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Effect of exercise on the inter-rectus distance in pregnant women with diastasis recti abdominis: an experimental longitudinal study

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Abstract

Objective To investigate the effect of acute contraction of the pelvic floor muscles (PFM) and abdominal exercises on the inter-rectus distance (IRD) compared to resting values, and differences between gestation weeks 27 and 37, in pregnant women with diastasis recti abdominis (DRA).
Design Experimental longitudinal design.
Setting Physiotherapy clinic, primary health care.
Participants Thirty-eight pregnant women with DRA ≥ 2.8 cm.
Interventions Two-dimensional ultrasound images of IRD 2 cm above and below the umbilicus were taken at rest and during PFM and abdominal exercises at gestation week 27 and 37. Repeated measures analyses of variance (ANOVAs) with post hoc tests was performed for each exercise for both locations and timepoints.
Main outcome measures Change in IRD.
Results There was a mean increase of the IRD from rest during a PFM contraction (2 mm, 95% CI: 2, 3), drawing-in (4 mm, 95% CI: 3, 5) and a combination of these (5 mm, 95% CI: 4, 6) There was a mean decrease of the IRD from rest during the headlift (−3 mm, 95% CI: −4, −2), the curl-up (−3 mm, 95% CI: −4, −2) and the diagonal curl up (−4 mm, 95% CI: −5, −3). Effect of time from gestation week 27–37 was a mean increase of 8 mm (95% CI: 6, 9).
Conclusion Pelvic floor and drawing-in exercise increased the IRD, whilst headlift, curl up and diagonal curl up decreased the IRD in pregnant women with DRA at gestation week 27 and 37.

Contribution of the paper

- This is the first study to investigate the acute effect of exercise on IRD in pregnant women with DRA.
- Diagonal curl-up, headlift and curl-up reduced the IRD in pregnant women with DRA at both gestation week 27 and 37. The drawing-in exercise and a PFM contraction increased the IRD at the same timepoints.
- As exercise involving the rectus abdominis muscle decrease the inter-rectus distance in pregnant women, clinicians should reconsider advising against such exercises.

Data availability

There are no data available.

Keywords: Diastasis; Exercise; Linea alba; Pregnancy; Ultrasonography

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Introduction

Diastasis recti abdominis (DRA) is a common condition in pregnant and postpartum women, with a reported prevalence of up to 100% during the last trimester of pregnancy, 60% 6 weeks postpartum and 32% 12 months postpartum [1,2]. DRA is defined as a stretching and weakness of the Linea alba increasing the distance between the two muscle bellies of the rectus abdominis muscle [3]. During pregnancy, this stretching and weakness is a result of the increased strain on the ventral abdominal wall caused by the growing foetus [3–5]. DRA is diagnosed by measuring the distance between the medial borders of the two rectus abdominis muscle bellies, referred to as the inter-rectus distance (IRD). There is however, no consensus on either the cut-off point for a clinically significant DRA, or where to measure the distance along the Linea alba [6]. Evidence suggest that DRA is associated with weak abdominal muscles and increased abdominal pain [7]. DRA is also believed to be associated with pelvic girdle pain, low back pain and urinary incontinence, however the evidence for these associations are weak [8–10].

Both palpation by finger width and calipers are considered valid and reliable screening methods for measuring IRD in clinical settings, however, ultrasound imaging of the IRD is the most reliable and recommended measurement tool when measuring and monitoring change in the IRD [6,11].

Physiotherapists in primary health care commonly treat women, both during pregnancy and the postpartum period, presenting with DRA [12]. Therapy aims for both prevention and reduction of DRA, however current clinical recommendations build on weak or sparse evidence as to which exercise modality is the most effective and feasible [4,13,14]. Based on well-established clinical beliefs pregnant women are often advised against exercises activating the rectus abdominis muscle as this is assumed to increase DRA [12,15].

Most studies on DRA have been conducted on postpartum populations, and to date there are no basic studies investigating the effect of different exercises on the IRD in pregnant women. As DRA mostly occurs and develops during 2nd and 3rd trimester, it is important to examine how the IRD is influenced by exercise during this period [1,2]. Identifying exercise with a potential influence on the IRD, is the first stage of knowledge in how to reduce the IRD in women with DRA and particularly the unresolved prevalence (32%) 12 months postpartum [2]. The aim of this present study was to identify the acute effect of a pelvic floor muscle (PFM) contraction and 4 different abdominal muscle exercises on the IRD in pregnant women presenting with DRA, measured at gestation week 27 and 37. Difference in between assessments were also investigated.

Methods

Design

A longitudinal experimental design with repeated measures was applied, where data was collected from all participants at two timepoints; gestation week 27 and gestation week 37.

Participants

Thirty-eight pregnant women were included, based on a power calculation performed with data from two previous studies where a clinically significant difference of 5 mm was used between IRD 2 cm above the umbilicus at rest and IRD during contraction of transversus abdominis muscle, with an estimated standard deviation (SD) for the difference of 11 mm [11,16]. A significance level.05 and power of 0.80 was applied.

Participants were recruited from local physiotherapy clinics, local health centres, and through social media platforms Facebook and Instagram.

The inclusion criteria were healthy pregnant primigravida and parous women aged > 18 years, less than 27 weeks pregnant. In accordance with Mota et al. [17] the participants had to present with a IRD of 2.8 cm or more, measured 2 cm above and/or below the umbilicus on initial assessment. Studies report the largest change in IRD is measured to 2 cm above the umbilicus, hence measurements were done 2 cm above and 2 cm below the umbilicus. Both cut-off point and measurement locations were set in accordance with similar studies on postpartum populations to ensure reliable measurements and comparisons of results [11,16–18]. Participants presenting with an abdominal wall protrusion along the linea alba were included, even though the IRD was measured to less than 2.8 cm, as suggested by Brauman et al. [19].

Exclusion criteria were pregnancies where exercise was contraindicated, serious illnesses regarding both mother and/or foetus, inability to understand and speak a Scandinavian language, failure to complete and present an informed consent and chronic physical or mental illness incompatible with the intervention. Exclusion criteria during the study period were stillbirth or premature birth before gestation week 37.

Participants were given oral and written information about the study. The study was approved by the Regional medical Ethics Committee (76296 2020/2304) and procedures agreed with the Helsinki Declaration.

Primary outcome measure

Change between IRD during exercise and at rest measured in mm [6,20].

Instrumentation and Examiner

Ultrasound images (B-mode) of the IRD were collected using a two-dimensional ultrasound diagnostic scanner with a linear probe (Alpinion Ecube8). Ultrasound imaging is found to be a reliable measurement method for the IRD, with a very good intra-tester reliability [11].

All assessments, images and measurements were performed by one investigator, a women's health physiotherapist with 22 years of clinical experience who had undergone specific training in ultrasound imaging of the pelvic floor and abdomen. Blinding of the investigator was ensured by converting all images to a digital format, allocating them a random number prior to measurements.

Procedures

All participants completed an online questionnaire on background variables prior to data collection. Age, body mass index, parity, single/multiple fetuses, protrusion, education, and smoking were considered relevant variables to describe the population included. Assessments were performed when the participants were in gestation week 27 and 37. Presence and size of DRA, and the ability to perform a correct PFM contraction and correct abdominal exercises were assessed prior to inclusion in the study. DRA was assessed and measured using the ultrasound machine`s integrated measurement tool. Presence of a protrusion was assessed by observation. The participant was instructed to perform an abdominal curl-up and if a doming along the linea alba occurred, the participant was eligible for inclusion. The ability to perform a correct pelvic floor contraction and the drawing-in exercise was assessed by ultrasonography and are described further, including descriptions of the different exercises, in Table 1.

The position of the participant during imaging was supine, knees hip-width apart and bent 90º, feet resting on plinth, and the head resting on a pillow. Arms were placed alongside the body or behind the head according to which exercise was performed. Measurement locations were initially marked on the skin to standardize the position of the ultrasound transducer when imaging the IRD; 2 cm above the umbilicus, measured from the upper edge of the umbilicus, and 2 cm below the umbilicus, with the lower edge of the umbilicus as point of reference.

The transducer was placed transversely along the midline of the abdomen and the bottom edge of the transducer corresponded with the skin markers. The transducer was moved laterally until the medial borders of the rectus abdominis muscles, and the Linea alba were visualized. To enable accurate measurements when the IRD was too large to be captured with standardized brightness mode (B-imaging), images were taken using an extended field of view or panoramic function to produce one long image displaying the IRD [21].

The images were collected in a set order. Prior to each imaging the participants were told to relax, take a deep breath in, and exhale before the exercises were performed. Images were collected immediately at the end of exhalation and care was taken so the pressure of the probe did not cause a reflexive response of the abdominal muscles [22]. The participants were told to hold the contractions for approximately three to five seconds to allow imaging. One image was collected at each location for each task. Ten images of the IRD at two different locations (2 cm above and below the umbilicus) were collected for each participant: (1) at rest (2) during a PFM contraction, (3) during a drawing-in exercise, (4) during a combined PFM contraction and drawing-in exercise, (5) during a head lift, (6) during a curl-up, (7) during a combined drawing-in exercise and curl-up, (8) during a combined PFM contraction, a drawing-in exercise and curl-up, (9) during a diagonal curl-up to the left, and (10) during a diagonal curl-up to the right.

Ultrasound images were stored on the ultrasound machine as Digital Imaging and Communications in Medicine (DICOM) format. The images were then transferred and stored at the SAFE server, University of Bergen, the University's information technology department database. Here, all participants images were allocated a random number to ensure blinding of the assessor. Measurements of the IRD were done using the MATLAB Image Processing Toolbox programme. The medial borders of rectus abdominis (outside the hyperechoic line) and the conjunction to the Linea alba on both sides were identified and the transverse linear distance between these borders, were measured. This measurement procedure is in line with the procedure described by Mota et al. [11].

Statistical analysis

SPSS (Version 28; IBM Corporation) was used for all statistical analyses. Background variables are presented as means with standard deviation and ranges, or number and percentages. Measures of IRD were presented as means with standard deviation and tested for normality using the Shapiro-Wilks test. Repeated-measures analysis of variance (ANOVA) with post hoc tests was performed for each exercise (above and below the umbilicus, and gestation week 27 and 37). Results were presented as means with 95% confidence interval (CI); statistical significance was set at $P < .05$ with Bonferroni correction for multiple comparisons. 95% Limits of Agreement in mean IRD between test and retest has previously been reported to be between −8.7 and 8.3 mm [11].

The effect of each exercise was defined as change in IRD from rest to each contraction, and the results are presented with a positive value with an increase in IRD during the exercise and a negative value with a decrease in IRD during the exercise. The diagonal curl-up values are presented as an average between left and right values.

Table 1
Operational description of the exercises, including description of how a correct performance was ensured.

Exercise	Operational description	Assessment
PFM contraction	**Position:** Supine, knees hip-width apparat and bent 90º, feet resting on plinth, head resting on a pillow, arms resting alongside the body **Instruction:** Squeeze muscles around all pelvic openings, lift up-wards and in-wards	Ultrasound imaging using a curved linear array transducer placed in the mid-sagittal plane immediately suprapubically observing the cranioventral displacement of the pelvic floor in a sagittal plane
Drawing-in	**Position:** Supine, knees hip-width apparat and bent 90º, feet resting on plinth, head resting on a pillow, arms resting alongside the body **Instruction:** Inhale, and at end of exhalation the umbilicus is drawn down towards the spine, activating the transversus abdominis muscle	Ultrasound imaging of the Transversus abdominis muscle on the lateral abdominal wall at the level of the umbilicus. A correct performed exercise involved minimal activation of the adjacent abdominal muscles.
PFM + drawing-in	**Position:** Supine, knees hip-width apparat and bent 90º, feet resting on plinth, head resting on a pillow, arms resting alongside the body **Instruction:** Contract the PFM first, and then add the drawing-in exercise	Observation that exercise was performed in accordance with operational description
Head lift	**Position**: Supine, knees hip-width apparat and bent 90º, feet resting on plinth, head resting on a pillow, arms resting alongside the body **Instruction:** Lift and clear the head off the plinth. Shoulders are to stay on the plinth during the manoeuvre.	Observation that exercise was performed in accordance with operational description
Curl-up	**Position:** Supine, knees hip-width apparat and bent 90º feet resting on plinth, head resting on a pillow, both hands behind head **Instruction:** Lift head and shoulders upwards until the shoulder blades clear the plinth	Observation that exercise was performed in accordance with operational description
Drawing-in + curl-up	**Position:** Supine, knees hip-width apparat and bent 90º, feet resting on plinth, head resting on a pillow. Both hands behind head **Instruction:** Start with the drawing-in exercise, and then do a curl-up	Observation that exercise was performed in accordance with operational description
PFM + drawing-in + curl up	**Position:** Supine, knees hip-width apparat and bent 90º, feet resting on plinth, head resting on a pillow Both hands behind head **Instruction:** Start with the PFM contraction, then add the drawing-in exercise, and then do a curl-up	Observation that exercise was performed in accordance with operational description
Diagonal curl-up left and right	**Position:** Supine, knees hip-width apparat and bent 90º, feet resting on plinth, head resting on a pillow **Instruction:** Placed right arm behind the head, elbow pointing laterally. Keep hand under head and move the elbow towards the left hip, lifting head and clearing the right shoulder blade of the plinth. Repeat on other side.	Observation that exercise was performed in accordance with operational description

Abbreviations: PFM, Pelvic Floor Muscle.

Results

Thirty-eight pregnant women completed both assessments, and demographic data are presented in Table 2. The descriptive statistics for the IRD measurements at gestation weeks 27 and 37 are presented in Table 3 and Table 4.

The variable of interest was the change in IRD between rest and 9 different exercises. The post hoc analysis indicates a mean increase in IRD during a PFM contraction of 2 mm (95% CI: 2, 3), $p < .001$, during a drawing-in exercise of 4 mm (95% CI: 3, 5), $p < .001$, and during a combined PFM contraction and the drawing-in exercise of 5 mm (95% CI: 4, 6), $p < .001$. The post hoc analysis indicates a mean decrease in IRD during a headlift of −3 mm (95% CI: −4, −2), $p < .001$, during a curl-up of −3 mm (95% CI: −4, −2), $p < .001$, and during a diagonal curl-up of −4 mm (95% CI: −5, −3), $p < .001$. The combined exercises drawing-in with curl-up and PFM contraction with drawing-in and curl-up showed no significant change from the resting value (Fig. 1).

These findings showed a main effect of location with 4 mm higher values above compared to below the umbilicus (95% CI 3, 5), $p < .001$, and a main effect of time with an increase from gestation week 27–37 of 8 mm (95% CI: 6, 9), $p < .001$, (Fig. 1).

Discussion

Overall, this study demonstrates that the instantaneous impact of exercise on the IRD in pregnant women with DRA varies by the exercises performed. These results were

Table 2
Descriptives of the study population (n = 38).

	n (%)	Mean (SD)	Range
Age (years)		34 (3)	28–41
Body mass index			
– gestation week 27		27 (5)	20–37
– gestation week 37		28 (5)	20–39
Inter-rectus distance (mm)			
– gestation week 27, au		31 (6)	13–56
– gestation week 37, au		40 (6)	24–58
– gestation week 27, bu		27 (7)	13–56
– gestation week 37, bu		34 (6)	24–58
Parity		0.8 (0.7)	0–2
Single pregnancies	38 (100)		
Protrusion	15 (40)		
University education	34 (90)		
Smoking	0 (0)		

Abbreviations: SD, standard deviation; au, above umbilicus; bu, below umbilicus.

consistent both above and below the umbilicus, and at gestation week 27 and 37. The results can be divided into three main trends, where [1] the IRD increases significantly with pelvic floor and transversus abdominis activation, [2] decreases significantly with headlift, curl-up and diagonal curl-up, and [3] shows no significant change compared to rest where exercises from the two groups are combined.

Exercises increasing the IRD

The present study found that the IRD increased significantly with a PFM contraction. These findings are in line with studies performed on postpartum populations using equivalent measurement methods, and hence adds strength to the view that PFM has no specific role in reducing the IRD [10,13,16,18,23]. Pregnant women are encouraged to do PFM training throughout the pregnancy and postpartum period, and there is Level 1 evidence (recommendation A) that PFM training should be the first treatment choice to prevent and reduce urinary incontinence (UI) [24]. Woodley et al. [24] found that continent pregnant women have 62% less risk of developing UI in late pregnancy and 29% during the mid-postnatal period if they do PFM training [24].

Even though we found a significant increase in IRD during a PFM contraction, this change was minimal. The longitudinal effect of PFM training on the IRD is yet to be investigated, as this study can only determine an immediate effect due to the study design. Pregnant women should still be encouraged to perform regular PFM training, but clinicians should be cautious postulating synergistic effects between the PFM and reduction of the IRD.

The largest increase of the IRD in this study, was measured during a combined PFM contraction and a drawing-in exercise activating the transversus abdominis. There is a synergistic co-contraction between the PFM and the transversus abdominis, so that when the PFM contracts, it enhances the contraction of the transversus abdominis [25,26]. This supports our findings as a combination of a PFM contraction and drawing-in exercise increased the IRD significantly more than an isolated drawing-in exercise. Similar effects have been reported in studies investigating the effect of pelvic floor and transversus abdominis muscle contraction on IRD in a postpartum population with DRA [16,18].

The activation of the transversus abdominis through a drawing-in exercise is postulated to be the gentlest and most effective to restore form and function of the linea alba [4,27]. Contraction of the transversus abdominis was previously thought to reduce the IRD, but recent studies have contradicted this assumption in the postpartum and general female population [18,28]. Our findings in a pregnant population are also in line with this, as the IRD significantly

Table 3
Mean difference in IRD (mm) between exercise and rest among 38 pregnant women in gestation week 27.

Measurement location	Exercise versus rest	Mean difference	SD	95% CI	*P*-value
2 cm above umbilicus	Pelvic floor muscle	2	2	2, 3	< .001
	Drawing-in	4	2	3, 4	< .001
	Pelvic floor + drawing in	5	3	4, 6	< .001
	Headlift*	–3	2	–3, –2	< .001
	Curl-up*	–3	3	–4, –2	< .001
	Drawing-in + curl-up*	–1	3	–2, –0	0.04
	Pelvic floor+drawing-in+curl-up*	0	4	–1, 1	0.96
	Diagonal curl up*	–4	3	–5, –3	< .001
2 cm below umbilicus	Pelvic floor muscle	2	1	2, 2	< .001
	Drawing-in	4	2	3, 5	0.99
	Pelvic floor + drawing in	5	2	4, 6	< .001
	Headlift*	–3	3	–4, –2	< .001
	Curl-up*	–2	3	–3, –1	0.02
	Drawing-in + curl-up*	–0	3	–1, 1	0.00
	Pelvic floor+drawing-in+curl-up*	–1	3	–0, 2	0.13
	Diagonal curl up*	–3	3	–4, –2	< .001

Abbreviations: IRD, inter-rectus distance; SD, standard deviation; CI, confidence interval.
* Negative value represents a decrease in IRD compared to rest

Table 4
Mean difference in IRD (mm) between exercise and rest among 38 pregnant women in gestation week 37.

Measurement location	Exercise versus rest	Mean difference	SD	95% CI	*P*-value
2 cm above umbilicus	Pelvic floor muscle	3	2	2, 3	< .001
	Drawing-in	4	2	4, 5	< .001
	Pelvic floor + drawing in	5	2	5, 6	< .001
	Headlift*	–4	3	–5, –3	< .001
	Curl-up*	–4	3	–5, –3	< .001
	Drawing-in + curl-up*	–2	3	–3, –1	< .001
	Pelvic floor+drawing-in+curl-up*	–1	4	–2, 0	0.06
	Diagonal curl up*	–6	3	–7, –5	< .001
2 cm below umbilicus	Pelvic floor muscle	2	2	2, 3	< .001
	Drawing-in	4	2	3, 5	< .001
	Pelvic floor + drawing in	5	3	4, 6	< .001
	Headlift*	–3	3	–4, –2	< .001
	Curl-up*	–2	3	–3, –1	< .001
	Drawing-in + curl-up*	–0	3	–1, 1	0.67
	Pelvic floor+drawing-in+curl-up	1	3	0, 2	0.04
	Diagonal curl up*	–3	3	–4, –2	< .001

Abbreviations: IRD, inter-rectus distance; SD, standard deviation; CI, confidence interval.
* Negative value represents a decrease in IRD compared to rest

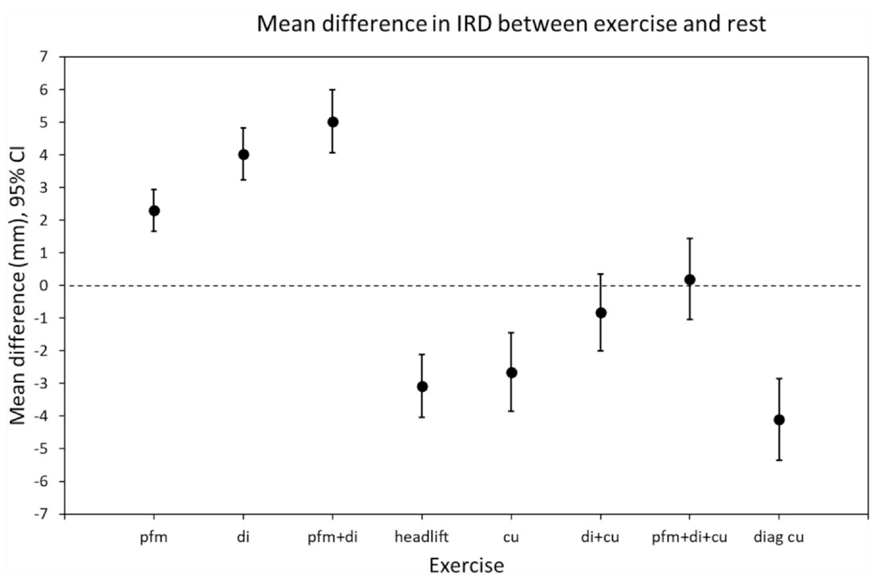

Fig. 1. Mean difference in IRD between exercise and rest measured at 27 and 37 weeks and analyzed with repeated measures ANOVA with post-hoc tests, Bonferroni correction for multiple comparisons. Abbreviations: IRD, inter-rectus distance; ANOVA, analysis of variance; mm, millimeters; CI, confidence interval; pfm, pelvic floor muscle; di, drawing-in; pfm+di, pelvic floor muscle and drawing-in; cu, curl-up; di+cu, drawing-in and curl-up; pfm+di+cu, pelvic floor muscle, drawing-in and curl-up; diag cu, diagonal curl-up.

increased during a drawing-in exercise. This contrasts with common physiotherapy practice, as Keeler et al. [12] report that most women health physiotherapists prescribe transversus abdominis (89%) and pelvic floor (87%) exercise to rehabilitate DRA [12]. One study has suggested that the aim of treatment ought to shift from reduction of IRD to function of the linea alba, and that transversus abdominis play a key role in restoring function despite increasing the IRD [28]. However, the measurement methods they applied have not been validated or tested for reliability and there is no evidence for this new theory. Literature investigating effects of surgical repairs of DRA, describes reducing the IRD as the main aim by restoring the rectus abdominis to the midline. This will both increase the function of the abdominal wall and enhances the patient's quality of life [29,30].

Exercises decreasing the IRD

Our findings show that diagonal curl-ups decrease the IRD the most. The curl-up and the headlift also reduced the IRD significantly, all in line with recent experimental studies investigating the effect of exercises involving the rectus abdominis on the IRD in postpartum women with

DRA [16, 18, 31]. These findings contrast with the advice given to pregnant women not to do exercise involving the rectus abdominis in the belief that this may add pressure to an already stretched linea alba [8,19] and further increase the IRD [12, 27, 28]. There is no evidence supporting this advice and based on the results of the present study clinicians should reconsider advice given to pregnant women regarding abdominal exercise. Randomised clinical trials on a pregnant population are warranted to further investigate whether exercise of the rectus abdominis during pregnancy can prevent or reduce presence of DRA during the postpartum period.

Combined exercises

The drawing-in exercise significantly increased the IRD, while the curl-up significantly decreased the IRD. When combined, the IRD did not change significantly either way from the resting values. It may seem that when combined, the two exercises counteract each other's immediate effect on the IRD. This was also reported in a systematic review investigating the evidence for abdominal exercise in postpartum population with DRA [13]. This suggest that curl-ups do not have the postulated negative effect on the IRD, and that curl-ups and exercise involving rectus abdominis may play a more significant role in reducing the IRD in patients with DRA. It may also indicate that normal movement involving both layers of abdominal musculature will not increase the IRD in women with DRA.

Strengths and weaknesses

To our knowledge this is the first study to investigate the effect of exercise on the IRD in a pregnant population. Strengths of this study are the number of participants based on an apriori power calculation and the longitudinal design. Measurements at two time points during pregnancy increase the power as the results are consistent between gestation week 27 and 37. Other strengths are blinding of the investigator, use of ultrasound for assessments of the IRD, measurements of 9 different exercises and measurements at both above and below the umbilicus. Participants included in this study were both primi- and multigravida resulting in a sample more reflective of the general population and hence increasing the external validity of the findings. Cut-off point for DRA, standardized assessments and imaging procedures were in accordance with similar studies done on both pregnant and postpartum populations to ensure comparison of results [16,18,31].

As there were 20 images for each participant at each timepoint we chose to do the exercises in a set order, to ensure that all images were taken. This might have caused an order effect, and hence, be a limitation of the study. However, we concluded that it was more important to obtain all images, than to counteract a potential order effect caused by fatigue among the participants. Ethnicity was not registered, and all participants were self-sampled. Both these factors may jeopardize representation of the general pregnant population. Another limitation is the study design, in which cross sectional data was analysed. This excludes the ability to conclude whether the effects of different exercises on the IRD are maintained over time.

Conclusion

The IRD in pregnant women increases with PFM and transversus abdominis exercise, and decreases with a headlift, curl-up and diagonal curl-up, both above and below the umbilicus, and at gestation week 27 and 37. This present study adds valuable novel knowledge of how the IRD in pregnant women with DRA is affected by different abdominal exercises.

Ethical approval: The study was approved by the Norwegian Regional Medical Ethics Committee, with ethical approval number 76296 2020/2304.

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Statement of financial disclosure and conflict of interest

None declared.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.physio.2023.08.001.

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