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Laura Fuentes Aparicio, Montserrat Rejano-Campo, Gráinne Marie Donnelly, Victoria Vicente-Campos

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Self-reported symptoms in women with diastasis rectus abdominis: a systematic review

Authors:

Laura Fuentes Aparicio, PT, PhD[1]

Montserrat Rejano-Campo, PT, MSc[2]

Gráinne Marie Donnelly, PT[3,4]

Victoria Vicente-Campos, PT[5]

[1] Faculty of Physiotherapy - University of Valencia Carrer de Gascó Oliag, 5, 46010 Valencia, Spain

[2] University Hospital of Caen Normandy, Avenue de la Côte de Nacre, 14000 Caen, France

[3] Physiotherapy Department, South West Acute Hospital, Western Health and Social Care Trust, N. Ireland, UK

[4] ABSOLUTE.PHYSIO, 7 Drumadagarve, Maguiresbridge, N. Ireland, UK

[5] Haro&Campos fisioterapia, Avenida Calvo Sotelo, 23, 10600 Plasencia, Spain

Correspondance to: Montserrat Rejano-Campo, University Hospital of Caen Normandy, Avenue de la Côte de Nacre, 14000 Caen, France, +33627083914, montserejano@gmail.com

Highlights

- Outcomes such as quality of life, physical perception, image satisfaction and abdominal pain seem to be related to the presence of diastasis rectus abdominis.
- It seems that no correlation exists between diastasis rectus abdominis and urinary incontinence, severity and presence of low back pain, voiding symptoms, vaginal symptoms or sexual matters.
- Due to the heterogenicity among studies regarding study design and population, these results should be interpreted with caution and healthcare professionals should remain alert to the developing evidence in this field.

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- LF, VV and MR contributed substantially to the conception and design of the work, acquisition and interpretation of data, and the drafted work. GD contributed substantially to the conception and design of the work, the interpretation of the data, and revised the work critically. All authors have approved the final version to be published and have agreed to be accountable for all aspects of the work.

- Declarations of interest: none.

ABSTRACT

Introduction

Diastasis rectus abdominis (DRA) diagnosis via clinical examination is well defined, however, the assessment of symptoms has been less investigated. Currently, there is also scant knowledge on the consequences of DRA. The aim of this review is to identify the relevant self-reported variables in the study of DRA in women.

Methods

We performed a systematic review of observational studies through Medline, Embase, and Cochrane Library databases. Studies evaluating the link between DRA and self-reported symptoms were searched using the following terms: "Diastasis rectus abdominis", "Diastasis recti", "Abdominis Rectus Muscle Diastasis", "Questionnaire", "Scale", "Survey", "Interview", "Index" and "Inventory". The methodological quality was assessed independently by two evaluators using the *NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies*.

Results

Fourteen observational studies met the eligibility criteria and were included in the qualitative analysis. Most of the studies were of low to fair quality. Different categories of symptoms were analyzed: quality of life, body image, lumbopelvic pain, other types of pain and pelvic floor dysfunction. A significant positive correlation was found between the presence of DRA and physical health and functioning, abdominal discomfort and body image. Heterogenous data were identified in relation to disability related with low back pain. No correlation has been found between DRA and urinary incontinence, severity and presence of low back pain, voiding symptoms, vaginal symptoms or sexual matters.

Conclusions

DRA presents with reduced quality of life due to compromised physical health and functioning; poorer physical perception; lower body image satisfaction; and higher degrees of abdominal pain that is frequently perceived as discomfort or bloating.

Key words: Diastasis recti, postpartum, pregnancy, body image, quality of life, disability

Word count

- Abstract: 259
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Abbreviations

DRA: diastasis rectus abdominis

IRD: inter-recti distance

QoL: quality of life

LBP: low back pain

FI: fecal incontinence

POP: pelvic organ prolapse

UI: urinary incontinence

INTRODUCTION

Diastasis rectus abdominis (DRA) is defined as the presence of divergence between the rectus abdominis muscles along the linea alba **(image 1)**[1–3]**.** This condition can present in both sexes; however, its prevalence is higher in women during the 3rd trimester of pregnancy and postpartum[1,4]. During pregnancy, rectus abdominis muscles elongate and may separate as the fetus increases in size[5]. This excessive muscle elongation tends to reduce during the postpartum months. Nevertheless, the literature has shown that DRA is still present in 39 to 45.5% of women 6 months after childbirth and in 32.6% at one year[3]. The variation between values depends on factors such as the use of different cut-off values and test locations along the linea alba.

The abdominal wall is related to several functions within the human body including the maintenance of posture, stability of the trunk and pelvis, respiration, regulation of intra-abdominal pressure and support of the abdominal viscera[6,7]. An alteration of these functions may occur secondarily to DRA, since the integrity of the fascial tissue is compromised. Increased inter-recti distance (IRD) has been shown to correlate with decreased trunk flexor strength: a significant moderate negative correlation between the presence of DRA and strength and endurance of the flexors and rotators of the trunk has been found in postpartum women[8].

At present, the quantitative evaluation of DRA is performed purely anatomically. This evaluation consists of measuring the separation between the two rectus abdominis muscles[9]. Even though this is the most commonly utilized method, we propose that additional parameters such as quality of life (QoL), perception of body image, pain and secondary functional limitations are also relevant and important to consider in women with DRA. These parameters are essential in order to understand the patient's perspective

and provide holistic patient-centered care. To date the study of self-reported signs and symptoms associated with DRA is less developed in the literature than other functional measurements. Some authors[4,5,10] have investigated the association between variables related with self-perception and DRA utilizing outcome measures for QoL, disability, body image or comorbidities. The presence of DRA has been correlated with the severity of low back pain (LBP), presence of pelvic and abdominal pain and with pelvic floor disorders[5,10–12]. Nevertheless, the relationship between the presence of DRA and lumbopelvic pain and pelvic floor dysfunction remains unclear[13–15].

A systematic review identifying musculoskeletal dysfunctions, pain and QoL in women with DRA was recently performed by Benjamin et al.[16]. It would be interesting to update and build upon their findings with other self-reported outcomes such as body image or disability.

The aim of this review was to identify the relevant self-reported symptoms in the study of DRA in adult women. The secondary aim is to categorize them and then to compare the magnitude and level of significance of the results between studies.

MATERIAL AND METHODS

A systematic review of observational studies was carried out to identify self-reported symptoms in a population of women with DRA. We identified data collection tools which are commonly used for the analysis of self-reported outcomes: studies utilizing instruments such as questionnaires, scales, surveys, indexes and inventories for the assessment of DRA symptoms were selected.

Data Sources

Our research was performed using the Medline, Embase and Cochrane databases and PubMed Central electronic archive. The reference lists of all relevant articles were also hand-searched.

Searches

Predetermined inclusion and exclusion criteria to assess eligibility for selection are described as follows. Articles including the word “diastasis” in the title or abstract, studying a sample of subjects with DRA and involving at least one questionnaire, scale, inventory, index or survey evaluating self-reported symptoms of DRA were included. In addition, they needed to include a comparison between a population with and without DRA, or a comparison based on the IRD.

Articles relating to the surgical repair of DRA or abdominal hernias were excluded, as were studies that did not exclusively analyze a sample of women with DRA. Only observational studies published in peer-reviewed journals were included. Case studies were excluded. No restrictions concerning the date or the language were applied. The final review was performed on 1st of June 2020. The following keywords were used: "Diastasis rectus abdominis", "Diastasis recti", "Abdominis Rectus Muscle Diastasis", "Questionnaire", "Scale", "Survey", "Interview", "Index" and "Inventory". The PubMed interface search was as follows: (“Diastasis recti” OR “Abdominis Rectus Muscle Diastasis” OR “Diastasis rectus abdominis” OR "Diastasis Recti And Weakness Of The Linea Alba" [Supplementary Concept]) AND (Questionnaire OR Scale OR Survey OR Index OR Inventory).

Study Selection

Based on selection criteria, two authors (MR and LF) independently screened and selected articles based on their title and abstract. If a study was considered to be potentially relevant to the research question, the full publication was reviewed. The software *Rayyan QCRI* was used to assist the selection process[17]. Disagreements regarding the eligibility of particular studies were resolved with a third reviewer (VV).

Data Extraction

Data extraction was performed using a specifically designed data extraction sheet. One reviewer (MR) extracted the data from studies and two others (VV and LF) checked the accuracy of the reported data. Disagreements were resolved by discussion between the authors.

Quality Assessment

The *NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies* was used to assess the methodological quality of the studies[18]. Disagreements in the critical appraisal were discussed in a panel composed by three of the authors.

A critical appraisal based on the design of our review was performed to establish the overall quality rating for each study. Different degrees of importance were given to the items of the scale in relation to how each item could specifically affect the results of our review. The results of the quality assessment were taken into account for the discussion drafting, especially when two articles led to dissimilar conclusions.

Data Synthesis and Analysis

Agreement between evaluators regarding the full-text selection and quality criteria assessment was calculated using Cohen's kappa coefficient. A minimum score of 0.61 was considered for an article to be eligible.

In order to facilitate the data analysis, self-reported variables were classified according to their category. We included all types of summary measures in our data analysis, prioritizing odds ratios, mean differences and correlations coefficients.

A thematic analysis was performed with the aim of qualitatively analyzing the results. A triangulation process was performed by three of the authors, who independently reviewed the articles and extracted the key aspects regarding the effect size and level of significance of diastasis-related self-reported variables. Perspectives and interpretations of the three authors were discussed, and disagreements were negotiated through consensus.

Role of the Funding Source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

RESULTS

The search and selection process for this review is outlined in the diagram displayed in **image 2**. After duplicate articles were eliminated, a total of 320 articles were analyzed according to their title and abstract. From these, 31 articles were selected for full-text reading. A total of 14 articles met the eligibility criteria and were included in the qualitative analysis[3–5,10–15,19–23]. Agreement between evaluators regarding the full-text selection was found to be strong ($\kappa = 0.8$)[24]. Disagreement concerning one article, Doubkova et al.[13], required further discussion as it analyzes a mixed sample of women and men. The predetermined inclusion criteria stipulated that selected studies should be

exclusively composed of women, however since this paper analyzes the data from women and men separately it was agreed to include it. The authors decided not to include the article by Candido et al.[25], which evaluated the prevalence and risk factors for DRA in immediately postpartum women. Despite analyzing multiple variables including parity, mode of delivery and the frequency of exercise prior to and during pregnancy, the results were studied as risk factors of DRA and not in terms of symptoms.

Quantitative analysis was not performed due to study heterogeneity and because of the large variability in assessment methods among studies.

Characteristics of the studies

The selected studies included 6 cross-sectional studies[10,12,13,21–23], 4 cohort studies[3,11,14,19], 1 exploratory analysis[5], 1 case series[20] and 2 case-control studies[4,15]. The study type, sample size, comparison, outcomes and instruments of measurement used are described in **table 1**.

Participants

A total of 2,665 women were included in our review. Of those women, at least 1,064 had a diagnosis of DRA, however the cut off values differ between studies. Some studies[10,12,22] did not specify the number of women with DRA, and reported data depending on the IRD value. **Table 2** illustrates the method and level of measurements, variation in cut-off values, average age, and IRD.

Methodological quality

The methodological quality of our study was assessed using the *NIH Quality Assessment Tool for Observational Cohort and Cross-sectional Studies*[18]. The agreement between

evaluators was found to be almost perfect ($\kappa = 0.97$)[24]. The results of the quality assessment following the consensus of the three reviewing authors are displayed in **table 3.**

Correlation between self-reported outcomes and DRA

A significant positive correlation was found between the presence of DRA and the following categorical dimensions: QoL, physical function, abdominal pain, body image and fecal incontinence (FI). Heterogenous data were identified in relation to lumbopelvic pain and pelvic floor disorders. Further details about the individual results are displayed in **table 4**.

QoL and DRA

The association between DRA and QoL was explored by Gitta et al.[4] through the SF-36 questionnaire. Physical health and functioning appear to be negatively affected in women with DRA (physical health: r = - 0.171, $p = 0.017$*; physical functioning: r = - 0.202, $p = 0.004$*). Nevertheless, the results regarding limitations of activities and general health were not significant.

Body image and DRA

The correlation between body image and DRA was studied by Keshwani et al.[10], who found a significant negative correlation between both conditions. Women with wider DRA reported a worse evaluation of their general physical appearance ($r = -0.44$, $p = 0.006$) and lower levels of satisfaction with their abdominal area ($r = -0.32$, $p = 0.037$).

Lumbopelvic pain and DRA

There was consistency among studies regarding the relationship between the presence and severity of lumbopelvic pain and DRA, with no significant correlation existing between both conditions.

With regards to disability due to LBP and its association with DRA, heterogenous results were presented. Two studies, Dalal et al.[20] and Gitta et al.[4], reported a significant positive correlation. The team of Dalal et al.[20] found a moderate positive correlation between LBP disability and DRA using the Oswestry Index ($p<0.05$). Gitta et al.[4] showed similar values, reporting a Pearson coefficient of r = 0.148 ($p = 0.039$*).

On the other hand, Hills et al.[15] and Parker et al.[5] found a positive but non-significant correlation. The paper of Keshwani et al.[10] was the only one reporting a negative non-significant value. It is important to note that this study did not evaluate a group with DRA versus a healthy group, but rather as a continuous variable based on the IRD.

Other types of pain and DRA

Four articles reported a positive correlation between DRA and abdominal pain, but only two of them showed significant results. Significant correlations were reported by Keshwani et al.[10] and Parker et al.[5], and corresponded to the worst abdominal pain in the past 24 hours, severity of pain at the time of the evaluation and abdominal pain measured together with pelvic pain severity.

Other authors reported a quasi-significant positive correlation between DRA and worst upper-mid back pain in past 24 hours ($p = 0.07$)[15] and with pelvic floor tenderness (OR = 1.18, $p > 0.05$)[11].

Pelvic floor dysfunction and DRA

Results concerning urogynecological complaints were heterogenous. The first team evoking a potential relationship between pelvic floor disorders and DRA were Spitznagle

et al.[11]. They found a significant positive correlation between DRA and pelvic floor dysfunction (stress urinary incontinence, FI and pelvic organ prolapse [POP]) (OR = 1.79, 95% CI 1.25–2.55, $p < 0.001$). When measuring the different symptoms of pelvic floor dysfunction individually, they found a non-significant positive correlation with stress urinary incontinence (OR = 1.28, 95% CI 0.9–1.82, $p > 0.05$), but a significant positive correlation with FI (OR = 2.56, 95% CI 1.04–6.31, $p < 0.05$).

Eight studies evaluated the link between urinary incontinence (UI) and DRA with most of them[4,11,14,15,22,23] reporting no significant correlation between conditions. Only the articles by Tosun et al.[12] and Blyholder et al.[21] found a positive and significant association.

With regards to other pelvic floor dysfunction symptoms, various studies evaluated anorectal symptoms, POP or sexual matters individually[11,12,15]. Parker et al.[5] found that women with DRA were more likely to experience bowel or bladder dysfunction. Tosun et al.[12] reported a positive and almost significant correlation between self-reported POP symptoms and DRA in a population of women ($p = 0.06$).

DISCUSSION

This systematic review of observational studies includes a comprehensive evaluation of the literature and provides a critical appraisal of the results. We found a potential association between DRA and the following variables: physical health and functioning, body image, abdominal pain and FI. However, factors such as the design, quality and sample size of some of the studies limit the ability to establish sufficient evidence to confidently confirm associations. These factors will be discussed and individually evaluated within this section.

Furthermore, it seems that there is a lack of association between DRA and the presence and severity of LBP, UI, voiding symptoms and sexual matters. Contradictory data have been identified regarding disability related with LBP.

Body image and DRA

Body image perception in subjects with DRA is not well studied. The majority of existing research evaluating this outcome measures the impact of surgical procedures, such as abdominoplasty or rectus plication, on body image[26,27]. They found an improvement in body image perception after surgical repair. We only identified one study, Keshwani et al.[10], that evaluated body image perception in women who currently had DRA using a validated questionnaire. This team suggested that DRA may cause a poorer physical perception and lower body satisfaction. These are the main reasons why women decide to undergo abdominal surgery. In addition, such negative body image may produce adverse psychological or emotional effects, such as anxiety or depression[28,29].

Given the importance of this aspect, it is noteworthy that only one article in our review evaluated body image perception and satisfaction in this population. A recently published study by Cardaillac et al. was identified after the article seletion date for our review and therefore not included. It is interesting to see that they found the aesthetic discomfort felt by patients to be significantly increased by the presence of DRA ($p = 0.03$)[30] further highlighting the need for more consideration and investigation into this relationship.

QoL and DRA

QoL seems to be reduced in women with DRA. When evaluating items of the SF-36 scale individually, Gitta et al.[4] found significant results for physical health and functioning, but not for general health. Physical limitations in subjects with DRA could be related to a

decreased capacity to stabilize the trunk in this population. It is worthy to note that the literature has previously described decreased strength of the trunk flexors in subjects with DRA[15,31]. These results are consistent with Cardaillac et al.[30], who confirmed that severe DRA significantly impacted upon QoL.

Abdominal pain and DRA

Regarding abdominal pain, all the studies reported a positive correlation between abdominal pain and DRA, demonstrating higher levels of pain in women with DRA compared to women without DRA. However, degrees of statistical significance are dissimilar. It should be acknowledged that the level of pain reported by some women is low and sometimes referred to as discomfort or bloating and occasionally confused with gastrointestinal sensations[10,32]. This fact could be a possible explanation for the non-significant values reported by Hills et al.[15], who used a numerical rating scale. This instrument may not be sensitive enough to detect sensations of discomfort.

Lumbopelvic pain and DRA

A potential association between LBP severity and DRA was suggested in the review by Benjamin et al.[16]. However, the values they presented in their study to support this statement corresponded to the *Oswestry Disability Index* values in Gitta et al's study[4]. This instrument is suitable for quantifying disability, but not the severity of pain. Our research identified 5 articles[3,5,10,13,19] evaluating the presence or severity of lumbopelvic pain. None of them showed a significant association between DRA and pain. We can therefore only assume that no correlation exists between DRA and the presence or severity of lumbopelvic pain.

Disability related with LBP could be affected in subjects with DRA, however the literature remains contradictory. A significant moderate correlation was found by the teams of Dalal[20] and Gitta[4], while no correlation was identified by Hills et al.[15] or Keshwani et al.[10]. Inconsistencies could be explained by differences in the methods of measurement, since Hills et al.[15] used the *Roland-Morris Low Back Pain And Disability Questionnaire*, and the other studies used the *Oswestry Disability Index*. Also, Dalal et al.[20] and Gitta et al.[4] measured DRA via caliper during a head lift, while the teams of Hills[15] and Keshwani[10] used ultrasound, which is accepted to be a more valid and reliable technique than using a caliper[32]. It is worth mentioning that the study of Dalal et al.[20] does not report the values and significance of their results. Due to the methodological disparities, it is not possible to establish solid assumptions regarding the association between DRA and disability related to LBP.

Nevertheless, it could be considered sensible to suggest the possibility that an excessive increase in IRD may impact the capacity to stabilize the lumbar spine, leading to disability[34]. Different mechanisms have been proposed to explain this ineffective stability: women with DRA may present with elongated lumbosacral and thoracolumbar fascia, which may be unable to generate tension. Additionally, a lack of stability could be justified by changes in rectus abdominis length, width and angle of insertion[20]. Hormonal changes, which are common during both pregnancy and menopause, can affect the properties of the connective tissue and may contribute to a lack of stability[20]. In this context, some subjects with an increased IRD may achieve function better than others, since lumbopelvic stability does not only depend on the status of the connective tissue of the linea alba, but also on the ability of abdominal muscles to transfer forces[35].

Another hypothesis regarding the dissimilarity of results, could lay on time-dependent factors. Most of the publications evaluate LBP in a population composed by females in the early postpartum period. DRA may not result in short term changes, but instead lead to changes developing over prolonged exposure. To discard this variable, it would be necessary to carry out studies in populations that have DRA over a longer period of time.

Pelvic floor dysfunction and DRA

Regarding pelvic floor disorders, only FI seemed to be correlated with DRA. FI was evaluated by Spitznagle et al.[11], who reported a significant positive correlation between this condition and DRA. Several biases in the methodology of this study could compromise the validity of their results. First of all, the authors did not provide information about methods of measurement of pelvic floor dysfunction symptoms, meaning it is not possible to confirm the validity and reliability of the measurement. Also, the cut off value for DRA differed from other studies, with values of more than 0.5 fingerbreadths considered as positive. This measurement corresponds to approximately 0.75cm, which is under the established cut-off values in the literature for the diagnosis of DRA[36]. Also, the location of the measurement along the linea alba was not reported.

An almost significant correlation between DRA and self-reported POP symptoms was reported by Tosun et al.[12]. It is important to specify that there was no control group without DRA for comparison in this study, but instead a classification based on the width of the IRD. Additionally, the studies of Spitznagle et al.[11], Tosun et al.[12] and Bø et al.[14] evaluated POP through the POP-Q clinical evaluation and not as a self-reported variable. For this reason, their data were not included in this aspect of our quality review. However, it is still notable that Spitznagle et al.[11] found a correlation between POP and DRA, but

Bø et al.[14] did not. Differences between the results could be explained by methodological variations within the studies. One example is the differing sample demographic recruited. The time-dependent hypothesis discussed previously may explain the conflicting findings if longer exposure to DRA influences the prevalence of POP. Also, it is important to note that the literature reported a poor association between clinical findings and self-reported symptoms in POP[37].

Results in relation to UI were fairly consistent among studies: 8 articles in our review agreed that no significant correlation between UI and DRA exists. Only the studies of Tosun et al.[12] and Blyholder et al.[21] reported a significant positive association between both conditions. An important bias in the paper of Blyholder et al.[21] involves the quantification of DRA, since they used each subject's self-perception of their separation between the rectus abdominis muscles. The validity of this method is insufficient to determine the DRA status. The positive results of Tosun et al.[12] could be justified by the fact that the categorization of subjects was based on a classification in function of the width of the IRD, and not on the presence/absence of DRA, as performed in other studies. In conclusion, after considering existing research, we support the findings that there is no significant correlation between UI and DRA.

Clinical relevance

Clinicians should be aware of the importance of identifying variables such as body image, abdominal discomfort and QoL when treating patients with DRA.

Functional aspects of DRA should be taken in account when planning physical therapy evaluation and treatment. Focusing only on reducing the IRD could be misguided if it is not accompanied by an improvement in functional aspects. Adequate management of DRA should improve not only functionality, but also its impact on QoL and body image.

For this reason, achieving functionality with DRA should be one of the main goals of rehabilitation.

When considering the evaluation of DRA, there is currently a lack of instruments or tools measuring relevant self-reported variables in women with this condition. Further research is necessary to create validated instruments to measure these outcomes.

Outcomes such as UI or lumbopelvic pain are still wrongly attributed to DRA in clinical practice. Clinicians should not presume that an association exists and should endeavor to avoid unnecessary fear surrounding such messages to patients.

Limitations

The findings of our review are subject to several limitations. First, we have to consider the possibility of overlooking relevant literature, due to limitations in our search strategy. Also, several factors could have affected the comparability of studies. Heterogeneity was found in the population: factors such as age, sex, hormonal status, previous abdominal surgeries or congenital factors varied between articles. Differences in the method of IRD measurement were also found. Cut-off values, locations along the linea alba and measurement tools varied between studies. Most of the studies used either ultrasound, fingerbreadths, or caliper. Ultrasound is accepted to have good validity and high reliability, while calipers and fingerbreadths show lower levels of internal validity[32,38]. Additionally, head lifting is needed for the measurement with calipers and fingerbreadths. This movement has been shown to decrease the IRD, since the rectus abdominis muscles approximate[39]. Thus, it is not suitable to compare measurements performed at rest and measurements during a head lift. Also, given the fact that most of the associations were measured by means of prevalence and Pearson's coefficient, it is not possible to know

whether the associations among studies are symptoms caused by or simply comorbid with DRA nor the directionality of the relationship.

In future studies, it would be interesting to standardize the position for measuring the IRD. Additionally, it would be appropriate to investigate DRA further by performing measurements in upright and functional positions to obtain a better representation of its impact upon daily activities[40].

CONCLUSIONS

The literature suggests that women with DRA present with reduced QoL due to compromised physical health and functioning; poorer physical perception; lower body image satisfaction; and higher degrees of abdominal pain that is frequently perceived as discomfort or bloating. Clinicians should take these outcomes into account within clinical practice, while still remaining alert to the developing evidence base. Self-reported symptoms of POP and FI could potentially be related with the presence of DRA, but studies reporting those results present a high risk of bias. For this reason, the estimated effect of these outcomes is very uncertain. Dissimilar results have been presented regarding the association between disability related with LBP and DRA. Further research is needed to clarify this eventual relationship. No correlation has been found between DRA and UI, severity and presence of LBP, voiding symptoms, vaginal symptoms or sexual matters. Further research is needed in order to establish more conclusive results regarding the presence of DRA and self-reported symptoms.

GLOSSARY

Diastasis rectus abdominis: presence of divergence between the rectus abdominis muscles along the linea alba.

Urinary incontinence: complaint of any involuntary leakage of urine.

Low back pain: pain localized at the level of the lumbar spine, with or without radiation to the hip or the leg.

Quality of life: state of complete physical, mental, and social well-being not merely the absence of disease.

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TABLES

Table 1. Description of the studies

Author	Design	Population	*n**	Comparison	Outcomes	Assessment tool
Spitznagle et al. 2007	Retrospective cohort	Women	541	DRA (*n*=281) No DRA (*n*=260)	Pelvic floor dysfunction	NR
Parker et al. 2009	Prospective exploratory analysis	Parous women	100	DRA (*n*=64) no DRA (*n*=36)	Low back pain severity Abdominal or pelvic pain LBP disability Pelvic floor disfunction	VAS VAS ODI PFQI/PFDI
Dalal et al. 2014	Case series	Parous women (> 3 months postpartum)	30	DRA (*n*=25) No DRA (*n*=5)	Low back pain severity Abdominal or pelvic pain LBP disability Pelvic floor dysfunction	VAS VAS MODI PFQI/PFDI
Fernandes da Mota et al. 2015	Cohort	Pregnant women: Gestational week 35 Parous women: 6 months postpartum	84	35 weeks DRA (*n*=84) 6 months: DRA (*n*=33) No DRA (*n*=51)	Lumbopelvic pain location Pain intensity	5 categories 0-2 scale
Sperstad et al. 2016	Cohort	Pregnant women Gestational week 18–22 Postpartum	299 178	21 weeks: DRA (*n*=99) no DRA (*n*=200) 12 months: DRA (*n*=58) No DRA (*n*=120)	Low back pain presence Pelvic girdle pain presence Pain location	Self-reported questionnaire
Blyholder et al. 2017	Cross-sectional	Parous women running at least once a week	506	DRA (*n*=186) No DRA (*n* = 320)	Stress urinary incontinence Antenatal MSK pain	Self-reported questionnaire
Bø et al. 2017	Cohort	Pregnant women: Gestational week 21 Parous women: 6 weeks postpartum 6 months postpartum 12 months postpartum	299 178	21 weeks: DRA (*n*=99) no DRA (*n*=200) 12 months: DRA (*n*=58) No DRA (*n*=120)	Urinary incontinence	ICIQ-UI-SF

Gitta et al. 2017	Case-control	Parous women	200	DRA (*n*=93) No DRA (*n*=107)	Low back pain disability Urinary incontinence Quality of life	ODI ICI-UI-SF SF-36
Keshwani et al. 2017	Cross-sectional	Primiparous women < 4 weeks postpartum	32	IRD (*n*=32)	Abdominal pain Lumbar pain Pelvic pain Self-perceived disability LBP Urogynecological complaints Physical attractiveness Body areas satisfaction (waist/stomach)	VAS (current/24h) VAS (current/24h) VAS (current/24h) ODI PFQI/PFDI MBSRQ: Appearance Body areas satisfaction
Doubkova et al. 2018	Cross-sectional	Women	69*	DRA (*n*=7) No DRA (*n*=62)	Chronic LBP	Self-reported
Hills et al. 2018	Case-control	12-14 months first postpartum	40	DRA (*n*=18) No DRA (*n*=22)	Disability Abdominal pain severity Low back pain severity Upper-mid back pain severity Pelvis or hips pain severity Vaginal symptoms Urinary tract symptoms	RDQ NRS(24h) NRS(24h) NRS(24h) NRS(24h) ICIQ-VS ICIQ-FLUTS
Braga et al. 2019	Cross-sectional	Parous women: 6 months postpartum	73	DRA (*n* NR)	Urinary incontinence	ICIQ
Tosun et al. 2019	Cross-sectional	Women	82	DRA (*n* NR)	Fecal incontinence PFD PFM tenderness Urogenital symptoms Overactive bladder Nocturia Prolapse	P-QOL SRQ VAS IIQ-7 UDI-6 OAB-AT OABq-SF NQOL PISQ-12
Wang et al. 2019	Cross-sectional	Parous women: 6–8 weeks postpartum	310	DRA (*n*=108) No DRA (*n*=202)	Urinary incontinence	SRQ

Abbreviations: DRA: Diastasis recti abdominis; NR: non-reported, LBP: low back pain; VAS: visual analog scale; ODI: Oswestry Disability Index; PFQI: Pelvic Floor Impact Questionnaire; PFDI: Pelvic Floor Distress Inventory; MODI: Modified Oswestry Disability Index; MSK: musculoskeletal; ICIQ-UI-SF: International Consultation on Incontinence Questionnaire-Urinary Incontinence-Short Form; SF-36: Short Form (36) Health Survey; IRD: inter-recti distance; MBSRQ: Multidimensional Body- Self Relations Questionnaire; RDQ: Roland-Morris Disability Questionnaire; NRS: Numeric Rating Scale; VS: vaginal symptoms; FLUTS: female lower urinary tract symptoms; PFD: pelvic floor dysfunction; PFM: pelvic floor muscles; P-QOL: Perceived Quality of Life scale; SRQ: Self-reported questionnaire; IIQ-7: Incontinence Impact Questionnaire Short Form; UDI-6: Urinary Distress Inventory Short Form; OABq-SF: Overactive Bladder Questionnaire short form; NQOL: nycturia quality of life; PISQ-12: Pelvic Organ Prolapse/Urinary Incontinence/Sexual questionnaire; *n* NR: non-reported sample.
* only women included in the DRA/ no DRA comparison

Table 2. Measurement of Diastasis Rectus Abdominis.

	Age, in years	Level of measurement	Cut-off	IRD, in cm	IRD instrument
Spitznagle et al. 2007	52.45 (16.65) [1]	Head lifting: NR level	> 0.5 fingers	NR	Fingerbreadth
Parker et al. 2009	41.4 (12.0)[1]	Head lifting: 4.5 cm SU Umbilicus 4.5 cm IU	2-2.5 cm ; > 2.5cm	**4.5 SU:** 1.77 (0.93)[1] **Umb:** 2.03 (0.92)[1] **4.5 IU:** 1.80 (1.08)[1]	Dial caliper
Dalal et al. 2014	27.4 (NR)[1]	Head lifting: 4.5 cm SU 4.5 cm IU	2-4 cm ; > 4 cm	NR	Caliper
Fernandes da Mota et al. 2015	32.1 (25-37)[2]	2 cm IU	1.6 cm	**Week 35:** 6.46 (19.0)[1] **6 months:** 1.53 (8.4)[1]	Ultrasound
Sperstad et al. 2016	28.7 (4.3)[1]	Head lifting: 4.5 cm SU Umbilicus 4.5 cm IU	> 2 ; 2-3 ; 3-4 and > 4 fingers	NR	Fingerbreadth
Blyholder et al. 2017	NR	NA	NA	NA	Perceived RA separation
Bø et al. 2017	28.7 (4.3)[1]	Head lifting: 4.5 cm SU Umbilicus 4.5 cm IU	>2 fingers	NR	Fingerbreadth
Gitta et al. 2017	32.53 (6.12)[1]	Head lifting:	≥3 cm	**10 cm SU:**	Digital caliper

		10 cm SU 5 cm SU Umbilicus 2.5 cm IU 5 cm IU		DRA: 2.96 cm, No DRA: 1.21 cm **5 cm SU:** DRA: 4.02 cm, No DRA: 1.58 cm **Umb**: DRA: 4.91 cm, No DRA: 1.95 cm **2.5 cm IU:** DRA: 4.29 cm, No DRA: 1.57 cm **5 cm IU:** DRA: 3.85 cm, No DRA: 1.28 cm	
Keshwani et al. 2017	32 ± 2[1]	Superior border of the umbilicus 3 cm SU 5 cm SU 3 cm IU	NA	Largest IRD regardless of measurement site: 2.97 (NR) [3] Average IRD across all measurement sites: 2.49 (NR) [3]	Ultrasound
Doubkova et al. 2018	NR*	Head lifting: 4.5 cm SU Umbilicus 4.5 cm IU	**<45 years old:** 4.5 cm SU: 10mm Umb: 27 mm 4.5 cm IU: 9mm **>45 years old:** 4.5 cm SU: 15 mm Umb: 27 mm 4.5 cm IU 14mm	NR	Digital caliper
Hills et al. 2018	31.5± 4.1[1]	Superior border of the umbilicus 3 cm SU 5 cm SU	>2.2 cm at 3cm SU and >2 cm mean of the 3 values	**DRA:** 2.5 (0.4)[1] **No DRA:** 1.4 (0.4)[1]	Ultrasound
Braga et al. 2019	UI: 38 (22-45)[3] No UI: 38 (21-45)[3]	Superior border of the umbilicus	NR	**UI:** 1.76 (0.81)[1] **No UI:** 1.69 (0.79)[1]	Ultrasound
Tosun et al. 2019	PFD 41.2 ± 6.71[4] Non PFD 35.7 ± 6.6[4]	Head lifting: 4.5 cm SU Umbilicus 4.5 cm IU	>2 cm	**PFD:** 1.8 (109) [sic][4] **Non-PFD:** 1.01 (1.2)[4]	Fingerbreadth
Wang et al. 2019	DRA: 32 (30 to 36)* No DRA: 32 (29 to 36)*	Head lifting: 4.5 cm SU Umbilicus 4.5 cm IU	>2 fingers	NR	Fingerbreadth

Abbreviations: IRD: inter-rectus distance; NR: non-reported; SU: supraumbilical; umb: umbilicus; IU: infraumbilical; NA: not applicable; RA: rectus abdominis; NR*: not reported specifically for women group; DRA: diastasis recti abdominis; UI: urinary incontinence; PFD: pelvic floor dysfunction
Superscripts: 1: Mean (SD), 2: Mean (Range), 3: Median (IQR), 4: Median (SD), *: Measurement type not reported

Table 3. Quality assessment of observational cohort and cross-sectional studies.

CRITERIA	STUDY													
	Spi	Par	Dal	Fer	Spe	Bly	Bø	Git	Kes	Dou	Hil	Bra	Tos	Wan
1 Research question	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2 Study population	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y
3 Eligible rate	NR	NR	NR	NR	Y	NR	Y	NR	NR	NR	NR	Y	Y	Y
4 Groups recruitment/eligibility criteria	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
5 Sample size justification	N	N	N	N	N	N	N	N	Y	Y	Y	Y	N	N
6 Exposure assessment.	N	N	N	Y	Y	N	Y	N	N	N	N	N	N	N
7 Timeframe for effect	N	N	N	CD	CD	N	CD	N	N	N	N	N	N	N
8 Levels of the exposure	NA	Y	NA	NA	NA	NA	NA	NA	Y	NA	NA	NA	NA	NA
9 Exposure measures/assessment	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
10 Repeated exposure assessment	N	N	N	Y	Y	N	Y	N	N	N	N	N	N	N
11 Outcome measures	NR	Y	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	N
12 Blinding of outcome assessors	NR	NR	NR	Y	Y	NR	Y	NR	NR	NR	Y	NR	NR	NR
13 Follow-up rate	NA	NA	NA	N	N	NA	N	NA	NA	NA	NA	NA	NA	NA
14 Statistical analyses	N	N	N	N	Y	N	Y	N	N	N	N	N	N	N
GLOBAL RATING	low	low	low	fair	fair	low	high	low	fair	low	fair	fair	low	low

Quality assessment according to the *NIH Quality Assessment Tool for Observational Cohort and Cross-sectional Studies* tool.
Abbreviations. Spi: Spitznagle et al. 2007; Par: Parker et al. 2009; Dal: Dalal et al. 2014; Fer: Fernandes da Mota et al. 2015; Spe: Sperstad et al. 2016; Bly: Blyholder et al. 2017; Bø: Bø et al. 2017; Git: Gitta et al. 2017; Kes: Keshwani et al. 2017; Dou: Doubkova et al. 2018; Hil: Hills et al. 2018; Bra: Braga et al. 2019; Tos: Tosun et al. 2019; Wan: Wang et al. 2019; Y = yes; N = no; CD = cannot be determined; NR = not reported; NA = not applicable.

Table 4. Associations between self-reported outcomes and diastasis rectus abdominis

Dimension	Outcome	Author	Correlation data	*P* value
Quality of life	Physical health	Gitta et al.	**r = - 0.171**	***p* = 0.02***
	Physical functioning	Gitta et al.	**r = - 0.202**	***p* = 0.004***
	Limitations of activities	Gitta et al.	r = - 0.051	*p* = 0.48
	General health	Gitta et al.	r = - 0.043	*p* = 0.55
Abdominal pain	Abdominal and pelvic pain severity	Parker et al.	**t = 2.313** **df = 96.4**	***p* = 0.03***
	Current severity	Keshwani et al.	**r = 0.32**	***p* = 0.04 ***
	Worst abdominal pain in past 24 hours	Keshwani et al.	**r = 0.45**	***p* = 0.005***
	Abdominal and pelvic pain severity	Dalal et al.	Positive correlation	**NR**
	Worst abdominal pain in past 24 hours	Hills et al.	NRS score 0-100, median (IQR) DRA: 0 (0–6) No DRA: 0 (0–1)	*p* = 0.35
Low back pain	LBP severity	Parker et al.	Positive correlation	NSC
		Sperstad et al.	Prevalence DRA: 38.6 % No DRA: 27.5 %	*p* = 0.17
	(last 24h)	Keshwani et al.	r = 0.02	*p* = 0.45
	Worst LBP in last 24h	Hills et al.	NRS score 0-100, median (IQR) DRA: 6 (0–11) No DRA: 7 (0–26)	*p* = 0.90
	Lumbopelvic pain severity	Fernandes da Mota et al.	OR (CI) = 0.99 (0.37, 2.65)	*p* = 0.99
	Pelvic girdle pain severity	Sperstad et al	Prevalence DRA: 15.8 % No DRA: 4.2 %	*p* = 0.82
	LBP presence	Doubkova et al.	OR= 1.44 (NR CI)	*p* = 0.66
	Lumbopelvic pain presence	Sperstad et al.	Prevalence DRA: 45.6 % No DRA: 32.5 %	*p* = 0.10
	Low back disability	Parker et al.	Positive correlation	NSC
		Dalal et al.	Moderate positive correlation	***p* = <0.05***
		Gitta et al.	r = 0.148	***p* = 0.039***
		Keshwani et al.	r = − 0.06	*p* = 0.36
		Hills et al.	RMDSQ score 0-24, median (IQR) DRA: 1(1–2) No DRA: 0 (0–1)	*p* = 0.22
Dorsal back pain	Worst upper-mid back pain in past 24 hours	Hills et al.	NRS score 0-100, median (IQR) DRA: 8 (0–18) No DRA: 0 (0–5)	*p* = 0.07
Pelvic floor myofascial pain	Pelvic floor tenderness	Spitznagle et al.	OR (CI) = 1.18 (0.81–1.73)	*p* > 0.05
General pain	Antenatal msk pain	Blyholder et al.	OR (CI) = 0.83 (0.42-1.63)	*p* = 0.58
Body image	Evaluation of physical appearance	Keshwani et al.	**r =−0.44**	***p* = 0.006***
	Satisfaction with: wrist and stomach	Keshwani et al.	**r = −0.32**	***p* = 0.04***
Pelvic floor dysfunction	Urinary incontinence	Spitznagle et al.	OR (CI) = 1.28 (0.9–1.82)	*p* > 0.05
		Gitta et al.	r = 0.072	*p* = 0.31
		Hills et al.	ICIQ-FLUTS score 0-20, median (IQR) DRA: 2 (2) No DRA: 2 (2)	NSC
		Braga et al.	DRA measurement, mean (SD) UI: 1.76 cm (0.81) No UI: 1.69 cm (0.79)	*p* = 0.91
		Tosun et al.	DRA measurement. Power > 3, median (SD): UI: 2 (1.06) cm	***p* = 0.04**
		Wang et al.	Prevalence DRA: 10.2% No DRA: 6.4%	*p* = 0.24
	SUI Gestational week 21	Bø et al.	Prevalence DRA: 32.3% No DRA: 32.5%	*p* = 1.00

	12 months postpartum	Bø et al.	Prevalence DRA: 22.8% No DRA: 36.7 %	$p = 0.09$
	Athletes	Blyholder et al.	OR (CI) = 2.25 (1.02-5.08)	**$p = 0.04$**
UUI	Gestational week 21	Bø et al.	Prevalence DRA: 9.1% No DRA: 12%	$p = 0.58$
	12 months postpartum	Bø et al.	Prevalence DRA: 17.5% No DRA: 9.2%	$p = 0.17$
MUI	Gestational week 21	Bø et al.	Prevalence DRA: 8.1% No DRA: 6.5%	$p = 0.79$
	12 months postpartum	Bø et al.	Prevalence DRA: 5.3% No DRA: 6.7 %	$p = 0.98$
Voiding symptoms		Hills et al.	ICIQ-FLUTS score 0-12, mean (SD): DRA: 1 (1) No DRA: 1 (1)	NSC
Pelvic organ prolapse symptoms		Tosun et al.	DRA measurement. Power > 3, median (SD): Prolapse: 2 cm (1.01)	$p = 0.06$
Fecal incontinence		Spitznagle et al.	OR (CI) = 2.56 (1.04–6.31)	**$p < 0.05$**
Vaginal symptoms		Hills et al.	ICIQ-VS score 0-53, mean (SD): DRA: 6 (4) No DRA: 5 (4)	NSC
Sexual matters		Hills et al.	ICIQ-VS score 0-56, mean (SD): DRA: 12 (15) No DRA: 8 (15)	NSC
Life impact in women with pelvic floor disorders		Parker et al.	NR	NSC
		Keshwani et al.	r = 0.22	$p = 0.12$
Quality of life in women with pelvic floor disorders		Parker et al.	r = 0.041	$p = 0.69$
		Dalal et al.	Moderate positive correlation	**$p < 0.05$***
		Keshwani et al.	r = 0.22	$p = 0.11$
Pelvic floor dysfunction		Spitznagle et al.	OR (CI) = 1.79 (1.25 – 2.55)	**$p < 0.001$**
		Tosun et al.	DRA measurement, median (SD): PFD: 1.8cm (109) [sic] non-PDF: 1.01cm (1.2)	**$p = 0.002$**

Abbreviations. r: Pearson correlation coefficient; t: t-value; df: degrees of freedom; NR: non-reported; NRS: numerical rating scale; IQR: interquartile range; DRA: Diastasis rectus abdominis; LBP: low back pain; OR: odds ratio; CI: confidence interval; NR: non reported; NSC: non-significant correlation; RMDSQ: Roland Morris disability questionnaire; ICIQ-FLUTS: International Consultation on Incontinence Questionnaire-Urinary Incontinence-female lower urinary tract symptoms; SD: standard deviation; UI: urinary incontinence; SUI: stress urinary incontinence; UUI: urgency urinary incontinence; MUI: mixed urinary incontinence; ICIQ-VS: International Consultation on Incontinence Questionnaire-Urinary Incontinence-vaginal symptoms; PFD: pelvic floor dysfunction.

FIGURES

Image 1. Diastasis rectus abdominis

* color should be used in print

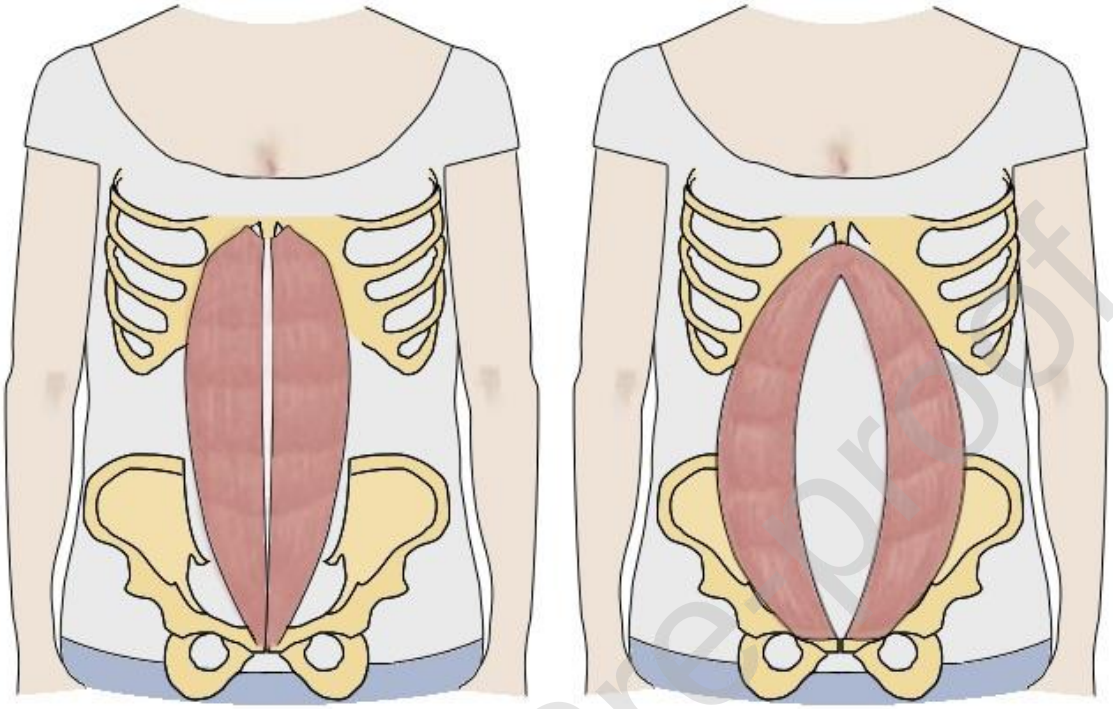

Image 2. PRISMA Diagram