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Impact of postpartum exercise on pelvic floor disorders and diastasis recti abdominis: a systematic review and meta-analysis

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ABSTRACT

Objective To examine the effect of exercise during the first year postpartum on pelvic floor disorders and diastasis recti abdominis.

Design Systematic review with random effects meta-analysis.

Data sources: MEDLINE, EMBASE, CINAHL, SPORTDiscuss, Evidence-Based Medicine Reviews (Ovid), Scopus, Web of Science and ClinicalTrials.gov were searched until 12 January 2024.

Eligibility criteria for selecting studies Studies of all designs (except case studies) and languages were included if they contained information on the Population (individuals in the first year postpartum), Intervention (subjective or objective measures of frequency, intensity, duration, volume or type of exercise alone ('exercise-only') or in combination with other intervention (eg, biofeedback; 'exercise+co-intervention')), Comparator (no exercise or different exercise measures) and Outcome (symptom severity and risk of urinary incontinence, anal incontinence, pelvic organ prolapse, diastasis recti abdominis and sexual function).

Results 65 studies (n=21 334 participants) from 24 countries were included. 'Moderate' certainty of evidence revealed that pelvic floor muscle training reduced the odds of urinary incontinence by 37% (seven randomised controlled trials (RCTs), n=1930; OR 0.63, 95% CI 0.41 to 0.97, I² 72%) and pelvic organ prolapse by 56% (one RCT, n=123; OR 0.44, 95% CI 0.21 to 0.91) compared with control groups. 'Low' certainty of evidence showed a greater reduction in inter-rectus distance measured at rest and during a head lift following abdominal muscle training compared with no exercise. Evidence on the effect of exercise on the risk of anal incontinence and diastasis recti abdominis, as well as the severity of anal incontinence, urinary incontinence, pelvic organ prolapse and sexual function, is limited.

Conclusion Evidence supports the effectiveness of postpartum pelvic floor muscle training in reducing the odds of urinary incontinence and pelvic organ prolapse and postpartum abdominal exercise training in reducing inter-rectus distance.

PROSPERO registration number CRD42022359282.

INTRODUCTION

Pelvic floor disorders and diastasis rectus abdominis are highly prevalent conditions following pregnancy and childbirth, which can adversely impact an individual's quality of life in the postpartum period. The

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ The pelvic floor and abdominal musculature undergo a period of prolonged stress during pregnancy that may lead to pelvic floor disorders and diastasis rectus abdominis following childbirth.
- ⇒ Pelvic floor muscle training with or without aerobic exercise reduces the odds of urinary incontinence by 50% during pregnancy and 37% in the postpartum period when exercise is performed during pregnancy.
- ⇒ Limited, inconclusive information exists regarding the effects of exercise initiated in the postpartum period on pelvic floor disorders and diastasis rectus abdominis.

WHAT THIS STUDY ADDS

- ⇒ Pelvic floor muscle training in the first year postpartum reduces the odds of urinary incontinence by 37% and pelvic organ prolapse by 56%.
- ⇒ Abdominal muscle training reduced inter-rectus distance at rest and during a head-lift task in postpartum individuals.
- ⇒ Currently, there is a lack of research to support the association between postpartum exercise and pelvic floor disorder severity, sexual function or the risk of anal incontinence and diastasis recti abdominis.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ The findings of this review support the inclusion of pelvic floor muscle training into the care of individuals in their first year postpartum to reduce the prevalence of urinary incontinence and pelvic organ prolapse.
- ⇒ More research is needed to better understand if and how pelvic floor muscle training and exercise interventions can improve other outcomes related to pelvic floor dysfunction, such as the symptom severity of urinary incontinence and pelvic organ prolapse, anal incontinence risk and symptom severity and sexual function.

most common pelvic floor disorder, urinary incontinence (involuntary loss of urine), affects approximately one-third of postpartum women a year after

delivery,¹ while anal incontinence (involuntary loss of solid stool, liquid stool, flatus or a combination of these)² has been shown to impact ~14% of women at 6 months and ~13% of women at 12 months postpartum.³ The prevalence of pelvic organ prolapse (one or more pelvic organs descending from its normal position into the vagina) has been found to affect 20%–65% of females when reported symptoms and pelvic examinations determine the prevalence⁴ and, if left untreated, the lifetime risk of surgery for pelvic organ prolapse or stress urinary incontinence is 20% by the age of 80 years.^{5,6} Additionally, the presence of pelvic floor disorders is a crucial risk factor for sexual dysfunction, which can impact 64% of postpartum individuals.⁷ While diastasis recti abdominis was previously proposed as a risk factor for pelvic floor disorders, contemporary evidence counters this hypothesis.⁸ Although the prevalence rate of diastasis recti abdominis varies in the literature due to the large variation in measurement methods and cut-off values,^{9–11} it has been observed in up to 45% and 33% of postpartum individuals at 6 months and 1 year after childbirth, respectively.¹² Considering the high prevalence of these conditions in the postpartum period, it is essential to identify optimal prevention and treatment interventions to enhance the quality of life of postpartum individuals.

Exercise is recommended as the first-line intervention for the treatment of pelvic floor disorders,^{13,14} sexual dysfunction¹⁵ and diastasis recti abdominis.^{16–18} However, the efficacy of exercise interventions, including pelvic floor muscle training and abdominal muscle training aimed at improving the muscular function of the pelvic floor and abdominal wall, has not been demonstrated exclusively in the first year postpartum.

The present systematic review and meta-analysis was conducted as part of a series of reviews that will form the evidence base for the development of the *Society of Obstetricians and Gynaecologists of Canada/Canadian Society for Exercise Physiology 2025 Canadian Guideline for Physical Activity, Sedentary Behaviour and Sleep throughout the First Year Postpartum* (here referred to as the *Guideline*). The purpose of this review was to examine the effect of exercise in the first year postpartum on the risk and symptom severity of urinary incontinence, anal incontinence, pelvic organ prolapse, sexual function, and diastasis recti abdominis.

METHODS

In April 2022, a panel of researchers, methodological experts and representatives from the Society for Obstetricians and Gynaecologists of Canada, Canadian Society for Exercise Physiology, College of Family Physicians of Canada, Canadian Physiotherapy Association, Canadian Association of Midwives and Canadian Academy of Sport and Exercise Medicine met to identify outcomes for inclusion in the *Guideline*. During this meeting, 10 critical maternal health outcomes, nine important maternal health outcomes and two important infant health outcomes were selected concerning postpartum maternal health behaviours (physical activity, sedentary behaviour and sleep).^{19,20} Urinary incontinence was determined to be a ‘critical’ outcome, and faecal incontinence, pelvic organ prolapse and sexual function as ‘important’ outcomes. For this review, the important outcome of faecal incontinence, the complaint of involuntary loss of faeces, was expanded to include the complaint of involuntary loss of faeces or flatus and therefore, the term anal incontinence will be used. Diastasis rectus abdominis was not ranked as a *Guideline* outcome.

This systematic review and meta-analysis were guided by the Preferred Reporting Items for Systematic Reviews and

Meta-Analyses (PRISMA) guidelines.²¹ The completed PRISMA checklist can be found in the online supplemental file.

Protocol and registration

The protocol for this systematic review examining the impact of postpartum health behaviours on maternal and infant health outcomes was registered with the International Prospective Register of Systematic Reviews (PROSPERO) on 20 September 2022 (registration number CRD42022359282; available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022359282), and updated 12 January 2024.

Eligibility criteria

This review was guided by the participants, interventions, comparisons, outcomes and study design (PICOS) framework.²¹

Population

The population of interest was postpartum individuals in their first year after delivery. A study that recruited participants beyond 12 months after delivery was included only if participants initiated the intervention in their first year postpartum.

Intervention (exposure)

The intervention/exposure of interest was objectively or subjectively measured postpartum exercise or physical activity of any frequency, intensity, duration, volume or type. Exercises could be a single session (acute) or habitual activity (chronic). Exercise and physical activity were defined as any bodily movement generated by skeletal muscles that results in energy expenditure above resting levels.^{22,23} Interventions including exercise alone (termed ‘exercise-only interventions’) or in combination with other interventions (such as biofeedback, termed ‘exercise+co-interventions’) were considered. Studies were included if the intervention was initiated in the first year postpartum. Interventions that began during pregnancy and continued postpartum were included if most of the intervention was during postpartum. For the purpose of this review, when a study included an ‘exercise-only intervention’ group and one or more ‘exercise+co-intervention’ groups, only the ‘exercise-only intervention’ group was used and compared with the control group.

Comparison

Eligible comparators were no intervention (including standard care), minimal contact (eg, online intervention or education only), different frequency, intensity, duration, volume or type of exercise, and active controls (eg, low-intensity exercise).

Outcome

Relevant outcomes were the risk and symptom severity of urinary incontinence, anal incontinence, pelvic organ prolapse, sexual function and diastasis recti abdominis during the first year after childbirth. A wide range of subjective and objective outcomes were considered, including self-reported presence and severity of symptoms, self-reported measures of pelvic floor dysfunction (eg, Urinary Distress Inventory, Short Form), condition-specific symptom severity questionnaires (eg, International Consultation on Incontinence Questionnaire-Urinary Incontinence Short Form) and inter-rectus distance measurements using a range of measurement tools (eg, calliper and ultrasound imaging). For intervention studies, the measurement period for each outcome was pre-intervention to immediately post-intervention. If outcomes were measured beyond immediate post-intervention, the measurement period was either immediate post-intervention

to follow-up (termed 'maintenance phase') or pre-intervention to follow-up (termed 'long-term effect'), depending on which data were provided.

Study design

Primary studies of any design were eligible, except for case studies ($n=1$), narrative syntheses and systematic reviews.

Additional considerations

We did not limit studies by publication language or date. Studies not published in English or French were initially translated using Google Translate to determine eligibility for inclusion. If selected for extraction, they were analysed with the assistance of a first-language speaker.

Information sources

A research librarian with systematic reviewing expertise created and ran a comprehensive search using the following databases: MEDLINE, EMBASE, CINAHL, SPORTDiscus, Evidence-Based Medicine Reviews (Ovid), Scopus, Web of Science and ClinicalTrials.gov up to 12 January 2024. We considered collaborator-nominated papers. We screened reference lists of included studies and relevant reviews for additional, relevant papers. Complete search strategies are presented in the online supplemental file.

Study selection

Search results were uploaded to Covidence (Melbourne, Victoria, Australia), an online systematic review management software, where duplicate records were removed. Two reviewers independently screened titles and abstracts of all retrieved articles. Abstracts deemed to have met the inclusion criteria by at least one reviewer were automatically retrieved as full-text articles. Two reviewers then independently screened full-text articles for the relevant population, intervention, comparators and outcomes before data extraction. If needed, disagreement was resolved through discussion between reviewers or with a third reviewer.

Data extraction

Data extraction tables were created using a standardised form. Two reviewers, not blinded to the study authors, independently extracted data from all included studies into a standardised form. A content expert independently verified the extracted data. For each individual study, the publication's most recent or complete version was selected as the 'parent' paper; however, relevant data from all publications related to each unique study were extracted.

Extracted data included study characteristics (eg, year, study design, country), population characteristics (eg, number of participants, age, prepregnancy body mass index, previous physical activity levels, parity, delivery mode and pregnancy complications), intervention (prescribed exercise frequency, intensity, duration, volume, type, duration of intervention), comparators (no exercise or different types of exercise), co-intervention type and outcomes. We contacted the study authors for additional information, if data were unavailable for extraction.

Certainty of evidence assessment

The certainty of evidence across included studies for each outcome and study design was assessed using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) framework.²⁴ Evidence from randomised controlled

trials (RCTs) was considered 'high' certainty and downgraded, if there was a concern with risk of bias (ROB),²⁵ indirectness,²⁶ inconsistency,²⁷ imprecision²⁸ or publication bias²⁹ because these factors reduce confidence in the observed effects. Evidence from non-RCTs and observational studies was considered 'low' certainty and, if there was no cause to downgrade, was upgraded if applicable according to the GRADE criteria (eg, large magnitude of effect, evidence of dose response).³⁰

Two reviewers independently and systematically assessed ROB of included studies at the individual study level. ROB was assessed according to the study design using a modification of the protocol outlined in the Joanna Briggs Institute (JBI) Manual for Evidence Synthesis.³¹ We used the JBI checklist to determine the extent to which a study had addressed the possibility of bias in its design, conduct and analysis. Specifically, we screened all studies for potential sources of bias, including inappropriate sampling, flawed measurement of exposure, flawed measurement of outcomes, selective/incomplete outcomes, unidentified confounding factors and inappropriate statistical analysis. In case of rating differences, discrepancies were resolved through discussion. The overall ROB of a study was defined as high risk when more than one-third of the factors (RCTs: ≥ 3 of 10 factors; non-RCTs: ≥ 4 of 13 factors; cross-sectional studies: ≥ 3 of 9 factors; cohort studies: ≥ 4 of 13 factors) were marked as high risk. We considered ROB across studies as 'serious' when studies with the greatest influence on the pooled result (assessed using weight (%) given in forest plots) presented high ROB. We determined the greatest influence on the pooled result as follows: the studies that had the greatest individual % contribution in the meta-analyses, when taken together, contributed to $>50\%$ of the weight of the pooled estimate.

We assessed inconsistency across studies using statistical tests and visual inspection of forest plots.²⁷ We used Cochran's Q ($\alpha=0.05$) to detect statistical heterogeneity and I^2 statistic to quantify the magnitude of statistical heterogeneity between studies. In the case where we observed high statistical heterogeneity ($I^2 > 50\%$), we considered downgrading the evidence if the direction of the effect was inconsistent across most studies, with minimal overlap of CIs, and if such heterogeneity remained unexplained after conducting meta-regression and/or subgroup analyses. We considered indirectness as 'serious' when PICO criteria differed substantially across studies. Imprecision was considered 'serious' or 'very serious' when the sample size was small (<300 in each arm or <100 in each arm, respectively) and/or when the effect estimate was imprecise with wide CI, including the no-effect value, which does not rule out a small harm or negative effect.²⁸ Publication bias was assessed when at least 10 studies were included in the meta-analysis. Otherwise, it was deemed non-estimable and not rated down. Initially, we planned to have two individuals independently assess the certainty of the evidence across each health outcome. However, it was amended for feasibility reasons. Therefore, one individual evaluated the certainty of the evidence, and a second individual checked the GRADE tables as a quality control measure.

Evidence synthesis: statistical analysis and narrative synthesis

Meta-analyses were conducted using ReviewManager (RevMan) V.5.4 (Cochrane, London, UK). The mean difference (MD) or the standardised mean difference (SMD) in change scores (ie, post-intervention minus pre-intervention scores) was calculated for continuous outcomes. SMD effect sizes were calculated using Hedges' g . An effect size of 0.2, 0.5 and 0.8 were considered small, moderate and large, respectively.³² Quantitative synthesis

of continuous outcomes was conducted using DerSimonian and Laird random effects models with an inverse-variance approach.³³ ORs were calculated using post-intervention events or percentage data for dichotomous outcomes. Dichotomous outcome analyses were conducted with a Mantel-Haenszel random effects method. Clinical significance was considered as a $\geq 25\%$ reduction in the odds of an outcome. Statistical significance was set at $p < 0.05$.

Meta-analyses were conducted separately by study design and outcomes. RCTs and non-RCTs that did not include a non-exercising control group were considered and analysed separately as superiority trials. Intervention 1 was the intervention thought to be more effective (most intensive or specific), and intervention 2 was the intervention thought to be less effective (less intensive or specific). For RCTs and non-RCTs, sensitivity analyses were performed to evaluate whether the observed effects differed when examining the impact of exercise-only (including standard care) versus exercise+co-interventions on the outcomes. When possible, the following a priori subgroup analyses were conducted for exercise-only interventions: (1) for the intervention initiation in postpartum (≤ 12 weeks vs > 12 weeks postpartum), (2) for the mode of delivery (vaginal vs caesarean section vs mixed) and (3) for the type of exercise (eg, PFMT, abdominal strengthening, aerobic exercise, mixed training). If a study did not provide sufficient details to allow it to be grouped into the a priori subgroups, an 'unclear' group was created. The following a posteriori subgroup analyses were conducted: (1) for when the intervention started (in pregnancy and continued during postpartum vs in postpartum only) and (2) for the mode of intervention delivery (group-based vs individual; supervised vs unsupervised exercise sessions). One additional a posteriori subgroup analysis was conducted for exercise-only interventions reporting on inter-recti distance: where the measure was taken (ie, above the umbilicus, at the umbilicus or below the umbilicus). The I^2 was calculated to indicate the per cent of total variability that was attributable to between-study heterogeneity. Tests for subgroup differences were conducted with statistical significance set at $p < 0.05$. If statistically significant differences were found, subgroup differences were interpreted.

To quantitatively synthesise the evidence on the acute effect of exercise on inter-rectus distance, we used a random effects multilevel meta-analytic approach to account for dependency between effect sizes (ie, the correlation between effect sizes due to multiple measures or submeasures of the same outcome within a study).^{34–35} In such cases, outcome measures and comparisons from the same study were nested within the study first, and variance in observed effect sizes was decomposed into sampling, within-study and between-studies variance. The statistical heterogeneity I^2 statistic was also estimated in the context of a multilevel meta-analytical approach, that is, within-cluster heterogeneity (multiple arms from the same study) and between-cluster heterogeneity (effect sizes across studies).

Unless otherwise specified, studies were not included in the meta-analyses if data were reported incompletely (eg, indices of dispersion or number of participants not provided). Studies reporting continuous outcomes in other measures of central tendency and/or dispersion (ie, median, range, SE) were converted to mean and SD for analyses.^{36–38} For studies reporting data that could not be meta-analysed, the results were presented as a narrative synthesis structured around each outcome. Within each outcome, results were organised by study design. In this respect, results from non-RCTs (pre-intervention vs post-intervention studies) reporting on inter-rectus distance

measured at rest were synthesised descriptively as measurement sites for inter-rectus distance varied across studies.

Equity, diversity and inclusion statement

Our study population included women of reproductive ages from 24 different countries, including low- and middle-income and high-income countries, from diverse socioeconomic backgrounds and with no exclusion criteria on gender, race, ethnicity, sexuality, socioeconomic status, chronic illness or disease. The author group consisted of students, researchers and clinicians at all career stages (junior, mid-career and senior) who spoke four languages (English, French, Spanish and Arabic). Two authors are people of colour. However, all members of the author group are from two high-income countries in North America.

Patient and public involvement statement

Patient preferences were obtained via an online survey to inform decisions made by the *Guidelines Consensus Panel* regarding the selection of the outcomes of interest but were otherwise not involved in the project.

RESULTS

Study selection

Figure 1 shows a PRISMA diagram of the search results, including reasons for exclusion. The online supplemental file presents a comprehensive list of excluded studies.

Study characteristics

In total, 65 unique studies ($n=21\,334$ postpartum participants) from 24 countries were included in this systematic review, of which two reported on both pelvic floor disorders and diastasis recti abdominis outcomes.^{39,40} Forty studies ($n=19\,900$) from 18 countries reported on pelvic floor disorder outcomes, 23 RCTs ($n=3298$),^{39,41–63} 11 non-RCTs ($n=1456$)^{40,64–74} and five observational studies ($n=15\,146$).^{75–79} Two publications by Sigurdardottir *et al*^{58,59} were based on the same cohort but reported on different outcomes; these studies were counted as one publication. Among the 23 RCTs, 18 were pelvic floor muscle training-only interventions,^{41–44,46–52,54–57,61–63} one was an abdominal muscle training-only intervention,³⁹ and four were pelvic floor muscle training+co-interventions.^{45,53,58–60} The co-interventions included biofeedback devices^{45,53,58,59} and therapeutic modalities.⁶⁰ RCTs that implemented general exercise interventions (eg, whole-body aerobic and/or resistance exercise) were not found. The frequency of pelvic floor muscle training interventions ranged from once a week to three times per day, the duration of exercise sessions ranged from 5 to 60 min per session, and the intensity of pelvic floor muscle exercises ranged from light to maximal contractions. Pelvic floor muscle training was initiated between the third trimester of pregnancy up to 24 weeks postpartum. Additional study details, including the urinary incontinence, anal incontinence, pelvic organ prolapse and sexual function assessments used in each study, can be found in the online supplemental tables 1–3.

Twenty-eight unique studies ($n=1588$) from 15 countries reported on diastasis recti abdominis. There were 14 RCTs ($n=626$),^{39,80–92} six non-RCTs ($n=530$)^{40,93–97} and one observational study ($n=84$)¹⁰ that explored the chronic effect of exercise on diastasis recti abdominis. Results from five studies were narratively reported due to incomplete reporting of results (one RCT,⁸⁶ one non-RCT⁴⁰ and three observational studies).^{76,77,98} Among the 14 RCTs reporting on diastasis recti abdominis, seven were abdominal muscle

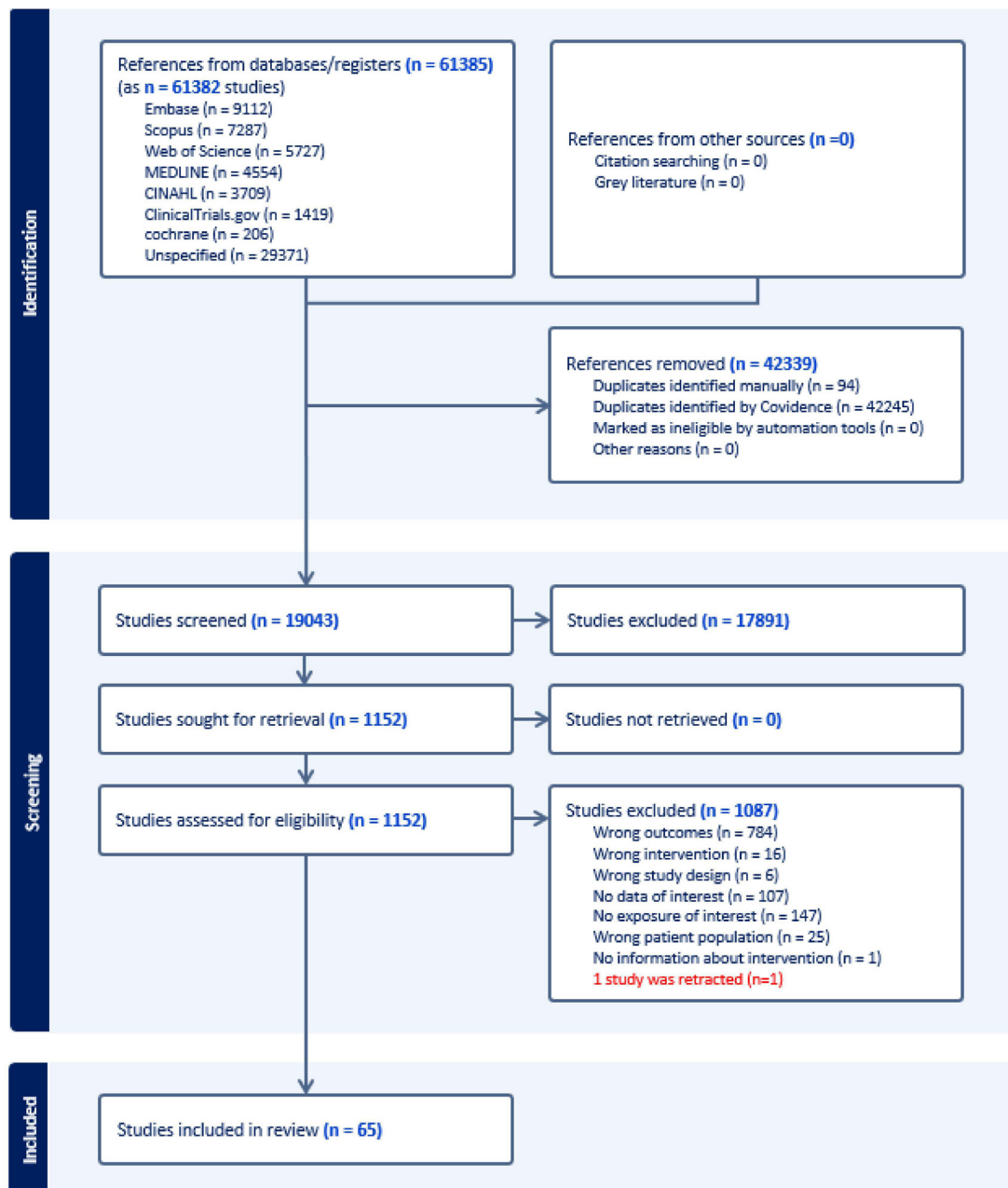


Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of the selection process for studies included.

training studies,^{39 84 85 88 90 92 99} four were abdominal muscle training+pelvic floor muscle training interventions,^{82 86 91 100} and three were exercise+co-interventions.^{80 81 89} The co-interventions included using an abdominal binder,⁸⁰ abdominal bracing techniques⁸⁹ and kinesiotaping.⁸¹ Among the included RCTs that implemented abdominal muscle training and pelvic floor muscle training interventions, the frequency of exercise ranged from 1 to 7 days per week, and the duration of exercise sessions ranged from 5 to 50 min per session. The start of the exercise interventions varied from the first week postpartum up to 52 weeks postpartum. RCTs that implemented general exercise interventions for diastasis recti abdominis (eg, whole-body aerobic and/or resistance exercise) were not found.

Seven studies investigated the acute effects of exercise on diastasis recti abdominis.^{98 100–105} Additional study details, including

the study's definition of diastasis recti abdominis, inter-rectus distance measurement tools and measurement locations, can be found in the online supplemental tables 4–6.

Quality of evidence

Overall, the certainty of evidence ranged from 'high' to 'very low' (see online supplemental tables 7–19). The most common reason for downgrading the certainty of the evidence was imprecision due to small sample size, that is, lack of power to detect differences with precision followed by indirectness (ie, exercise intervention was combined with other interventions, eg, supervised and unsupervised pelvic floor muscle education and training, advice on posture and lifting mechanics, electromyography biofeedback, neuromuscular electrical stimulation, kinesiotherapy, abdominal

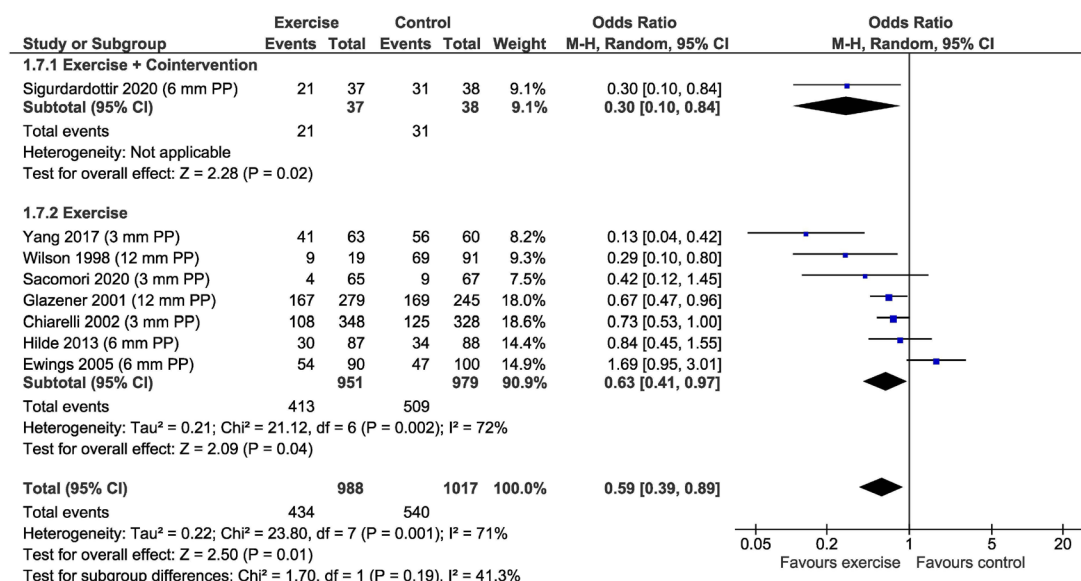


Figure 2 Effects of postpartum pelvic floor muscle training (PFMT) compared with control on the odds of urinary incontinence following the intervention (randomised controlled trials). Sensitivity analyses were conducted using studies that included PFMT+co-interventions and PFMT-only interventions. Analyses were conducted with a random effects model. M-H, Mantel-Haenszel method.

bracing). Publication bias was not possible to assess as <10 studies were included in meta-analyses.

Synthesis of data

The data from RCTs, as well as a brief summary of results from other study designs, are presented below. Complete data from other study designs are presented in the online supplemental file.

Risk of urinary incontinence

Pre-intervention, 62% of women in the pelvic floor muscle training group and 63% of those in the control group experienced urinary incontinence (five RCTs, $n=1912$; OR 1.18, 95% CI 0.55 to 2.57; see online supplemental figure 1). Post-intervention, the pooled summary estimate showed a 41% decrease in the odds of urinary incontinence between pelvic floor muscle training and control groups (eight RCTs, $n=2005$; OR 0.59, 95% CI 0.39 to 0.89, I^2 71%; figure 2).^{42 46 47 49 55 58 62 63} The overall certainty of this evidence was rated as ‘moderate’ and downgraded for concerns regarding indirectness.

Sensitivity analysis: Test for subgroup differences between pelvic floor muscle training-only (7 RCTs, $n=1930$; OR 0.63, 95% CI 0.41 to 0.97, I^2 72%) and pelvic floor muscle training+co-intervention (1 RCT, $n=75$; OR 0.30, 95% CI 0.10 to 0.84, I^2 NA) was not significant ($p=0.19$; figure 2).

Subgroup analyses: subgroup analyses were either not statistically different between groups (timing of intervention initiation in postpartum, $p=0.71$; mode of delivery, $p=0.74$; mode of intervention delivery (level of supervision, $p=0.38$ and type of programme, $p=0.38$), see online supplemental figures 3–6) or not possible due to lack of data (type of exercise, timing of intervention start).

Change in urinary incontinence symptom severity

The baseline urinary incontinence self-reported symptom severity of the pelvic floor muscle training and control groups ranged from non-symptomatic to severe (see online supplemental figure 15). The pooled summary estimate showed no difference in change in urinary incontinence symptom severity

between pelvic floor muscle training and control groups (six RCTs, $n=294$; SMD -0.04 , 95% CI -0.49 to 0.42 , I^2 65%; figure 3).^{41 45 52 54 56 60} The overall certainty of this evidence was rated as ‘very low’ and downgraded for concerns regarding inconsistency, indirectness and imprecision. Similar results were found with post-intervention data, including the studies by Glazener *et al*,⁴⁷ Kahyaoglu *et al*⁵⁰ and Yang *et al*,⁶³ for which it was not possible to calculate change scores (no postpartum pre-intervention data) (see online supplemental figure 16).

Sensitivity analysis: ‘low’-certainty evidence (downgraded for concerns regarding indirectness and imprecision) demonstrated that symptom severity of urinary incontinence in the pelvic floor muscle training+co-intervention studies^{45 60} were increased compared with controls following the intervention while they were not in the pelvic floor muscle training interventions^{41 52 54 56} ($p=0.03$ for subgroup differences; figure 3).

Subgroup analyses: ‘moderate’-certainty evidence (downgraded for concerns regarding imprecision) demonstrated a greater reduction in symptom severity of urinary incontinence when the intervention was delivered in a group-based, supervised setting (one RCT, SMD -1.22 , 95% CI -2.21 to -0.23 , see online supplemental figures 20 and 21)⁵⁴ compared with when intervention was delivered individually and unsupervised (home programme) ($p=0.02$).^{41 52 56} The other subgroup analyses were either not statistically different between groups (timing of intervention initiation in postpartum, $p=0.37$; mode of delivery, $p=0.07$; timing of intervention start, $p=0.60$; see online supplemental figures 17–19) or not possible due to lack of data (type of exercise).

Risk of anal incontinence

Pre-intervention, 20% of women in the pelvic floor muscle training group and 21% of those in the control group presented with anal incontinence (two RCTs, $n=831$; OR 0.97, 95% CI 0.67 to 1.40; see online supplemental figure 42). The pooled summary estimate showed a 42% reduction in the odds of anal incontinence between pelvic floor muscle training and control groups (three RCTs, $n=694$; OR 0.58, 95% CI 0.31 to 1.11, I^2 33%; see figure 4).^{47 58 62} The overall certainty of this evidence

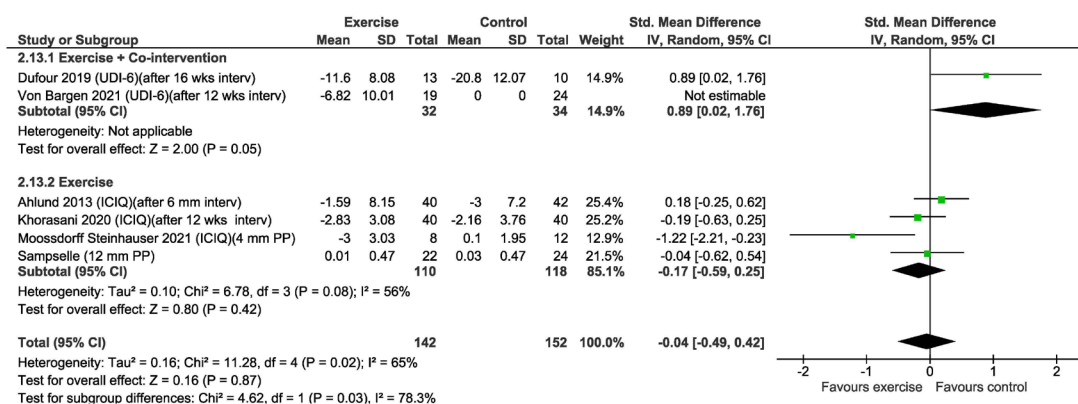


Figure 3 Effects of postpartum pelvic floor muscle training (PFMT) compared with control on change in urinary incontinence symptom severity following the intervention (randomised controlled trials). Sensitivity analyses were conducted using studies that included PFMT+co-interventions and PFMT-only interventions. Analyses were conducted with a random effects model. IV, inverse variance.

was rated as 'low' and downgraded for concerns regarding indirectness and imprecision.

Sensitivity analysis: test for subgroup differences between pelvic floor muscle training and pelvic floor muscle training+co-intervention was not significant ($p=0.87$; figure 4).

Subgroup analyses: subgroup analyses were either not statistically different between groups (timing of intervention initiation in postpartum, $p=0.08$; see online supplemental figure 43) or not possible due to lack of data (mode of delivery, type of exercise, timing of intervention start, mode of intervention delivery).

Change in anal incontinence symptom severity

One RCT ($n=43$)⁶⁰ reported on the change in anal incontinence symptom severity. At baseline, the pelvic floor muscle training group had significantly more pelvic floor symptoms and bother than the control group, including anal incontinence, as measured by the Colorectal-Anal Distress Inventory 8 (see online supplemental figure 37). The researchers found a greater reduction in symptom severity of anal incontinence with the pelvic floor muscle training+co-intervention compared with the control group (MD -0.71 , 95% CI -1.34 to -0.09 , I^2 n/a; see online supplemental figure 46). The overall certainty of this evidence was rated as 'low' and downgraded for concerns regarding indirectness and imprecision.

Change in sexual function

Two RCTs ($n=118$)^{44,60} reported on the change in self-reported sexual function using the Female Sexual Function Index (FSFI). The pooled summary estimate showed no difference in change in sexual function between the pelvic floor muscle training and control groups (two RCTs, $n=118$; SMD 0.31, 95% CI -0.96 to 1.58 , I^2 91%; see online supplemental figure 77).^{44,60} The overall certainty of this evidence was rated as 'very low' and downgraded for concerns regarding inconsistency and imprecision.

Sensitivity analysis: 'moderate'-certainty evidence (downgraded for concerns regarding imprecision) demonstrated that sexual function in the pelvic floor muscle training intervention study⁴⁴ was improved compared with controls following the intervention, while it was worse in the exercise+co-intervention study⁶⁰ ($p=0.001$ for subgroup differences; see online supplemental figure 77).

Subgroup analyses: subgroup analyses were not possible as only one exercise-only study was included.

Risk of pelvic organ prolapse

Two RCTs ($n=197$) reported on the association between postpartum pelvic floor muscle training and the odds of pelvic organ prolapse.^{59,63} No difference was found between the pelvic floor

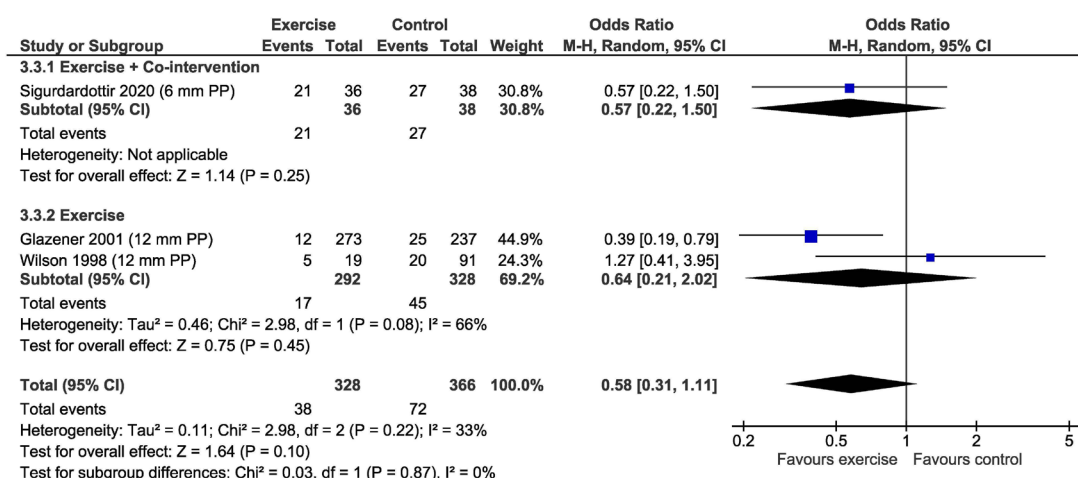


Figure 4 Effects of postpartum pelvic floor muscle training (PFMT) compared with control on the odds of anal incontinence following the intervention (randomised controlled trials). Sensitivity analyses were conducted using studies that included PFMT+co-interventions and PFMT-only interventions. Analyses were conducted with a random effects model. M-H, Mantel-Haenszel method.

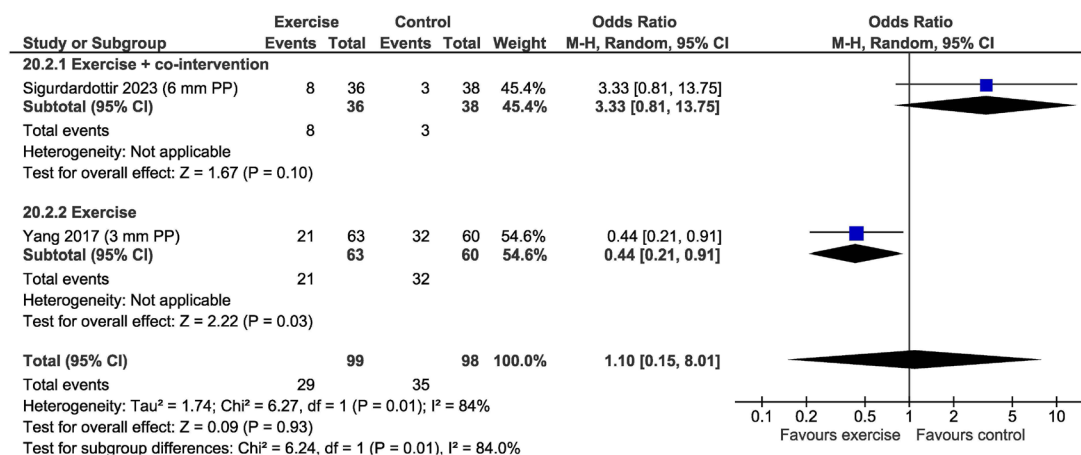


Figure 5 Effects of postpartum pelvic floor muscle training (PFMT) compared with control on the risk of pelvic organ prolapse following the intervention (randomised controlled trials). Sensitivity analyses were conducted with studies including PFMT+co-interventions and PFMT-only interventions. Analyses were conducted with a random effects model. M-H, Mantel-Haenszel method.

muscle training+co-intervention compared with control groups (OR 1.10, 95% CI 0.15 to 8.01, I² 84%; see figure 5). The overall certainty of this evidence was rated as ‘low’ and downgraded for concerns regarding imprecision. Similar results were found when looking at the maintenance of the intervention effect (see online supplemental figure 55).⁵⁹

Sensitivity analysis: ‘moderate’-certainty evidence (downgraded for concerns regarding imprecision) demonstrated that the odds of pelvic organ prolapse in the pelvic floor muscle training group⁶³ were decreased compared with controls following the intervention (1 RCT, n=123; OR 0.44, 95%CI 0.21 to 0.91; see figure 5), while they were not in pelvic floor muscle training+co-interventions⁵⁹ (p=0.01 for subgroup differences; see figure 5).

Subgroup analyses: subgroup analyses were not possible as only one pelvic floor muscle training study was included.

Change in inter-recti distance measured at rest

Pre-intervention pooled inter-rectus distance measured at rest was 2.39±0.62 cm in the abdominal muscle training group and 2.38±0.77 cm in the control group (see online supplemental figure 93). The reported pre-intervention inter-rectus distance at rest was comparable to the mean inter-rectus distance (2.2 cm±1.3 cm) in a general adult population.¹⁰⁶ Following the intervention, the pooled summary estimate showed a greater reduction of 0.52 cm after abdominal muscle training compared with the control group (five RCTs, n=173; MD -0.52, 95% CI -0.99 to -0.05, I² 91%; figure 6).^{81 83 85 90 92} The overall certainty of this evidence was rated as ‘low’ and downgraded for concerns regarding indirectness and imprecision.

Sensitivity analysis: a greater decrease of 1.54 cm in inter-rectus distance was observed in the abdominal muscle training group+co-interventions group (one RCT, n=40; MD -1.54, 95% CI -1.77 to -1.31, rated as ‘low’ and downgraded due to concern regarding indirectness and imprecision)⁸¹ and of 0.35 cm in abdominal muscle training-only interventions group (four RCTs, n=133; MD -0.35, 95% CI -0.59 to -0.10, I² 52%, rated as ‘moderate’ and downgraded due to concern regarding imprecision)^{83 85 90 92} compared with control group. However, the decrease was greater with abdominal muscle training+co-interventions (p<0.00001; see figure 6).

Subgroup analysis: ‘moderate’-certainty evidence (downgraded for concerns regarding imprecision) demonstrated a

greater reduction in inter-rectus distance when the intervention was unsupervised (one RCT, MD -0.87, 95% CI -1.36 to -0.38, see online supplemental figure 97)⁹⁰ compared with when the intervention was supervised (p=0.02).^{83 85 92} The other tests for subgroup differences were either not significant (site of measurement of inter-rectus distance, p=0.56; type of exercise, p=0.21; mode of intervention delivery (group-based vs individual, p=0.22), see online supplemental figures 94–96) or not possible due to lack of data (timing of intervention start, timing of intervention initiation in postpartum).

Change in inter-recti distance measured during a head lift task

Pre-intervention, pooled inter-rectus distance measured during a head lift task was 2.32±0.90 cm in the abdominal muscle training group and 2.31±0.88 cm in the control group (see online supplemental figure 105). Again, the reported pre-intervention inter-rectus distance measured during a head lift task was comparable to the mean inter-rectus distance at rest (2.2 cm±1.3 cm) in a general adult population.¹⁰⁶ The pooled summary estimate showed the abdominal muscle training intervention had a 0.47 cm greater reduction in inter-rectus distance during a head lift task compared with controls (two RCTs, n=84; MD -0.47, 95% CI -0.92 to -0.02, I² 63%; see figure 7).^{90 92} The average reduction in inter-rectus distance for the abdominal muscle training group was 0.62 cm (SD=0.62) and 0.12 cm (SD=0.63 cm) for the control group. The overall certainty of this evidence was rated as ‘moderate’ and downgraded for concerns regarding imprecision.

Sensitivity analysis: sensitivity analysis was not possible as no exercise+co-interventions were included.

Subgroup analyses: ‘moderate’-certainty evidence (downgraded for concerns regarding imprecision) demonstrated a reduction in inter-rectus distance measured during a head lift task following an abdominal muscle training intervention, which included transverse abdominis training, and was an unsupervised, individual intervention (one RCT, MD -0.79 cm 95% CI -1.23 to -0.35, see online supplemental figure 106, 108 and 109)⁹⁰ compared with controls but a reduction was not found in the intervention that included the curl up exercise and was a supervised, group-based intervention (p=0.02).⁹² The other test for subgroup differences were either not significant (inter-rectus

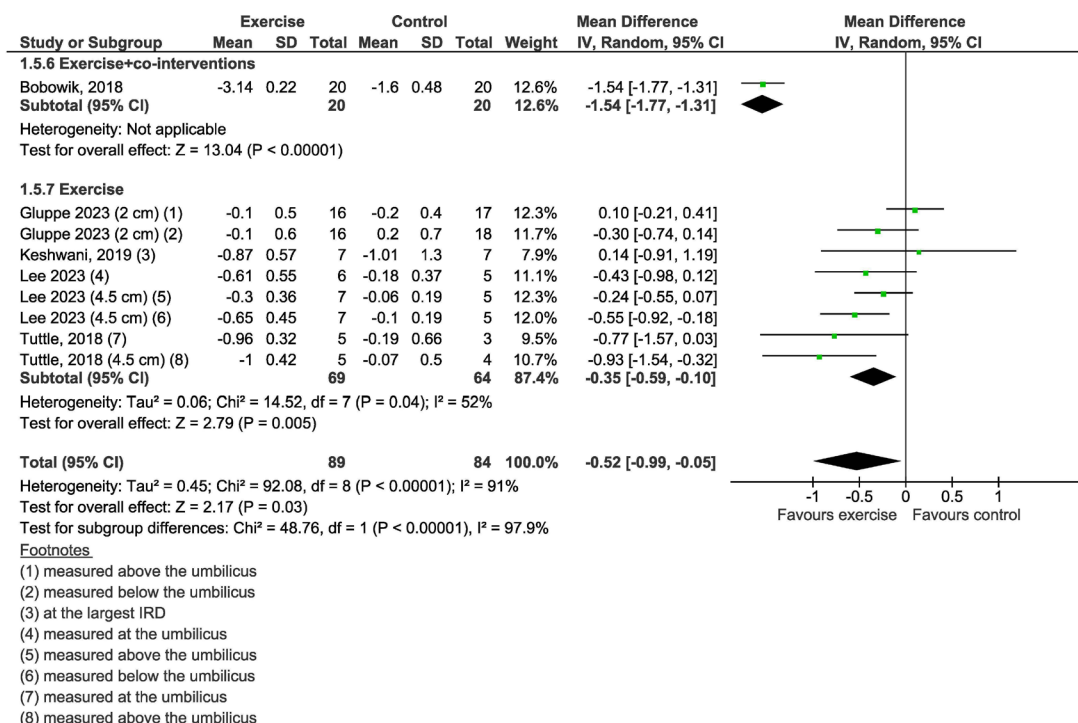


Figure 6 Effects of postpartum abdominal muscle training (AMT) compared with control on inter-recti distance measured at rest following the intervention (randomised controlled trials). Sensitivity analyses were conducted with studies including AMT+co-interventions and AMT-only interventions. Analyses were conducted with a random effects model. IV, inverse variance. *Note:* when a study reported on measurements taken at multiple places, the sample size was divided by the number of groups.

distance measurement site, $p=0.77$, see online supplemental figure 107) or not possible due to lack of data (timing of intervention start, timing of intervention initiation in postpartum).

Data from other study designs reporting on urinary incontinence, anal incontinence and inter-rectus distance are presented in the online supplemental file and partially support those of RCTs. Data from studies reporting on symptom severity of pelvic organ prolapse, on sexual function and sexual efficacy and on the odds of diastasis recti abdominis are also presented

in the online supplemental file, and no impact or association of exercise was found.

DISCUSSION

This systematic review and meta-analysis demonstrate that pelvic floor muscle training, performed during the first year postpartum, can reduce the odds of urinary incontinence and pelvic organ prolapse by 37% and 56%, respectively. We also

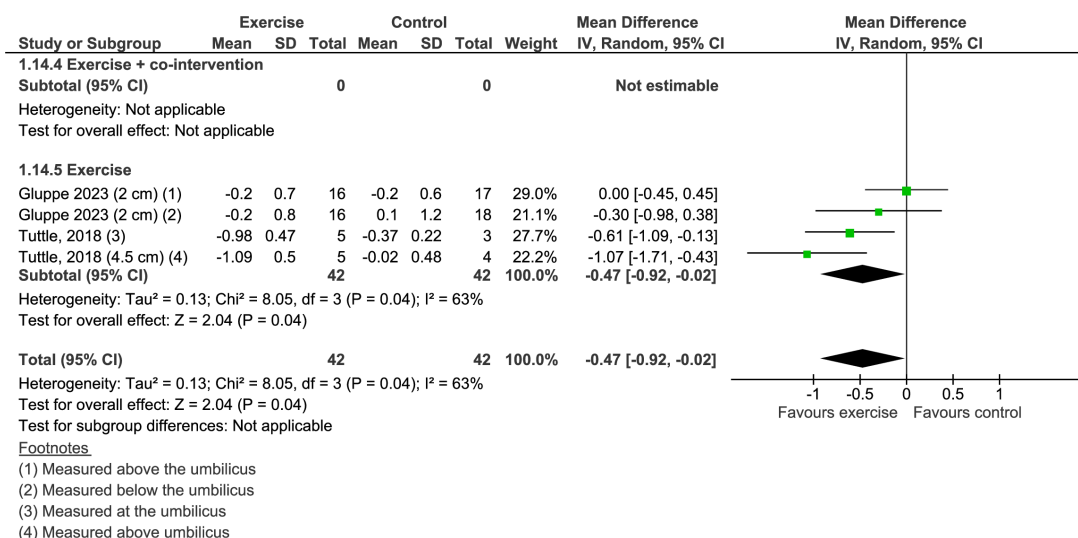


Figure 7 Effects of postpartum abdominal muscle training (AMT) compared with control on change in inter-rectus distance measured during a head lift task following the intervention (randomised controlled trials). Analyses were conducted with a random effects model. IV, inverse variance. *Note:* when a study reported on measurements taken at multiple places along the linea alba, the sample size was divided by the number of groups.

found that abdominal muscle training during the first year postpartum reduces inter-rectus distance. The remaining outcomes were not different between groups, but this finding is based on a limited number of studies.

Urinary incontinence and pelvic organ prolapse are prevalent, debilitating conditions that are often underdiagnosed and undertreated,^{107–109} which can adversely impact an individual's physical, psychological and social health and, subsequently, their well-being and quality of life.¹¹⁰ The financial costs of incontinence across personal, employer and healthcare costs have risen over the last two decades and were estimated to exceed US\$82 billion in 2020 in the USA.^{111–112} The current meta-analysis provides empirical evidence for the efficacy of pelvic floor muscle training as a clinically relevant, accessible and relatively inexpensive prevention and treatment option for pelvic floor disorders, specifically urinary incontinence and pelvic organ prolapse. Implementing pelvic floor muscle training in the care provided to individuals in the first year postpartum has the potential to decrease financial burden (eg, fewer personal hygiene expenses, fewer physiotherapy visits and reduced healthcare costs), improve psychological health and improve quality of life while decreasing the lifetime risk of surgery for pelvic floor disorders and is an optimal time to educate individuals about their pelvic floor health.^{113–115} Our findings are in agreement with the International Continence Society's (ICS) level 1 evidence and recommendation A, which states that pelvic floor muscle training should be offered as first-line conservative therapy to individuals with persistent urinary incontinence symptoms 2–3 months after delivery.¹¹⁶ Additionally, our results highlight that pelvic floor muscle training interventions initiated beyond 2–3 months postpartum, extending into the postpartum year, can reduce the odds of urinary incontinence during the first year postpartum. This aligns with the ICS recommendation grade B, which advocates for pelvic floor muscle training to be provided to all postpartum women by a health professional, regardless of their current or prior continence status. Interestingly, similar to what Brennen *et al* found among pregnant individuals,¹¹⁷ we found moderate-certainty evidence that a postpartum supervised group-based pelvic floor muscle training intervention⁵⁴ could be more effective in reducing urinary incontinence symptom severity than individual, unsupervised pelvic floor muscle training intervention (home programme).^{41–52–56} However, this was based on limited evidence, and future research is needed to confirm this finding.

Although our findings support integrating pelvic floor muscle training into the care of postpartum individuals, it is important to note that the training programmes used in the included studies vary immensely, making it challenging to provide clear guidance on an optimal pelvic floor muscle training programme. The variance in exercise interventions and the limited data supporting the proposed mechanisms underlying pelvic floor muscle training¹¹⁸ highlight the need for future research that explores how pelvic floor muscle training directly impacts pelvic floor health. The included RCTs used interventions that align with what the ICS would consider to be an 'intensive' pelvic floor muscle strength training programme in terms of supervision and exercise content.¹¹⁶ However, interventions varied in frequency, intensity and time parameters, and notably, no intervention explicitly implemented the training principle of progressive overload. Recovery from pregnancy and childbirth presents unique challenges to pelvic floor structures, and exercise progressions must recognise the importance of being individualised, gradual and symptom-based. Early return to exercise and progressive loading, as tolerated, while monitoring for signs

and symptoms of pelvic floor disorders during the proliferative healing phase (3 days to 4 weeks postpartum), may potentially assist with tissue healing, similar to findings in the Achilles tendon rupture and ankle sprain literature.^{119–123} However, future research is needed to explore the potential positive effects of initiating exercise interventions in the first 4 weeks postpartum. To elicit meaningful change, exercise interventions may need to overload the pelvic floor musculature progressively, and future research should consider moving away from focusing on pelvic floor muscle training in static positions to exercise programmes that progressively incorporate greater load through functional movements. We agree with the ICS¹¹⁶ that there is a need for large, pragmatic, well-conducted and explicitly reported RCTs with a long-term follow-up, but these studies should consider the importance of incorporating individualised, progressive, functional pelvic floor muscle strength training into the interventions provided. The impact of other forms of exercise, including moderate-to-vigorous exercise and resistance training, on pelvic floor health in the postpartum period should also be investigated.

Based on the results of one RCT,⁶³ our review demonstrates that pelvic floor muscle training, performed during the first year postpartum, can reduce the odds of pelvic organ prolapse by 56%. Although this finding is promising, it is important to emphasise that it is based on a limited, specific study population, as Yang *et al* only included postpartum individuals who had experienced an episiotomy or second-degree perineal tear during labour,⁶³ and therefore, the results should not be generalised to other postpartum populations. Interestingly, we also found moderate-certainty evidence demonstrating a greater decrease in pelvic organ prolapse symptom severity when an abdominal muscle training intervention was implemented before 12 weeks postpartum,³⁹ while no difference was found when pelvic floor muscle training started after 12 weeks.⁵⁷ Future research is needed to explore the potential positive effects of initiating exercise interventions in the first 12 weeks postpartum.

The International Urogynecological Association and ICS propose that lifestyle modification interventions may improve sexual function by promoting a healthy weight, appropriate sleep, increased physical fitness and management of mood disorders.¹²⁴ This recommendation is supported by a recent systematic review and meta-analysis of RCTs, which found that pelvic floor muscle training improved arousal, orgasm, satisfaction, pain and the FSFI overall score (four studies, 342 participants).¹⁵ However, we found very limited and inconclusive evidence regarding the effect of postpartum pelvic floor muscle training on sexual function (two RCTs, $n=118$). Thus, our findings warrant further investigation.

We found low certainty of evidence from pooled results demonstrating that abdominal muscle training can reduce inter-rectus distance when measured at rest and with a head-lift task during the first postpartum year. As pregnancy progresses, the inter-rectus distance naturally increases and then, decreases during the first 26 weeks postpartum.¹¹ The RCTs included in our review began their interventions during the first 6–8 weeks postpartum, with intervention durations ranging from 4 to 16 weeks. Our results suggest that implementing an exercise intervention, including pelvic floor muscle training and abdominal muscle training, during the first 6–8 weeks postpartum may have the potential to accelerate the natural recovery of inter-rectus distance. However, future research is needed to confirm this hypothesis. Our findings also demonstrated that during acute bouts of exercise, the inter-rectus distance decreases with a head-lift task and increases during a transversus abdominis

contraction when measurements are taken at 2 cm above and below the umbilicus. This finding agrees with previous research on the general adult population¹²⁵ and contradicts the common clinical belief that gentle exercises involving the contraction of the transverse abdominis and internal oblique can reduce diastasis recti abdominis in the postpartum period.^{126 127}

A recent systematic review by Benjamin *et al*¹⁸ investigated the effect of exercise on diastasis recti abdominis in pregnant and postpartum individuals (up to 3 years postpartum) and found moderate certainty of evidence that abdominal exercises reduced inter-rectus distance (MD -0.43 cm, 95% CI -0.82 to -0.05) compared with usual care. Benjamin *et al* concluded that conservative interventions do not lead to clinically significant reductions in postpartum inter-rectus distance.¹⁸ The focus of our review was on the first year postpartum and, therefore, did not include studies that included participants exclusively during pregnancy and that were beyond their first year postpartum, as done in the work of Benjamin *et al*. However, our research builds on the work of Benjamin *et al* with the addition of six newer RCTs.^{39 84–86 88 92} Although our review produced similar findings in individuals in their first year postpartum, it is important to highlight that a clinically meaningful difference in inter-rectus distance has not been established in the literature and was not defined in the work of Benjamin *et al*.¹⁸ Therefore, we would argue that the conclusion by Benjamin *et al*, that conservative interventions do not lead to clinically significant reductions in inter-rectus distance in women postnatally, may be premature.

A consensus on an inter-rectus distance cut-off to diagnose diastasis rectus abdominis also does not currently exist in the literature. Ultrasound studies often draw on Beer *et al*,¹²⁸ who classified women to have diastasis recti abdominis if the mean inter-rectus distance (measured at 3 cm above the umbilicus) is greater than the 90th percentile of the normative values reported for nulliparous women (>2.2 cm). However, more recently, Kaufmann *et al*¹⁰⁶ conducted a retrospective cross-sectional study to define diastasis recti abdominis in adults using CT and found that an inter-rectus distance at 3 cm above the umbilicus may be considered normal up to 3.4 cm (80th percentile in asymptomatic adults).¹⁰⁶ This is an important finding to reflect on, as the exercise intervention studies in this review included exercise groups with participants who had inter-rectus distances below the 80th percentile, as proposed by Kaufman *et al*. More research is needed investigating inter-rectus distance in postpartum individuals who present with larger inter-rectus distances (ie, >5 cm). The clinical significance of an increased inter-rectus distance must be determined before postpartum individuals are prescribed abdominal muscle training to treat diastasis recti abdominis. There is limited evidence suggesting an increased inter-rectus distance is associated with decreased abdominal strength and endurance^{129–131} and with low back pain severity,¹³² which may provide a rationale for abdominal muscle training in the postpartum period; however, more research is needed in this area.

Furthermore, contemporary evidence has proposed that a wide (or increased) inter-rectus distance may not be functionally problematic if the linea alba can stiffen when a task demands load transfer across the midline.¹³³ Therefore, until a link between a clinically meaningful inter-rectus distance and the functional limitations of diastasis recti abdominis is established,^{12 126 134} it may be premature to conduct RCTs that focus on inter-rectus distance as a primary outcome. There is evidence that suggests postpartum individuals who present with diastasis recti abdominis are concerned about the appearance of their diastasis recti abdominis,^{8 99} and they report feeling weak in their abdominal

muscles.⁸ Therefore, future research that investigates the impact of an increased inter-rectus distance on perceived abdominal strength, abdominal pain, physical function and body image satisfaction is needed and may prove to be more clinically meaningful to postpartum individuals.¹³⁵

Strengths and limitations

The strength of our systematic review and meta-analysis is that it followed rigorous methodology (JBI, GRADE) to guide our work process. Grey literature, all study designs and languages were included to reduce overall publication bias, increase the comprehensiveness of the review and foster a balanced overview of available scientific evidence. Sensitivity and a priori subgroup analyses on change scores permitted detailed consideration of heterogeneity and the influence of various factors (eg, time when the exercise interventions were initiated, type of exercise and location and task used to measure inter-rectus distance) on the outcomes of interest.

Limitations of this systematic review include the high heterogeneity that was not reduced with subgroup analysis. For example, despite the decrease in urinary incontinence prevalence, we did not find a change in urinary incontinence symptom severity in this review. However, a wide range of study populations were used in the included studies investigating urinary incontinence symptom severity. Dufour *et al*⁴⁵ included participants with and without urinary incontinence symptoms, Von Bargaen *et al*⁶⁰ only included participants with vaginal deliveries complicated by an obstetric anal sphincter injury (third-degree or fourth-degree laceration), Ahlund 2013 *et al*⁴¹ and Moossdorff-Steinhaus *et al*⁵⁴ only included participants presenting with urinary incontinence at recruitment and the study population in Khorasani *et al*⁵² presented with both stress urinary incontinence and low back pain at the time of recruitment. High statistical heterogeneity was found with all outcomes, which may be due to several factors, including the inclusion of a diverse range of patient populations, the vast range in the components included in each exercise intervention (eg, exercise frequency, intensity and volume, education and supervision provided, duration of the intervention) as well as the diverse range in what is considered 'standard care' for postpartum individuals globally. This limitation is similar to reviews in pregnant populations and may also be related to the variability in the tools used to evaluate pelvic floor disorders and the lack of clarity on how diastasis recti abdominis is defined and measured in the postpartum period. Additionally, no urinary incontinence, anal incontinence, pelvic organ prolapse or sexual function study assessed the impact of exercise without pelvic floor muscle training, limiting the ability to draw conclusions on the effect of aerobic and resistance exercise on pelvic floor disorders and diastasis recti abdominis.

CONCLUSION

Pelvic floor muscle training effectively reduces the odds of urinary incontinence and pelvic organ prolapse during the first year postpartum, and abdominal muscle training can reduce inter-rectus distance at rest and during a head-lift task. Future research should continue to investigate the potential benefits of individualised exercise programmes as a component of a multi-factorial approach to pelvic floor disorders and diastasis recti abdominis in postpartum individuals.

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development of the search strategy. AS conducted the systematic search. S-MR, MJG, TNS and GB completed the acquisition of data. S-MR, GB and MUA performed the data analysis. NFB, MHD, S-MR and MUA assisted with the interpretation. NFB, S-MR and MHD were the principal writers of the manuscript. All authors contributed to the drafting and revision of the final article. All authors approved the final submitted version of the manuscript. S-MR is the guarantor.

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