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PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA SAÚDE
FACULDADE DE MEDICINA

ALANA LEANDRO CABRAL

EFEITOS DA INTERVENÇÃO FISIOTERAPÊUTICA NA DIÁSTASE DOS RETOS
ABDOMINAIS EM GESTANTES

Uberlândia

2024

ALANA LEANDRO CABRAL

**EFEITOS DA INTERVENÇÃO FISIOTERAPÊUTICA NA DIÁSTASE DOS RETOS
ABDOMINAIS EM GESTANTES**

Tese apresentada ao Programa de Pós-Graduação em Ciências da Saúde da Faculdade de Medicina da Universidade Federal de Uberlândia, como requisito parcial para a obtenção do título de Doutora em Ciências da Saúde.

Área de Concentração: Ciências da Saúde

Orientadora: Profa. Dra. Vanessa Santos Pereira Baldon

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FOLHA DE APROVAÇÃO

Alana Leandro Cabral

Efeitos da intervenção fisioterapêutica na diástase dos retos abdominais em gestantes

Presidente da banca (orientadora): Profa. Dra. Vanessa Santos Pereira Baldon

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Reuniu-se em web conferência pela plataforma Mconf-RNP, pela Universidade Federal de Uberlândia, a Banca Examinadora, designada pelo Colegiado do Programa de Pós-graduação em Ciências da Saúde, assim composta: Profs. Drs. Patrícia Gonçalves Fernandes da Mota (Escola Superior de Tecnologia da Saúde de Lisboa), Mariana Tirolli Rett Bergamasco (UFS), Andrea Lemos Bezerra de Oliveira (UFPE) e Ana Paula Magalhães Resende Bernardes (UFU) e Vanessa Santos Pereira Baldon (UFU), orientadora da candidata.

Iniciando os trabalhos, presidente da mesa, Profa. Dra. Vanessa Santos Pereira Baldon, apresentou a Comissão Examinadora e a candidata, agradeceu a presença do público, e concedeu a Discente a palavra para a exposição do seu trabalho. A duração da apresentação da Discente e o tempo de arguição e resposta foram conforme as normas do Programa.

A seguir o senhor(a) presidente concedeu a palavra, pela ordem sucessivamente, aos(às) examinadores(as), que passaram a arguir o(a) candidato(a). Ultimada a arguição, que se desenvolveu dentro dos termos regimentais, a Banca, em sessão secreta, atribuiu o resultado final, considerando o(a) candidato(a):

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Nada mais havendo a tratar foram encerrados os trabalhos. Foi lavrada a presente ata que após lida e achada conforme foi assinada pela Banca Examinadora.



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DEDICATÓRIA

À minha avó Edith, minha mãe Lunamaris,
meu irmão lury e meu namorado Hélio, que
me apoiaram e me inspiraram em todos os
momentos.

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RESUMO

Introdução: A diástase dos retos abdominais (DRA), comum em mulheres grávidas, é caracterizada pelo aumento da distância inter-retos (DIR), geralmente mensurada por ultrassom (US). Exercícios que focam na ativação do músculo transverso do abdômen (TrA) são frequentemente recomendados para diminuir a DIR, enquanto os exercícios de retos abdominais são evitados. No entanto, a eficácia dessas recomendações não é comprovada devido à falta de evidências científicas. Além disso, existe uma lacuna no conhecimento sobre esses exercícios em gestantes. Para preencher essa lacuna, foram realizados dois estudos. **Objetivos:** Artigo 1: Avaliar a confiabilidade intra e inter-examinador, e calcular a mínima diferença detectável (MDC) e o erro padrão das medições da DIR em nulíparas, usando US. Artigo 2: Comparar exercícios de ativação do TrA e dos músculos retos abdominais com exercícios sem ativação específica dessa musculatura na DIR de gestantes, e verificar suas repercussões nas disfunções dos músculos do assoalho pélvico (MAP). **Material e Métodos:** Artigo 1: 21 nulíparas foram submetidas à mensuração da DIR, em duas posições diferentes (repouso e flexão de tronco) e em duas regiões diferentes (supraumbilical e infraumbilical), por dois radiologistas experientes em dois momentos diferentes. Artigo 2: 63 gestantes foram divididas em 3 grupos de intervenção: Drawing-in (exercícios com ativação de TrA); Abdominal crunch (exercícios com ativação de retos abdominais); Controle (exercícios sem ativação específica dos músculos abdominais). A intervenção teve duração de 12 semanas, com avaliações iniciais e ao final desse período, através da mensuração da DIR (nos mesmos locais e posições das mulheres nulíparas) e do Questionário de Incômodo do Assoalho Pélvico (PFBQ). **Resultados:** Artigo 1: As medidas da DIR apresentaram alta confiabilidade intraexaminador para todas as variáveis, com ICC acima de 0.80. A confiabilidade interexaminador foi moderada na região supraumbilical em ambas as posições, com ICC: repouso: 0.720 (0.492; 0.857) e flexão 0.760 (0.447; 0.891). No entanto, a confiabilidade foi baixa na região infraumbilical em ambas as posições, repouso: 0.276 (-0.038, 0.558) e flexão 0.257 (-0.109, 0.564). Os valores de MDC variaram entre 0,22 e 0,50 cm. Artigo 2: Para a variável DIR, não foi demonstrada interação grupo-tempo quando avaliada em repouso supraumbilical [$F(2,60) = 0.30$; $p = 0.742$] e infraumbilical [$F(1,40) = 0.107$; $p = 0.899$]. Isso também ocorreu na posição

de flexão na região supraumbilical [$F(2,60) = 1.03$; $p = 0.362$] e infraumbilical [$F(2,60) = 1.23$; $p = 0.301$]. Não houve diferenças entre os grupos em nenhuma das variáveis. Para o PFBQ, os valores de p sugerem que não houve interação grupo-tempo [$F(2,60) = 2.14$; $p = 0.126$], nem houve efeito de tempo ou grupo. **Conclusão:** Artigo 1: O US é um método confiável para medir a DIR na região supraumbilical. Artigo 2: Os exercícios abdominais específicos não induzem alterações no tamanho da DIR em gestantes. Além disso, não provocam modificações nos sintomas das disfunções dos MAP.

Palavras-chave: Distância inter-retos; Transverso do Abdômen; Retos Abdominais; Ultrassom; Ensaio Clínico Randomizado; Gravidez.

ABSTRACT

Introduction: Diastasis recti abdominis (DRA), common in pregnant women, is characterized by an increase in the inter-rectus distance (IRD), generally measured by ultrasound (US). Exercises that focus on activating the transverse abdominis (TrA) muscle are often recommended to decrease DIR, while rectus abdominis exercises are avoided. However, the effectiveness of these recommendations is not proven due to a lack of scientific evidence. Furthermore, there is a gap in knowledge about these exercises in pregnant women. To fill this gap, two studies were carried out. **Objectives:** Article 1: To evaluate intra- and inter-rater reliability, and calculate the minimum detectable difference (MDC) and standard error of IRD measurements in nulliparous women, using US. Article 2: Compare exercises that activate the TrA and the rectus abdominis muscles with exercises without specific activation of these muscles in the IRD of pregnant women, and verify their repercussions on the dysfunctions of the pelvic floor muscles (PFM). **Material and Methods:** Article 1: 21 nulliparous women underwent IRD measurement, in two different positions (rest and trunk flexion) and in two different regions (supraumbilical and infraumbilical), by two experienced radiologists at two different times. Article 2: 63 pregnant women were divided into 3 intervention groups: Drawing-in (exercises with TrA activation); Abdominal crunch (exercises with activation of the rectus abdominis); Control (exercises without specific activation of the abdominal muscles). The intervention lasted 12 weeks, with initial assessments and at the end of this period, through measuring the DIR (in the same locations and positions as nulliparous women) and the Pelvic Floor Discomfort Questionnaire (PFBQ). **Results:** Article 1: DIR measurements showed high intra-rater reliability for all variables, with ICC above 0.80. Inter-rater reliability was moderate in the supraumbilical region in both positions, with ICC: rest: 0.720 (0.492; 0.857) and flexion 0.760 (0.447; 0.891). However, reliability was low in the infraumbilical region in both positions, rest: 0.276 (-0.038, 0.558) and flexion 0.257 (-0.109, 0.564). MDC values varied between 0.22 and 0.50 cm. Article 2: For the DIR variable, no group-time interaction was demonstrated when evaluated at supraumbilical rest [$F(2,60) = 0.30$; $p = 0.742$] and infraumbilical [$F(1,40) = 0.107$; $p = 0.899$]. This also occurred in the flexion position in the supraumbilical region [$F(2,60) = 1.03$; $p = 0.362$] and infraumbilical [$F(2,60) = 1.23$; $p = 0.301$]. There were no differences between the

groups in any of the variables. For the PFBQ, the p values suggest that there was no group-time interaction [$F(2,60) = 2.14$; $p = 0.126$], nor was there any effect of time or group. **Conclusion:** Article 1: US is a reliable method for measuring IRD in the supraumbilical region. Article 2: Specific abdominal exercises do not induce changes in the size of the IRD in pregnant women. Furthermore, they do not cause changes in the symptoms of PFM dysfunctions.

Keywords: Inter-Recti Distance; Transverse Abdominis; Rectus Abdominis; Ultrasound; Randomized Clinical Trial; Pregnancy.

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1. INTRODUÇÃO

A gestação promove diversas mudanças anatômicas e fisiológicas no corpo da mulher, consequência do aumento da demanda física e metabólica, visando proporcionar o desenvolvimento do feto e garantir a sobrevivência da mãe e do bebê durante o parto (TAN; TAN, 2013; SOMA-PILLAY et al., 2016). Uma dessas alterações pode ser observada na anatomia dos músculos retos abdominais (GILLEARD & BROWN, 1996).

Os músculos retos abdominais, que se apresentam em um par separados pela linha alba, possuem uma distância fisiológica entre eles, denominada distância inter-retos (DIR) (REINPOLD et al., 2019). Entretanto, ao longo da gravidez, esses músculos, que comumente mantêm sua orientação vertical, curvam-se em torno da protuberância abdominal, podendo separarem-se e provocarem um enfraquecimento da linha alba, aumentando sua largura e, conseqüentemente, a DIR (BOISSONNAULT; BLASCHAK, 1988; FAST et al., 1990; GILLEARD & BROWN, 1996). Essa condição é definida como diástase dos retos abdominais (DRA) (AXER; KEYSERLINGK; PRESCHER, 2001; REINPOLD et al., 2019).

A DRA é muito frequente nas mulheres, principalmente no período gestacional e no pós-parto, ocorrendo em cerca de 33,1% na 21ª semana gestacional e em 60% seis semanas após o parto (SPERSTAD et al., 2016). Apesar de poder desaparecer espontaneamente durante o puerpério, essa condição pode se estender por mais tempo, permanecendo em 45,4% das mulheres seis meses após o parto e em 32,6% doze meses após o parto (SPERSTAD et al., 2016).

Além de ser considerada uma questão estética, com as mulheres apresentando um abdômen flácido e protuberante, a DRA é, usualmente, relacionada a dor abdominal, lombar, pélvica e disfunções do assoalho pélvico (BENJAMIN et al., 2019). Também, pode estar associada a fraqueza dos músculos abdominais, de forma que, durante a execução de exercícios físicos, poderá ocorrer um abaulamento da parede abdominal, gerando um aumento da pressão intra-abdominal, o que, a longo prazo, é capaz de ocasionar o surgimento de hérnias epigástricas e umbilicais (CHEESBOROUGH; DUMANIAN, 2015; GLUPPE; ELLSTRÖM ENGH; KARI, 2021).

Diante de todas essas consequências, diversos estudos têm buscado alternativas para prevenir a DRA, com foco na DIR, principalmente através de exercícios físicos (BENJAMIN; VAN DE WATER; PEIRIS, 2014). Supõe-se que a atividade física possa desempenhar um papel importante nesse contexto, razão pela qual intervenções com esse enfoque têm ganhado destaque (KEELER et al., 2012; BENJAMIN; VAN DE WATER; PEIRIS, 2014; BERG-POPPE et al., 2022). Presume-se que isso possa contribuir para a manutenção do tônus, força e controle dos músculos abdominais, gerando potencialmente um efeito protetor contra o desenvolvimento da DRA (BOISSONNAULT; BLASCHAK, 1988). No entanto, ainda não existem evidências suficientes para confirmar essa hipótese (BENJAMIN; VAN DE WATER; PEIRIS, 2014).

Apesar do número limitado de artigos científicos sobre a DRA, a prescrição de exercícios abdominais é bastante comum, principalmente aqueles que focam na ativação dos músculos da parede abdominal lateral, em especial o músculo transverso do abdômen (TrA) (KEELER et al., 2012). Isso se deve ao fato de que a ativação pode movimentar mecanicamente a linha alba, estimulando a formação e o alinhamento do colágeno, ampliando assim a sua capacidade de transmitir cargas (BUCKWALTER; GRODZINSKY, 1999; KJÆR et al., 2009; LEE; HODGES, 2016).

Em contraste, os exercícios que focam nos músculos retos abdominais são normalmente evitados, pois são considerados um risco para o desenvolvimento de DRA (BENJAMIN; VAN DE WATER; PEIRIS, 2014; BOISSONNAULT; BLASCHAK, 1988). No entanto, isso diverge do estudo transversal de Mota e colaboradores (2015), que visava determinar o efeito imediato de dois exercícios abdominais (um focado na ativação do músculo TrA e o outro na contração dos músculos retos abdominais) em gestantes e puérperas. Ao final, concluiu-se que o exercício focado na ativação dos músculos retos abdominais mostrou ser mais eficaz no estreitamento da DIR, em comparação com o exercício de ativação do músculo TrA (MOTA et al., 2015b).

A revisão sistemática de Gluppe e colaboradores (2021) também encontrou evidências insuficientes para recomendar programas de exercícios específicos para a DRA (GLUPPE; ELLSTRÖM ENGH; KARI, 2021). Isso reitera a falta de consenso e evidências na literatura sobre como lidar com essa condição.

O panorama contemporâneo de pesquisas sobre a DRA é permeado por uma notável ausência de concordância e evidências científicas, culminando em um déficit informativo entre numerosos fisioterapeutas acerca de como proceder clinicamente

com a DRA e a relevância do aumento da DIR como um problema de saúde (GUSTAVSSON; ERIKSSON-CROMMERT, 2020). A escassez de evidências tem propiciado um aumento nas intervenções cirúrgicas para DRA, as quais possuem potencial para desencadear complicações (NAHABEDIAN, 2018). Além disso, a maioria das pesquisas concentra-se em protocolos de tratamento (BENJAMIN; VAN DE WATER; PEIRIS, 2014; GLUPPE; ENGH; BØ, 2021; BENJAMIN et al., 2023), deixando um hiato de conhecimento sobre quais intervenções poderiam atenuar a separação dos músculos retos abdominais durante o período gestacional.

Adicionalmente, os estudos existentes são limitados e apresentam uma variedade de metodologias, muitos dos quais não exibem adequada qualidade metodológica nem consideram os efeitos em longo prazo (BENJAMIN; VAN DE WATER; PEIRIS, 2014; GLUPPE; ENGH; BØ, 2021; BENJAMIN et al., 2023). Isso ressalta a necessidade de um estudo que explore a correlação entre os exercícios e a DRA no contexto do cuidado pré-natal.

2. FUNDAMENTAÇÃO TEÓRICA

2.1. Distância Inter-Retos e Diástase dos Retos Abdominais

Desde a concepção, o corpo da mãe passa por inúmeras adaptações fisiológicas para garantir a nutrição e o desenvolvimento do feto (LOCKITCH; GAMER, 1997; TAN; TAN, 2013; SOMA-PILLAY et al., 2016). Essas alterações continuam e se intensificam à medida que a gestação avança, persistindo até o parto (TAN; TAN, 2013; SOMA-PILLAY et al., 2016). Caso a gestação transcorra sem complicações, a maioria dessas adaptações desaparecerá no pós-parto, de maneira imediata ou gradual (KAZMA et al., 2020).

Observam-se alterações em diversos sistemas do corpo, incluindo os sistemas cardíaco, renal, respiratório, endócrino e musculoesquelético (SOMA-PILLAY et al., 2016; KAZMA et al., 2020). No que se refere às alterações musculoesqueléticas, nota-se um aumento da lordose lombar, frouxidão ligamentar e maior mobilidade das articulações sacroilíacas e da sínfise púbica (SOMA-PILLAY et al., 2016). Adicionalmente, devido ao crescimento do útero gravídico e as alterações hormonais, ocorre uma modificação na anatomia dos músculos retos abdominais (GILLEARD & BROWN, 1996).

Esse músculo se arqueia ao redor do abdômen saliente, aumentando a sua distância fisiológica, a DIR, que comumente apresenta até 2,0 centímetros (BOISSONNAULT; BLASCHAK, 1988; FAST et al., 1990; GILLEARD & BROWN, 1996; REINPOLD et al., 2019). Com isso, ocorre um afastamento desse par de músculos, e um enfraquecimento e alargamento da linha alba, combinado com frouxidão do músculo abdominal (BOISSONNAULT; BLASCHAK, 1988; FAST et al., 1990; GILLEARD & BROWN, 1996). Quando isso acontece, temos o que é denominado de DRA (AXER; KEYSERLINGK; PRESCHER, 2001; REINPOLD et al., 2019).

Existem três sistemas retratados para a classificação da DRA: a classificação de Nahas, que se baseia na causa e na deformidade miofascial; a classificação de Rath, que se apoia no nível de abrandamento em relação ao umbigo e na idade do paciente; e a classificação de Beer, que se fundamenta na largura normal da linha alba (RATH et al., 1996; NAHAS FX, 2001; BEER et al., 2009). Quando se utilizam as

categorizações de Rath e Beer, o diagnóstico é obtido ao se medir a DIR (RATH et al., 1996; BEER et al., 2009).

A DRA não possui unanimidade quanto ao ponto de corte para o seu diagnóstico (VAN DE WATER; BENJAMIN, 2016). E há diversas categorias que apresentam relevância clínica, com a DIR oscilando entre 1,5 cm e 2,7 cm, e a sua localização podendo ser acima, abaixo e/ou ao nível do umbigo (BENJAMIN; VAN DE WATER; PEIRIS, 2014).

Existem vários métodos na literatura atual para a mensuração da DIR: largura dos dedos, paquímetro, fita métrica e ultrassom (US) (BENJAMIN et al., 2020). Além disso, é possível realizar essa medição através da tomografia computadorizada (TC) e ressonância magnética (RM), no entanto, esses instrumentos são de difícil acesso e apresentam alto custo (CHEN; ZHAO; HU, 2023). Dentre os métodos, o US tem ganhado destaque por ser um método confiável e não invasivo (LIAW et al., 2011; MOTA et al., 2012; VAN DE WATER; BENJAMIN, 2016).

A mensuração ultrassonográfica é realizada com o paciente em posição supina, apresentando flexão de joelho e de quadril (OPALA-BERDZIK et al., 2023). Este procedimento pode ser executado tanto em repouso quanto durante uma atividade muscular (OPALA-BERDZIK et al., 2023). As imagens são, comumente, capturadas ao final da expiração (OPALA-BERDZIK et al., 2023). Normalmente, empregam-se transdutores lineares, cujo tamanho varia entre 3 e 11 cm, e cuja frequência oscila entre 3 e 18 MHz (OPALA-BERDZIK et al., 2023). Adicionalmente, recursos extras podem ser utilizados nas configurações, como o modo panorâmico (OPALA-BERDZIK et al., 2023).

Em relação aos locais de medição, considerando que a linha alba varia em tamanho ao longo do abdômen, recomenda-se que a medida seja realizada em mais de um ponto (OPALA-BERDZIK et al., 2023). Dessa forma, a DIR é medida nas regiões supraumbilical (entre 2 cm e 12 cm acima do umbigo) e/ou infraumbilical (entre 2 cm e 4,5 cm abaixo do umbigo) (OPALA-BERDZIK et al., 2023). A região infraumbilical apresenta maiores desafios para a mensuração, devido à alta concentração de fibras transversais (OPALA-BERDZIK et al., 2023). Ademais, normalmente com o US, as medições não são realizadas no umbigo devido a dificuldades técnicas (CHIARELLO; MCAULEY, 2013).

A mensuração da DIR através do US é dependente do examinador, tornando-se necessário ter experiência prévia, para obter os resultados mais fidedignos (VAN

DE WATER; BENJAMIN, 2016; WIJNTJES; VAN ALFEN, 2021). Além disso, há uma falta de padronização em relação a essa mensuração, no que concerne aos locais de medição na região abdominal, ao diagnóstico de DRA, à posição do paciente para essa medição, ao momento da respiração e ao modo de ativação dos músculos abdominais (BENJAMIN; VAN DE WATER; PEIRIS, 2014; MOTA; GIL PASCOAL; BO, 2015; DUFOUR et al., 2019; WERNER; DAYAN, 2019; OPALA-BERDZIK et al., 2023).

A inexistência de normatização impacta na taxa real de prevalência da DRA, tornando-a desconhecida, apesar de ser frequente (CAVALLI et al., 2021). Essa é uma condição comum em mulheres, especialmente durante a gravidez, afetando aproximadamente 30 a 70% delas (BOISSONNAULT; BLASCHAK, 1988), com 33,1% sendo afetadas na 21ª semana gestacional (SPERSTAD et al., 2016). No período de seis semanas após o parto, a DRA está presente em 60% das novas mães (SPERSTAD et al., 2016). Embora possa se resolver naturalmente durante o pós-parto, essa situação pode persistir por um período mais longo, continuando a afetar 45,4% das mulheres seis meses após o parto e 32,6% doze meses após o parto (SPERSTAD et al., 2016). Além disso, está presente em mais de 52% das mulheres com sintomas uroginecológicos na menopausa (SPITZNAGLE; LEONG; VAN DILLEN, 2007).

Em relação aos fatores de risco para a DRA, a gravidez é um deles, de modo que quanto mais gestações uma mulher tiver, maior será a probabilidade de desenvolver essa condição (CAVALLI et al., 2021; WU et al., 2021). Contrariamente, a idade é considerada um fator de proteção, pois mulheres mais jovens têm maiores chances de apresentar DRA, o que pode estar relacionado à idade reprodutiva (WU et al., 2021). Ademais, um Índice de Massa Corporal (IMC) elevado é um fator de risco para o desenvolvimento de DRA, uma vez que pessoas com sobrepeso ou obesidade tendem a ter maior quantidade de gordura na região abdominal, o que pode aumentar a circunferência e a pressão intra-abdominal, levando ao afastamento dos retos (WU et al., 2021). A diabetes também é considerada um fator de risco, pois a doença pode levar à perda de função e massa muscular (WU et al., 2021).

É notório que a DRA está associada a uma protuberância abdominal, que pode resultar em uma imagem corporal negativa e, por sua vez, pode levar a uma qualidade de vida reduzida e, também, dor e fraqueza abdominal (BENJAMIN et al., 2019; GLUPPE; ELLSTRÖM ENGH; KARI, 2021). Adicionalmente, pode haver sintomas

uroginecológicos e o desenvolvimento de hérnias epigástricas e umbilicais (CHEESBOROUGH; DUMANIAN, 2015; OLSSON et al., 2019; GLUPPE et al., 2021).

Apesar de todas essas consequências, a prevenção e tratamento dessa disfunção ainda são desconhecidos (CHEN; ZHAO; HU, 2023). Isso tem provocado um aumento na procura por diretrizes, especialmente em situações em que a DRA não se resolve naturalmente após o parto (CARLSTEDT et al., 2021; LAFRAMBOISE; SCHLAFF; BARUTH, 2021). Dessa forma, existem duas opções de tratamento: cirúrgico e conservador (CARLSTEDT et al., 2021; LAFRAMBOISE; SCHLAFF; BARUTH, 2021). Prioriza-se, primeiramente, o tratamento conservador, que inclui alterações no estilo de vida, perda de peso e fisioterapia (CARLSTEDT et al., 2021; LAFRAMBOISE; SCHLAFF; BARUTH, 2021).

No que se refere à fisioterapia, os métodos encontrados na literatura que têm sido utilizados são: exercícios abdominais, treinamento dos músculos do assoalho pélvico (TMAP), tapping, terapia manual e Estimulação Elétrica Neuromuscular (EENM) (CHEN; ZHAO; HU, 2023). Entre estes, destacam-se os exercícios abdominais, pois acredita-se que sejam capazes de aumentar a força e a espessura da musculatura abdominal (BOISSONNAULT; BLASCHAK, 1988; GLUPPE; ELLSTRÖM ENGH; BØ, 2023). Portanto, gestantes devem ser encorajadas a praticá-los visando à prevenção da DRA (CHEN; ZHAO; HU, 2023).

Porém, muitos fisioterapeutas manifestam que há um déficit de informações sobre como abordar a DRA nos ambulatorios e a relevância do aumento da DIR como um problema clínico de saúde (GUSTAVSSON; ERIKSSON-CROMMERT, 2020). Devido a essa falta de evidências em relação à atuação fisioterapêutica para essa condição, as pesquisas demonstram que tem sido muito comum a execução de cirurgias para DRA (NAHABEDIAN, 2018). Isso, consequentemente, pode causar complicações para as mulheres, como infecção de ferida, seroma, dor crônica, cicatriz complexa e lesão visceral (NAHABEDIAN, 2018). Além disso, as taxas de recorrência após o tratamento cirúrgico variam de 0 a 40%, nos estudos que fizeram acompanhamento a longo prazo (CARLSTEDT et al., 2021).

2.2. Transverso do Abdômen e Diástase dos Retos Abdominais

O músculo transverso do abdômen (TrA) é o mais profundo dos músculos abdominais, e em conjunto com o oblíquo abdominal (externo e interno) compõe os músculos abdominais laterais (WILLIAMS, 1996; MOORE, DALLEY AND AGUR, 2009). Quando associados com os dois músculos abdominais anteriores (retos abdominais e piramidais), eles constituem a parede abdominal anterolateral (WILLIAMS, 1996; MOORE, DALLEY AND AGUR, 2009).

Esse músculo tem origem nas cartilagens costais da 7^a à 12^a costelas, fáscia toracolombar, crista ilíaca e ligamento inguinal, inserindo-se na linha alba, crista púbica e linha pectina do púbis (WILLIAMS, 1996; MOORE, DALLEY AND AGUR, 2009). Ele contorna horizontalmente da parte de trás para a frente do corpo, de forma que há um TrA de cada lado ligado por uma lâmina fascial que os associa e possibilita que trabalhem como um músculo sólido (WILLIAMS, 1996; MOORE, DALLEY AND AGUR, 2009).

Sua principal função é manutenção de tônus dos órgãos abdominais, assim ele é capaz de realizar contração bilateral (comprimindo vísceras abdominais, aumentando a pressão intra-abdominal) e contração unilateral (contração do tronco), estabilizando o tronco e a pelve (WILLIAMS, 1996; MOORE, DALLEY AND AGUR, 2009). Em consequência da compressão das vísceras abdominais, o TrA aumenta a pressão intra-abdominal, favorecendo ações expulsivas como expiração forçada, micção, defecação e na fase expulsiva do parto (WILLIAMS, 1996; MOORE, DALLEY AND AGUR, 2009). Além disso, sua ativação é capaz de gerar uma co-contração sinérgica dos músculos do assoalho pélvico (MAP) (BØ et al., 2009).

Em razão das suas características anatômicas e fisiológicas, o TrA tem ganhado destaque no manejo da DRA, através do exercício de retração (“drawing-in”) (KEELER et al., 2012). Esse exercício provoca uma contração concêntrica do TrA bilateralmente, associada com o deslizamento bilateral da fáscia abdominal anterior, aumentando a espessura do músculo oblíquo interno (HIDES et al., 2006). Com isso, acredita-se que ele seja capaz de diminuir a DIR, por gerar uma aproximação dos ventres dos músculos retos abdominais, reestabelecendo a integridade da linha alba e ampliando a tensão fascial, possibilitando transferência efetiva de carga e geração de torque (LEE; LEE; MCLAUGHLIN, 2008).

A revisão sistemática de Benjamin e van de Water (2014), que incluiu oito estudos, entre ensaios clínicos randomizados e estudos de caso (com um total de 336 mulheres, tanto gestantes quanto no período pós-parto), indicou que os exercícios focados na contração do TrA podem prevenir ou diminuir a DRA. Os resultados mostraram que, quando praticados durante a gestação, esses exercícios reduziram a chance de apresentar DRA e foram capazes de diminuir a largura da DIR, tanto durante o pré-natal quanto após o parto (BENJAMIN; VAN DE WATER; PEIRIS, 2014).

Em concordância com isso, o estudo piloto randomizado controlado realizado por Tuttle e colaboradores (2018) envolveu 33 mulheres puérperas (entre 6 e 12 semanas pós-parto). O estudo concluiu que os exercícios focados no TrA podem ser eficazes na diminuição da DIR, de modo que as avaliações foram realizadas mensurando a DIR com US. As participantes deste estudo receberam instruções para a correta execução do exercício de TrA, executaram avaliações em casa e tiveram contatos/visitas periódicas. Além disso, foram realizadas 12 semanas de exercícios. No entanto, os autores sugerem que os exercícios não foram supervisionados por um profissional de saúde, o que não garante que as participantes tenham executado os exercícios corretamente e/ou seguido todo o protocolo (TUTTLE et al., 2018).

Contrastando com esses resultados, o estudo experimental transversal de Sancho e colaboradores (2015), descreveu o efeito imediato de diferentes exercícios abdominais na DIR, medida através do US, em puérperas entre 10 e 12 semanas de pós-parto. Os autores concluíram que o exercício focado no TrA resultou em um aumento da DIR, enquanto o exercício focado nos retos abdominais gerou uma diminuição dessa distância. Assim, os autores alertaram sobre a recomendação desse tipo de exercício para mulheres que realizaram cesarianas (SANCHO et al., 2015).

Isso também se assemelha aos resultados do estudo experimental longitudinal de Theodorsen e colaboradores (2023). Nesta pesquisa, o objetivo foi avaliar o impacto imediato do repouso, da contração dos músculos do assoalho pélvico (MAP) e de cinco exercícios abdominais na DIR de gestantes, especificamente na 27ª e 37ª semana gestacional. A avaliação foi realizada por meio de US, na região supraumbilical (2 cm acima da borda umbilical) e infraumbilical (2 cm abaixo da borda umbilical). Ao final do estudo, observou-se um aumento da DIR nos exercícios com ativação do Tra (THEODORSEN et al., 2023).

Uma revisão sistemática atual com metanálise, realizada por Gluppe e colaboradores (2021), teve como um dos objetivos investigar a eficácia dos programas de exercícios para a DRA. Essa revisão foi composta por sete ensaios clínicos randomizados. Concluiu-se que há uma falta de padronização nos protocolos de exercícios, o que dificulta a comparação entre eles. Além disso, as evidências são muito fracas para afirmar que exercícios com foco no TrA possam ser mais efetivos para a DRA do que uma intervenção mínima (GLUPPE; ENGH; BØ, 2021).

2.3. Reto Abdominal e Diástase dos Retos Abdominais

O músculo reto abdominal, que é o mais superficial entre os músculos abdominais, origina-se das fibras laterais da crista púbica e das fibras mediais da sínfise púbica (MOORE, DALLEY AND AGUR, 2009; STANDRING, 2016; RAI et al., 2018). Localiza-se posterior ao músculo piramidal, medial aos músculos oblíquos (externo e interno) e ao transverso do abdômen (TrA), e lateral à linha alba (MOORE, DALLEY AND AGUR, 2009; STANDRING, 2016; RAI et al., 2018).

Este músculo insere-se na quinta à sétima cartilagens costais e no apêndice xifóide (MOORE, DALLEY AND AGUR, 2009; STANDRING, 2016; RAI et al., 2018). Ele é responsável por flexionar o tronco anteriormente, estabilizar e controlar a inclinação da pelve e, assim como o TrA, quando associado a outros músculos abdominais, é capaz de comprimir as vísceras abdominais, aumentando a pressão intra-abdominal (MOORE, DALLEY AND AGUR, 2009; STANDRING, 2016; RAI et al., 2018).

É separado pela linha alba, de modo que se apresenta em um par de ventres, entre o qual há um afastamento fisiológico, que é a DIR (MOORE, DALLEY AND AGUR, 2009; STANDRING, 2016; RAI et al., 2018; REINPOLD et al., 2019). A DIR aumenta gradualmente, durante a gestação, a partir da 14ª semana até o parto (GILLEARD & BROWN, 1996).

Diferentemente dos exercícios que ativam o TrA, muitos profissionais desaconselham as gestantes a realizarem exercícios focados na contração dos retos abdominais (como o “abdominal crunch” e o “curl-up”), quando o objetivo é prevenir o aumento ou diminuir a DIR (LIAW et al., 2011; BENJAMIN; VAN DE WATER; PEIRIS,

2014; GLUPPE; ENGH; BØ, 2021). No entanto, em contraste com a prática clínica comum, pesquisas experimentais constataram que esse tipo de exercício resulta em uma diminuição no tamanho da DIR (PASCOAL et al., 2014; SANCHO et al., 2015; LEE; HODGES, 2016; THEODORSEN; STRAND; BØ, 2019). Acredita-se que isso ocorra porque o fortalecimento dessa musculatura pode ser capaz de diminuir o diâmetro horizontal abdominal (SANCHO et al., 2015). Isso provocaria a formação de uma força horizontal que promoveria a diminuição do afastamento dos ventres dos músculos retos abdominais, consequentemente reduzindo a DIR (SANCHO et al., 2015).

O estudo transversal realizado por Mota e colaboradores (2015) apresentou uma perspectiva semelhante a isso. O objetivo era determinar o efeito imediato de dois exercícios abdominais em gestantes (com 35 a 41 semanas gestacionais) e puérperas: um focado na ativação do músculo TrA e o outro na contração dos retos abdominais. A conclusão indicou que o exercício voltado para a ativação dos retos abdominais foi mais eficaz no estreitamento da DIR, em comparação com a ativação do músculo TrA (MOTA et al., 2015a).

O ensaio clínico randomizado conduzido por Gluppe e colaboradores (2023) objetivou investigar a repercussão dos exercícios de ativação dos retos abdominais durante 12 semanas em mulheres que estavam entre 6 e 12 meses pós-parto, através de avaliações realizadas com o US. Concluiu, com base nos resultados, que esses exercícios não aumentaram a DIR e promoveram um aumento da força muscular abdominal e da espessura do reto abdominal, indicando que puérperas não devem ser desencorajadas de realiza-los (GLUPPE; ELLSTRÖM ENGH; BØ, 2023).

Observa-se que a literatura apresenta controvérsias significativas quanto aos efeitos concretos da prática de exercícios voltados para a ativação dos músculos retos abdominais e do transversos abdominal, especialmente no que se refere à DIR e à DRA. Além disso, a maior parte das pesquisas concentra-se em investigar protocolos de tratamento, e pouco é conhecido a respeito de intervenções que possam reduzir o afastamento das porções do músculo reto abdominal durante a gestação.

2.4. Exercícios Físicos na Gestação

A prática de exercícios físicos, em todas as fases da vida, promove inúmeros benefícios que superam os riscos para a maioria dos adultos, conforme afirmado pela Organização Mundial de Saúde (OMS) e pelo Colégio Americano de Medicina Desportiva (HASKELL et al., 2007; WORLD HEALTH ORGANIZATION, 2010). A gestação não é uma exceção a essa regra (WORLD HEALTH ORGANIZATION, 2010; ACOG COMMITTEE OPINION, 2020). Portanto, mulheres sem contraindicações que já eram fisicamente ativas, antes da gravidez, devem continuar com suas atividades físicas, enquanto aquelas que levavam um estilo de vida sedentário devem ser encorajadas a iniciar a prática de exercícios (WORLD HEALTH ORGANIZATION, 2010; ACOG COMMITTEE OPINION, 2020).

Recomenda-se que as gestantes realizem pelo menos 150 minutos de atividade física por semana para obter os benefícios dessa prática (WORLD HEALTH ORGANIZATION, 2010; MOTTOLA et al., 2018; ACOG COMMITTEE OPINION, 2020). Esses minutos devem ser distribuídos em pelo menos três dias da semana e os exercícios devem incluir tanto atividades aeróbicas quanto de resistência, bem como o treinamento dos músculos do assoalho pélvico (TMAP) (WORLD HEALTH ORGANIZATION, 2010; MOTTOLA et al., 2018; ACOG COMMITTEE OPINION, 2020).

Dentre os exercícios seguros para serem praticados durante a gestação estão incluídos: caminhada, uso de bicicleta estacionária, atividades aeróbicas, dança, exercícios de resistência (que podem ser realizados com pesos, faixas elásticas, entre outros), alongamentos, hidroterapia e hidroginástica (WORLD HEALTH ORGANIZATION, 2010; MOTTOLA et al., 2018; ACOG COMMITTEE OPINION, 2020). Os benefícios que podem ser obtidos com a prática incluem, entre outros: melhora na qualidade de vida, maior incidência de parto vaginal, menor incidência de Diabetes Mellitus Gestacional, de nascimento prematuro, de cesáreas, de distúrbios hipertensivos gestacionais, de depressão pós-parto, redução da incapacidade por dor, menores dores lombares e ciáticas (WORLD HEALTH ORGANIZATION, 2010; MOTTOLA et al., 2018; ACOG COMMITTEE OPINION, 2020).

Visando o alívio das dores lombares, é recomendado o fortalecimento dos músculos abdominais (ACOG COMMITTEE OPINION, 2020). No entanto, muitas mulheres sentem-se inseguras em realizar exercícios focados nessa musculatura durante a gestação, por receio de aumentar ou desenvolver DRA. Nestas situações, é possível obter esse fortalecimento de forma indireta, através de outros exercícios

(HODGES; RICHARDSON, 1997; SAUNDERS; RATH; HODGES, 2004; CLARK et al., 2021). Isso ocorre porque os músculos abdominais desempenham a função de controlar o tronco e a coluna, bem como a posição do tronco em relação à base de apoio do corpo (HODGES; RICHARDSON, 1997, 1999; ANDERSON; BEHM, 2005).

Dessa forma, é possível ativar essa musculatura mesmo em outros tipos de exercícios, como aqueles que envolvem a movimentação dos membros inferiores e superiores (HODGES; RICHARDSON, 1997; SAUNDERS; RATH; HODGES, 2004; CLARK et al., 2021). Uma sugestão é o exercício de agachamento, que é um exercício de cadeia cinética fechada, muito semelhante aos movimentos das atividades diárias e que é realizado através da flexão e extensão do quadril, joelho e tornozelo (CLARK; LAMBERT; HUNTER, 2012), sendo assim uma opção em um protocolo de exercícios para gestantes.

É crucial que a mulher mantenha o hábito de praticar exercícios físicos após o parto, retornando de forma gradual assim que receber a liberação médica (ACOG COMMITTEE OPINION, 2020). A incorporação contínua dessa prática em sua rotina não só contribui para a saúde e bem-estar, mas também facilita o desenvolvimento de um hábito saudável para toda a vida (ACOG COMMITTEE OPINION, 2020).

3. Objetivo Geral

Investigar os efeitos dos exercícios de ativação do músculo transverso do abdômen e dos exercícios de ativação dos músculos retos abdominais na distância inter-retos (DIR) em gestantes, comparando-os com exercícios que não envolvem a ativação específica dos músculos abdominais.

3.1. Objetivos Específicos

- Comparar o efeito dos exercícios de ativação do transverso do abdômen e dos exercícios de ativação dos retos abdominais na DIR em gestantes
- Avaliar o impacto dos exercícios com foco no transverso do abdômen na DIR em gestantes, em comparação com a execução de exercícios que não envolvem a ativação específica dos músculos abdominais
- Analisar o efeito dos exercícios de ativação dos retos abdominais na DIR em gestantes, em relação à execução de exercícios que não envolvem a ativação específica dos músculos abdominais
- Analisar os resultados obtidos no Questionário de Avaliação do Incômodo Relacionado às Disfunções do Assoalho Pélvico, antes e após a intervenção fisioterapêutica.
- Avaliar a confiabilidade interexaminador e intraexaminador das medições da DIR realizadas por ultrassonografia em mulheres nulíparas.
- Calcular a mínima diferença detectável e o erro padrão da medida das medições da DIR realizadas por ultrassonografia em mulheres nulíparas.

REFERÊNCIAS

- ACOG COMMITTEE OPINION, NUMBER 804. Physical Activity and Exercise During Pregnancy and the Postpartum Period. **Obstet Gynecol**, v. 135, p. 178–188, abr. 2020. <https://doi.org/10.1097/AOG.0000000000003772>
- ANDERSON, K.; BEHM, D. G. Trunk Muscle Activity Increases With Unstable Squat Movements. **Canadian Journal of Applied Physiology**, v. 30, n. 1, p. 33–45, 1 fev. 2005. <https://doi.org/10.1139/h05-103>
- AXER, H.; KEYSERLINGK, D. G. V.; PRESCHER, A. Collagen Fibers in Linea Alba and Rectus Sheaths. **Journal of Surgical Research**, v. 96, n. 1, p. 127–134, mar. 2001. <https://doi.org/10.1006/jsre.2000.6070>
- BEER, G. M. et al. The normal width of the linea alba in nulliparous women. **Clinical Anatomy**, v. 22, n. 6, p. 706–711, set. 2009. <https://doi.org/10.1002/ca.20836>
- BENJAMIN, D. R. et al. Relationship between diastasis of the rectus abdominis muscle (DRAM) and musculoskeletal dysfunctions, pain and quality of life: a systematic review. **Physiotherapy**, v. 105, n. 1, p. 24–34, mar. 2019. <https://doi.org/10.1016/j.physio.2018.07.002>
- BENJAMIN, D. R. et al. Establishing measurement properties in the assessment of inter-recti distance of the abdominal muscles in a postnatal women. **Musculoskeletal Science and Practice**, v. 49, p. 102–202, out. 2020. <https://doi.org/10.1016/j.msksp.2020.102202>
- BENJAMIN, D. R. et al. Conservative interventions may have little effect on reducing diastasis of the rectus abdominis in postnatal women – A systematic review and meta-analysis. **Physiotherapy**, v. 119, p. 54–71, jun. 2023. <https://doi.org/10.1016/j.physio.2023.02.002>
- BENJAMIN, D. R.; VAN DE WATER, A. T. M.; PEIRIS, C. L. Effects of exercise on diastasis of the rectus abdominis muscle in the antenatal and postnatal periods: a systematic review. **Physiotherapy**, v. 100, n. 1, p. 1–8, mar. 2014. <https://doi.org/10.1016/j.physio.2013.08.005>
- BERG-POPPE, P. et al. Use of Exercise in the Management of Postpartum Diastasis Recti: A Systematic Review. **Journal of Women's Health Physical Therapy**, v. 46, n. 1, p. 35–47, jan. 2022. <https://doi.org/10.1097/JWH.0000000000000231>
- BØ, K. et al. Evidence for benefit of transversus abdominis training alone or in combination with pelvic floor muscle training to treat female urinary incontinence: A systematic review. **Neurourology and Urodynamics**, v. 28, n. 5, p. 368–373, jun. 2009. <https://doi.org/10.1002/nau.20700>
- BOISSONNAULT, J. S.; BLASCHAK, M. J. Incidence of Diastasis Recti Abdominis During the Childbearing Year. **Physical Therapy**, v. 68, n. 7, p. 1082–1086, 1 jul. 1988. <https://doi.org/10.1093/ptj/68.7.1082>

BUCKWALTER, J. A.; GRODZINSKY, A. J. Loading of Healing Bone, Fibrous Tissue, and Muscle: Implications for Orthopaedic Practice: **Journal of the American Academy of Orthopaedic Surgeons**, v. 7, n. 5, p. 291–299, set. 1999. <https://doi.org/10.5435/00124635-199909000-00002>

CARLSTEDT, A. et al. Management of diastasis of the rectus abdominis muscles: recommendations for swedish national guidelines. **Scandinavian Journal of Surgery**, v. 110, n. 3, p. 452–459, set. 2021. <https://doi.org/10.1177/1457496920961000>

CAVALLI, M. et al. Prevalence and risk factors for diastasis recti abdominis: a review and proposal of a new anatomical variation. **Hernia**, v. 25, n. 4, p. 883–890, ago. 2021. <https://doi.org/10.1007/s10029-021-02468-8>

CHEESBOROUGH, J. E.; DUMANIAN, G. A. Simultaneous Prosthetic Mesh Abdominal Wall Reconstruction with Abdominoplasty for Ventral Hernia and Severe Rectus Diastasis Repairs: **Plastic and Reconstructive Surgery**, v. 135, n. 1, p. 268–276, jan. 2015. <https://doi.org/10.1097/PRS.0000000000000840>

CHEN, B.; ZHAO, X.; HU, Y. Rehabilitations for maternal diastasis recti abdominis: An update on therapeutic directions. **Heliyon**, v. 9, n. 10, p. e20956, out. 2023. <https://doi.org/10.1016/j.heliyon.2023.e20956>

CHIARELLO, C. M.; MCAULEY, J. A. Concurrent Validity of Calipers and Ultrasound Imaging to Measure Interrecti Distance. **Journal of Orthopaedic & Sports Physical Therapy**, v. 43, n. 7, p. 495–503, jul. 2013. <https://doi.org/10.2519/jospt.2013.4449>

CLARK, D. R. et al. Impact of resistance training status on trunk muscle activation in a fatiguing set of heavy back squats. **European Journal of Applied Physiology**, v. 121, n. 2, p. 597–608, fev. 2021. <https://doi.org/10.1007/s00421-020-04540-0>

CLARK, D. R.; LAMBERT, M. I.; HUNTER, A. M. Muscle activation in the loaded free barbell squat: a brief review. **J Strength Cond Res**, v. 26, n. 4, p. 1169–78, abril. 2012. <https://doi.org/10.1519/JSC.0b013e31822d533d>

DUFOUR, S. et al. Establishing Expert-Based Recommendations for the Conservative Management of Pregnancy-Related Diastasis Rectus Abdominis: A Delphi Consensus Study. **Journal of Women's Health Physical Therapy**, v. 43, n. 2, p. 73–81, abr. 2019. <https://doi.org/10.1097/JWH.0000000000000130>

FAST A, WEISS L, DUCOMMUN EJ, MEDINA E, BUTLER JG. Low-back pain in pregnancy. Abdominal muscles, sit-up performance, and back pain. **Spine (Phila Pa 1976)**, v. 15, p. 28–30, jan. 1990. <https://doi.org/10.1097/00007632-199001000-00008>

GILLEARD, W. L., & BROWN, J. M. Structure and function of the abdominal muscles in primigravid subjects during pregnancy and the immediate postbirth period. **Physical therapy**, v. 76, p. 750–762, 1996. <https://doi.org/10.1093/ptj/76.7.750>

GLUPPE, S. B.; ELLSTRÖM ENGH, M.; BØ, K. Curl-up exercises improve abdominal muscle strength without worsening inter-recti distance in women with diastasis recti abdominis postpartum: a randomised controlled trial. **Journal of**

Physiotherapy, v. 69, n. 3, p. 160–167, jul. 2023.

<https://doi.org/10.1016/j.jphys.2023.05.017>

GLUPPE, S.; ELLSTRÖM ENGH, M.; KARI, B. Women with diastasis recti abdominis might have weaker abdominal muscles and more abdominal pain, but no higher prevalence of pelvic floor disorders, low back and pelvic girdle pain than women without diastasis recti abdominis. **Physiotherapy**, v. 111, p. 57–65, jun. 2021.

<https://doi.org/10.1016/j.physio.2021.01.008>

GLUPPE, S.; ENGH, M. E.; BØ, K. What is the evidence for abdominal and pelvic floor muscle training to treat diastasis recti abdominis postpartum? A systematic review with meta-analysis. **Brazilian Journal of Physical Therapy**, v. 25, n. 6, p. 664–675, nov. 2021.

<https://doi.org/10.1016/j.bjpt.2021.06.006>

GUSTAVSSON, C.; ERIKSSON-CROMMERT, M. Physiotherapists' and midwives' views of increased inter recti abdominis distance and its management in women after childbirth. **BMC Women's Health**, v. 20, n. 1, p. 37, dez. 2020.

<https://doi.org/10.1186/s12905-020-00907-9>

HASKELL WL, LEE IM, PATE RR, POWELL KE, BLAIR SN, FRANKLIN BA, MACERA CA, HEATH GW, THOMPSON PD, BAUMAN A. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. **Med Sci Sports Exerc.**, v. 39, p. 1423–34, 2007. <https://doi.org/10.1249/mss.0b013e3180616b27>

HIDES, J. et al. An MRI Investigation Into the Function of the Transversus Abdominis Muscle During “Drawing-In” of the Abdominal Wall: **Spine**, v. 31, n. 6, p. E175–E178, mar. 2006. <https://doi.org/10.1097/01.brs.0000202740.86338.df>

HODGES, P. W.; RICHARDSON, C. A. Feedforward contraction of transversus abdominis is not influenced by the direction of arm movement. **Experimental Brain Research**, v. 114, n. 2, p. 362–370, 16 abr. 1997.

<https://doi.org/10.1007/PL00005644>

HODGES, P. W.; RICHARDSON, C. A. Transversus abdominis and the superficial abdominal muscles are controlled independently in a postural task. **Neuroscience Letters**, v. 265, n. 2, p. 91–4, abril 1999. [https://doi.org/10.1016/S0304-3940\(99\)00216-5](https://doi.org/10.1016/S0304-3940(99)00216-5)

KAZMA, J. M. et al. Anatomical and physiological alterations of pregnancy. **Journal of Pharmacokinetics and Pharmacodynamics**, v. 47, n. 4, p. 271–285, ago. 2020.

<https://doi.org/10.1007/s10928-020-09677-1>

KEELER, J. et al. Diastasis Recti Abdominis: A Survey of Women's Health Specialists for Current Physical Therapy Clinical Practice for Postpartum Women. **Journal of Women's Health Physical Therapy**, v. 36, n. 3, p. 131–142, set. 2012.

<https://doi.org/10.1097/JWH.0b013e318276f35f>

KJÆR, M. et al. From mechanical loading to collagen synthesis, structural changes and function in human tendon. **Scandinavian Journal of Medicine & Science in Sports**, v. 19, n. 4, p. 500–510, ago. 2009. <https://doi.org/10.1111/j.1600-0838.2009.00986.x>

LAFRAMBOISE, F. C.; SCHLAFF, R. A.; BARUTH, M. Postpartum Exercise Intervention Targeting Diastasis Recti Abdominis. **Int J Exerc Sci**, v. 14, n. 3, p. 400–409, abril. 2021. PMID: 34055160; PMCID: PMC8136546.

LEE, D. G.; LEE, L. J.; MCLAUGHLIN, L. Stability, continence and breathing: The role of fascia following pregnancy and delivery. **Journal of Bodywork and Movement Therapies**, v. 12, n. 4, p. 333–348, out. 2008.

<https://doi.org/10.1016/j.jbmt.2008.05.003>

LEE, D.; HODGES, P. W. Behavior of the Linea Alba During a Curl-up Task in Diastasis Rectus Abdominis: An Observational Study. **Journal of Orthopaedic & Sports Physical Therapy**, v. 46, n. 7, p. 580–589, jul. 2016.

<https://doi.org/10.2519/jospt.2016.6536>

LIAW, L.-J. et al. The Relationships Between Inter-recti Distance Measured by Ultrasound Imaging and Abdominal Muscle Function in Postpartum Women: A 6-Month Follow-up Study. **Journal of Orthopaedic & Sports Physical Therapy**, v. 41, n. 6, p. 435–443, jun. 2011. <https://doi.org/10.2519/jospt.2011.3507>

LOCKITCH, G.; GAMER, P. R. Clinical Biochemistry of Pregnancy. **Critical Reviews in Clinical Laboratory Sciences**, v. 34, n. 1, p. 67–139, jan. 1997.

<https://doi.org/10.3109/10408369709038216>

MOORE, K. L., DALLEY, A. F. AND AGUR, A. M. R. **Clinically Oriented Anatomy**. 6th edn. Lippincott Williams & Wilkins, 2009. ISBN 10: 1605476528 ISBN 13: 9781605476520

MOTA, P. et al. Test-Retest and Intrarater Reliability of 2-Dimensional Ultrasound Measurements of Distance Between Rectus Abdominis in Women. **Journal of Orthopaedic & Sports Physical Therapy**, v. 42, n. 11, p. 940–946, nov. 2012.

<https://doi.org/10.2519/jospt.2012.4115>

MOTA, P. et al. The Immediate Effects on Inter-rectus Distance of Abdominal Crunch and Drawing-in Exercises During Pregnancy and the Postpartum Period. **Journal of Orthopaedic & Sports Physical Therapy**, v. 45, n. 10, p. 781–788, out. 2015a.

<https://doi.org/10.2519/jospt.2015.5459>

MOTA, P. G. F. D. et al. Prevalence and risk factors of diastasis recti abdominis from late pregnancy to 6 months postpartum, and relationship with lumbo-pelvic pain.

Manual Therapy, v. 20, n. 1, p. 200–205, fev. 2015b.

<https://doi.org/10.1016/j.math.2014.09.002>

MOTA, P.; GIL PASCOAL, A.; BO, K. Diastasis Recti Abdominis in Pregnancy and Postpartum Period. Risk Factors, Functional Implications and Resolution. **Current Women s Health Reviews**, v. 11, n. 1, p. 59–67, 14 set. 2015.

<https://doi.org/10.2174/157340481101150914201735>

MOTTOLA, M. F. et al. 2019 Canadian guideline for physical activity throughout pregnancy. **British Journal of Sports Medicine**, v. 52, n. 21, p. 1339–1346, nov. 2018.

<https://doi.org/10.1136/bjsports-2018-100056>

NAHABEDIAN, M. Management Strategies for Diastasis Recti. **Seminars in Plastic Surgery**, v. 32, n. 03, p. 147–154, ago. 2018. <https://doi.org/10.1055/s-0038-1661380>

NAHAS FX. An aesthetic classification of the abdomen based on the myoaponeurotic layer. **Plast Reconstr Surg**, v. 108, p. 1787–95, 2001. <https://doi.org/10.1097/00006534-200111000-00058>

OLSSON, A. et al. Cohort study of the effect of surgical repair of symptomatic diastasis recti abdominis on abdominal trunk function and quality of life. **BJS Open**, v. 3, n. 6, p. 750–758, dez. 2019. <https://doi.org/10.1002/bjs5.50213>

OPALA-BERDZIK A, RUDEK-ZEPRZAŁKA M, NIESPOREK J, CEBULA M, BARON J, GRUSZCZYŃSKA K, PASCOAL AG, MOTA P, CHMIELEWSKA D. Technical aspects of inter-recti distance measurement with ultrasonographic imaging for physiotherapy purposes: the scoping review. **Insights Imaging**, v. 14, p. 92, 18 maio 2023. <https://doi.org/10.1186/s13244-023-01443-4>

PASCOAL, A. G. et al. Inter-rectus distance in postpartum women can be reduced by isometric contraction of the abdominal muscles: a preliminary case–control study. **Physiotherapy**, v. 100, n. 4, p. 344–348, dez. 2014. <https://doi.org/10.1016/j.physio.2013.11.006>

PETER L. WILLIAMS. **Gray's Anatomy: The Anatomical Basis of Medicine and Surgery**. 38. ed. Churchill Livingstone, 1996.

RAI, R. et al. Tendinous Inscriptions of the Rectus Abdominis: A Comprehensive Review. **Cureus**, 4 ago. 2018. <https://doi.org/10.7759/cureus.3100>

RATH, A. et al. The abdominal linea alba: an anatomo-radiologic and biomechanical study. **Surgical and Radiologic Anatomy**, v. 18, n. 4, p. 281–288, dez. 1996. <https://doi.org/10.1007/BF01627606>

REINPOLD, W. et al. Classification of Rectus Diastasis—A Proposal by the German Hernia Society (DHG) and the International Endohernia Society (IEHS). **Frontiers in Surgery**, v. 6, p. 1, 28 jan. 2019. <https://doi.org/10.3389/fsurg.2019.00001>

SANCHO, M. F. et al. Abdominal exercises affect inter-rectus distance in postpartum women: a two-dimensional ultrasound study. **Physiotherapy**, v. 101, n. 3, p. 286–291, set. 2015. <https://doi.org/10.1016/j.physio.2015.04.004>

SAUNDERS, S. W.; RATH, D.; HODGES, P. W. Postural and respiratory activation of the trunk muscles changes with mode and speed of locomotion. **Gait & Posture**, v. 20, n. 3, p. 280–290, dez. 2004. <https://doi.org/10.1016/j.gaitpost.2003.10.003>

SOMA-PILLAY, P. et al. Physiological changes in pregnancy. **Cardiovascular Journal of Africa**, v. 27, n. 2, p. 89–94, 18 maio 2016. <https://doi.org/10.5830/CVJA-2016-021>

SPERSTAD, J. B. et al. Diastasis recti abdominis during pregnancy and 12 months after childbirth: prevalence, risk factors and report of lumbopelvic pain. **British**

Journal of Sports Medicine, v. 50, n. 17, p. 1092–1096, set. 2016.
<https://doi.org/10.1136/bjsports-2016-096065>

SPITZNAGLE, T. M.; LEONG, F. C.; VAN DILLEN, L. R. Prevalence of diastasis recti abdominis in a urogynecological patient population. **International Urogynecology Journal**, v. 18, n. 3, p. 321–328, mar. 2007. <https://doi.org/10.1007/s00192-006-0143-5>

STANDRING, S. **Gray's Anatomy: The Anatomical Basis of Clinical Practice**. 41. ed. Elsevier, 2016.

TAN, E. K.; TAN, E. L. Alterations in physiology and anatomy during pregnancy. **Best Practice & Research Clinical Obstetrics & Gynaecology**, v. 27, n. 6, p. 791–802, dez. 2013. <https://doi.org/10.1016/j.bpobgyn.2013.08.001>

THEODORSEN, N.-M. et al. Effect of exercise on the inter-rectus distance in pregnant women with diastasis recti abdominis: an experimental longitudinal study. **Physiotherapy**, v. 121, p. 13–20, dez. 2023.
<https://doi.org/10.1016/j.physio.2023.08.001>

THEODORSEN, N.-M.; STRAND, L. I.; BØ, K. Effect of pelvic floor and transversus abdominis muscle contraction on inter-rectus distance in postpartum women: a cross-sectional experimental study. **Physiotherapy**, v. 105, n. 3, p. 315–320, set. 2019.
<https://doi.org/10.1016/j.physio.2018.08.009>

TUTTLE, L. J. et al. Noninvasive Treatment of Postpartum Diastasis Recti Abdominis: A Pilot Study. **Journal of Women's Health Physical Therapy**, v. 42, n. 2, p. 65–75, maio 2018. <https://doi.org/10.1097/JWH.000000000000101>

VAN DE WATER, A. T. M.; BENJAMIN, D. R. Measurement methods to assess diastasis of the rectus abdominis muscle (DRAM): A systematic review of their measurement properties and meta-analytic reliability generalisation. **Manual Therapy**, v. 21, p. 41–53, fev. 2016. <https://doi.org/10.1016/j.math.2015.09.013>

WERNER, L. A.; DAYAN, M. Diastasis Recti Abdominis-diagnosis, Risk Factors, Effect on Musculoskeletal Function, Framework for Treatment and Implications for the Pelvic Floor. **Current Women's Health Reviews**, v. 15, n. 2, p. 86–101, 7 fev. 2019. <https://doi.org/10.2174/1573404814666180222152952>

WIJNTJES, J.; VAN ALFEN, N. Muscle ultrasound: Present state and future opportunities. **Muscle & Nerve**, v. 63, n. 4, p. 455–466, abr. 2021.
<https://doi.org/10.1002/mus.27081>

WORLD HEALTH ORGANIZATION. Global recommendations on physical activity for health. **Recommandations mondiales sur l'activité physique pour la santé**, p. 58, 2010.

WU, L. et al. Diastasis recti abdominis in adult women based on abdominal computed tomography imaging: Prevalence, risk factors and its impact on life. **Journal of Clinical Nursing**, v. 30, n. 3–4, p. 518–527, fev. 2021.
<https://doi.org/10.1111/jocn.15568>

ARTIGO 1

Reliability and Minimal Detectable Change of Inter-Recti Distance Measurement by Ultrasonography in Nulliparous Women

Artigo a ser submetido ao periódico Journal of Ultrasound in Medicine (JUM) - JCR:
2.3

Abstract

Objective: To analyze the interrater and intrarater reliability of inter-recti distance (IRD) measurement, using ultrasonography, in nulliparous women. **Methods:** Twenty-one nulliparous women, aged between 18 and 52 years, were recruited. Initially, an online questionnaire was applied to collect socioeconomic and anthropometric data. Then, the IRD measurement was performed by two experienced radiologists (Examiner 1 and Examiner 2) who were blinded to each other's measurements. The IRD measurement was performed with the participant in two different positions (at rest and with trunk flexion) and in two different regions (supraumbilical and infraumbilical). **Results:** The IRD measurements had high intrarater reliability for all variables, with intraclass correlation coefficients (ICC) above 0.80. The results showed moderate reliability and agreement between the examiners in the supraumbilical region in both positions, with ICC: rest: 0.720 (0.492, 0.857) and flexion 0.760 (0.447, 0.891). However, the reliability and agreement were low in the infraumbilical region in both positions, rest: 0.276 (-0.038, 0.558) and flexion 0.257 (-0.109, 0.564). **Conclusion:** Ultrasound is a reliable method for measuring IRD in the supraumbilical region, in both resting and trunk flexion positions, with very good intrarater reliability and good interrater reliability.

Keywords: inter-recti distance; ultrasonography; reliability; nulliparous women; diastasis.

Introduction

Diastasis recti abdominis (DRA) is a condition characterized by an increased inter-recti distance (IRD), which is the separation between the rectus abdominis muscles.^{1,2} DRA can affect both men and women, but it is more prevalent in the latter group, especially during pregnancy and postpartum.^{3,4} In the context of one year postpartum, it is observed that 33% of women continue to exhibit symptoms of DRA.³⁻⁶

DRA is not only an aesthetic concern, as it may cause the abdomen to appear flaccid and protruded, but also a functional problem, as it is associated with abdominal, lumbar, and pelvic pain, as well as pelvic floor dysfunctions.^{7,8} Moreover, DRA can impair the abdominal muscles' ability to stabilize the trunk and prevent the abdominal wall from bulging during physical activities.^{9,10} This can increase the intra-abdominal pressure and lead to the development of epigastric and umbilical hernias over time.^{9,10}

Given these consequences, it is essential to assess DRA accurately for diagnosis and monitoring. Ultrasound has been recommended as a reliable method for measuring IRD.¹¹⁻¹³ Nonetheless, the scoping review by Opala-Berdzik *et al.* (2023)¹⁴ indicated a lack of standardization in the measurement of IRD using this method among existing studies. They also developed recommendations for conducting the assessment using ultrasound, based on the review findings.¹⁴

However, no research articles implementing the recommendations outlined in this scoping review have been found. Therefore, it is important to conduct research that investigates the reliability of ultrasound in measuring DIR, using the indications suggested by the scoping review. Thus, this study aims to analyze the inter-rater and intra-rater reliability of inter-recti distance measurements via ultrasonography in nulliparous women.

Methods

The investigation was an interrater and intrarater reliability study that applied the Guidelines for Reporting Reliability and Agreement Studies (GRRAS)¹⁵ and was conducted at the Clinical Hospital of the Federal University of Uberlândia in Brazil in October 2022.

Ethical approval was obtained from the Ethics and Research Committee of the Federal University of Uberlândia (no.5.591.586). All participants were informed about the objectives of the study and signed a consent form.

The estimated sample size was based on guidance from Walter et al. (1998)¹⁶ who suggested that with 2 raters, a significance level of 0.05, and power of 80%, 19 samples were required to determine an ICC score of 0.7.¹⁶ A 10% greater number of participants were included in case of possible sample loss, totaling 21 participants.

To compose the sample, an announcement was made among university community and those who showed interest were connected to verify the criteria. The inclusion criteria were nulliparous women, regardless of their age and body mass index (BMI). The exclusion criteria were participants with some limitation that prevented the understanding/execution of the proposed procedures.

The initial phase of the research was to assess the participants' socioeconomic (age) and anthropometric (height, weight, Body Mass Index – BMI) characteristics using an online questionnaire.

Subsequently, the IRD measurement was performed, using an ultrasound device, by two examiners. One of the examiners was a radiologist with more than ten years of experience in performing ultrasounds, while the other had three years of experience. The PHILIPS EPIQ5r USA equipment was used, with a 5-12 MHz linear probe, 45-mm linear transducer and a musculoskeletal preset. Additional features were also used: panoramic imaging, trapezoid mode, and extended field-of-view to measure wider DRA.

The IRD measurement was performed with the participant in two different positions (at rest and with trunk flexion) and in two different regions (supraumbilical and infraumbilical). Furthermore, in each region, for each position, two IRD measurements were taken and then the average was calculated to obtain the final IRD value.

To measure the IRD, the participants were positioned in supine, with their knees flexed at 90 degrees, their arms placed by their sides and their feet resting on the examination table. Next, a researcher who was not one of the two examiners marked the participants' skin with a

marker, to standardize the measurement locations for the IRD measures. Two markings were made: 2 cm above the upper umbilical edge (supra-umbilical) and 2 cm below the lower umbilical edge (infra-umbilical).^{13,17–23} These distances were measured with a tape measure.

Each examiner entered the room only after the other examiner had completed and left the room, ensuring that they were blind to each other's measurements. Additionally, there was no communication between the examiners during the evaluations.

First, the IRD measurement was performed in the resting position. For this, the participant remained in the initial position, where the skin markings were made, and maintained her natural breathing pattern. Then, Examiner 1 positioned the transducer transversely on the mark of the supraumbilical region and, at the end of the participant's expiration, measured the IRD. Next, a 1-minute interval was performed, and the same procedure was repeated. After that, the measurement of the infraumbilical region was performed, following the same procedures.

For the measurement of the IRD in the trunk flexion position, the transducer position and the sequence of procedures adopted by Examiner 1 were the same as in the resting position. The participant kept her knees at 90 degrees, with her feet in contact with the examination table and her arms positioned in front of her body.^{24,25} She was subsequently instructed to execute a trunk flexion, engaging the abdominal muscles to a degree sufficient to facilitate the elevation of the shoulders and scapulae from the examination table, coinciding with an exhalation.^{24,25} At the end of the expiration, Examiner 1 performed the IRD measurement. For each measurement and each region (supraumbilical and infraumbilical), the participant performed the trunk flexion.

It was standardized that Examiner 1 always performed the measurements first. After completing the measurements, Examiner 1 left the room. Subsequently, Examiner 2 entered and performed the DIR measurement, adhering to the same criteria as established.

After a week, the examiners repeated all the same measurements with the same participants to assess the intra-examiner reliability.

Statistical Analysis

We used descriptive analysis to characterize the sociodemographic and clinical variables. For quantitative variables, we reported the mean, standard deviation, and 95% confidence interval. For qualitative variables, we reported the percentages. We assessed the

interrater and intrarater reliability using the intraclass correlation coefficient (ICC) with a 1-way random-effects model. We followed Altman's scale to classify the reliability values: poor ($ICC \leq 0.20$), fair ($0.21 \leq ICC \leq 0.40$), moderate ($0.41 \leq ICC \leq 0.60$), good ($0.61 \leq ICC \leq 0.80$), and very good ($0.81 \leq ICC \leq 1.00$).

The standard error of measurement (SEM) and coefficients of variation (CV) were calculated. The minimal detectable change (MDC) was calculated as $MDC = SEM * 1.96 * \sqrt{2}$.²⁶ We set the significance level at 5%. We performed the analysis using Jamovi software (Version 1.6).

Results

The study involved 21 participants, with a mean age of 28.12 and a mean BMI of 24.14. The sample had the following characteristics: mean weight of 63.80 kg e mean height of 162.09 cm. Table 1 summarizes these data.

Table 1. Clinical and demographic characteristics of the study participants.

Variables		<i>CI (95%)</i>
Age (years), mean (SD)	28.12 (6.24)	24.11 to 29.79
Weight (kg), mean (SD)	63.80 (13.97)	57.45 to 70.17
Height (cm), mean (SD)	162.09 (5.83)	159.44 to 164.74
Body mass index (kg/m ²), mean (SD)	24.14 (4.31)	22.18 to 26.11

Ultrasound Intrarater Reliability

Table 2 shows the mean and 95% confidence interval (CI) of the inter-recti distance (IRD) in centimeters (cm) for each examiner and each variable: supraumbilical rest, infraumbilical rest, supraumbilical flexion, and infraumbilical flexion.

Table 2. IRD mean and CI by Examiner and Variable.

	Examiner 1	Examiner 2	Examiner 1	Examiner 2
	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>CI (95%)</i>	<i>CI (95%)</i>
Supraumbilical rest	0.789 (0.30)	0.855 (0.30)	0.657, 0.920	0.723, 0.987
Infraumbilical rest	0.361 (0.11)	0.268 (0.07)	0.312, 0.409	0.234, 0.302
Supraumbilical trunk flexion	0.872 (0.38)	1.04 (0.395)	0.707, 1.21	0.868, 1.21
Infraumbilical trunk flexion	0.507 (0.25)	0.455 (0.14)	0.400, 0.614	0.393, 0.517

mean= mean value of the outcome's distribution; SD= standard deviation of the mean value of the outcome's distribution; CI= 95% confidence interval.

Table 3 reports the intraclass correlation coefficient (ICC) and confidence interval (CI 95%) values for each Examiner in the supraumbilical and infraumbilical regions and the two positions of the participants: rest and flexion. The table also presents the SEM, MDC, and CV% for each variable. The examiners demonstrated high ICC values for all regions, indicating very good intrarater reliability. It is noteworthy that the ICC values are higher for the supraumbilical region compared to the infraumbilical region, suggesting an easier evaluation of this area. The confidence intervals, denoted in parentheses, are relatively narrow, demonstrating good precision of the ICC values.

Table 3. ICC (CI 95%), SEM, MDC and CV% values by Examiner, Region and Position.

IRD (cm)	ICC (CI 95%)	SEM	MDC	CV%
Examiner 1				
Supraumbilical rest	0.923 (0.845, 0.963)	0.0870	0.2412	7.95
Infraumbilical rest	0.913 (0.826, 0.958)	0.0344	0.0954	6.89
Supraumbilical trunk flexion	0.980 (0.959, 0.991)	0.0546	0.1513	4.44
Infraumbilical trunk flexion	0.912 (0.823, 0.957)	0.0753	0.2087	10.64
Examiner 2				
Supraumbilical rest	0.904 (0.807, 0.954)	0.0949	0.2630	7.92
Infraumbilical rest	0.848 (0.705, 0.925)	0.0316	0.0876	8.56
Supraumbilical trunk flexion	0.939 (0.873, 0.971)	0.0962	0.2667	6.56
Infraumbilical trunk flexion	0.839 (0.689, 0.920)	0.0610	0.1691	9.88

ICC= Intraclass Correlation Coefficient; SEM= Standard Error of Measurement (cm); MDC= Minimal Detectable Change (cm); CV= Coefficient of Variation.

Ultrasound Interrater Reliability

Table 4 shows the ICC (CI 95%), SEM, MDC and CV% values for the comparison between Examiner 1 and Examiner 2 in the rest and flexion positions and in the supraumbilical and infraumbilical regions. The supraumbilical region had good reliability, while the infraumbilical region had poor reliability in both positions.

Table 4. ICC (CI 95%), SEM, MDC and CV% values for the comparison between Examiner 1 and Examiner 2 by position and region.

IRD (cm)	ICC (CI 95%)	SEM	MDC	CV%
Supraumbilical rest	0.720 (0.492, 0.857)	0.1751	0.4854	16.28
Infraumbilical rest	0.276 (-0.038, 0.558)	0.0807	0.2237	21.87
Supraumbilical trunk flexion	0.760 (0.447, 0.891)	0.1763	0.4887	13.62
Infraumbilical trunk flexion	0.257 (-0.109, 0.564)	0.1832	0.5078	34.11

ICC= Intraclass Correlation Coefficient; SEM= Standard Error of Measurement (cm); MDC= Minimal Detectable Change (cm); CV= Coefficient of Variation.

Discussion

The present study demonstrated a very good intrarater reliability, with ICC above 0.81, in both resting and trunk flexion positions, in the supraumbilical and infraumbilical regions, assessed by ultrasound. Regarding interrater reliability, the supraumbilical region, in the resting position and trunk flexion, had good reliability, also evaluated by ultrasound, using the same protocol and equipment.

These results are consistent with the data presented in the review and meta-analysis by Van de Water and Benjamin (2016)¹¹, demonstrating that ultrasound is a reliability method for assessing IRD. Additionally, it is cost-effective and non-invasive.²⁷ However, its reliability is dependent on the examiner's expertise. In our study, we employed examiners with years of experience, ensuring the reliability of our data.^{11,27}

Moreover, our investigation adhered to numerous guidelines outlined in the scoping review by Opala-Berdzik *et al.* (2023)¹⁴. These guidelines pertain to the position of the participant (knees at 90 degrees, with feet touching the examination table), the timing of IRD measurement (at the end of expiration), and the regions of measurement (supraumbilical and infraumbilical).

Concerning interrater reliability in the infraumbilical region, in both positions, the ICC values were low. A possible explanation for this is that the region below the umbilicus has more transverse fibers, which result in greater resistance to stretching, determined by the linea alba.^{9,28} Consequently, this region has a very narrow IRD, especially in nulliparous women, which can complicate the analysis.^{9,28} Moreover, this location typically contains more subcutaneous fat, which further complicates the assessment.¹²

We also calculated the Minimal Detectable Change (MDC), alternatively referred to as the smallest detectable change or smallest real change.²⁹ This statistical measure identifies the smallest change in a measurement that can be considered significant, distinguishing it from random variations or measurement errors.²⁹ Consequently, the MDC plays a crucial role in assessing the accuracy and reliability of measurements in both intra-rater and inter-rater reliability studies, ensuring that the measurements are accurate, reliable, and reproducible.²⁹ A lower MDC value, therefore, enhances the reliability and accuracy of the measurements. In the study by Liaw *et al.* (2011),¹² which utilized ultrasound to analyze the change in IRD and

abdominal strength and endurance in postpartum women and to relate IRD to muscle function, the MDC values for the IRD measurements ranged from 0.33 to 0.55 cm, like the findings in the present study which varied between 0.22 and 0.50 cm.

A strength of our study is the fact that the examiners are blind to each other's measurements and are experienced radiologists, this has an impact on the quality of the evaluation. Furthermore, all participants were positioned, marked in the abdominal region, and instructed in the same way to standardize the IRD measurements, which ensured that the two examiners performed the procedure under comparable conditions.

In addition, a homogeneous group was used, as it is known that the IRD varies by gender and parity.⁴ Therefore, examiners must consider the variations in the characteristics of the individuals when evaluating other populations.³⁰

Our results indicate that the measurement of IRD, using the ultrasound device, and following the methodology adopted in this study, can generate reliable results, thus contributing to the accurate assessment of the presence or absence of DRA. These results can also be useful for the evaluation of DRA in non-pregnant women, since the study sample consisted of nulliparous women who had not experienced pregnancy or childbirth, which are known risk factors for DRA.

It is suggested that more studies investigate the reliability of ultrasound in different populations and its ability to verify changes in IRD before and after DRA interventions.

Conclusion

Based on the results of this study, the authors conclude that ultrasound is a reliable method for measuring IRD in the supraumbilical region, in both resting and trunk flexion positions, with very good intrarater reliability and good interrater reliability.

References

1. Benjamin DR, van de Water ATM, Peiris CL. Effects of exercise on diastasis of the rectus abdominis muscle in the antenatal and postnatal periods: a systematic review. *Physiotherapy*. 2014;100(1):1-8. doi:10.1016/j.physio.2013.08.005
2. Michalska A, Rokita W, Wolder D, Pogorzelska J, Kaczmarczyk K. Diastasis recti abdominis — a review of treatment methods. *Ginekologia Polska*. 2018;89(2):5.
3. Boissonnault JS, Blaschak MJ. Incidence of Diastasis Recti Abdominis During the Childbearing Year. *Physical Therapy*. 1988;68(7):1082-1086. doi:10.1093/ptj/68.7.1082
4. Chiarello CM, Zellers JA, Sage-King FM. Predictors of Inter-recti Distance in Cadavers. *Journal of Women's Health Physical Therapy*. 2012;36(3):125-130. doi:10.1097/JWH.0b013e318276f60e
5. Mota PGF da, Pascoal AGBA, Carita AIAD, Bø K. Prevalence and risk factors of diastasis recti abdominis from late pregnancy to 6 months postpartum, and relationship with lumbo-pelvic pain. *Manual Therapy*. 2015;20(1):200-205. doi:10.1016/j.math.2014.09.002
6. Sperstad JB, Tennfjord MK, Hilde G, Ellström-Engh M, Bø K. Diastasis recti abdominis during pregnancy and 12 months after childbirth: prevalence, risk factors and report of lumbopelvic pain. *Br J Sports Med*. 2016;50(17):1092-1096. doi:10.1136/bjsports-2016-096065
7. Benjamin DR, Frawley HC, Shields N, van de Water ATM, Taylor NF. Relationship between diastasis of the rectus abdominis muscle (DRAM) and musculoskeletal dysfunctions, pain and quality of life: a systematic review. *Physiotherapy*. 2019;105(1):24-34. doi:10.1016/j.physio.2018.07.002
8. Parker MA, Millar LA, Dugan SA. Diastasis Rectus Abdominis and Lumbo-Pelvic Pain and Dysfunction-Are They Related?. *Journal of Women's Health Physical Therapy*. 2009;33(2):15-22. doi:10.1097/01274882-200933020-00003
9. Mendes D de A, Nahas FX, Veiga DF, et al. Ultrasonography for measuring rectus abdominis muscles diastasis. *Acta Cir Bras*. 2007;22(3):182-186. doi:10.1590/S0102-86502007000300005

10. Cheesborough JE, Dumanian GA. Simultaneous Prosthetic Mesh Abdominal Wall Reconstruction with Abdominoplasty for Ventral Hernia and Severe Rectus Diastasis Repairs. *Plastic and Reconstructive Surgery*. 2015;135(1):268-276.
doi:10.1097/PRS.0000000000000840
11. van de Water ATM, Benjamin DR. Measurement methods to assess diastasis of the rectus abdominis muscle (DRAM): A systematic review of their measurement properties and meta-analytic reliability generalisation. *Manual Therapy*. 2016;21:41-53.
doi:10.1016/j.math.2015.09.013
12. Liaw LJ, Hsu MJ, Liao CF, Liu MF, Hsu AT. The Relationships Between Inter-recti Distance Measured by Ultrasound Imaging and Abdominal Muscle Function in Postpartum Women: A 6-Month Follow-up Study. *J Orthop Sports Phys Ther*. 2011;41(6):435-443.
doi:10.2519/jospt.2011.3507
13. Mota P, Pascoal AG, Sancho F, Bø K. Test-Retest and Intrarater Reliability of 2-Dimensional Ultrasound Measurements of Distance Between Rectus Abdominis in Women. *J Orthop Sports Phys Ther*. 2012;42(11):940-946. doi:10.2519/jospt.2012.4115
14. Opala-Berdzik A, Rudek-Zeprzałka M, Niesporek J, et al. Technical aspects of inter-recti distance measurement with ultrasonographic imaging for physiotherapy purposes: the scoping review. *Insights Imaging*. 2023;14(1):92. doi:10.1186/s13244-023-01443-4
15. Kottner J, Audigé L, Brorson S, et al. Guidelines for Reporting Reliability and Agreement Studies (GRRAS) were proposed. *Journal of Clinical Epidemiology*. 2011;64(1):96-106. doi:10.1016/j.jclinepi.2010.03.002
16. Walter SD, Eliasziw M, Donner A. Sample size and optimal designs for reliability studies. *Statist Med*. 1998;17(1):101-110. doi:10.1002/(SICI)1097-0258(19980115)17:1<101::AID-SIM727>3.0.CO;2-E
17. Gluppe SB, Engh ME, Bø K. Immediate Effect of Abdominal and Pelvic Floor Muscle Exercises on Interrecti Distance in Women With Diastasis Recti Abdominis Who Were Parous. *Physical Therapy*. 2020;100(8):1372-1383. doi:10.1093/ptj/pzaa070
18. Theodorsen NM, Fersum KV, Moe-Nilssen R, Bo K, Haukenes I. Effect of a specific exercise programme during pregnancy on diastasis recti abdominis: study protocol for a

randomised controlled trial. *BMJ Open*. 2022;12(2):e056558. doi:10.1136/bmjopen-2021-056558

19. Mota P, Pascoal AG, Carita AI, Bø K. The Immediate Effects on Inter-rectus Distance of Abdominal Crunch and Drawing-in Exercises During Pregnancy and the Postpartum Period. *J Orthop Sports Phys Ther*. 2015;45(10):781-788. doi:10.2519/jospt.2015.5459
20. Theodorsen NM, Strand LI, Bø K. Effect of pelvic floor and transversus abdominis muscle contraction on inter-rectus distance in postpartum women: a cross-sectional experimental study. *Physiotherapy*. 2019;105(3):315-320. doi:10.1016/j.physio.2018.08.009
21. Iwan T, Garton B, Ellis R, HSc P. The reliability of measuring the inter-recti distance using high- resolution and low-resolution ultrasound imaging comparing a novice to an experienced sonographer. *New Zealand J of Phys*. 2014; 42 (3):154-162. doi: 10.15619/NZJP/42.3.07
22. Balasch-Bernat M, Pérez-Alenda S, Carrasco JJ, Valls-Donderis B, Dueñas L, Fuentes-Aparicio L. Differences in Inter-Rectus Distance and Abdominopelvic Function between Nulliparous, Primiparous and Multiparous Women. *IJERPH*. 2021;18(23):12396. doi:10.3390/ijerph182312396
23. Depledge J, McNair P, Ellis R. Exercises, Tubigrip and taping: can they reduce rectus abdominis diastasis measured three weeks post-partum? *Musculoskeletal Science and Practice*. 2021;53:102381. doi:10.1016/j.msksp.2021.102381
24. Barbosa S, de Sá RAM, Coca Velarde LG. Diastasis of rectus abdominis in the immediate puerperium: correlation between imaging diagnosis and clinical examination. *Arch Gynecol Obstet*. 2013;288(2):299-303. doi:10.1007/s00404-013-2725-z
25. Belo M, Melo A, Delgado A, Costa A, Anísio V, Lemos A. The Digital Caliper's Interrater Reliability in Measuring the Interrecti Distance and Its Accuracy in Diagnosing the Diastasis of Rectus Abdominis Muscle in the Third Trimester of Pregnancy. *Journal of Chiropractic Medicine*. 2020;19(2):136-144. doi:10.1016/j.jcm.2020.02.002
26. Weir JP. Quantifying Test-Retest Reliability Using the Intraclass Correlation Coefficient and the SEM. *J Strength Cond Res*. 2005;19(1):231. doi:10.1519/15184.1

27. Wijntjes J, Van Alfen N. Muscle ultrasound: Present state and future opportunities. *Muscle and Nerve*. 2021;63(4):455-466. doi:10.1002/mus.27081
28. Gräbel D, Prescher A, Fitzek S, Keyserlingk DG v., Axer H. Anisotropy of human linea alba: A biomechanical study. *Journal of Surgical Research*. 2005;124(1):118-125. doi:10.1016/j.jss.2004.10.010
29. Beckerman H, Roebroek ME, Lankhorst GJ, Becher JG, Bezemer PD, Verbeek ALM. Smallest real difference, a link between reproducibility and responsiveness. *Qual Life Res*. 2001;10:571–578. doi: 10.1023/A:1013138911638.
30. Chiarello CM, McAuley JA. Concurrent Validity of Calipers and Ultrasound Imaging to Measure Interrecti Distance. *J Orthop Sports Phys Ther*. 2013;43(7):495-503. doi:10.2519/jospt.2013.4449

ARTIGO 2

Transversus Abdominis and Rectus Abdominis Activation Exercises do not alter Inter-Recti Distance in Pregnant Women: A Randomized Controlled Clinical Trial

Artigo a ser submetido ao periódico Journal of Physiotherapy - JCR: 10.7

Abstract

Question: Do transverse abdominis muscle (TrA) activation exercises and rectus abdominis activation exercises effectively prevent an increase in the inter-recti distance (IRD) compared to exercises without specific abdominal activation in pregnant women? **Method:** A randomized controlled clinical trial was conducted with parallel randomization, assessor blinding, and concealed allocation across three arms, along with an intention-to-treat analysis. **Participants:** Sixty-three pregnant women were allocated into 3 groups: drawing-in group (n=21); abdominal crunch group (n=21); and control group (n=21). **Intervention:** Drawing-in group focused on the activation of the TrA, performing two exercises: drawing-in and drawing-in with an elastic band. Abdominal crunch group focused on the activation of the Rectus Abdominis muscle, performing two exercises: abdominal crunch and abdominal crunch with an elastic band. In addition to their specific exercises, both groups also performed the same exercises as the control group. The control group performed global exercises, including passive and active stretches, strength training, and floor and ball exercises. Interventions were carried out over 12 weeks (comprising 24 sessions, twice weekly) in all 3 groups, starting between the 18th and 21st gestational week. **Outcome measures:** The primary outcome, the change in the IRD, was assessed using ultrasound in both resting and trunk flexion positions, with measurements taken in the supraumbilical and infraumbilical regions. The secondary outcome was the perceived change of the condition with the final score of the Pelvic Floor Bother (PFBQ) Questionnaire. **Results:** For the IRD variable, no group-time interaction was demonstrated when evaluated at rest in the supraumbilical [$F(2,60) = 0.30$; $p = 0.742$] and infraumbilical [$F(1,40) = 0.107$; $p = 0.899$] regions. The same was observed with the participant in trunk flexion in the supraumbilical [$F(2,60) = 1.03$; $p = 0.362$] and infraumbilical [$F(2,60) = 1.23$; $p = 0.301$] regions. In all measurements, a group effect was observed, demonstrating a significant increase in the values of the IRD after the intervention compared to the pre-intervention values. However, there were no differences between the groups in any of the variables. For the PFBQ Questionnaire, the p-values suggest that there was no group-time interaction [$F(2,60) = 2.14$; $p = 0.126$], nor was there a time or group effect in any of the three groups. **Conclusion:** A 12-week training program incorporating abdominal exercises with either TrA or Rectus Abdominis muscle activation does not induce changes in the size of the IRD, compared to exercises that do not involve the specific activation of these muscles. Additionally, we did not observe any improvement or worsening of the symptoms of Pelvic Floor Muscle (PFM) dysfunctions. **Registration:** RBR-4v2r4bg.

Key words: Inter-Recti Distance; Transverse Abdominis; Rectus Abdominis; Ultrasound; Randomised Controlled Trial; Pregnancy.

Introduction

Pregnancy induces various anatomical and physiological changes in the female body, including a notable shift in the anatomy of the rectus abdominis muscles, which are typically separated by the linea alba and maintain a physiological distance known as the inter-recti distance (IRD).¹⁻⁴ These changes, which are a consequence of the increased physical and metabolic demand to support fetal development, cause the rectus abdominis muscles to curve around the abdominal protrusion.^{1-3,5,6} This may result in a separation of these muscles, weakening and widening of the linea alba, and consequently, an increase in the IRD, a condition known as diastasis recti abdominis (DRA).³⁻⁷

DRA is a common condition in women, particularly during pregnancy and postpartum, affecting approximately 33.1% of women at the 21st week of gestation.⁸ Although it may spontaneously disappear, DRA persists in 32.6% of women one year after childbirth.⁸ This condition, in addition to being an aesthetic concern, is associated with abdominal, lower back, and pelvic pain, pelvic floor dysfunctions, and weakness of the abdominal muscles.^{9,10} Such weakness during the performance of physical exercises can lead to a bulging of the abdominal wall, increasing intra-abdominal pressure and, in the long term, potentially resulting in the emergence of hernias.^{11,12}

In response to the consequences of DRA, a series of studies have explored preventive alternatives, with emphasis on the IRD, primarily through physical exercises.¹³ It is believed that physical activity may play a crucial role in this scenario, which has led to an increase in the prominence of interventions with this approach.¹³⁻¹⁵ The assumption is that this may assist in maintaining the tone, strength, and control of the abdominal muscles, potentially generating a protective effect against the development of DRA.⁵ However, there is not yet sufficient evidence to confirm this assumption.¹³

Despite the lack of scientific articles on DRA, the prescription of abdominal exercises is quite frequent, especially those that focus on the activation of the muscles of the lateral abdominal wall, such as the transverse abdominis muscle (TrA).^{15,16} In contrast, exercises that focus on the rectus abdominis muscles are generally avoided, as they are considered a risk for the development of DRA.^{5,13} However, this contrasts with short-term experimental studies and randomized clinical trial, which concluded that exercises focusing on the rectus abdominis were effective in narrowing the IRD.^{17,18}

Currently, the research on DRA is characterized by a notable lack of consensus and scientific evidence, leading to an information deficit among many physiotherapists on how to clinically manage DRA and the relevance of the increase in IRD as a health issue.¹⁹ Due to the paucity of evidence, surgeries for DRA have become common, with the potential to lead to complications.²⁰ Most research focuses on treatment protocols, leaving a knowledge gap about interventions that may minimize the separation of the rectus abdominis muscle during pregnancy.^{11,13} Furthermore, existing studies are limited and vary in methodology, many of which do not present good methodological quality nor consider long-term effects.^{11,13} This highlights the need for a study that explores the relationship between exercises and DRA in prenatal care.

Therefore, the aim of the study was to investigate the effects of TrA activation exercises and rectus abdominis activation exercises on the IRD in pregnant women, comparing them with exercises that do not involve specific activation of the abdominal muscles. The research question for this randomized clinical trial was:

“Do TrA activation exercises and rectus abdominis activation exercises effectively prevent an increase in the IRD compared to exercises without specific abdominal activation in pregnant women?”

Material and Methods

The study's protocol was registered in advance, and the report of the study adhered to the CONSORT statement.²¹

Design

A randomized controlled clinical trial (RCT) was conducted with parallel randomization, assessor blinding, and concealed allocation across three arms, along with an intention-to-treat analysis.

Participants who met the established criteria were allocated into three groups: the drawing-in group, the abdominal crunch group, and the control group. The randomization procedure was conducted using computer-generated random numbers. A researcher, who was not involved in data collection or analysis, developed a randomization schedule, and placed the group assignments in sequentially numbered opaque and sealed envelopes, which were then distributed to each participant.

Participants, therapists, and centers

The study was conducted from February 2022 to February 2023 at the Campus Physical Education facilities of the Federal University of Uberlândia in Brazil. Information about the research was disseminated to the Uberlândia community through the university's department of social communication and various social media platforms. Prospective participants, who were pregnant women, initiated contact with the research team and underwent an evaluation process to determine their eligibility for the study.

The inclusion criteria encompassed healthy pregnant women aged between 18 and 40 years, either primigravida or those with previous pregnancies terminated by the 21st week. Additional criteria included a single pregnancy between the 18th and 21st week of gestation, a Body Mass Index (BMI) less than 30, and no history of abdominal surgery. The exclusion criteria at the initial assessment stage included the presence of high gestational risk, protrusion along the linea alba, significant bone deformities and muscle dysfunctions incompatible with the intervention, neurological and/or cognitive deficiencies that impeded understanding of the

proposed procedures, and failure to complete the informed consent form. During the study period, participants were excluded if they developed serious illnesses affecting either the mother or the fetus, or if the pregnancy was terminated before the final evaluation.

The IRD was measured by an examiner, who was a medical radiologist, with three years of experience utilizing an ultrasound device. The interventions conducted across the three study groups were executed by a physiotherapist possessing nine years of experience in women's health.

Common interventions

A total of 24 interventions were conducted across all three groups over a period of 12 weeks, commencing between the 18th and 21st gestational weeks. These interventions were administered twice weekly by a physical therapist who was blinded to the evaluations. Each session was conducted in groups of five pregnant women and was supervised by both the physical therapist and a research assistant.

A set of exercises was suggested for each group, with moderate intensity, determined according to each woman's perceived effort (ranging from 13 to 14 on the Borg Scale).²² Furthermore, the exercises, in all three groups, were performed in 3 sets of 8-12 repetitions, with a 1-minute interval between each set, and a 2-minute interval between each exercise.^{23,24}

Participants in each group were instructed not to perform specific abdominal muscle contraction techniques between sessions. All three groups underwent sessions lasting approximately 60 minutes in total.

Experimental intervention

In the drawing-in group, at the start of each session, the pregnant women were positioned in supine position, with knees and hips flexed, feet on the mat, arms beside the body, and performed two exercises focusing on the activation of the TrA: drawing-in and drawing-in with elastic band. Firstly, the drawing-in was performed. Then, a verbal command was given to the pregnant women that said: "Inhale and exhale. Pull your navel inward and backward towards the spine. Do not move your pelvis. Hold it there for 3 seconds".²⁵ This exercise was performed in 3 sets of 12 repetitions. Between each repetition, there was a rest interval of 6 seconds.²⁵ Between each set, there was a rest interval of 2 minutes, and, between each exercise,

there was also a 2-minute interval.²⁴ Subsequently, the drawing-in exercise with an elastic band was performed. For this, the pregnant women received the same verbal command as before, however, in addition to performing this movement, they performed horizontal shoulder abduction with the band, during the abdominal contraction. The same time intervals were observed. After this second exercise, the participants performed the same exercises as those of the control group.

In the abdominal crunch group, participants were initially positioned in the same position as in the drawing-in group, and then they performed two exercises: the abdominal crunch and the abdominal crunch with an elastic band. The abdominal crunch was executed first. For this, participants were asked to lift their heads and shoulders until their shoulder blades left the mat and perform an abdominal contraction while exhaling.²⁵ This exercise was carried out in 3 sets of 12 repetitions, with a two-minute rest interval between each set, and a two-minute rest interval between each exercise.²⁴ Subsequently, the abdominal crunch with an elastic band was performed in a similar position to the previous exercise, but with the participants also performing a horizontal shoulder abduction with the band during the abdominal contraction. The same rest intervals were used. At the end of this second exercise, the participants performed the same exercises that the control group.

Control group intervention

Each session consisted of global exercises, with different exercises performed in each session. The exercises comprised both passive and active stretches (focusing on the cervical area, lower back, calves, quadriceps, chest, and gluteal region), strength training (using free weights and elastic bands, targeting all major muscle groups), and floor and ball exercises (ball squats, spinal rotation, spinal flexion, pelvic tilts on the ball). The emphasis was on exercises for the trunk, upper limbs, and lower limbs, without specific activation of the abdomen.^{23,24}

Outcome Measures

Assessments were performed at two time points - baseline (prior to the intervention) and after 24 sessions - by an examiner blinded to the intervention. The primary outcome was the change in the IRD, and the secondary outcome was the perceived change of the condition with the final score of the Pelvic Floor Bother Questionnaire.

The researcher responsible for the evaluations conducted the initial investigation on the test-retest reproducibility of the outcomes. The researcher assessed 10 nulliparous women at two different times with one-week intervals to determine the intraclass correlation coefficient (ICC) of the investigated variables. To calculate the ICC, a one-way random-effects model was used.

In the initial evaluation, a standard online questionnaire was administered to the eligible pregnant women to gather information about their socioeconomic (age) and anthropometric (height, weight, Body Mass Index – BMI) characteristics. Additionally, it was also verified whether the woman was engaged in any physical activity previously.

Primary outcome

The primary outcome was the change in the IRD, measured using an ultrasound. The PHILIPS EPIQ5r USA equipment was utilized, equipped with a 5-12 MHz linear probe, a 4,5-cm linear transducer, and a musculoskeletal preset. Additional features such as panoramic imaging, trapezoid mode, and extended field-of-view were also employed to measure wider DRA.

The IRD measurement was performed with the participant in two different positions (at rest and with trunk flexion) and in two different regions (supraumbilical and infraumbilical). In each region, for each position, two IRD measurements were taken and then averaged to obtain the final IRD value.

To measure the IRD, the participants were positioned supine, with their knees flexed at 90 degrees, their arms placed by their sides, and their feet resting on the examination table. Subsequently, a researcher, who was not the examiner, marked the participants' skin with a marker to standardize the measurement locations for the IRD measures. Two markings were made: 2 cm above the upper umbilical edge (supraumbilical) and 2 cm below the lower umbilical edge (infraumbilical). These distances were measured with a tape measure.

First, the IRD measurement was performed in the resting position. For this, the participant remained in the initial position, where the skin markings were made, and maintained her natural breathing pattern. Then, examiner positioned the transducer transversely on the mark of the supraumbilical region and, at the end of the participant's expiration, measured the IRD (ICC= 0.904). Next, a 1-minute interval was performed, and the same procedure was repeated.

After that, the measurement of the infraumbilical region was performed, following the same procedures (ICC= 0.848).

For the measurement of the IRD in the trunk flexion position, the transducer position and the sequence of procedures adopted by examiner were the same as in the resting position. The participant kept her knees at 90 degrees, with her feet in contact with the examination table and her arms positioned in front of her body. She was subsequently instructed to execute a trunk flexion, engaging the abdominal muscles to a degree sufficient to facilitate the elevation of the shoulders and scapulae from the examination table, coinciding with an exhalation. At the end of the expiration, Examiner performed the IRD measurement. For each measurement and each region (supraumbilical and infraumbilical), the participant performed the trunk flexion (ICC= 0.939 and ICC= 0.839).

Secondary outcome

The secondary outcome was the perceived change of the condition with the final score of the Pelvic Floor Bother Questionnaire, a self-administered online questionnaire. This questionnaire consists of nine items that assess symptoms related to urinary incontinence, urinary urgency, and frequency, voiding difficulty, pelvic organ prolapses, obstructed defecation, fecal incontinence, and dyspareunia. The scores for each item range from 0 to 5, resulting in a total questionnaire score ranging from 0 to 45. Higher scores indicate greater bother.

Data analysis

The minimum sample size for each group was determined using the a priori test in the G*Power software (3.1.9.2, Germany) to contrast three study groups. The study was powered to detect a between-group difference of at least 2 cm (SD 1.5) for the IRD, based on previous studies.^{26,27} Considering statistical power of 90% and an alpha value of 0,01, a sample size of 21 participants per group was calculated. Additionally, a 20% sample loss rate was considered, resulting in a total of 75 participants (25 women per group).

The statistical analysis was conducted by a researcher who was not involved in any of the phases of data collection. Analyses were performed using commercial software Statistical Package for the Social Sciences (SPSS). The Shapiro-Wilk test was used to assess data

normality. To compare data between groups before and after the intervention, the repeated measures ANOVA test was used, with Tukey's post-hoc test. To estimate the clinical significance of the results, the effect size was calculated for all outcomes. The effect size considered was low when less than 0.06, medium when between 0.061 and 0.13, and large when greater than 0.14.²⁸ The significance level established was 5%. All statistical procedures were performed according to the intention-to-treat principle.

Results

Flow of participants through the study

The flow diagram in Figure 1 shows the assessment profile and the number of dropouts in each group. In each of the groups, three participants did not complete the final assessment. All participants were included in the analyses. Regarding adherence to the training program, the drawing-in group had an adherence of 87.7%; the abdominal crunch group had an adherence of 81.4%, and the control group had an adherence of 85.9%.

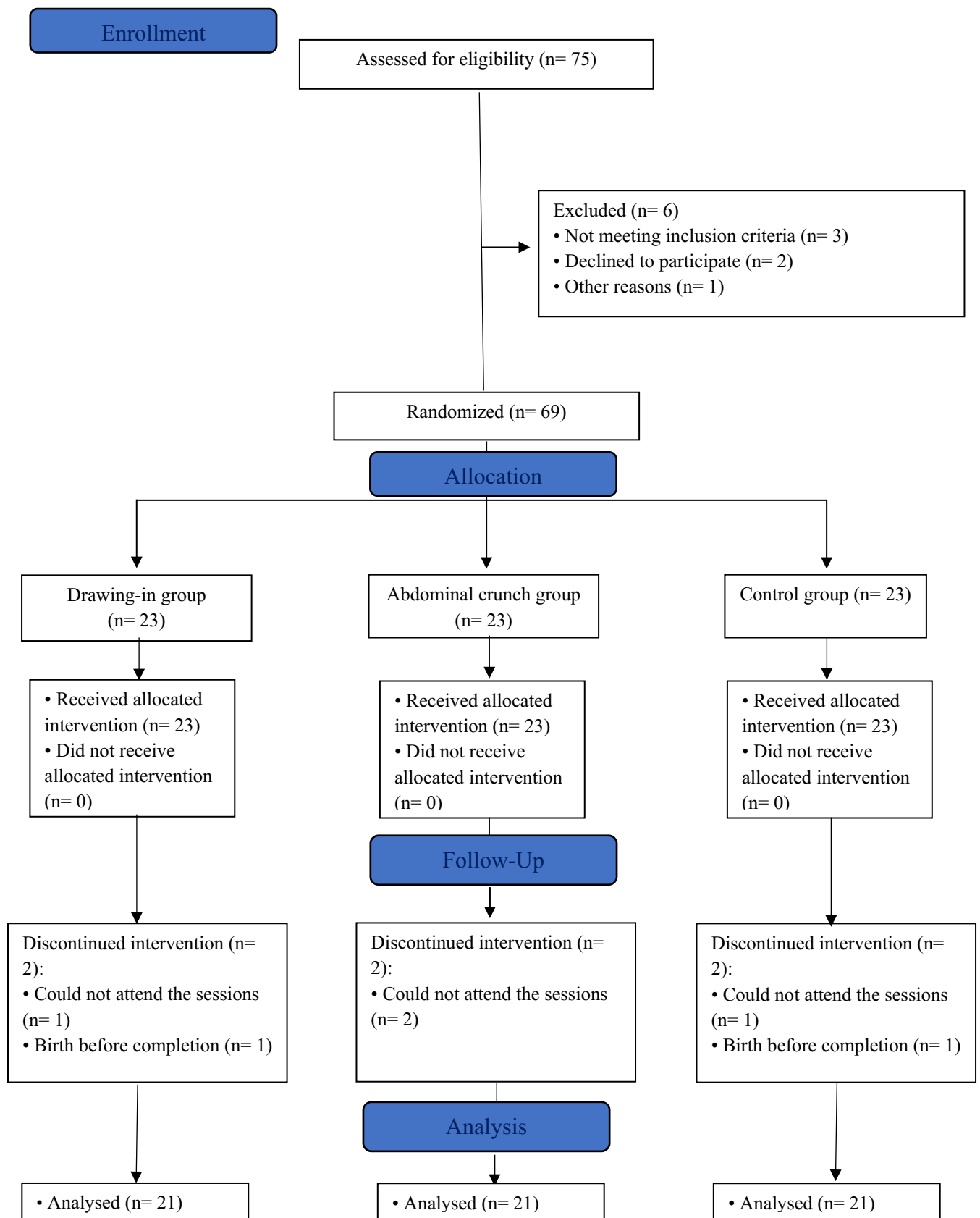


Figure 1. Design and flow of participants through the trial.

Compliance with the study protocol

Every participant was administered the intervention as designated. All documented primary and secondary outcomes underwent measurement and were subsequently reported.

Characteristics of participants

The study involved 63 participants. The assessed groups presented similar data in terms of age, weight, height, body mass index and exercises performed prior to initiating the protocol (Table 1). No participants presented side effects resulting from the interventions.

Table 1. Clinical and demographic characteristics of the study participants.

Variables	Drawing-in Group (n=21)	Abdominal Crunch Group (n=21)	Control Group (n=21)
Age (years), mean (SD)	29.4 (4.53)	31.5 (4.13)	31.2 (4.09)
Weight (kg), mean (SD)	71.7 (9.52)	67.9 (10.36)	63.1 (8.39)
Height (cm), mean (SD)	164.1 (5.11)	162.9 (5.49)	165.2 (7.47)
Body mass index (kg/m ²), mean (SD)	26.6 (2.83)	25.5 (3.26)	23.1 (2.83)
Activity level, no. (%)			
Yes	10 (47.61)	11 (52.38)	12 (57.14)
No	11 (52.38)	10 (47.61)	9 (42.85)

Effect of intervention

Primary outcome

Table 2 presents data on the effects of different groups (Drawing-in, Abdominal Crunch, and Control) over a period of 12 weeks. It displays the measurements of the IRD in centimeters (cm) at the baseline and after 12 weeks, including mean values, standard deviations (SD), confidence intervals (CI), and effect size.

The two-way ANOVA test did not demonstrate that there was a group-time interaction for the variable IRD when evaluated at rest in the supraumbilical region [$F(2,60) = 0.30$; $p = 0.742$] and infraumbilical region [$F(1,40) = 0.107$; $p = 0.899$]. The same occurred when the IRD values were analyzed with the participant in trunk flexion in the supraumbilical region [$F(2,60) = 1.03$; $p = 0.362$] and infraumbilical region [$F(2,60) = 1.23$; $p = 0.301$]. In all measurements, a group effect was observed, demonstrating a significant increase in the values of the IRD after the intervention compared to the pre-intervention values. However, there were no differences between the groups in any of the variables (Table 3).

Secondary outcome

Table 2 presents the mean, SD, CI, and effect size values for the PBFQ Questionnaire for each group at baseline and after 12 weeks. The p-values suggest that there was no group-time interaction [$F(2,60) = 2.14$; $p = 0.126$], or time and group effect (Table 3).

Table 2. Values for the Assessments at Baseline and After 12 Weeks Regarding IRD (cm).

Outcome Measure	Baseline			Week 12			Effect Size
	Drawing-in (n= 21) Mean $\pm$ SD (CI 95%)	Abdominal crunch (n= 21) Mean $\pm$ SD (CI 95%)	Control (n= 21) Mean $\pm$ SD (CI 95%)	Drawing-in (n= 21) Mean $\pm$ SD (CI 95%)	Abdominal crunch (n= 21) Mean $\pm$ SD (CI 95%)	Control (n= 21) Mean $\pm$ SD (CI 95%)	
Supraumbilical rest (cm)	2.43 $\pm$ 0.72 (2.10, 2.76)	2.61 $\pm$ 0.77 (2.26, 2.96)	2.59 $\pm$ 0.74 (2.25, 2.93)	4.25 $\pm$ 1.21 (3.70, 4.80)	4.22 $\pm$ 1.14 (3.69, 4.74)	3.81 $\pm$ 1.61 (3.08, 4.55)	0.033
Infraumbilical rest (cm)	1.18 $\pm$ 0.88 (0.78, 1.58)	1.21 $\pm$ 1.04 (0.74, 1.69)	0.90 $\pm$ 0.58 (0.63, 1.17)	2.92 $\pm$ 0.95 (2.49, 3.36)	3.46 $\pm$ 1.10 (2.96, 3.97)	2.63 $\pm$ 0.87 (2.24, 3.04)	0.039
Supraumbilical trunk flexion (cm)	1.96 $\pm$ 0.72 (1.64, 2.29)	1.87 $\pm$ 0.80 (1.50, 2.24)	1.88 $\pm$ 0.80 (1.52, 2.25)	3.31 $\pm$ 1.16 (2.78, 3.84)	3.16 $\pm$ 1.15 (2.64, 3.69)	3.05 $\pm$ 1.42 (2.41, 3.70)	0.004
Infraumbilical trunk flexion (cm)	0.96 $\pm$ 0.80 (0.59, 1.33)	0.86 $\pm$ 0.88 (0.45, 1.26)	0.62 $\pm$ 0.49 (0.40, 0.85)	2.43 $\pm$ 0.95 (1.99, 2.86)	2.58 $\pm$ 1.17 (2.05, 3.11)	2.18 $\pm$ 0.99 (1.73, 2.63)	0.010
PFBQ	8.05 $\pm$ 7.58 (4.60, 11.50)	7.05 $\pm$ 4.82 (4.85, 9.24)	4.90 $\pm$ 4.37 (2.92, 6.89)	6.62 $\pm$ 4.39 (4.62, 8.62)	9.24 $\pm$ 6.20 (6.42, 12.06)	6.48 $\pm$ 6.58 (3.48, 9.47)	0.067

CI= 95% confidence interval; mean= mean value of the outcome's distribution; SD= standard deviation of the mean value of the outcome's distribution.

Table 3. Linear mixed model analysis for group by time effect.

Outcome Measure	Mean (SD) change within group			Mean (SD) change between group		
	Drawing-in (n= 21)	Abdominal crunch (n= 21)	Control (n= 21)	Drawing-in - Control	Abdominal crunch - Control	Drawing-in – abdominal crunch
Supraumbilical rest (cm)	1.82 (1.41)	1.60 (1.17)	1.22 (1.50)	0.44 (-1.33 to 0.45)	0.40 (-0.98 to 0.16)	0.03 (-0.70 to 0.76)
Infraumbilical rest (cm)	1.74 (1.06)	2.25 (1.42)	1.73 (1.16)	0.28 (-0.85 to 0.29)	0.83 (-1.45 to -0.21)	-0.54 (-0.29 to 0.85)
Supraumbilical trunk flexion (cm)	1.34 (1.17)	1.29 (1.30)	1.17 (1.27)	0.25 (-1.07 to 0.55)	0.11 (-0.91 to 0.69)	0.15 (-0.57 to 0.87)
Infraumbilical trunk flexion (cm)	1.46 (0.99)	1.72 (1.28)	1.55 (1.01)	0.25 (-0.86 to 0.36)	0.40 (-1.08 to 0.28)	-0.15 (-0.82 to 0.50)
PFBQ	-1.42 (7.46)	2.19 (5.64)	1.57 (4.77)	0.14 (-3.62 to 3.34)	2.76 (-6.74 to 1.22)	-2.62 (-5.96 to 0.72)

Mean= mean value of the outcome's distribution; SD= standard deviation of the mean value of the outcome's distribution.

Discussion

In this RCT, we observed no significant differences between the studied groups in terms of IRD values in pregnant women. Therefore, exercises with specific activation of the abdominal muscles (whether the transverse abdominis or the rectus abdominis) have the same effect as exercises without specific abdominal activation on IRD in pregnant women.

The findings from our research disagree with our initial hypothesis based on the longitudinal experimental study conducted by Theodorsen et al. (2023).²⁹ In their research, the aim was to assess the immediate impact of rest, pelvic floor muscle (PFM) contraction, and five abdominal exercises on diastasis in pregnant women, specifically at the 27th and 37th weeks of gestation. The assessment was carried out using ultrasound, at the same measurement locations as in our study: the supraumbilical region (2 cm above the umbilical edge) and infraumbilical region (2 cm below the umbilical edge). At the conclusion of the study, it was determined that IRD increased in the following exercises: PFM, drawing-in, and PFM + drawing-in. Conversely, IRD decreased in exercises focusing on rectus abdominis activation: head lift, curl up, and diagonal curl-up (left and right). No significant differences were observed in relation to rest in the exercises: drawing-in + curl up and PFM + drawing-in + curl up.

Based on these findings, our hypothesis was that pregnant women who performed exercises focusing on rectus abdominis activation would have a reduction in IRD after the intervention. However, our research demonstrated that there was no significant difference in relation to rest measurements when performing a 12-week exercise program focusing on transverse abdominis activation and rectus abdominis activation. Thus, our results corroborate the notion that there is no need to discourage pregnant women from performing exercises focused on rectus abdominis muscle activation.¹⁰ Therefore, it is recommended that during the gestational period, women remain physically active, considering the numerous benefits that physical exercise provides for both the mother and the baby, and also perform exercises focusing on rectus abdominis activation, aiming for improvements in abdominal strength and thickness.^{10,22,30}

Furthermore, we did not observe an increase in IRD in the group that performed exercises with an emphasis on TrA activation. This finding contradicts the results of other experimental studies, which identified an immediate increase in IRD when performing such an exercise.^{17,29,31} Our findings, therefore, may suggest that this increase does not sustain in the long term, nor is it capable of permanently modifying the IRD.

Our results are in line with the discoveries of the systematic reviews by de Gluppe et al. (2021),¹¹ Weingerl et al. (2022),³² and Benjamin et al. (2023)³³ which concluded that abdominal exercises do not produce effects in reducing DRA. The inability of abdominal exercises to reduce IRD can be explained by the fact that, although such exercises may strengthen the abdomen, they are not capable of correcting defects in the connective tissue, which composes the linea alba along with the fascia.^{34,35} Thus, despite the connective tissue being able to exhibit contractile activity, its effects are not equivalent to those of the muscle.³⁶

In our study, we observed an increase in the IRD in all groups when comparing the initial values with those after 12 weeks. This was predictable, as all our final evaluations took place in the third trimester of pregnancy, a period in which the reported prevalence of DRA is 70%.^{8,37} Furthermore, our results align with the indications of Mota et al. (2018),³⁸ who suggest that IRD values tend to be higher in primiparas than in nulliparas and that an increase in IRD during pregnancy is expected.

Within the scope of our research, no group remained inactive. Even our control group, which did not perform exercises specifically targeting abdominal activation, carried out upper and lower limb exercises that indirectly promote this activation.³⁹⁻⁴¹ This approach was chosen because it is widely recognized that physical exercises are recommended for this population due to their numerous advantages.^{22,30,42}

Regarding complaints of PFM dysfunctions, as verified through the PBFQ questionnaire, no significant difference was observed after the 12-week exercise protocol. Symptoms remained stable, without improvement or worsening. Therefore, despite the increase in intra-abdominal pressure (IAP) during exercise being associated with an impact on these muscles,⁴³ in our research, this potentially generated impact was not sufficient to aggravate the symptoms of dysfunction. This suggests that performing abdominal exercises may be safe for the PFM in this respect. Moreover, some studies have found that the abdominal crunch exercise can generate a smaller increase in IAP compared to other activities, such as seated exercises.^{44,45} However, it should be noted that pressure variation is individual, making it impossible to establish universal recommendations.

Despite the increase in IRD in the groups, the fact that there was no worsening in the symptoms of pelvic floor dysfunction corroborates the results of the retrospective cohort study by Fei et al. (2021).⁴⁶ This study evaluated the IRD of postpartum women, with and without diastasis, through ultrasound and the strength of the PFMs. In the end, they concluded that there is no difference in the occurrence of urinary incontinence and pelvic organ prolapse in women

with and without DRA. Therefore, there is no relationship between the increase in IRD and the severity of pelvic floor dysfunctions.

During our intervention sessions, Pelvic Floor Muscle Training (PFMT) was not performed, nor was the contraction of these muscles requested during the execution of the exercises by the participants. However, the contraction of the TrA is capable of generating a synergistic co-contraction of the PFM^s.⁴⁷ The absence of symptom improvement may indicate that this co-contraction is not sufficient to increase the strength of the PFM^s. This suggests that protocols aiming to improve PFM dysfunctions should focus on performing PFMT to improve symptoms.⁴⁷

As we did not perform an evaluation of the PFM^s, our conclusions about the absence of symptom improvement or worsening are based on assumptions. Therefore, we suggest that future research investigate the effects of exercises with and without specific abdominal activation in relation to the impact on the PFM^s.

To the best of our knowledge, the present study was the first to analyze the effects in pregnant women of exercises focused on the activation of the TrA and rectus abdominal muscles, compared to a control group, over a period of 12 weeks. All exercise sessions were supervised, and we incorporated specific recommendations for muscle strengthening into the proposed exercises. As a limitation of our study, we highlight the impossibility of blinding the participants and the therapist responsible for the interventions, although the latter was blind to the evaluations. Furthermore, we did not evaluate variables such as PFM strength and abdominal strength and thickness.

Based on our findings, we conclude that a twelve-week training program for pregnant women, incorporating abdominal exercises with either TrA or Rectus Abdominis muscle activation, does not induce changes in the size of the IRD, as measured by ultrasound, compared to exercises that do not involve the specific activation of these muscles. Additionally, we did not observe any improvement or worsening of the symptoms of PFM dysfunctions.

What was already known on this topic: At the 21st week of gestation, it is observed that 33.1% of women present alterations in the IRD. Despite the limited research, abdominal exercises, particularly those activating the TrA, are frequently prescribed. However, exercises focusing on the Rectus Abdominis muscles are generally avoided. The need for comprehensive research exploring exercises in prenatal care is evident.

What this study adds: This study provides valuable insights into the effects of a twelve-week training program on pregnant women, specifically focusing on abdominal exercises with TrA or Rectus Abdominis muscle activation. Our findings suggest that these exercises do not lead to changes in the size of the IRD, as measured by ultrasound, when compared to exercises that do not involve the specific activation of these muscles. Furthermore, we did not observe any significant changes in the symptoms of PFM dysfunctions. These findings contribute to the existing body of knowledge by demonstrating that the specific activation of TrA or Rectus Abdominis muscles during pregnancy does not necessarily lead to changes in IRD or PFM dysfunctions.

Ethics approval: The study was approved by the Ethics and Research Committee of the Federal University of Uberlândia (no 4.785.678) and was conducted in agreement with the Declaration of Helsinki.

Competing interests: Nil.

References

1. Soma-Pillay P, Nelson-Piercy C, Tolppanen H, Mebazaa A. Physiological changes in pregnancy. *CVJA*. 2016;27(2):89-94. doi:10.5830/CVJA-2016-021
2. Tan EK, Tan EL. Alterations in physiology and anatomy during pregnancy. *Best Practice & Research Clinical Obstetrics & Gynaecology*. 2013;27(6):791-802. doi:10.1016/j.bpobgyn.2013.08.001
3. Gilleard, W. L., & Brown, J. M. Structure and function of the abdominal muscles in primigravid subjects during pregnancy and the immediate postbirth period. *Physical therapy*. 1996;76:750-762. doi:https://doi.org/10.1093/ptj/76.7.750
4. Reinpold W, Köckerling F, Bittner R, et al. Classification of Rectus Diastasis—A Proposal by the German Hernia Society (DHG) and the International Endohernia Society (IEHS). *Front Surg*. 2019;6:1. doi:10.3389/fsurg.2019.00001
5. Boissonnault JS, Blaschak MJ. Incidence of Diastasis Recti Abdominis During the Childbearing Year. *Physical Therapy*. 1988;68(7):1082-1086. doi:10.1093/ptj/68.7.1082
6. Fast A, Weiss L, Ducommun EJ, Medina E, Butler JG. Low-back pain in pregnancy. Abdominal muscles, sit-up performance, and back pain. *Spine (Phila Pa 1976)*. 1990;15:28-30. doi:10.1097/00007632-199001000-00008
7. Axer H, Keyserlingk DGV, Prescher A. Collagen Fibers in Linea Alba and Rectus Sheaths. *Journal of Surgical Research*. 2001;96(1):127-134. doi:10.1006/jsre.2000.6070
8. Sperstad JB, Tennfjord MK, Hilde G, Ellström-Engh M, Bø K. Diastasis recti abdominis during pregnancy and 12 months after childbirth: prevalence, risk factors and report of lumbopelvic pain. *Br J Sports Med*. 2016;50(17):1092-1096. doi:10.1136/bjsports-2016-096065
9. Benjamin DR, Frawley HC, Shields N, Van De Water ATM, Taylor NF. Relationship between diastasis of the rectus abdominis muscle (DRAM) and musculoskeletal dysfunctions, pain and quality of life: a systematic review. *Physiotherapy*. 2019;105(1):24-34. doi:10.1016/j.physio.2018.07.002
10. Gluppe SB, Ellström Engh M, Bø K. Curl-up exercises improve abdominal muscle strength without worsening inter-recti distance in women with diastasis recti abdominis postpartum: a randomised controlled trial. *Journal of Physiotherapy*. 2023;69(3):160-167. doi:10.1016/j.jphys.2023.05.017
11. Gluppe S, Engh ME, Bø K. What is the evidence for abdominal and pelvic floor muscle training to treat diastasis recti abdominis postpartum? A systematic review with meta-analysis. *Brazilian Journal of Physical Therapy*. 2021;25(6):664-675. doi:10.1016/j.bjpt.2021.06.006
12. Cheesborough JE, Dumanian GA. Simultaneous Prosthetic Mesh Abdominal Wall Reconstruction with Abdominoplasty for Ventral Hernia and Severe Rectus Diastasis Repairs: *Plastic and Reconstructive Surgery*. 2015;135(1):268-276. doi:10.1097/PRS.0000000000000840

13. Benjamin DR, Van De Water ATM, Peiris CL. Effects of exercise on diastasis of the rectus abdominis muscle in the antenatal and postnatal periods: a systematic review. *Physiotherapy*. 2014;100(1):1-8. doi:10.1016/j.physio.2013.08.005
14. Berg-Poppe P, Hauer M, Jones C, Munger M, Wethor C. Use of Exercise in the Management of Postpartum Diastasis Recti: A Systematic Review. *Journal of Women's Health Physical Therapy*. 2022;46(1):35-47. doi:10.1097/JWH.0000000000000231
15. Keeler J, Albrecht M, Eberhardt L, Horn L, Donnelly C, Lowe D. Diastasis Recti Abdominis: A Survey of Women's Health Specialists for Current Physical Therapy Clinical Practice for Postpartum Women. *Journal of Women's Health Physical Therapy*. 2012;36(3):131-142. doi:10.1097/JWH.0b013e318276f35f
16. Gluppe S, Ellström Engh M, Bø K. Primiparous women's knowledge of diastasis recti abdominis, concerns about abdominal appearance, treatments, and perceived abdominal muscle strength 6–8 months postpartum. A cross sectional comparison study. *BMC Women's Health*. 2022;22(1):428. doi:10.1186/s12905-022-02009-0
17. Mota P, Pascoal AG, Carita AI, Bø K. The Immediate Effects on Inter-rectus Distance of Abdominal Crunch and Drawing-in Exercises During Pregnancy and the Postpartum Period. *J Orthop Sports Phys Ther*. 2015;45(10):781-788. doi:10.2519/jospt.2015.5459
18. Gluppe SB, Engh ME, Bø K. Immediate Effect of Abdominal and Pelvic Floor Muscle Exercises on Interrecti Distance in Women With Diastasis Recti Abdominis Who Were Parous. *Physical Therapy*. 2020;100(8):1372-1383. doi:10.1093/ptj/pzaa070
19. Gustavsson C, Eriksson-Crommert M. Physiotherapists' and midwives' views of increased inter recti abdominis distance and its management in women after childbirth. *BMC Women's Health*. 2020;20(1):37. doi:10.1186/s12905-020-00907-9
20. Nahabedian M. Management Strategies for Diastasis Recti. *Seminars in Plastic Surgery*. 2018;32(03):147-154. doi:10.1055/s-0038-1661380
21. Schulz KF, Altman DG, Moher D. CCoOrresNpoSndOenRceT 2010 Statement: updated guidelines for reporting parallel group randomised trials. Published online 2010.
22. ACOG Committee Opinion, Number 804. Physical Activity and Exercise During Pregnancy and the Postpartum Period. *Obstet Gynecol*. 2020;135:178-188. doi:10.1097/AOG.0000000000003772
23. Suchomel TJ, Nimphius S, Bellon CR, Stone MH. The Importance of Muscular Strength: Training Considerations. *Sports Med*. 2018;48(4):765-785. doi:10.1007/s40279-018-0862-z
24. Garber CE, Blissmer B, Deschenes MR, et al. Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise. *Medicine & Science in Sports & Exercise*. 2011;43(7):1334-1359. doi:10.1249/MSS.0b013e318213feff
25. Mota P, Pascoal AG, Sancho F, Bø K. Test-Retest and Intrarater Reliability of 2-Dimensional Ultrasound Measurements of Distance Between Rectus Abdominis in Women. *J Orthop Sports Phys Ther*. 2012;42(11):940-946. doi:10.2519/jospt.2012.4115

26. Tuttle LJ, Fasching J, Keller A, et al. Noninvasive Treatment of Postpartum Diastasis Recti Abdominis: A Pilot Study. *Journal of Women's Health Physical Therapy*. 2018;42(2):65-75. doi:10.1097/JWH.0000000000000101
27. Keshwani N, Mathur S, McLean L. The impact of exercise therapy and abdominal binding in the management of diastasis recti abdominis in the early post-partum period: a pilot randomized controlled trial. *Physiotherapy Theory and Practice*. 2021;37(9):1018-1033. doi:10.1080/09593985.2019.1675207
28. Jacob Cohen. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Routledge; 1988.
29. Theodorsen NM, Strand LI, Bø K. Effect of pelvic floor and transversus abdominis muscle contraction on inter-rectus distance in postpartum women: a cross-sectional experimental study. *Physiotherapy*. 2019;105(3):315-320. doi:10.1016/j.physio.2018.08.009
30. Mottola MF, Davenport MH, Ruchat SM, et al. 2019 Canadian guideline for physical activity throughout pregnancy. *Br J Sports Med*. 2018;52(21):1339-1346. doi:10.1136/bjsports-2018-100056
31. Sancho MF, Pascoal AG, Mota P, Bø K. Abdominal exercises affect inter-rectus distance in postpartum women: a two-dimensional ultrasound study. *Physiotherapy*. 2015;101(3):286-291. doi:10.1016/j.physio.2015.04.004
32. Weingerl I, Kozinc Ž, Šarabon N. The Effects of Conservative Interventions for treating Diastasis Recti Abdominis in Postpartum Women: a Review with Meta-analysis. *SN Compr Clin Med*. 2022;5(1):10. doi:10.1007/s42399-022-01353-4
33. Benjamin DR, Frawley HC, Shields N, et al. Conservative interventions may have little effect on reducing diastasis of the rectus abdominis in postnatal women – A systematic review and meta-analysis. *Physiotherapy*. 2023;119:54-71. doi:10.1016/j.physio.2023.02.002
34. Spector M. Musculoskeletal connective tissue cells with muscle: Expression of muscle actin in and contraction of fibroblasts, chondrocytes, and osteoblasts. *Wound Repair Regeneration*. 2001;9(1):11-18. doi:10.1046/j.1524-475x.2001.00011.x
35. Aagaard P, Andersen JL, Dyhre-Poulsen P, et al. A mechanism for increased contractile strength of human pennate muscle in response to strength training: changes in muscle architecture. *The Journal of Physiology*. 2001;534(2):613-623. doi:10.1111/j.1469-7793.2001.t01-1-00613.x
36. Schleip R, Gabbiani G, Wilke J, et al. Fascia Is Able to Actively Contract and May Thereby Influence Musculoskeletal Dynamics: A Histochemical and Mechanographic Investigation. *Front Physiol*. 2019;10:336. doi:10.3389/fphys.2019.00336
37. Mota PGFD, Pascoal AGBA, Carita AIAD, Bø K. Prevalence and risk factors of diastasis recti abdominis from late pregnancy to 6 months postpartum, and relationship with lumbo-pelvic pain. *Manual Therapy*. 2015;20(1):200-205. doi:10.1016/j.math.2014.09.002
38. Mota P, Pascoal AG, Carita AI, Bø K. Normal width of the inter-recti distance in pregnant and postpartum primiparous women. *Musculoskeletal Science and Practice*. 2018;35:34-37. doi:10.1016/j.msksp.2018.02.004

39. Clark DR, Lambert MI, Grigson C, Hunter AM. Impact of resistance training status on trunk muscle activation in a fatiguing set of heavy back squats. *Eur J Appl Physiol*. 2021;121(2):597-608. doi:10.1007/s00421-020-04540-0
40. Hodges PW, Richardson CA. Contraction of the Abdominal Muscles Associated With Movement of the Lower Limb. *Physical Therapy*. 1997;77(2):132-142. doi:10.1093/ptj/77.2.132
41. Saunders SW, Rath D, Hodges PW. Postural and respiratory activation of the trunk muscles changes with mode and speed of locomotion. *Gait & Posture*. 2004;20(3):280-290. doi:10.1016/j.gaitpost.2003.10.003
42. World Health Organization. Global recommendations on physical activity for health. *Recommandations mondiales sur l'activité physique pour la santé*. Published online 2010:58.
43. Herschorn S. Female Pelvic Floor Anatomy: The Pelvic Floor, Supporting Structures, and Pelvic Organs.
44. O'Dell KK, Morse AN, Crawford SL, Howard A. Vaginal pressure during lifting, floor exercises, jogging, and use of hydraulic exercise machines. *Int Urogynecol J*. 2007;18(12):1481-1489. doi:10.1007/s00192-007-0387-8
45. Cobb WS, Burns JM, Kercher KW, Matthews BD, James Norton H, Todd Heniford B. Normal Intraabdominal Pressure in Healthy Adults. *Journal of Surgical Research*. 2005;129(2):231-235. doi:10.1016/j.jss.2005.06.015
46. Fei H, Liu Y, Li M, et al. The relationship of severity in diastasis recti abdominis and pelvic floor dysfunction: a retrospective cohort study. *BMC Women's Health*. 2021;21(1):68. doi:10.1186/s12905-021-01194-8
47. Bø K, Mørkved S, Frawley H, Sherburn M. Evidence for benefit of transversus abdominis training alone or in combination with pelvic floor muscle training to treat female urinary incontinence: A systematic review. *Neuourology and Urodynamics*. 2009;28(5):368-373. doi:10.1002/nau.20700