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Systematic review

Effects of exercise on diastasis of the rectus abdominis muscle in the antenatal and postnatal periods: a systematic review☆

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Abstract

Background Diastasis of the rectus abdominis muscle (DRAM) is common during and after pregnancy, and has been related to lumbopelvic instability and pelvic floor weakness. Women with DRAM are commonly referred to physiotherapists for conservative management, but little is known about the effectiveness of such strategies.
Objectives To determine if non-surgical interventions (such as exercise) prevent or reduce DRAM.
Data sources EMBASE, Medline, CINAHL, PUBMED, AMED and PEDro were searched.
Study selection/eligibility Studies of all designs that included any non-surgical interventions to manage DRAM during the ante- and postnatal periods were included.
Study appraisal and synthesis methods Methodological quality was assessed using a modified Downs and Black checklist. Meta-analysis was performed using a fixed effects model to calculate risk ratios (RR) and 95% confidence intervals (CI) where appropriate.
Results Eight studies totalling 336 women during the ante- and/or postnatal period were included. The study design ranged from case study to randomised controlled trial. All interventions included some form of exercise, mainly targeted abdominal/core strengthening. The available evidence showed that exercise during the antenatal period reduced the presence of DRAM by 35% (RR 0.65, 95% CI 0.46 to 0.92), and suggested that DRAM width may be reduced by exercising during the ante- and postnatal periods.
Limitations The papers reviewed were of poor quality as there is very little high-quality literature on the subject.
Conclusion and implications Based on the available evidence and quality of this evidence, non-specific exercise may or may not help to prevent or reduce DRAM during the ante- and postnatal periods.

Keywords: Diastasis recti and weakness of the linea alba; Exercise; Abdominal muscles; Pregnant women; Postnatal care

Introduction

During and after pregnancy, many women experience an increase in the inter-recti abdominal muscle distance due to stretching and thinning of the linea alba [1]. A widening of >2.7 cm at the level of the umbilicus is considered a pathological diastasis of the rectus abdominis muscle (DRAM) [2]. Other studies have defined DRAM as an inter-recti distance of >2 cm at one or more assessment points (at the level of the umbilicus or 4.5 cm above or below the umbilicus) [3,4]. DRAM occurs due to hormonal elastic changes of the connective tissue, mechanical stresses placed on the abdominal wall by the growing fetus, and displacement of the abdominal organs [4–7]. DRAM usually appears in the second trimester of pregnancy and is found most frequently in the third trimester [6]. Studies have demonstrated that the inter-recti distance increases at approximately 14 weeks of gestation and continues to increase until delivery [7]. Natural resolution and greatest recovery of DRAM occurs between 1 day and 8 weeks after delivery, after which time recovery plateaus [8].

DRAM is relatively common and can have negative health consequences for women during and after pregnancy (ante- and postnatal periods). Varying estimates of incidence of

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DRAM have been reported ranging from 66% to 100% during the third trimester of pregnancy [6,9], and up to 53% immediately after delivery [10]. The abdominal wall has important functions in posture, trunk and pelvic stability, respiration, trunk movement and support of the abdominal viscera. An increase in the inter-recti distance puts these functions in jeopardy [11–13], and can weaken abdominal muscles and influence their functions [14,15]. This may result in altered trunk mechanics, impaired pelvic stability and changed posture, which leave the lumbar spine and pelvis more vulnerable to injury [4,7,13].

Despite DRAM being a common and significant clinical problem, little is known about its prevention or management. Risk factors such as multiparity, maternal age and childcare responsibilities have been associated with DRAM. There is conflicting evidence linking DRAM with weight gain and higher body mass index [4,10,16]. Surgical correction of DRAM has been demonstrated to reduce some of the effects of a wide diastasis such as back pain [17]. Anecdotally, regular exercise prior to pregnancy and during the antenatal period seems to reduce the risk of developing DRAM and reduce the size of DRAM, respectively [6]. Abdominal exercises are also frequently prescribed to postnatal women who have DRAM. Other regularly used non-surgical interventions in women with DRAM include postural and back care education, external support (e.g. tubigrip or corset) and aerobic exercises [18–21]. However, it is unclear what types of non-surgical interventions, including exercise, are effective to prevent and/or reduce DRAM.

Therefore, the aims of this review were to determine whether non-surgical interventions can prevent or reduce DRAM in the antenatal period, and reduce DRAM and health-related negative effects of DRAM in the postnatal period.

Methods

This systematic review was registered in the PROSPERO database (CRD42012002944).

Data sources

A search strategy was developed to search the electronic databases of Medline, EMBASE, CINAHL, PEDro, PubMed and AMED to look for published studies involving non-surgical interventions to prevent and/or reduce DRAM during the ante- and postnatal periods (Appendix A, see online supplementary material). These electronic databases were searched from the earliest date available to 31 July 2012. Manual searching of the reference lists of included studies and citation tracking were conducted to ensure that all relevant studies were found. No study design or language restrictions were applied.

Study selection

Two reviewers (DB and CP) applied the inclusion criteria independently (Table A, see online supplementary material) to the titles and abstracts of all studies retrieved. Reviews, editorials, opinions and theses were excluded. Full-text articles were retrieved and reviewed by re-application of the criteria for potentially eligible studies. Any disagreements were resolved by discussion between the two reviewers. If consensus could not be reached, a third reviewer was consulted.

Data extraction

A data extraction form was developed *a priori* based on the Cochrane Consumers and Communication Review Group data extraction template [22], which was revised to suit this review. The form was pilot tested on a selection of studies and subsequently refined. One reviewer (DB) extracted the data, and a second reviewer (CP) checked the accuracy of the data extracted. Where there were discrepancies, the reviewers referred back to the original study. Where there were missing data, attempts were made to contact the authors of the trial for clarification. Data were extracted from each study on participant characteristics (age, parity, mode of delivery), intervention (type, duration, frequency, delivery, setting), outcomes (primary and secondary, method and timing of assessment), results and adverse events.

Outcomes

The primary outcomes of interest were the presence/absence of DRAM and DRAM width (cm). Secondary outcomes were back pain, abdominal strength, ability to complete activities of daily living and quality of life. Ultrasound may be considered the gold standard for clinical measurement of DRAM width with a low standard error of measurement (SEM) of 0.05 to 0.20 cm [3,15]. Other methods such as callipers (SEM 0.01 to 0.41 cm) or palpation/finger width have been found to be reliable for the measurement of DRAM, but may be less valid to measure the exact inter-recti distance [3,23].

Quality assessment

All studies were appraised independently by two reviewers (DB and CP) for methodological quality using the modified Downs and Black checklist for randomised and non-randomised studies of healthcare interventions (Appendix B, see online supplementary material) [24–26]. Total scores ranged from 0 to 28 points. Studies were rated as excellent if they scored 26 to 28, good if they scored 20 to 25, fair if they scored 15 to 19, and poor if the total score was 14 or less [26]. Any disagreements were resolved by discussion between the two reviewers, and a third reviewer was consulted if consensus could not be reached. Trials were not excluded on the

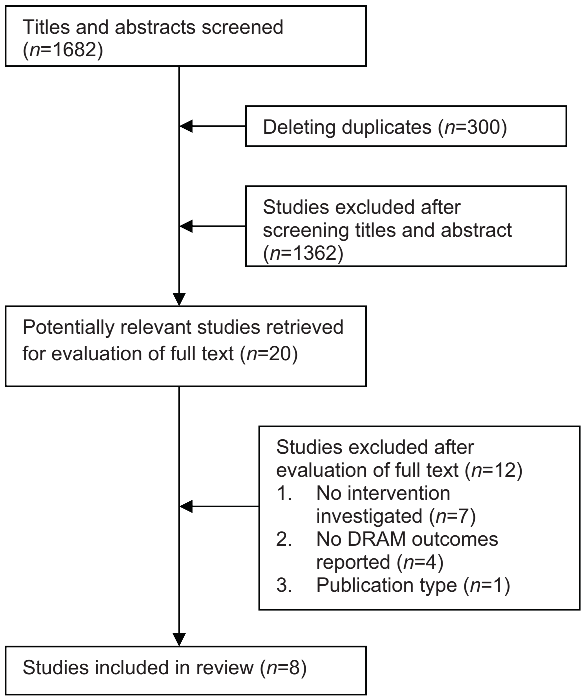

Fig. 1. Flow of studies through the review.

basis of quality, but the quality of the study was taken into account when interpreting the results.

Data analysis

Analysis was performed separately for interventions to prevent DRAM during the antenatal period and for interventions to treat DRAM during the postnatal period. Meta-analysis was performed among studies with similar interventions that reported on the same outcomes. Where there were sufficient and appropriate data to combine, a meta-analysis was conducted using a fixed effects model for the primary outcome (presence or absence of DRAM) using inverse variance to yield a risk ratio (RR) with 95% confidence interval (CI) using RevMan 5.1 (The Cochrane IMS. Available at: http://ims.cochrane.org/revman, 2008). Statistical heterogeneity was assessed using the I^2 statistic, with values of more than 50% representing substantial levels of heterogeneity [27]. Fixed effects meta-analysis was applied to combine data in the absence of significant heterogeneity between the trials. Where it was not possible to pool data, a narrative summary of the studies was completed.

Results

Flow of studies through the review

The search strategy yielded 1382 potentially relevant studies. Selection on title and abstract excluded 1362 studies, and the full text of 20 articles was reviewed (Fig. 1). A further 12 potential studies were excluded based on the full-text evaluation due to no intervention being investigated ($n = 7$), no DRAM outcomes reported ($n = 4$), and the type of publication ($n = 1$). A manual search of the reference lists of included studies did not result in more eligible studies. Consensus was reached to yield a total of eight relevant studies for inclusion in the review. The inter-rater agreement for study selection was moderate (κ = 0.62, 95% CI 0.41 to 0.83).

Characteristics of studies

The eight studies included in this review were of varying design (Table 1): four studies examined interventions during the antenatal period to reduce the risk of developing DRAM, and four studies examined the effects of postnatal interventions to reduce the width of DRAM and aid recovery.

Participants

This review included 336 participants, of whom 170 were exposed to interventions to decrease the risk of developing DRAM in the antenatal period and 53 participated in interventions to reduce DRAM width in the postnatal period. Participants were aged between 18 and 40 years, of mixed parity and had various modes of delivery.

Interventions

All interventions included some form of exercise (Table 1). Prescribed exercises mainly targeted abdominal muscles and core strengthening. Exercise was carried out in isolation as the only intervention [3,4,28] or in conjunction with corset/tubigrip application and/or education [1,21,29,30]. Two studies [4,10] looked at activity levels retrospectively. The exercise settings, delivery, frequency and duration varied between the studies (Table 1).

Methodological quality

The quality of the included studies was fair, with scores ranging from 12/32 to 23/32 [Table 1 and Appendix C (see online supplementary material)]. Four case studies [1,21,29,30] and one study with a quasi-experimental post-test design [3] were of poor quality, while the retrospective studies were of fair quality [4,10]. The randomised controlled trial [28] scored well across all domains and achieved a good quality rating of 23/28. There was substantial agreement between reviewers when rating individual items on the Downs and Black checklist for each trial (κ = 0.82, 95% CI 0.74 to 0.89). The case studies scored poorly on the items relating to reporting, external validity and power. There was a lack of blinding in all of the trials.

DRAM measurements

The methods of measuring DRAM were quite varied amongst the studies. Three studies used callipers (digital or dial) [1,3,28], two studies used tape measures [10,21], and two studies did not specify how the measurements were taken

Table 1
Study characteristics.

Study	Design	Quality score	Number of participants	Age in years, mean (SD)	Parity	Mode of delivery	Intervention	Comparison	Outcomes
Antenatal: prevention of DRAM									
Candido *et al.* 2005	Retrospective observational study	18/28	Intervention 106 Control 102	32.0 (5.1)	Primiparous: 122 Multiparous: 86	Vaginal: 122 Caesarean: 86	Walking or vigorous activity/exercise during antenatal period	No exercise/activity	DRAM presence (>2.5 cm)
Chiarello *et al.* 2005	Quasi-experimental post-test design	14/28	Intervention 8 Control 10	Intervention 32.0 (2.2) Control 30.4 (3.95)	Intervention Multiparous: 8 Control Multiparous: 10	Not reported	6/52 prenatal abdominal strengthening exercise programme (1 × 90-minute class per week)	No formal exercise	DRAM presence (>2 cm) DRAM width (cm)
Hsia and Jones 2000	Case studies	14/28	Intervention 1 Control 1	Intervention 36 Control 33	Primiparous: 2	Vaginal: 2	Antenatal fitness classes from week 30/40 to 39/40	No formal exercise	DRAM width (cm)
Lo *et al.* 1999	Retrospective observational study	18/28	55	34.0 (4.3)	Primiparous: 18 Multiparous: 37	Vaginal: 21 Caesarean: 19	Activity levels (nil, ADLs only or active) during antenatal period	No comparison	Time to recovery
Postnatal: reduction of DRAM									
Mesquita *et al.* 1999	Randomised controlled trial	23/28	Intervention 25 Control 25	18 to 40[a]	Intervention Primiparous: 10 Multiparous: 15 Control Primiparous: 7 Multiparous: 18	Vaginal: 50	Individualised, progressed abdominal and pelvic floor exercise regime post partum	Usual activities – no formal exercise	DRAM width
Sheppard 1996	Case study	12/28	1	39	Multiparous	Vaginal	Education, tubigrip and abdominal exercises post partum Postnatal exercise group at 5/12	No comparison	DRAM presence (>2 finger width) DRAM width TA activation endurance (hold seconds)
Thornton *et al.* 1993	Case study	14/28	1	38	Multiparous	Vaginal	Corset from 26/40 with 3rd gestation and ceased post delivery Tubigrip postnatal for 3/52 and graduated exercise programme	No comparison	DRAM presence DRAM width (cm)
Zappile-Lucis 2009	Case study	13/28	1	36	Multiparous	Vaginal	Core strengthening and stabilisation exercises, aerobic activity and neuromuscular re-education. 12 sessions over 6 weeks	No comparison	Quality of life (SF36)

DRAM, diastasis of the rectus abdominis muscle; ADLs, activities of daily living; TA, transversus abdominis; SF36, Short Form 36; SD, standard deviation.
[a] Mean (SD) not reported.

[4,29]. Also, the inter-recti distance that was considered to indicate DRAM varied: Sheppard [21] defined it as >2 cm separation, Lo *et al.* [4] and Candido *et al.* [10] defined it as >2.5 cm, Mesquita *et al.* [28] defined it as >3 cm separation, and Chiarello *et al.* [3] defined it as a two-finger separation on sit-up. Thornton and Thornton [29] did not provide a definition of DRAM.

Effects of antenatal exercise on DRAM

DRAM prevention (presence/absence)

Compared with non-exercising controls in three studies ($n = 228$), antenatal exercise reduced the presence of DRAM by 35% (RR 0.65, 95% CI 0.46 to 0.92). Pooling of data showed low to moderate heterogeneity ($I^2 = 39\%$) [31]. From this RR, the number needed to treat was 3. This means that for every three pregnant women treated with exercise, one woman would be prevented from developing DRAM.

DRAM width

Evidence from two studies ($n = 20$) demonstrated that antenatal exercise reduced DRAM width during the antenatal [1,3] and postnatal periods [1] (Table 2). Following a 6-week course of antenatal abdominal strengthening exercises, DRAM width during the antenatal period was significantly smaller in the intervention group {mean 1.14 [standard deviation (SD) 0.38] cm} compared with the non-exercising control group [mean 5.95 (SD) 2.36 cm] (mean difference 4.81 cm, 95% CI 3.83 to 5.80) [3] (Table 2). In the case study [1], the participant who attended antenatal fitness classes had reduced DRAM 48 hours after delivery. Comparatively, both studies found that non-exercising controls had an increase in DRAM width after delivery (Table 2).

DRAM time to recovery

A retrospective study [4] ($n = 55$) that looked at risk factors associated with developing DRAM reported that antenatal exercise may have been associated with faster recovery of DRAM; however, when parity and mode of delivery were taken into account, the effect was not significant.

Effects of postnatal exercise on DRAM

DRAM width

Three studies [21,28,29] included postnatal abdominal exercise with the aim of reducing DRAM width. Pooling of data was not possible due to insufficient data.

The randomised controlled trial [28] evaluated individualised abdominal and pelvic floor exercises delivered in two one-on-one sessions with a physiotherapist 6 and 18 hours after delivery. Measurements were taken 6 and 18 hours after delivery and 18 hours after the intervention. The intervention group had a mean decrease in DRAM width of 0.44 cm (13%), compared with 0.17 cm (5%) for the control group (Table 2). The single case studies [21,29] combined abdominal exercises with a tubigrip/corset and or posture/back care education to reduce DRAM in the postnatal period. Both studies showed a reduction in DRAM width after delivery (Table 2). Sheppard [21] also reported improved transversus abdominis muscle activation on palpation and abdominal muscle endurance with the interventions, while Thornton and Thornton [29] claimed that the corset helped to reduce low back pain.

Secondary outcomes

One case study [30] described the effects of DRAM on quality of life. In this study, a woman with DRAM (who had delivered 8 years previously) had associated abdominal and lumbar back pain, weakness, fatigue and reduced lifestyle participation. A 6-week programme of core strengthening and aerobic exercise and neuromuscular education was instituted, resulting in 79% improvement in physical Short Form 36 (SF36) score and 48% improvement in social SF36 scores (Table 2). No other included studies reported results on any other secondary outcomes.

Adverse events

No adverse events were reported in any of the eight studies. Most of the attrition was due to non-compliance with appointments or exercise regimens. Chiarello *et al.* [3] reported that two participants dropped out due to the development of high-risk pregnancies. Lo *et al.* [4] reported that one patient was excluded from the study due to persistent DRAM which was thought to be associated with diabetes needing medical intervention (Table 2).

Discussion

This systematic review analysed eight studies of varying designs evaluating interventions to prevent and/or reduce DRAM. All studies presented some form of exercise as an intervention alone or in combination with education and/or external support garments. Due to the low number and quality of included articles, there is insufficient evidence to recommend that exercise may help to prevent or reduce DRAM.

Although all studies showed that exercise was protective for the development and/or reduction of DRAM, which is consistent with earlier hypotheses [6], caution should be applied given the limited amount and poor quality of included studies, and previous conflicting anecdotal observations that showed less promising results [7].

A possible explanation for how exercise during the antenatal period may reduce the risk of developing DRAM is that exercise helps to maintain tone, strength and control of the abdominal muscles [3,5], consequently reducing stress on the linea alba. Additionally, women who exercise during pregnancy generally also exercise prior to pregnancy and, therefore, may be fitter and have better conditioned abdominal muscles compared with women who do not exercise

Table 2
Study results.

Study	Outcomes DRAM presence	DRAM width in cm, mean (SD)	Other	Notes
Antenatal: prevention of DRAM				
Candido *et al.* 2005	Intervention group[a] 31/106(29%) Control group[a] 45/102(44%)			Measurements were taken 48 hours after delivery
Chiarello *et al.* 2005	Intervention group 1/8(12%) Control group 9/10(90%)	Intervention group 25 weeks 1.14 (0.38)[b] Control group 25 weeks 5.95 (2.36)[b]		Measurements were taken at umbilicus at 25 weeks of gestation. Significant differences between groups regarding previous pregnancies ($P = 0.029$) were accounted for with ANCOVAs. Effect of previous pregnancies on DRAM was not significant ($P = 0.66$)
Hsia and Jones 2000	Intervention group 0/1(0%) Control group 1/1(100%)	Intervention group 38 weeks pre 1.57 48 hours 1.42 12 weeks post 0.70 Control group 36 weeks pre 0.80 48 hours 3.95 12 weeks post 2.85		Measurements were taken at umbilicus and 4.5 cm above and below umbilicus at 36 to 38 weeks of gestation, 48 hours and 12 weeks after delivery. Data from measurements at the umbilicus are presented here, measurements at other levels showed similar trends
Lo *et al.* 1999			Time to recovery: antepartum activity regression coefficient 0.003 ($P = 0.99$)	No raw data presented; upon request, raw data were discarded due to expiry
Postnatal: reduction of DRAM				
Mesquita *et al.* 1999	$n = 25$; DRAM present 6 hours after delivery	Intervention group 6 hours 3.45 (0.43) 18 hours 2.64 (0.46)[b] Control group 6 hours 3.16 (0.26) 18 hours 2.99 (0.28)[b]		Measurements were taken 4.5 cm above the umbilicus at 6 and 18 hours after delivery
Sheppard 1996	$n = 1$ case study; DRAM present 5 days after delivery	5 days pre 12.5 3 months post 2.5		Measurements were taken at umbilicus 5 days pre-natal and 3 months after delivery
Thornton *et al.*1993	$n = 1$ case study; DRAM present at 40 weeks of gestation	40 weeks pre 23.0 6 months post 1.5		Measurement were taken at umbilicus at 40 weeks pre-natal and 6 months after delivery
Zappile-Lucis 2009	$n = 1$ case study; DRAM present 8 years after delivery		Pre-intervention SF36 physical 32% SF36 social 43% Post-intervention SF36 physical 111% SF36 social 91%	Surveyed 8 years after delivery (pre-intervention) and 6 weeks later (post-intervention)

DRAM, diastasis of the rectus abdominis; muscle; TA, transversus abdominis muscle; SD, standard deviation.
[a] Retrospective self-reported activity levels.
[b] Significant difference between groups ($P < 0.05$).

during pregnancy [4]. Similarly, the reduction of DRAM width and faster recovery of DRAM observed with exercise may be explained by the type of exercise instituted. Five studies investigated abdominal/core strengthening exercises targeted at transversus abdominis muscle activation [3,21,28–30]. It must be noted that these exercises were varied in how this activation was achieved. The transversus abdominis muscle is the deepest abdominal muscle, and has strong fascial links with the rectus abdominis muscle and the linea alba [32]. Activation and exercise of the transversus abdominis muscle draws the bellies of the rectus abdominus muscle together, improves the integrity of the linea alba and increases fascial tension, allowing efficient load transference and torque production [13]. Potentially, transversus abdominis muscle activation could be protective of the linea alba and may help to prevent or reduce DRAM and speed up recovery, allowing women to return to their usual physical and social activities more quickly. However, future high-quality studies are needed to evaluate this.

In addition to exercise, two case studies [21,29] used external support garments (i.e. tubigrip, corsets) with the aim of reducing DRAM. External support garments may provide compression and support to the abdominal and lumbopelvic region by mimicking facial tension of the transversus abdominis muscle, and may provide biofeedback for the transversus abdominis muscle to assist with its activation. These external supports could be used in addition to transversus abdominis muscle exercises, but evidence is lacking about their use in the management of DRAM and further research is required.

Strengths and limitations

This review followed the PRISMA guidelines on high-quality reporting of systematic reviews and meta-analysis [33], and has several methodological strengths. Search strategies were comprehensive with no language, date or design restrictions applied, reducing selection bias and ensuring that all relevant studies were found. Methods used to extract and analyse data were robust. Methodological quality assessment used the modified Downs and Black checklist which has good validity and reliability [34]. The pooled results were clinically homogenous and of low to moderate heterogeneity.

Although the findings are significant, caution is required when interpreting and applying the results of this review due to the design and quality of the included studies. Studies were of varying design (e.g. single case studies, retrospective), had inadequately powered sample sizes, and were of varying methodological quality. Definitions of DRAM and methods of measuring DRAM also varied between studies and contributed to the inability of the review to draw strong conclusions. Evidence supporting exercise prescription during the antenatal period was primarily retrospective and lacked detail on the exercises completed. The quasi-experimental study [3], although randomised, had groups that were not similar at baseline in terms of one known risk factor for DRAM. The control group had a greater average number of previous pregnancies, which may have put them at higher risk for the development of DRAM. Three of the four postnatal studies were case studies with mixed interventions. Although of good methodological quality, the one randomised controlled trial [28] investigating postnatal exercise presented limitations within its protocol; for example, the number of measurements carried out on the intervention and control groups was not consistent. Additionally, the timing of the interventions within the first 6 to 18 hours after delivery may not be clinically relevant. Postnatal abdominal exercise and assessments instituted after 48 hours may give more accurate results of exercise-induced change as removal of stretch on the anterior abdominal wall immediately after delivery generally decreases the inter-recti distance [1].

Implications

This review included eight studies of varying design and low methodological quality, highlighting the lack of high-quality research on non-surgical interventions to prevent and reduce DRAM. The result of this review and meta-analysis identifies the need for adequately powered, high-quality prospective randomised controlled trials targeting specific non-surgical management strategies. This may enable a single exercise intervention, rather than a varied regime of different exercises and strategies, to be recommended. This would be time and resource saving for clinics, clinicians and women with diastasis.

Conclusion

Due to the poor quality of the current literature, current evidence suggests that non-specific exercise may or may not help to prevent or reduce DRAM during the ante- and postnatal periods.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.physio.2013.08.005.

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