The Immediate Effects on Inter-Rectus Distance of Abdominal Crunch and Drawing in Exercises during Pregnancy and the Postpartum Period

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STUDY DESIGN: Longitudinal descriptive exploratory study.

OBJECTIVES: To evaluate the immediate effect induced by drawing in and abdominal crunch exercises on inter-rectus distance (IRD) of first time pregnant women measured at 4 time points during pregnancy and in the postpartum period.

BACKGROUND: There is scant knowledge on the effect of different abdominal exercises on IRD in pregnant and postpartum women.

METHODS: The study included 84 primiparous participants. Ultrasound images were recorded with a 12 MHz linear transducer at rest and during abdominal drawing in and abdominal crunch exercises, at 3 locations on the linea alba. IRD was measured at 4 time points: gestational weeks 35-41 and 6^{th} to 8^{th}, 12^{th} to 14^{th}, and 24^{th} to 26^{th} weeks postpartum. Separate 2-way repeated measures ANOVA were performed for each exercise (drawing in and abdominal crunch) and each measurement location to evaluate the immediate effects of exercises on IRD at each of the 4 time points. Similarly, 2-way ANOVAs were used to contrast the effects of the 2 exercises on IRD.

RESULTS: Performing the DI exercise caused a significant change in width of the IRD at the location 2 cm below the umbilicus, narrowing the IRD by a mean (95% CI) of 3.8 mm (1.2, 6.4) at gestational week 35-41 and widening the IRD by 3.0 mm (1.4, 4.6) at 6^{th} to 8^{th}, by 1.8 mm (0.6, 3.1) at 12^{th} to 14^{th}, and by 2.5 mm (1.4, 3.6) at 24^{th} to 26^{th} weeks postpartum ($P<.01$). Performing the AC exercise led to a significant narrowing of the IRD ($P<.01$) at all 3 locations at all 4 time points, with the exception of 2 cm below the umbilicus at postpartum week 24-26. The average amount of narrowing varied from 1.6 to 20.9 mm, based on time and location.

CONCLUSION: Overall, there was a contrasting effect of the 2 exercises, with the abdominal crunch exercise consistently producing a significant narrowing of the IRD. In contrast, the DI exercise generally led to small widening of the IRD.

KEY WORDS: abdominals, diastasis recti, ultrasound imaging.

INTRODUCTION

Diastasis recti abdominis (DRA) has been defined as an impairment characterized by a midline separation of the 2 rectus abdominis muscles along the linea alba.[27,34] This increased inter-recti distance (IRD) is reported to usually begin during pregnancy or the first weeks following childbirth.[25] As the fetus grows and the abdominal wall expands, the 2 rectus abdominis, connected by the linea alba, elongate and curve, and separation of the muscle bellies,[4] with protrusion of the umbilicus, may occur.[7,11,13,15] DRA may affect between 30% and 70% of pregnant women,[7] and that separation may remain in the immediate postpartum period in up to 60% of women.[7,8,9] However, the condition has also been found in 38.7% of older parous women undergoing abdominal hysterectomy[30] and in 52% of urogynecological menopausal patients.[34] DRA is also seen in men, and is thought to be associated with increasing age, weight fluctuations, weight lifting, performing full sit-ups, congenital weakness of the abdominal muscles, chronic or intermittent abdominal distention, and activities which may induce high intra-abdominal pressure.[6,21,26]

Criteria and cut off points for the diagnosis of DRA vary in the literature,[1] and to date there is no international consensus on the measurement location. In a cadaver study, Rath et al[31] defined a widening of the IRD of more than 10 mm, when measured above the umbilicus, 27 mm at the level of the umbilicus, and 9 mm below the umbilicus, as pathological DRA. Others defined DRA as an IRD width of greater than 25 mm at 1 or more measurement locations.[10] In a more recent study, using ultrasound imaging, Beer et al[4] suggest that in nulliparous women, the linea alba should be considered “normal” when the IRD width is less than 15 mm at the xiphoid level, 22 mm when measured 3 cm above the umbilicus, and 16 mm when measured 2 cm below the umbilicus.

Published case reports indicate a partial resolution of the DRA at 4[19] and 8 weeks postpartum,[7,11] and the authors of a recent longitudinal study reported that prevalence of DRA at 2 cm below the umbilicus decreased from 100% in late pregnancy to 39% at 6 months postpartum.[25] It is suggested that failure to treat DRA successfully can lead to long term sequelae,[10] including abnormal posture,[7] lumbo-pelvic pain, and cosmetic defects.[10] However, to our knowledge there are no high quality clinical studies to support these suggestions.

Postnatal women often wish to resume abdominal exercises shortly after delivery to improve trunk function and restore abdominal figure and fitness. Unfortunately, to date, there is scant knowledge on both the appropriateness and effectiveness of abdominal exercises both during pregnancy and after childbirth, in particular to reduce DRA. Performing abdominal crunch exercises has been considered a risk for the development of DRA,[6] but the abdominal crunch has also been used to assess abdominal muscle strength and endurance in women during the postpartum period.[20] More recently, performing an abdominal drawing in exercise, which includes activation of the transversus abdominis, has been recommended for both the general population[22,32,33] as well as for women during pregnancy and after childbirth.[5] It has been proposed that transversus abdominis muscle activation could protect the linea alba and may help to prevent or reduce DRA.[5] However there are no data to support this suggestion.

The primary goal of this study was to determine the immediate effect of 2 abdominal strengthening exercises, the drawing in and the abdominal crunch, on IRD of women during pregnancy (gestational week 35th – 41st) and 6th to 8th, 12th to 14th, and 24th to 26th weeks postpartum. The secondary goal was to contrast the effect of the 2 exercises.

METHODS

This study used cross sectional data from a longitudinal study on prevalence of DRA.[25] The immediate effect of the drawing in and abdominal crunch exercises on the width of the IRD were assessed at gestational week 35 to 41 and 6 to 8, 12 to 14, and 24 to 26 weeks postpartum.

Participants

Women attending pre-natal courses in the Lisbon, Portugal area were referred to the study by community gynecologists, physiotherapists, fitness coaches, and nurses. They were eligible for the study if it was their first pregnancy, agreed to participate in 4 testing sessions (1 session during pregnancy between gestational week 35 and 41, and 3 sessions postpartum) and were able to perform the 2 different abdominal exercises. Exclusion criteria were any conditions affecting the ability to perform activities of daily living or any symptoms that required medical attention (eg, high-risk pregnancy, delivery before gestational week 37, previous spinal or abdominal surgery, and neuromuscular diseases). Women were also excluded if any of the 4 testing sessions was missed.

One hundred and twenty-three women agreed to participate in this study, of which 84 completed all 4 testing sessions. Twenty-two women were excluded before the first measurement: 11 because of pregnancy complications, 3 lived too far away to attend the testing sessions following delivery, 6 were unable to schedule a testing time, and 2 for unknown reasons. The other 17 women were excluded because they missed at least 1 testing session due to personal issues.

The study was approved by the Review Board of the University of Lisbon, Faculty of Human Kinetics. Written informed consent was obtained before participation and the rights of the participants were protected and were provided in verbal and written form following the Helsinki declaration.

Instrumentation

An ultrasound scanner (GE Logic-*e*) with a 4-12 MHz, 39 mm linear transducer was used on a fixed frequency of 12 MHz, to collect images in brightness mode (B-mode). The ultrasound data collection protocol and analysis of the images were discussed and practiced with an experienced radiologist prior to the start of the study. The investigator, who performed all measurements, was a physiotherapist with 10 years of experience, with specific training on ultrasound imaging, including 3 years of experience assessing IRD.

Prior to the start of the study, data were collected to establish the reliability of the IRD measurements made by the investigator.[23] During the test-retest study, IRD ultrasound images were recorded on 24 healthy female participants at rest and for 2 exercise conditions: abdominal crunch and drawing-in. Measurements were made for 2 locations: one below and one above the umbilicus. The investigator, blinded as to the identity of the participant, measured the IRD offline from 2 different ultrasound images collected on 2 different days (between days intrarater test-retest reliability). Additionally, re-analyses of the same ultrasound images were done on 2 separate occasions (intra-image intrarater reliability). Test-retest measurements of IRD demonstrated "good" to "very good" reliability with intraclass correlation coefficients (ICCs) between 0.74 and 0.90. The only exception was for IRD measured 2 cm below the umbilicus for the abdominal crunch exercise, for which the ICC was 0.50. The standard error of measurement (SEM) was between 2.28 and 4.36 mm and the minimal detectable change (MDC) ranged from 6.32 to 12.08 mm. For intra-image reliability, the ICC values were all greater than 0.90 with SEM between 0.65 and 1.99 mm and MDC between 1.80 and 4.29 mm.[23]

Procedures

The ultrasound transducer was placed transversely along the midline of the abdomen at 3 locations, using the center of the umbilicus as a reference: 2 cm below the umbilicus, and 2 and 5 cm above the umbilicus. To standardize the position of the transducer, each measurement location was marked with ink on the skin, with the participant in supine resting position, knees bent at 90º, feet resting on the plinth, and arms alongside the body.

During image acquisition the bottom edge of the transducer was positioned to coincide with the correspondent ink mark and moved laterally until the medial borders of both rectus abdominis muscles were visualized. The orientation of the transducer was then adjusted to optimize visualization of the desired anatomy. Based on the recommendations of Teyhen et al,[36] images were collected immediately at the end of exhalation, as determined by visual inspection of the abdomen. Additionally particular attention was paid to the force applied on the probe to avoid a reflex response from the participants.

Static images were obtained with participants in the supine resting position (knees bent at 90º and feet resting on the plinth, arms alongside the body) and for 2 abdominal exercises performed in that same position: drawing in and abdominal crunch. Testing was performed in the following order for all participants: rest, drawing in, and abdominal crunch. A single image was taken for each location on the linea alba for each condition. Participants maintained each exercise contraction for 3 to 5 seconds for data collection.

The abdominal crunch was started from the resting position and the participants were instructed to raise their head and shoulders upwards until their shoulder blades cleared the table while exhaling. Drawing in exercise started from the same resting position. The participants were instructed to inhale, and after exhaling, draw in their navel towards their spine.[18] Before starting the procedure, the participants were verbally instructed about correct performance of the 2 exercises. All participants were instructed how to perform drawing in according to procedures described by Richardson et al.[32] During the drawing in maneuver, activation of transversus abdominis was first confirmed by placing the ultrasound transducer laterally between the iliac crest and rib cage and observing the changes in transversus abdominis muscle thickness.[35] If necessary, participants were given visual ultrasound biofeedback to optimize performance of the drawing in maneuver, defined as maximal preferential activation of transversus abdominis muscle.[35] Every contraction was held for 3 to 5 seconds with a resting time of 6 to 10 seconds between each repetition.[23] The participants were requested not to practice abdominal crunch and drawing in exercises between testing sessions during the study period. All participants in the study reported that they complied with the request not to practice these 2 exercises during the study period.

The 36 images captured for each participant: 3 conditions (rest, abdominal crunch, and drawing in), 3 locations (2 cm below and 2 and 5 cm above the umbilicus), and 4 time points (gestational week 35 - 41, 6 to 8 weeks postpartum, 12 to 14 weeks postpartum, and 24 to 26 weeks postpartum), were exported in Digital Imaging and Communications in Medicine (DICOM) format for further offline processing. The investigator was blinded to the participants' identification and to the values of the IRD from previous examinations.

IRD measurements

Analyses of 2D ultrasound distances were conducted offline by the same investigator, using a customized program (Matlab, Image Processing Toolbox, Mathworks Matlab, USA), which randomly selects the images to measure, without any information from the participant and the IRD value measured. Throughout the study, the examiner had no opportunity to know the IRD values of any participant, condition, location, or time. Once the offline measurements were completed at the end of the study, the IRD values of all the participants, conditions, locations, and time points were imported into SPSS software for statistical analyses.

Ultrasound images were interpreted as a pixel based coordinate system, with the origin in the top left hand corner of the image. In this system an '*x*' and '*y*' coordinate could be used to locate a point in the image and the distance between 2 or more points could be calculated. On ultrasound images the IRD is characterized by the transverse linear distance from the medial border of rectus abdominis on one side to the corresponding position of its counterpart on the other side. Using this procedure, 2 points corresponding to the medial borders of the rectus abdominis muscle bellies on the linea alba must be identified on the ultrasound images.[23,24] Mota et al[23] found ultrasound imaging using this procedure to be a reliable method to measure IRD with intrarater ICC values greater than 0.90.

Effect of exercise on IRD

The immediate effect of the drawing in and abdominal crunch exercises on IRD was defined as the difference between the IRD measured during the exercise and the IRD measured at rest. Therefore, a positive value represents an increase in IRD during the exercise, and a negative value a decrease in IRD during the exercise.

Statistical Analyses

All statistical analyses were performed using commercially available software (IBM-SPSS, Version 21) and statistical significance was set at $P < .05$. The data for each variable, using the Shapiro-Wilk test, were found to satisfy assumptions of normality.[29] For the primary analysis, a separate 2-way repeated measures analysis of variance (ANOVA) was performed for each exercise (drawing in and abdominal crunch) and for each of the 3 measurement locations, to evaluate the immediate effects on IRD at each of the 4 time points. Each of the six 2 by 4 repeated measures ANOVAs had condition (rest and exercise) as one factor and time (the 4 time points) as the other factor. Post-hoc, in the presence of a significant interaction, pairwise t-tests with Bonferroni correction were used at each time point, to determine when the difference was significant. In the absence of significant interaction, the condition main effect was assessed. The main effect of time was not assessed as this was not the intent of the study.

For the secondary analysis, a separate 2-way repeated measures ANOVA was performed to contrast the effects of the 2 exercises (drawing in and abdominal crunch) on IRD for each of the 3 measurement locations, at each of the 4 time points. The variable of interest was the change in width between rest and contracted state, with each of the 3 repeated measures ANOVAs having exercise (drawing in and abdominal crunch) as one factor and time (the 4 time points) as the other factor. Post-hoc, in the presence of a significant interaction, pairwise t-tests with Bonferroni correction were used in each time point, to indicate when the difference was significant. In the absence of significant interaction, the exercise main effect was assessed. The main effect of time was not assessed as this was not the intent of the study.

RESULTS

The demographic and morphologic data of the participants are presented in **TABLES 1 and 2**, respectively. The descriptive statistics for the immediate effect of the drawing in and abdominal crunch exercises on IRD, at each location on the linea alba, for each time point, are presented in **TABLES 3 and 4**.

There was a significant condition by time point interaction ($P<.001$) for the IRD measurements made 2 cm below the umbilicus when performing the drawing in exercise. Post-hoc analysis indicated a significant ($P<.0125$) narrowing of the IRD at gestational week 35-41, which was in contrast to the significant ($P<.0125$) widening of the IRD at the 3 postpartum time points (**TABLE 3 and FIGURE**). For the locations 2 and 5 cm above the umbilicus there was no significant interaction ($P = .538$ and $P = .073$ respectively), but there was a significant main effect of condition ($P=.003$ and $P = .006$ respectively).

For the abdominal crunch exercise, there was a significant condition by time point interaction ($P<.001$) for the IRD measurements made at all 3 locations. Post-hoc analysis indicated a statistically significant (P<.0125), but of varied magnitude, narrowing of the IRD at all time-points for all 3 locations with the exception of 2 cm below the umbilicus at postpartum week 24-26 (**TABLE 4 and FIGURE**).

When comparing the change in IRD width produced by the 2 exercises, the results indicated a significant interaction (P<.001) between exercise and time point, for all 3 measurement locations (**FIGURE**). Post-hoc analysis indicated a statistically significant (P<.0125), but of varied magnitude, difference in the effect of the 2 exercises on the width of the IRD.

DISCUSSION

The present study demonstrated the immediate effect of the abdominal drawing in and abdominal crunch exercise on IRD in women during pregnancy (gestational week 35^{th} – 41^{st}) and 6^{th} to 8^{th}, 12^{th} to 14^{th}, and 24^{th} to 26^{th} weeks postpartum.

Performing the DI exercise caused a significant change in width of the IRD at the location 2 cm below the umbilicus, narrowing the IRD at gestational week 35-41 and widening the IRD during postpartum. Above the umbilicus there were significant differences between the rest and abdominal drawing in exercise overall 4 time points. However these small amounts of changes towards widening in IRD were within measurement errors. Performing the AC exercise led to a significant narrowing of the IRD at all 3 locations and 4 time points, with the exception of 2 cm below the umbilicus at postpartum week 24-26.

Comparing the two exercises, the change in IRD from rest to contraction over the time points differed between the abdominal crunch and the drawing in exercises. Performing the abdominal crunch exercise generally led to a significant narrowing of the IRD and the drawing in exercise generally led to small widening of the IRD.

The transversus abdominis has been described to be as particularly active during the drawing in exercise[35] and it has been suggested that it draws the bellies of the rectus abdominis muscles together.[5] However, the results of our study found that the IRD significantly increased during execution of this exercise during postpartum for the location 2 cm below the umbilicus, with minimal changes imparted above the umbilicus. The result may be explained by the orientation and attachments of the transversus abdominis muscle. Posteriorly the transversus abdominis arises from the thoracolumbar fascia between the iliac crest and the 12th rib at the lateral raphe and the internal aspects of the lower 6 costal cartilages. Anteriorly, the muscle forms a complex and variable bilaminar aponeurosis[16] creating a 3-dimensional mesh on the linea alba with 3 different architectural zones according to the course of collagen fibril bundles.[2] This is also the case in the rectus sheaths, which has a variable number of layers of collagen fibril bundles.[2] In the linea alba 35 to 60% of the fibers are from the transverse abdominis fibers.[2] Maybe because of this fiber orientation, the contraction of transversus abdominis pulls both rectus abdominis laterally. Above the umbilicus, the increase in width of the IRD was significant but within measurement errors, below the umbilicus the significant differences that were noted, were all greater than the minimal detectable change for this exercise and location, and should be considered clinically significant.

Although the abdominal crunch has been considered an exercise that could induce back pain, it is still a commonly used exercise in fitness classes. As an abdominal crunch with Valsalva maneuver might increase intra-abdominal pressure, it may stress the already weakened abdominal wall after pregnancy.[7] Prior research by Axler and McGill[3] demonstrated that the abdominal crunch presents the highest muscular challenge among 12 different exercises tested. Also Gilleard et al[14] reported that women's ability to raise their trunk during an abdominal crunch and stabilize the pelvis was compromised during pregnancy. The deficit lasted until 8 weeks postpartum, especially in women with wider IRD. Our results showed that the IRD narrows during the execution of abdominal crunch at every location on the linea alba. These results are consistent with the results of a previous study performed in an heterogeneous sample of postpartum women.[28] In our study, the narrowing of the IRD was statistically significant and greater than the minimal detectable change for almost all time points and locations tested, and should therefore be considered clinically significant.

During pregnancy the location of the widest IRD was measured at 2 cm above the umbilicus. This is in agreement with the results reported by Liaw et al[20] and may indicate that below the umbilicus the linea alba has a greater ability to counteract the stress imposed during pregnancy. A possible explanation is that while the collagen fiber architecture above (from xiphoid to umbilicus) and below the umbilicus (from the umbilicus to the symphysis pubis) have a similar 3 dimensional construction consisting of fibers arranged from superficial to deep in an oblique layer,[2,17] below the umbilicus there is a greater amount of transverse fibers providing a greater ability to resist tensile stresses imposed on the linea alba.

According to Wolfe and Davies[12] abdominal strengthening exercises should be done during pregnancy to promote good posture, strengthen the muscles for labor, and prevent low back pain and diastasis recti. However, the authors state the need to discontinue abdominal exercise if diastasis recti develops.[12] Assuming that an exercise that induces an immediate decrease in the width of the linea alba will lead to a long-term reduction in IRD following exercise training over time, our results suggest that abdominal crunch may be more effective in narrowing the IRD than drawing in. Further randomized controlled trials are needed to test this assumption and evaluate the long-term effect of different abdominal exercises on IRD and diastasis recti both during pregnancy and in the postpartum period.

To our knowledge, this is the first study to follow a cohort of first time pregnant women with ultrasound assessment of the IRD from pregnancy until 6 months postpartum. Strengths of the study are the number of participants, monitoring of 3 abdominal locations, the use of a reliable method to assess IRD, and blinding of the investigator. We measured IRD during 2 commonly used exercises in pregnant and postpartum women.

A limitation of the study is the lack of pre-pregnancy assessment of the IRD. However, measurement of nulliparous women planning to become pregnant is a challenge, and there are few studies in this group of women worldwide. Also, in this study, we decided to use only 1 measurement instead of the mean of 3 measurements, as done in other studies, due to the number of images to be taken and the effort required during the abdominal exercises, especially at the first measurement time point during pregnancy. However, in future intervention studies, and especially during the postpartum period, more than 1 image on each condition and location should be taken. Finally, future studies should randomize order of testing to eliminate potential order effect.

In our study the only structural parameter measured was the IRD, which may not reflect all of the structural changes that may take place in the fascial and muscular structures of the abdominal wall. The measurements of other structures (muscle length, thickness) could be of value in future research. In addition, this sample was drawn from a population attending pre-natal courses in private centers, and therefore may not be reflective of the larger population. The participants were instructed not to perform these exercises (abdominal crunch and drawing in) during the study, and all of them received the same information about pelvic floor muscle training. However, in a future intervention study, the participation in general exercise training and the amount of pelvic floor muscle training should be controlled and documented as it may influence abdominal muscle strength. Furthermore, our study only assessed the immediate effect during 2 exercises, and randomized controlled trials are needed to assess the effect of abdominal training over time.

CONCLUSION

The overall results of this study demonstrate contrasting effect of the abdominal crunch and the drawing in exercise on the width of the IRD. Performing the abdominal crunch exercise generally led to a significant narrowing of the IRD at all 3 locations and at all 4 time points (gestational week 35-41 and at 6th to 8th, 12th to 14th, and 24th to 26th weeks postpartum). In contrast, performing the drawing in exercise resulting in significant changes in the width of the IRD at the location 2 cm below the umbilicus, narrowing the IRD at gestational week 35-41 and widening the IRD postpartum. The drawing in exercise had minimal statistically significant widening effect on the IRD at 2 and 5 cm above the umbilicus. Further high quality randomized controlled trials on the effect of different abdominal exercises on the DRA are warranted.

KEY POINTS

Findings: This study demonstrated that during pregnancy and in the postpartum period the IRD narrowed during the abdominal crunch exercise. The change in IRD during the drawing in exercise generally led to a widening of the IRD, but these changes were considered quite small.

Implications: These data suggest differential effect of the 2 exercises that were studied.

Caution: Only the immediate effect of the exercises was measured, therefore these data cannot be used to suggest effectiveness of treatment as an intervention or as regular exercises.

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TABLE 1. Demographic variables (n=84). *Data are mean (minimum-maximum).

Age (years)*	32.1 (25-37)
Gestational week of birth*	38.8 (37-41)
Birth weight of baby (kg)*	3.1 (2.3-4.0)
University education, n (%)	68 (81%)
Vaginal delivery, n (%)	52 (61.9%)
Caesarean section, n (%)	32 (38.1%)

TABLE 2. Morphologic data (n=84).

	Before pregnancy	35 - 41 gestational week	6-8 weeks postpartum	12-14 weeks postpartum	24-26 weeks postpartum
Weight (kg)*	59.3 +/- 8.9	71.8 +/- 9.6	63.0 +/- 9.1	61.6 +/- 9.7	60.5 +/- 9.6
Exercise, n (%)*	42 (50%)	53 (63%)	24 (29%)	40 (48%)	38 (45%)

*Data are means +/- standard deviations, before pregnancy data provide by self-report.

** Participation in general physical activity defined as regular exercise classes 2 or more times a week, obtained by self-report.

TABLE 3. Change in inter-rectus distance (IRD) during Drawing in (DI).

Data are means ± standard deviations for the IRD measured at rest and during DI in mm.

Data are means ± standard deviations (95% confidence intervals) for the change in IRD in mm. Positive values indicate widening of the IRD, negative values narrowing. N=84 participants. * Significant change in IRD, P<.0125

Abbreviations: AU, above the umbilicus; BU, below the umbilicus.

Time	Probe location	IRD at Rest	IRD during DI	Change in IRD with DI
Gestational week 35 - 41	2 cm BU	64.6 ± 19.0	60.8 ± 19.7	-3.8 ± 11.8 (-6.4, -1.2)*
	2 cm AU	66.9 ± 19.4	68.3 ± 21.6	1.3 ± 10.8 (-1.0, 3.7)
	5 cm AU	61.0 ± 19.3	60.9 ± 18.2	-0.1 ± 8.8 (-2.0, 1.8)
Postpartum week 6 - 8	2 cm BU	18.8 ± 10.7	21.8 ± 12.4	3.0 ± 7.1 (1.4, 4.6)*
	2 cm AU	26.8 ± 9.3	27.7 ± 9.6	0.9 ± 5.1 (-0.2, 2.0)
	5 cm AU	23.0 ± 9.2	24.1 ± 8.6	1.1 ± 3.6 (0.3, 1.8)
Postpartum week 12 -14	2 cm BU	17.2 ± 8.9	19.1 ± 8.9	1.8 ± 5.6 (0.6, 3.1)*
	2 cm AU	23.8 ± 7.3	24.2 ± 7.6	0.4 ± 4.0 (-0.5, 1.2)
	5 cm AU	19.7 ± 7.8	22.0 ± 9.1	2.3 ± 6.3 (1.0, 3.7)
Postpartum week 24 -26	2 cm BU	15.3 ± 8.4	17.8 ± 8.3	2.5 ± 5.2 (1.4, 3.6)*
	2 cm AU	22.4 ± 7.4	24.0 ± 8.1	1.6 ± 3.1 (0.9, 2.2)
	5 cm AU	18.7 ± 8.4	19.4 ± 8.1	0.7 ± 3.4 (-0.0, 1.5)

TABLE 4. Change in inter-rectus distance (IRD) during Abdominal Crunch (AC).*

*Data are mean +/- standard deviations (95% confidence intervals) for the difference in IRD measured at rest and during AC in mm. Positive values indicate widening of the IRD, negative values narrowing. N=84 participants. * Significant change in IRD, P<.0125

Abbreviations: AC, abdominal crunch; AU, above the umbilicus; BU, below the umbilicus.

Time	Probe location	IRD at Rest	IRD during AC	Change in IRD with AC
Gestational week 35 - 41	2 cm BU	64.6 ± 19.0	43.7 ± 14.7	-20.9 ±14.5 (-24.0, -17.7)*
	2 cm AU	66.9 ± 19.4	49.8 ± 17.2	-17.1 ± 11.8 (-19.7, -14.6)*
	5 cm AU	61.0 ± 19.3)	49.8 ± 18.7	-11.2 ± 12.5 (-14.0, -8.6)*
Postpartum week 6 - 8	2 cm BU	18.8 ± 10.7	13.7 ± 8.6	-5.1 ± 8.2 (-7.0, -3.3)*
	2 cm AU	26.8 ± 9.3	21.2 ± 6.8	-5.6 ± 8.1 (-7.3, -3.8)*
	5 cm AU	23.0 ± 9.2	18.6 ± 7.9	-4.4 ± 6.6 (-5.9, -3.0)*
Postpartum week 12 -14	2 cm BU	17.2 ± 8.9	13.6 ± 7.0	-3.6 ± 7.0 (-5.2, -2.1)*
	2 cm AU	23.8 ± 7.3	21.0 ± 6.0	-2.8 ± 4.8 (-3.9, -1.8)*
	5 cm AU	19.7 ± 7.8	18.1 ± 7.0	-1.6 ± 4.6 (-2.6, -0.6)*
Postpartum week 24 -26	2 cm BU	15.3 ± 8.4	14.9 ± 8.3	-0.4 ± 5.6 (-1.6, 0.8)
	2 cm AU	22.4 ± 7.4	19.9 ± 5.8	-2.5 ± 5.2 (-3.6, -1.4)*
	5 cm AU	18.7 ± 8.4	16.6 ± 6.8	-2.1 ± 4.6 (-3.1, -1.1)*

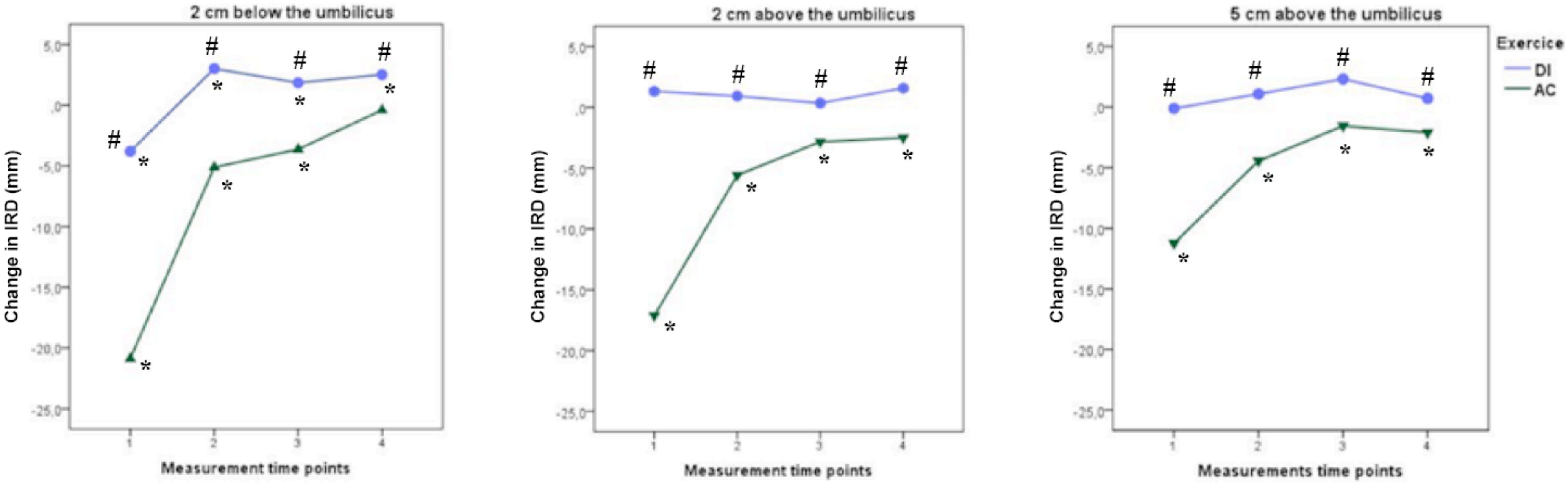

FIGURE: Average change in inter-rectus distance (IRD), defined as the difference between the IRD measured during the exercise and the IRD measured at rest, at 4 time points (1, gestational week 35 – 41; 2, 6-8 weeks postpartum; 3, 12-14 weeks postpartum; 4, 24-26 weeks postpartum). Positive values indicate widening of the IRD, negative values indicate narrowing. N = 84 participants. # Significant difference between exercises at that time point, P<.001. * Significantly different than the resting condition, P<.0125. Abbreviations: AC, abdominal crunch; DI, drawing in