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Correlation Between Diastasis Recti Abdominis and Thoracic Expansion in Post-Partum Mothers

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Abstract

Background: The core muscles function as the pressure regulatory system, with the diaphragm marking the superior boundary and the pelvic floor muscles marking the inferior boundary. The posterior aspect is marked by multifidus, while the transversus abdominis comprises the inner walls of the abdominal cylinder. A dysfunction in any component of the core muscles can lead to compensation from other components of the core, leading to long-term adaptation or injury to one or more components of the core. During pregnancy, the hormonal activity and growing foetus can alter the integrity of the abdominal wall. This can further alter the mechanics of respiration during the puerperal period, as both core stability and rib cage expansion depend on coordinated diaphragm–abdominal–pelvic floor function. **Objective:** To evaluate the relationship between Diastasis Recti Abdominis and thoracic expansion in postpartum mothers. **Methods:** An observational cross-sectional study was conducted on 46 postpartum women (2 months to 2 years post-delivery). The Inter-recti Distance (IRD) was measured at three levels—above, at, and below the umbilicus using a digital calliper during the curl-up test, while thoracic expansion was assessed at axillary, mid-thoracic, and lower thoracic levels using an inch tape. Pearson's correlation coefficient was used to analyse relationships between IRD and thoracic expansion. **Results:** A significant negative correlation ($p < 0.001$) was found between IRD at all levels and thoracic expansion at all three thoracic regions. The strongest correlation was between below-umbilical IRD and lower thoracic expansion ($r = -0.911$). **Conclusion:** The increase in inter-recti distance can have a negative influence on the thoracic expansion in postpartum women, which indicates a strong correlation between the integrity of the abdominal wall and the mechanism of breathing. This can have an impact on the activities of daily living. Early diagnosis and intervention can improve both core stability and restore normal breathing.

Major Findings: A significant negative correlation was found between inter-recti distance and thoracic expansion at all measured levels in postpartum women ($p < 0.001$). These findings suggest that diastasis recti abdominis negatively influences respiratory mechanics in postpartum mothers.

Keywords: Breathing Mechanics, Calliper Measurement, Core Stability, Diastasis Recti Abdominis, Inter-Recti Distance, Postpartum Rehabilitation, Tape Measurement, Thoracic Expansion, Thoracic Mobility

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1. Introduction

A woman's body undergoes both physiological and anatomical changes that are necessary to meet the demands of a growing foetus and also to prepare the body for birth.

Diastasis Recti Abdominus (DRA) is the most common musculoskeletal condition that is seen in postpartum mothers as a result of antenatal adaptations of the body[1].

DRA is an increased inter-recti distance at the midline. This includes weakness of the anterior abdominal wall muscles with thinning and widening

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of the linea alba[2]. It commonly occurs during the late second or third trimester of pregnancy and the early postpartum period[3].

Previous studies suggest an increase in the prevalence of DRA among postnatal mothers, with an incidence ranging approximately from 21% - 30%. It is also noted that young women have an incidence rate of more than 50% when compared to middle-aged or older women[3,4].

The fluctuations of hormones (Relaxin and Estrogen) during pregnancy lead to increased laxity of connective tissue in the abdominal wall, which, when combined with the contribution of an expanding uterus, can cause mechanical stress and stretching of the abdominal wall, which adds to the pathophysiology of DRA. Other factors, like increased intra-abdominal pressure, obesity, can further exacerbate DRA[5].

It is noted that DRA coexists with other clinical manifestations like urinary incontinence, lower back pain, lack of trunk strength, body dissatisfaction, and significantly impaired quality of life[6].

In the antenatal and postnatal period, DRA can compromise the integrity of the whole core system, and not just the rectus abdominis muscle. Core is the functional unit that comprises global stabilisers, including transverse abdominis, internal obliques, multifidus and global mobilizers- rectus abdominis, external obliques, along with diaphragm, pelvic floor and connective fascial structures like thoracolumbar fascia and linea alba. These structures function coordinately to regulate the intra-abdominal pressure, facilitate force transfer during movement and also allow controlled respiration[7]. The compromise of integrity in DRA can have its effects even on deep core stabilising muscles like the transverse abdominus in providing mechanical stability.

In addition to the stability, the core system is closely linked to respiratory mechanics. The diaphragm, abdominal wall, and pelvic floor muscles work as a canister system, with the diaphragm marking the superior border, the abdominal wall marking the sides of the canister, and the pelvic floor marking the inferior border of the canister. During Inspiration, the diaphragm contracts and descends downwards, increasing the dimensions of the thoracic cavity. The descent of the diaphragm causes compression of the abdominal contents with eccentric lengthening of the abdominal wall, with an increase in the intra-abdominal pressure. The pelvic floor muscles, in response to an increase in IAP, eccentrically lengthen and descend slightly, whereas the transverse abdominis coactivates with the diaphragm to maintain intra-abdominal pressure[8,9].

In DRA, the ability of the canister to maintain the mechanical pressure will be reduced due to the diminished fascial tension. This creates a weak link between the core and the diaphragm, thus reducing effective coordination during breathing. This may lead to changes in natural breathing patterns and the utilisation of accessory muscles for breathing. Furthermore, during exhalation, the abdominal wall fails to generate optimal IAP due to the separation of the muscles. This alters resting diaphragm position and reduces the zone of apposition, thereby decreasing mechanical efficiency during subsequent inspiration[10].

The capacity of the lung to expand and contract during breathing is defined as thoracic expansion. Physiological and anatomical changes, such as the upward displacement of the growing uterus with increased abdominal pressure and the influence of hormones on the mobility of the rib cage, alter the respiratory mechanism[11]. The fibres of the diaphragm lengthen with an increase in curvature as the pregnancy advances. This causes an expansion in the rib cage, which enhances respiratory function despite the increased workload. However, during the postpartum period, the diaphragm's workload decreases, but the structural and functional changes persist, maintaining breathing efficiency[12].

The pelvic floor muscles, along with the transverse abdominis, work as a pressure management system. When the transverse abdominis is activated, there is sub-maximal co-contraction of the pelvic floor muscles. In DRA, the recruitment pattern may be altered, thus reducing the co-contraction between the muscles. This can further lead to maladaptive compensatory strategies, resulting in pelvic floor overload[13,14].

The relationship between the thoracic, abdominal, and pelvic floor plays a major role in therapeutic intervention, as rehabilitation focusing on the involvement of all three systems together has demonstrated long-term benefits in improving core strength, continence, and quality of life[15].

DRA remains common during the third trimester and can persist into the postpartum phase. However, the common effects on abdominal strength and pelvic floor function are commonly studied, but their effect on thoracic mechanics remains poorly understood in postpartum women. Thus, the objective of the current study is to evaluate the relationship between diastasis

recti abdominis and thoracic expansion in postpartum mothers.

2. Methodology

In this observational study, postpartum mothers were recruited from various maternity hospitals across Bangalore. A total of 46 mothers with the following inclusion criteria: women aged 20–45 years, multigravida postpartum mothers (within 2 months to 2 years postpartum), no history of any major surgeries (except caesarean section) or medical complications, and individuals with inter recti distance more than 2cm were included in the study. Exclusion criteria included individuals with pre-existing thoracic or abdominal conditions, pregnant women, those with cardiorespiratory disorders, women with significant musculoskeletal or spinal deformities affecting posture, those who had undergone surgical correction for DRA, individuals with high-risk pregnancies or severe postpartum complications, and women actively participating in intensive postpartum rehabilitation programs targeting core or respiratory function.

After obtaining ethical clearance from the institutional ethical committee, the participants were screened and recruited based on the inclusion and exclusion criteria. The purpose of the study was explained, and consent was obtained from the subjects. The subjects were then taken to a calm and well-ventilated closed room. Participants were asked to wear loose and comfortable clothing during the assessment.

Diastasis recti were assessed by the researcher using a standardised clinical measurement of Inter-Recti Distance (IRD) during a slight active curl-up task, using a digital calliper. Participants were asked to lie supine with knees flexed and perform a small head-and-shoulder lift. The medial border of the rectus abdominus was palpated, and three reference points were noted: Point A- 4.5cms above the umbilicus, Point B- at the umbilicus, and Point C- 4.5cms below the umbilicus with the help of non-stretchable inch tape. These reference points were marked with a water-soluble marker. A digital caliper was used to assess the inter-recti distance. The inside jaws of the caliper were used to measure the IRD width at each marked point. Previous studies have used these reference points for measuring IRD. Three readings were taken at each point, and the average of the three was recorded. An IRD > 2.0 cm was considered indicative of DRA[16].

Thoracic expansion was performed by the researcher using non-stretchable inch tape. The subjects stood with their elbows slightly flexed and their hands resting on their hips. With the chest exposed, the chest expansion was measured at three levels- 2nd Intercostal Space, 4th Intercostal Space and at the level of the Zyphoid process. The subject was asked to exhale as much air as possible and then take a maximal deep inspiration. The difference between the full expiration and full inspiration was noted. Three trials were given at each level, and the average of three readings was noted[17].

Table 1. Descriptive statistics for age and postpartum months

(n = 46)	Range	Mean	S.D.
Age (Years)	25 to 41	31.11	3.97
Postpartum months	2 to 24	11.80	6.49

Table 2. Assessment of diastasis recti abdominis

Diastasis recti	Range	Mean	S.D.
Above the umbilicus (Cm)	1.7 to 3.3	2.49	0.42
Umbilicus (Cm)	2.4 to 4.6	3.44	0.61
Below the umbilicus (Cm)	1.6 to 3.4	2.34	0.49

3. Results

The collected data were summarised using descriptive statistics. The Pearson correlation coefficient ("r") was used to find the relation between diastasis recti abdominis, thoracic expansion, age (Years), and postpartum months. To find the relation of diastasis recti and thoracic expansion with gravidity parity index, Spearman's ratio was used. The Independent sample t-test was used to compare diastasis recti and thoracic expansion according to physical activity. The One-way ANOVA was used to compare diastasis recti and thoracic expansion; according to type of physical activity. The p value < 0.05 was considered as significant. Data were analyzed by using the SPSS software (SPSS Inc.; Chicago, IL) version 29.0.10.

Table 3. Assessment of thoracic expansion

Thoracic expansion	Range	Mean	S.D.
Axillary (Cm)	2.2 to 2.7	2.01	0.41
Mid-thoracic (Cm)	2.4 to 4.3	3.34	0.59
Lower-thoracic (Cm)	2.8 to 3.7	2.73	0.56

Table 4. Relation between diastasis recti abdominis and thoracic expansion

		Axillary (Cm)	Mid-thoracic (Cm)	Lower-thoracic (Cm)
Above umbilicus (Cm)	"r"	-0.650	-0.628	-0.656
	p value	< 0.001*	< 0.001*	< 0.001*
Umbilicus (Cm)	"r"	-0.655	-0.642	-0.663
	p value	< 0.001*	< 0.001*	< 0.001*
Below umbilicus (Cm)	"r"	-0.907	-0.899	-0.911
	p value	< 0.001*	< 0.001*	< 0.001*

("r" = Pearson correlation coefficient; * Significant)

The age of the participants ranged from 25 to 41 years, with a mean age of 31.11 years and a standard deviation of 3.97 years, indicating that most participants were in their early thirties. The postpartum period of the participants ranged from 2 to 24 months.

Above the umbilicus, the IRD ranged from 1.7 to 3.3 Cm with a mean: 2.49±0.42 Cm; at the level of the umbilicus, the IRD ranged from 2.4 to 4.6 Cm with a mean: 3.44±0.61 Cm; and below the umbilicus, the IRD ranged from 1.6 to 3.4 Cm with a mean: 2.34±0.49 Cm.

At the axillary level, expansion ranged from 1.3 to 2.7 Cm with mean: 2.01±0.41 Cm; at mid-thoracic level, the expansion ranged from 2.4 to 4.3 Cm with mean: 3.34±0.59 Cm; and at the lower-thoracic level, the expansion ranged from 1.8 to 3.7 Cm with mean: 2.73±0.56 Cm.

The relationship between diastasis recti abdominis and thoracic expansion was determined using the Pearson correlation coefficient ("r"). There was a negative correlation ($p < 0.05$) between the axillary (Cm), mid-thoracic (Cm), and lower-thoracic (Cm) and the above, below, and above umbilicus (Cm).

4. Discussion

This study focuses on the examination of the relationship between diastasis recti abdominis and thoracic expansion in postpartum mothers. The results of the current study revealed a significant negative relation between all three levels of inter-recti distances and thoracic expansion at all three levels ($p<0.001$). A strong correlation was noted between lower thoracic expansion and below-umbilical IRD ($r=0.911$), thus suggesting the association between greater abdominal wall separation and reduced thoracic expansion. This further suggests that the integrity of the core directly influences the mechanism of respiration.

4.1 Prevalence and Characteristics of DRA in the Study Population

The mean IRD in the current study was highest at the umbilical level (3.44±0.61 cm), followed by above (2.49±0.42 cm) and below the umbilicus (2.34±0.49 cm). These findings are consistent with the previous cohort study by Sperstad *et al.*[18] which demonstrated that in 300 Norwegian women, the IRD was predominantly concentrated at the umbilical level. It was also noted that the highest prevalence of diastasis recti abdominus was at 6 weeks, 6 months and 12 months postpartum, and prevalence decreased from 60% at 6 weeks to 32.6% at 12 months postpartum. This pattern was further confirmed in a recent systematic review by Gluppe *et al.*,[19] where it was concluded that the widest IRD at the umbilical level are due to the thinning of the linea alba at the level of the umbilicus.

The mean IRD values in our study were in line with a previous study conducted by Benjamin *et al.*,[20] who found mean IRD values to be 2.5 cm above, 3.2 cm at, and 2.1 cm below the umbilicus in postpartum. These findings suggest that the diastasis recti abdominus follows an anatomical pattern, with the umbilical region being the most common site for separation.

4.2 Thoracic Expansion Measurements in Postpartum Women

The thoracic expansion values observed in this study were notably reduced compared to normative values in non-pregnant women. These findings are consistent with research by LoMauro and Aliverti,[21] who documented that pregnancy-induced respiratory changes may persist into the postpartum period, affecting chest wall mechanics and respiratory muscle function.

A study conducted by Gilleard and Brown,[22] examined the respiratory function in postpartum mothers and found that the chest wall expansion and diaphragmatic excursion remained altered up to 6 months postpartum, mostly in mothers with persisting abdominal wall dysfunction.

A more recent study in the year by Chen *et al.*,[10] demonstrated through their randomised controlled trial

that postpartum women with DRA showed significant improvements in both inter-recti distance and respiratory function following a 6-week core muscle strength and stability-oriented breathing training program. The very large effect sizes reported in their intervention group support our observation that core integrity and respiratory mechanics are intimately linked in the postpartum population.

4.3 Negative Correlation Between DRA and Thoracic Expansion

The study highlights a negative correlation between IRD and thoracic expansion (r values ranging from -0.628 to -0.911), thus demonstrating the integrated function of core cylinder system. The study also highlighted a strong correlation between below-umbilical IRD and lower thoracic expansion (r = -0.911). This explains the direct anatomical and functional relationship between the lower abdominal wall and the diaphragm's zone of apposition. A study conducted by Kolar *et al.*,[23] described how the lower abdominal wall, particularly the transversus abdominis, plays a crucial role in maintaining optimal diaphragmatic position and function. When this region is compromised by DRA, the diaphragm's resting position may shift superiorly, reducing its zone of apposition with the lower rib cage and consequently decreasing the mechanical advantage for generating thoracic expansion during inspiration.

4.4 Core-Breathing Interaction and Clinical Implications

The findings of this study support the growing body of evidence emphasizing the relationship between core stability and respiratory function. Talasz *et al.*,[24] demonstrated that proper abdominal wall function is essential for coordinated diaphragm-pelvic floor interaction during breathing. In women with DRA, this coordination is disrupted, leading to altered breathing patterns and potential respiratory inefficiency.

Theodorsen *et al.*,[25] found that postpartum women with larger IRD reported significantly more breathing difficulties during physical activities and complained of reduced exercise tolerance compared to women with minimal or no DRA. These subjective reports align with our objective findings of reduced thoracic expansion in women with greater abdominal separation.

4.5 Clinical Significance

The reduced thoracic expansion observed in women with DRA may manifest as:

- Exercise intolerance
- Fatigue
- Postural compensations
- Compromised core rehabilitation

These findings support the need for comprehensive postpartum rehabilitation programs that address both core dysfunction and breathing mechanics simultaneously. Programs focusing solely on abdominal strengthening without addressing breathing patterns may be incomplete. Kamel and Yousif,[26] demonstrated that combined core and respiratory training yielded superior outcomes in reducing IRD and improving functional capacity compared to isolated abdominal exercises.

4.6 Implications for Rehabilitation

Based on our findings, postpartum rehabilitation should incorporate:

1. **Breathing Re-education:** Teaching diaphragmatic breathing patterns with awareness of abdominal wall engagement. Studies by Lee *et al.*,[27] have shown that integrating breathing exercises with core activation improves both DRA closure and respiratory function.
2. **Pressure Management Training:** Educating women on proper IAP management during daily activities. Chen C *et al.*,[10] demonstrated that teaching pressure management strategies reduced symptoms and improved function in postpartum women with pelvic floor dysfunction.
3. **Progressive Core Strengthening:** Emphasizing exercises that promote coordinated activation of all core cylinder components. Gluppe *et al.*,[19] found that exercise programs focusing on transversus abdominis activation with breath coordination were more effective in reducing IRD than traditional abdominal exercises.
4. **Functional Integration:** Incorporating breathing awareness into functional movements and activities of daily living. Thabet and Alshehri[28] showed that functional training approaches that integrated breathing with movement resulted in better long-term outcomes.

4.7 Strengths and Limitations

Strengths of this Study Include:

- Comprehensive assessment at multiple anatomical levels for both DRA and thoracic expansion
- Standardized measurement protocols
- Clear inclusion and exclusion criteria
- Statistical analysis appropriate for the research questions

Limitations Include:

- Cross-sectional design prevents establishment of causality.
- Relatively small sample size from a single geographic region.
- Did not assess respiratory muscle strength or pulmonary function tests.
- Did not evaluate pelvic floor function, which is part of the core cylinder.
- No assessment of breathing pattern disorders or compensatory strategies.
- Limited generalizability to primigravida women or those outside the study's time frame.

Future research should employ longitudinal designs to track changes in both DRA and thoracic expansion over time, incorporate objective respiratory function testing such as spirometry, include assessment of pelvic floor function, evaluate the effectiveness of integrated core-breathing rehabilitation programs, and investigate the relationship between these variables and quality of life or functional capacity.

5. Conclusion

This study demonstrates a significant negative correlation between diastasis recti abdominis and thoracic expansion in postpartum women, with greater abdominal separation associated with reduced chest wall expansion. These findings underscore the integrated nature of the core cylinder system and highlight the importance of addressing both core integrity and breathing mechanics in postpartum rehabilitation. The strong correlations observed (particularly r = -0.911 between below-umbilical IRD and lower thoracic expansion) suggest that DRA has substantial effects beyond cosmetic concerns or isolated trunk weakness, extending to fundamental respiratory mechanics that may impact daily function and quality of life.

Healthcare providers working with postpartum women should screen for both DRA and respiratory dysfunction, implementing comprehensive rehabilitation programs that address the entire core cylinder system rather than isolated components. Early identification and intervention may prevent long-term adaptations and improve both functional outcomes and quality of life in this population.

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Author Contribution

N. S. Jagrruthi: Conceptualization, study design, methodology, supervision, data interpretation, manuscript review and editing, and final approval of the manuscript. S. Dimple Souparnika: Data collection, data analysis, literature review, manuscript drafting, and preparation of tables and figures. Sathvik Acharya: Data collection, literature review, data analysis, manuscript drafting, formatting and editing.