethical approval: This study was approved by the Dubai Scientific Research Ethics Committee (DSREC) Dubai Health Authority (The certificate number was DSREC-SR-08/2020_01), and by the Research Ethics Committee of University of Sharjah (The certificate number was REC-20–06–11–03-S).

Results

During the study period, 32 participants were recruited. Inter rectus distance was measured using an ultrasound machine. Participants were divided to three groups: six participants with no DRA (18.8 %), eighteen with DRA (56.3 %) and eight with severe DRA (25 %) [21]. The participants ranged in age from 28 to 40 years old, the average age and postpartum period for the three groups were normally dis-

tributed. Non-Arab outlander were significantly higher (55.55 %) than Emirati nationals (22.22 %) and Non- Emirati Arab outlander (22.22 %). All demographic findings are shown in ▶ **Table 1**. Basal and clinical data distributed in group of Non-DRA, DRA and severe DRA.

The frequency of diastasis recti abdominis was 26 (81.3 %) out of 32 participants. The incidents of Diastasis rectus abdominis was increased at early postpartum period. Fourteen participants which were (12–24) weeks postpartum; had DRA mean of (43.66 ± 19.11). In addition, 14 participants were (25–48) weeks postpartum with DRA mean of (33.97 ± 16.64). Only 4 participants were (40–70) weeks with the DRA mean of (37.05 ± 7.56). Statistical significance ($r_s = -0.39$), ($p = 0.003$) was found between the presence diastasis recti abdominis and postpartum period. According to PFDI questionnaire, participants who had DRA scored higher POPDI, CRAD8 and UDI. ▶ **Table 2** shows the *(mean ± SD)* of IRD for the participants and their prevalence with the other variables. Also, statistical significance association was found between diastasis recti abdominis and pelvis floor dysfunction as the following; Pelvic Organ prolapse Distress Inventory 6 (POPDI-6) ($r_s = 0.51$), *($p = 0.01$),* Colorectal-Anal distress Inventory 8 (CRAD-8) *($r_s = 0.49$), ($p = 0.01$),* Urinary distress Inventory 6 (UDI-6) ($r_s = 0.59$), *($p = 0.00$).* No association was present between diastasis recti abdominis and sacroiliac joint dysfunction ($r_s = 0.89$), *($p = 0.8$).* The *p* – value (0.06) showed no significant association of diastasis recti abdominis and quality of life. In addition, there was an association between POPDI-6 and postpartum period *($p = 0.03$).* Significant relation was found between POPDI-6 and SF12-mental (▶ **Table 3**).

Also, there was association between (CRAD-8) and age with *($p = 0.02$)*. Statistical significance *($p = 0.04$)* was found between (CRAD-8) and SF12 –Mental. Urinary distress Inventory 6 was associated with age *($p = 0.02$)* and SF12-Mental *($p = 0.01$)* as well. UDI-6 was the only variable statistically associated with sacroiliac dysfunction *($p = 0.04$).*

Discussion

Age

Previous studies documented higher prevalence of DRA with age and parity. At this study, older postpartum women had higher IRD. The mean age was (33 ± 3.58) among total participants. These participants were divided into two subgroups (▶ **Table 4**). Significant association was found between PFDI and age *$p = 0.03$*, the older the participant the more likely she would complain of urogenital impairments. Spitzangle study suggested a possible relationship between age and DRA in women seeking for urogenital examination [22]. Physiological and hormonal changes with age explain the connective tissue changes that contribute to DRA [23]. In addition, this study found that age is highly associated with pelvic organ prolapse with *p value = 0.00*. In previous study, age was found one of the main risk factors for primary and recurrence pelvic organ prolapse as mentioned in a systematic review. It explained that age produce support-related pelvic floor dysfunction [23].

Postpartum period

This study found a solid predictive association of DRA and pelvic floor dysfunction in women in the postpartum period. There was a significant and robust association between DRA and the postpartum period. Those in the earlier postpartum group showed more significant DRA measurements (▶ **Fig. 4**). Mean DRA was reported at the early postpartum period (12–24) weeks with the mean of (43.66 ± 19.11) IRD with subjects reporting significantly lower DRA dysfunction at < 24 weeks compared to subjects between 24–36 weeks postpartum ($r_s = -0.39$; *$p = 0.00$).* In one study it was found that the prevalence of DRA at early postpartum period is 50 to 60 %. [24]. This period is affected by the healing process that plateaus approximately around eight weeks after birth. Major external factor is the presence of Relaxin which increases the elasticity of the abdominal and pelvic floor muscles. Also, postnatal guidelines advise women to gradually return to activity which might contribute

▶ **Table 1** Sample Characteristics

Demographic	**No DRA n = 6 (18.8 %)**	**DRA n = 18 (56.3 %)**	**Severe DRA n = 8 (25 %)**
	(Mean ± SD)	**(Mean ± SD)**	**(Mean ± SD)**
Maternal Age	33 (30 to 40)	34.33 (28 to 39)	31.38 (28 to 38)
	33 ± 4	34.33 ± 3.39	31.38 ± 3.20
Nationality %			
Emirati	2 (33.33 %)	4 (22.22 %)	2 (25 %)
Non-Arab outlander	4 (66.66 %)	10 (55.55 %)	6 (75 %)
Non-Emirati Arab outlander	0 (0 %)	4 (22.22 %)	0 (0 %)
Deliveries			
One CS	2 (33.3 %)	8 (44.4 %)	3 (37.5 %)
Two Cs	4 (66.7 %)	10 (55.6 %)	5 (62.5 %)
Postpartum period	30.33 ± 12.54	37.44 ± 17.80	20.5 ± 5.21

DRA: Diastasis recti abdominis, CS: cesarean section, n : number of cases. Mean, Standard deviation, median and percentage were calculated

▶ **Table 2** Descriptive data (n = 32)

Age	Number of cases	IRD *(mean ± Standard Deviation)*
(28–33) years	15	(37.51 ± 11.44)
(33–40) years	17	(39.56 ± 21.39)
Nationality		
Emirati	8	(36.14 ± 17.06)
Non-Arab outlander	20	(41.32 ± 18.62)
Non-Emirati Arab Outlander	4	(29.9 ± 4.63)
Delivery		
One CS	13	(40.01 ± 17.23)
Two CS	19	(37.63 ± 17.61)
Postpartum Period		
(12–24) weeks	14	(43.66 ± 19.11)
(25–48) weeks	14	(33.97 ± 16.64)
(49–72) weeks	4	(37.05 ± 7.56)
Pelvic Organ prolapse Distress Inventory 6 (POPDI-6)		
zero	6	(27.79 ± 12.83)
(1–25)	17	(38.66 ± 19.61)
(26–50)	7	(46.94 ± 12.46)
(51–75)	2	(41.35 ± 8.88)
Colorectal-Anal distress Inventory 8 (CRAD-8)		
zero	5	(31.29 ± 12.35)
(1–25)	15	(38.29 ± 20.17)
(26–50)	5	(39.06 ± 16.77)
(51–75)	5	(43.82 ± 6.0)
(76–100)	2	(46.95 ± 32.59)
Urinary distress Inventory 6 (UDI-6)		
zero	4	(23.50 ± 6.84)
(1–25)	17	(37.53 ± 18.58)
(26–50)	9	(44.45 ± 12.59)
(51–75)	0	nill
(76–100)	2	(51.55 ± 26.09)
Pelvic Floor Distress Inventory		
zero	1	nill
(1–100)	22	(37.43 ± 18.97)
(101–200)	9	(42.45 ± 13.16)
(201–300)	0	nill
Short Form 12 Physical		
(20–30)	5	(44.12 ± 19.42)
(31–40)	7	(47.14 ± 18.23)
(41–50)	13	(35.59 ± 16.18)
(51–60)	7	(31.70 ± 15.45)
Short Form 12 Mental		
(20–30)	2	(29.50 ± 7.91)
(31–40)	4	(59.15 ± 11.48)
(41–50)	13	(32.87 ± 15.36)
(51–65)	13	(39.40 ± 17.34)
Sacroiliac Joint Dysfunction		
Negative	15	(40.42 ± 19.51)
Positive	17	(36.99 ± 15.34)

to fear of movement [25]. A systematic review by Yang, recommended early postpartum assessment within 3 weeks of delivery to face early postpartum dysfunctions, and perform a fully individualized postpartum visit within 12 weeks of delivery (4–6 weeks of delivery) [26]. This highlights the importance of proper rehabilitation starting from early postpartum period to avoid future complications such as pelvic girdle pain.

A significant predictive association was found between DRA and Pelvic floor dysfunction for the following categories; Pelvic Organ prolapse Distress Inventory-6 (POPDI-6) (rs = 0.513) *($\rho = 0.01$);* Colorectal-Anal Distress Inventory-8 (CRAD-8) ($r_s = 0.494$) *($\rho = 0.017$);* Urinary Distress Inventory-6 (UDI-6)($r_s = 0.596$)*($\rho = 0.002$).* Similarly recent study found association between DRA and pelvic floor diseases, they explained that DRA is weakness of the connective tissue which is a major factor in pelvic floor diseases [27]. No association was present between DRA and sacroiliac joint dysfunction ($r_s = 0.08$) *($\rho = 0.8$).* Though a significant association was not found between DRA and HRQoL, a negative trend was observed between DRA and HRQoL ($r_s = -0.324$) ($\rho = 0.06$). On the other hand, a cohort study found no correlation between mild and moderate inter rectus distance and quality of life among postpartum Finnish women [28]. In addition, no association was found between DRA and parity. However, all participants with two C-sections had a later postpartum period which might affect the results.

Pelvic floor dysfunction

Pelvic Organ Prolapse

Pelvic floor dysfunction has a significant role in the quality of life for postpartum women, as mentioned in various studies [7–9]. This study found an association between inter-rectus distance and PFD in all three aspects measured by PFDI ($r_s = 0.40$); ($\rho = 0.06$). Firstly looking at the Pelvic Organ prolapse Distress Inventory 6 (POPDI-6), which had the highest correlation and significance with DRA ($r_s = 0.51$); ($\rho = 0.00$) , participants with DRA and severe DRA mostly complained of experiencing pressure at the lower abdomen. This predictive relationship between DRA and POP can be explained due to the changes in motor control among DRA postpartum women. These changes are presented by compromised deep muscles and augmented superficial muscles. Lee explained that pelvic floor muscles are one of the vital deep localizers [7]. These findings came in line with a study with retrospective data suggesting a higher prevalence of pelvic organ prolapse in women with DRA than those without DRA [27]. Age, parity and abdominal muscle weakness were the explanation for such results [29]. In this study, it was also found that there was an association between POPDI and postpartum period. In which higher prevalence was recorded at the early postpartum period. This can be explained through the higher DRA mean presented at early postpartum period. Also, there was a significant association between POPDI and ethnicity ($\rho = 0.02$) mainly with south Asian. In addition, there was a significant association with quality of life at the mental section (SF12 –Mental) ($\rho = 0.04$). Participants with the highest POPDI score complained of feeling downhearted and blue most of the time also accomplished less due to emotional problems.

Colorectal- Anal distress On the other hand, in this study higher prevalence of Colorectal-Anal distress symptoms was found in older

▶ **Table 3** Correlations between Interrectus Distance and outcome measures in Postpartum Women (n = 32).

Outcome measures	Spearman Correlation Coefficient (rs)	*p*
Postpartum period	*−0.39	***0.00
Pelvic Floor Distress Inventory (PFDI)	* 0.40	0.06
Pelvic Organ prolapse Distress Inventory 6 (POPDI-6)	**0.51	***0.01
Colorectal-Anal distress Inventory 8 (CRAD-8)	**0.49	***0.01
Urinary distress Inventory 6 (UDI-6)	**0.59	***0.00
Health Quality of Life (HQoL)		
Short Form 12 Physical	−0.34	0.06
Short Form 12 Mental	−0.22	0.38
SIJ Dysfunction	0.08	0.89
Active Straight Leg Raise Test (ASLR)	*0.38	0.07
Posterior Pelvic Provocation Test (P4)	0.04	0.09
Long Dorsal Sacral Ligament Test (LDL)	0.12	0.25

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed). ***P < 0.05 statistically significant. Spearman Correlation Coefficient, Kruskal Wallis Test ρ value were calculated

▶ **Table 4** Age subgroups and statistical interferences among outcomes

	Age (28–32) years	Age (33–40) years	
	n = 15	*n* = 17	*ρ value*
IRD	(37.51 ± 11.44)	(39.56 ± 21.39)	*0.45*
Postpartum period	(34.64 ± 17.94)	(29.88 ± 13.93)	*0.93*
Pelvic Floor Distress Inventory	(86.66 ± 63.5)	(48.02 ± 48.42)	*0.03*
Pelvic Organ prolapse Distress Inventory 6 (POPDI-6)	(27.49 ± 20.70)	(12.49 ± 10.41)	*0.00*
Colorectal-Anal distress Inventory 8 (CRAD-8)	(29.99 ± 25.87)	(19.35 ± 26.48)	*0.94*
Urinary distress Inventory 6 (UDI-6)	(29.16 ± 23.41)	(16.17 ± 19.48)	*0.13*
SF12 Physical	(44.35 ± 8.44)	(41.78 ± 8.24)	*0.57*
SF12 Mental	(49.11 ± 10.74)	(48.68 ± 10.40)	*0.71*

n :number of cases, IRD: Inter- Rectus Distance Mean, standard deviation and t-test ρ value were calculated

participants with the significant association of ($\rho = 0.02$) between CRAD and age.

According to literature, age, higher parity, gravity levels, and weaker pelvic floor muscles resulted in this distress in participants with DRA. It was found that increased pelvic floor muscle tone will raise the anal resting pressure. This muscle tone increment can be presented as pelvic floor muscle spasm. This spasm is due to the inability of these muscles to overcome the increased intra-abdominal pressure. Women present with hypertonic pelvic floor muscles are supposed to practice relaxation techniques. [31]. Also, caesarean section is one of the risk factors [32], in the present study only C-section participants were included (▶ **Figure 1–3**).

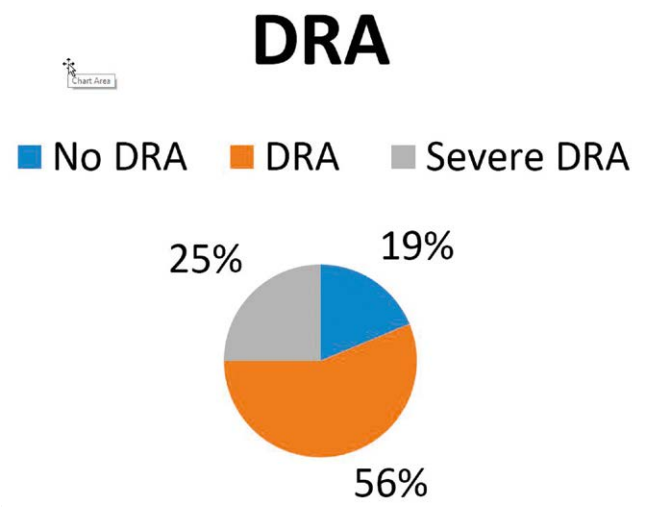
Urinary distress Also at this study, it was found that DRA was associated with urinary tract dysfunction. In which postpartum DRA women are more likely to have urine leakage. The association was highly correlated and significant ($r_s = 0.59$); ($\rho = 0.00$). This is due to increased intra-abdominal pressure, which is greater than pelvic floor muscle force. Contraction of these muscles closes the urethra, anus, and vagina. The inability of these muscles to contract efficiently will cause this dysfunction. Also, hyperactivity of these muscles will affect the urine voiding. Literature proved this association between DRA and urinary incontinence [7, 22] (▶ **Figure 5,6**).

Contralateral to these findings, one study suggested that there is no relation between DRA and urinary incontinence [33]. At previous study, the Average of IRD was in the two groups between (16.9–17.9) mm in which is a mild DRA according to Swedish National Guidelines [21]. In this study, the DRA spectrum is wider in which women with more than 20 mm and lower than 50 mm were included. At this wider rate of IRD, clearly there was high correlation between IRD and UDI-6 (▶ **Figure 7**).

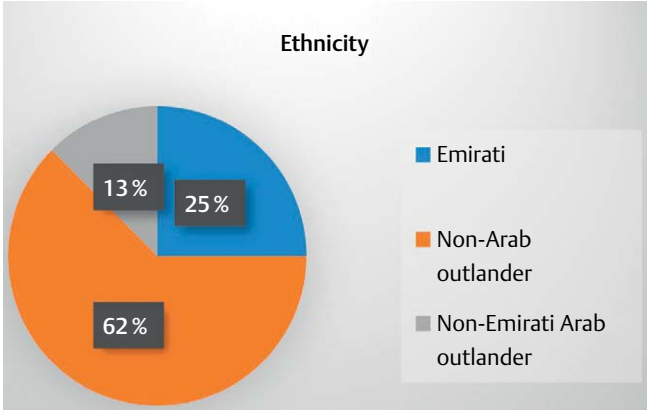
To sum it up, DRA has a major role in the efficacy of pelvic floor muscles contraction. The loss of proper function at the trunk muscle control, presented by transverse abdominis, internal oblique, and external oblique, affects linea alba's ability to transmit loads from lateral abdominal wall through the linea alba [7]. Many postpartum women who suffered from DRA did not have that ability which might increase their chances to have low back pain and urine incontinence [7]. This study found that participants who suffered from urine distress symptoms had a higher prevalence of sacroiliac joint dysfunction ($r_s = 0.00$); ($\rho = 0.04$). Clinically, the key to the treatment of DRA is the activating of the deep core muscles. Transverse abdominis muscle, multifidus, diaphragm and pelvic floor muscles training is started from static position progressing to dynamic and functional activities. Studies found that women should avoid exercises that bulge the abdominal wall which results in IRD increment and more separation between the recti. Such as crunches, reverse crunches and sit ups as well as lifting heavy objects [5, 30].

Sacroiliac joint dysfunction

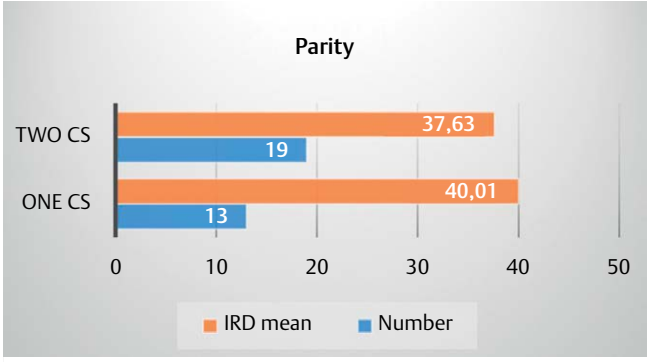
Concerning sacroiliac joint dysfunction, it was found that there was no significant impact between participants with or without DRA. There was no association with participants who had positive tests and DRA ▶ **Table 2**. This reflects same results of previous studies [1, 2, 34]. It was argued that these results might be due to the ab-



▶ **Fig. 1** DRA among Sample.

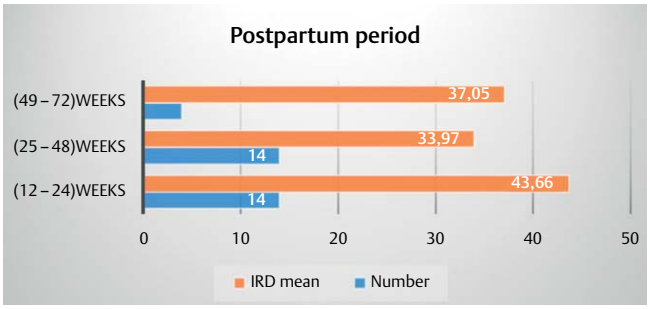


▶ **Fig. 2** Ethnicity among sample.

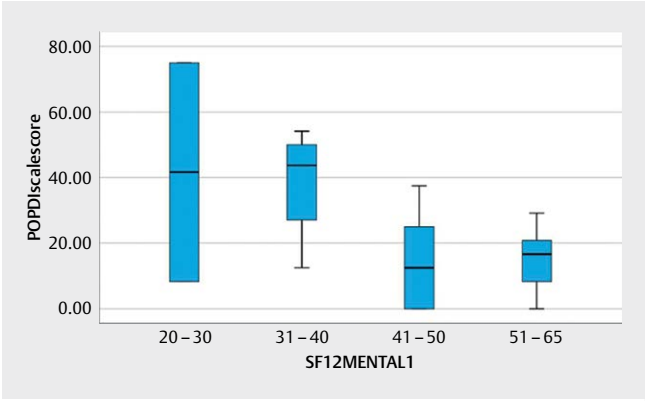


▶ **Fig. 3** Parity and DRA.

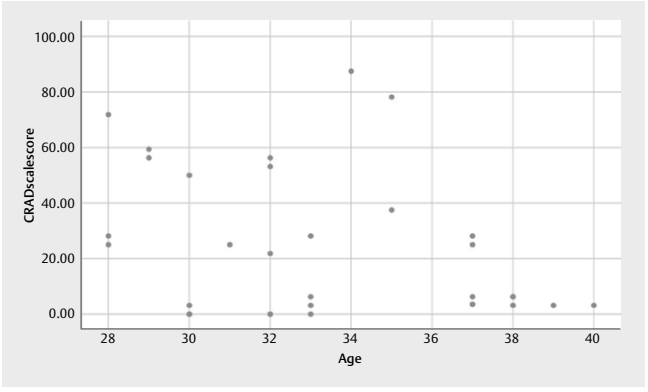
sence of severe DRA in the participants. This study had eight participants with severe DRA. However, it was found that only one study found an association between IRD and pelvic girdle pain or low back pain in women with DRA [34]. The evidence among this association is conflicting.



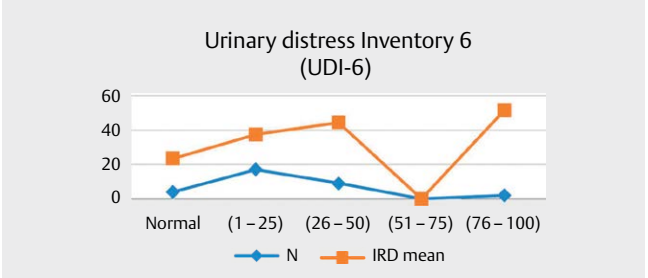
▶ **Fig. 4** IRD and postpartum period.



▶ **Fig. 5** Association between POPDI and SF12 Mental.



▶ **Fig. 6** Association between CRAD and age.



▶ **Fig. 7** IRD and Urinary distress Inventory 6 (UDI-6).

Limitations

One of the significant limitations of the study was the small sample size due to the difficulty in participants' recruitment as a result of COVID-19 pandemic. Period of Conducting the study, many facility constraints were applied due to the pandemic. In addition, postpartum mother's preferred to use telemedicine which is not applicable to the study. Many participants explained their high burden.

This participant high burden, lack of financial incentive and facility constraints tightened the study time frame. For future, a longitudinal study is encouraged to recruit a larger sample size.

Also, pre-pregnancy status and Body Mass Index were not recorded, affecting the generalizability of the results.

Strength

This study focused only on C-section women because of the high-risk factor in developing DRA. On the other hand, vaginal delivery might bias the results as it is one of the major factors in developing pelvic floor dysfunction. Although including C- section is affecting the generalizability of the data, internal validity of the results is solely influenced by the presence of DRA minimizing the bias because of the delivery mode. Only women with a maximum of two C-sections were included to avoid chronic secondary factors affecting the results. In addition, the study sample had wide range of IRD including DRA and severe DRA. Also wide age range was included.

In this study ultrasound imaging was used for the measurement of IRD. Ultrasound is named the gold standard for noninvasive IRD assessment [35]. Palpation using the finger width had lesser inter-rater reliability as it is liable to individual differences in finger width and/or abdominal pressure interpretation. On the other hand, Ultrasound imaging measurements are reported to be consistent and more responsive to the change in IRD [36].

This study is the only study investigating the range of exact measured IRD association with pelvic floor dysfunction, sacroiliac joint dysfunction and quality of life.

Clinically, the results of this study suggested that DRA is a strong predictor of pelvic floor dysfunction. DRA rehabilitation will have a positive effect on pelvic floor rehabilitation. Facilitation of Transverse abdominis muscle has a key role in improving trunk stabilization mechanism. Moreover, abdominal muscle action utilization can be used in initiation of pelvic floor muscles tonic activity, automatic recruitment, and coordination.

Conclusion

This study reported a higher prevalence of DRA in the early postpartum period for women with cesarean birth mode. DRA had a direct significant association with pelvic floor dysfunction with strong significant associations with pelvic organ prolapse (POPDI-8), colorectal-anal distress (CRADI-6) and urological symptoms (UDI-6)

Disclosure statement

No author has any financial interest or received any financial benefit from this study.

Availability of data and materials

The datasets generated and analyzed during the current research are not publicly available due to privacy protection but are available for corresponding author on reasonable request.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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