

A randomized clinical trial of exercise to alleviate postpartum depressed mood

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Abstract

Objective. To evaluate whether a 12-week home-based exercise program is more effective than usual care for alleviating depressive symptomatology in the postpartum.

Methods. Eighty-eight women experiencing postpartum depressed mood were randomly assigned to a 12-week home-based exercise program or usual care. Outcomes assessed immediately post-treatment and 3-months post-treatment were the Hamilton Rating Scale for Depression (HAM-D) and Edinburgh Postnatal Depression Scale (EPDS).

Results. In the intention-to-treat analysis, the effect of the intervention on EPDS did not change from 3 to 6 months evaluations, but was modified by the baseline EPDS score, with subjects with greater depression at baseline (EPDS > 13) in the intervention group having a significantly lower postbaseline EPDS score compared with the usual care group (mean difference 4.06 points, 95%CI 1.51–6.61, $p < 0.001$). After adjusting for baseline HAM-D, subjects in the intervention group had a significantly lower HAM-D score at post-treatment compared with subjects in the usual care group (mean difference 1.83 points, 95%CI 0.24–3.41, $p = 0.02$). The difference in HAM-D became non-significant at 3-months post-treatment.

Conclusions. Home-based exercise is a feasible nonpharmacological intervention with the potential to alleviate postpartum depressive symptoms, especially in women with higher initial depressed mood scores as measured by the EPDS. These findings may guide the design of future exercise clinical trials with postpartum depressed women.

Keywords: Postpartum depressed mood, home-based exercise, randomized controlled trial

Introduction

Postpartum depression (PPD) affects 10–16% of women [1], with symptoms lasting up to 1 year postdelivery [2]. Moreover, children of depressed mothers, including those with subclinical depression, may experience disturbances in attachment, cognitive and behavioral development [3–5]. Despite its high prevalence and serious consequences, elevated depressive symptoms in the postpartum often goes undiagnosed and untreated by health care providers [6]. Although a few well controlled studies have demonstrated the efficacy of pharmacological and psychosocial interventions for the treatment of PPD [7–9] there are concerns about adverse effects of pharmacological therapy on the breastfed newborn [6–10]. Women may also opt against antidepressant or psychotherapeutic interventions for treating

depression because of financial and social stigma associated with these treatment modalities [11,12]. Alternative nonmedical interventions for treating depression in the postpartum have not been widely investigated, resulting in limited evidence-based nonpharmacological treatment options.

Prospective epidemiological studies have shown that individuals who become or remain physically active are less likely to suffer clinical depression [13–16]. However, a lack of methodological rigor has been identified in many of the earlier studies that have evaluated exercise as an intervention for the management of depression [17]. More recently, a randomized clinical trial (RCT) comparing aerobic exercise, antidepressant medication and combined exercise and medication in older patients with major depression found all three groups achieved comparable and significant reductions in depressive symptoms [18].

To date, studies evaluating exercise for the treatment of depression have mainly targeted older adults and patients with chronic conditions [18–20]. Only one small RCT has examined the effects of exercise for treatment of PPD in 19 women [21]. A 12-week aerobic pram-walking intervention significantly reduced depressive symptomology compared with social support [21]. However, that study had a small sample size, did not control for concurrent therapies, and used only one measure of depression. Other modes of exercise, such as home-based exercise which could be more feasible in colder climates, have not been investigated in women with PPD. A recent review of the limited studies to date concluded that exercise may be a viable nonpharmacological intervention for alleviating depressive symptoms in the postpartum [22].

Using the Edinburgh Postpartum Depression Scale (EPDS) [23] and the Hamilton-Rating Scale for Depression (HAM-D) [24] as the primary outcome measures, we evaluated the effectiveness of a 12-week home-based exercise intervention, compared with usual care control group, in reducing depressive symptomology among women reporting elevated depressed mood in the postpartum.

Methods

Subjects

Women in the postpartum period (4–38 weeks) experiencing symptoms of PPD were recruited at obstetrician/gynecologists offices and through media advertisement, as well as pamphlets and flyers sent to delivery units of major hospitals and community health facilities in the Montreal area. Interested participants were screened over the telephone and women scoring ≥ 10 on the EPDS [23] were invited to participate. Eligible women were able to understand English or French, had no current alcohol or substance abuse, were not currently participating in regular moderate or high-intensity exercise (30 min, at least three times per week) and had no obstetrical or concomitant diseases which would have precluded participation in an exercise program. This trial was carried out from November 2001 until November 2004. Approval from the McGill University Faculty of Medicine Institutional Review Board was obtained. All subjects signed informed consent.

Primary outcome measures

Edinburgh Postnatal Depression Scale (EPDS) is an instrument developed and validated for new mothers to measure depressive symptomology in the past 7 days [23]. A cutoff point of 10 has been shown to have high sensitivity and specificity when compared with a diagnosis of minor and major depression using

a psychiatric interview such as the Structured Clinical Interview for the DSM-II-R [25–27]. The EPDS was selected to assess treatment effect as it is the most widely used measure to screen and assess depressive symptomology in previous postpartum trials [21,28–30].

The 17-item Hamilton Rating Scale for Depression (HAM-D) was used to assess depression severity. Its validity and reliability has been established in numerous studies [24,31]. A trained clinical interviewer, blinded to treatment assignment, administered the HAM-D by telephone. As in other studies which administered the scale over the telephone [9,18,32], the interviewer used direct questioning to elicit information usually obtained through observation (agitation and retardation).

Procedures. Following the telephone interview conducted by a trained research assistant, participants completed a physician supervised graded maximal exercise stress test, using the Bruce protocol [33], prior to randomization and at post-treatment. This test was used to screen participants according to the American College of Sports Medicine guidelines (ACSM) [34,35], determine baseline fitness, and individualize the exercise prescription for participants assigned to the exercise group. Fitness was evaluated by time on test and maximal metabolic equivalent capacity [36].

Participants were randomly assigned to the exercise group or to a usual care control group, using stratification on baseline depression severity (mild: HAM-D score < 17 vs. moderate/severe: HAM-D score ≥ 17) [24,31]. Within each stratum, a blocked randomization procedure, with blocks of 4–6, was used to minimize group size imbalance. The study personnel remained blinded regarding the allocation of the next woman until her randomization.

Post-treatment and at 3-months post-treatment, the clinical interviewer administered the HAM-D. The EPDS was included in the questionnaire battery mailed to participants for completion. Data collection procedures were the same for the two groups.

Exercise intervention. Participants assigned to the exercise group met four times with the same exercise physiologist. The first visit was ~ 90 min with 30 min follow-ups scheduled at 1, 3, and 9 weeks thereafter. The first visit included a review of the cardiovascular fitness results, an overview on the benefits of exercise, an individualized exercise prescription, and a supervised exercise session. Principles of warm-up and cool-down, and general exercise precautions were reviewed to minimize the risk of injury.

The exercise prescription was individualized and followed ACSM guidelines for developing and maintaining cardiorespiratory fitness [35]. These guidelines suggest individuals perform 60–120 min/

week of aerobic exercise within their target heart rate zone (60–85% of maximal heart rate). Duration is dependent on the intensity of the activity. Programs were individualized depending on access to equipment, time constraints, weather and enjoyment of various activities. Exercise intensity began at 60–70% of maximal heart rate and increased gradually to 75–85%, depending on the subject's adaptation to the exercise. Stretching and strength exercises were also prescribed, with the amount of each depending on the subject's needs. The follow-up sessions with the exercise physiologist during the 12-week training phase consisted of providing guidance and support, solving any difficulties, and gradually increasing exercise intensity.

Heart rate monitors were provided to assure proper intensity of training. All subjects maintained an exercise log during the 12-week training and monthly thereafter. Following each exercise session, participants completed exercise logs which included type of exercise performed (stretching and cardiovascular), frequency, duration, and heart rate. This approach was previously validated [37,38].

Statistical analyses. Descriptive statistics were used to compare the baseline characteristics of the two randomization groups. Fisher exact test and Student's *t*-test were employed to compare, respectively, categorical and quantitative characteristics of subjects who did not complete some follow-up assessments with those of the completers.

The main study hypotheses were tested using the intention-to-treat approach (ITT). Separate analyses assessed changes from baseline for the two primary outcomes: EPDS and HAM-D, using the mixed linear model for longitudinal analyses of repeated measures [39]. The mixed model approach allowed us to account for both (a) dependence of consecutive outcomes for the same subject, and (b) missing values [40].

In all multivariable analyses, the outcome scores observed at 3 and 6 months represented the repeated measures of the dependent variable. The independent variables included the intervention group, and indicators of primiparity and cesarean delivery for both of which there were clinically meaningful differences between the two randomization groups. Furthermore, we included an indicator of the more severe depressive symptoms at baseline, defined using *a priori* defined cutoffs of ESPD ≥ 14 and HAM-D ≥ 17 [23,24,31]. In addition all models also included a binary indicator of the assessment time, which accounted for the possible changes over time in the depression scores.

For each outcome, a mixed model initially also included three interaction effects. First, we expected that the longitudinal changes in the depression scores, as well as the effect of the intervention on these

changes, may vary depending on the baseline severity of depression. Therefore, we included the interactions between the respective indicator of baseline severity and (i) intervention group, and (ii) assessment time [40]. In addition, we *a priori* expected that the putative beneficial effect of the intervention may decrease with increasing time because of trial completion. Therefore, we also tested the interaction between intervention group and assessment time. To account for low statistical power for interaction testing [41], each of the three interactions was tested at the two-tailed 0.10 significance level. In the case of a significant interaction between either time or baseline severity and the intervention group, we estimated the separate effects of the intervention for each of the two times on the two severity levels, respectively [42], and tested these effects with Type III tests, which adjusted for all other effects in the multivariable mixed model [40].

In addition to primary ITT analyses, efficacy analyses were performed. These analyses compared the control subjects with the 'adherent' subjects in the intervention group, i.e., those who did engage in cardiovascular exercise, for at least 1 h per week.

In all the above analyses, the intervention effect was tested at two-tailed 0.05 significance level. A total sample size of 88 subjects was estimated to obtain 80% statistical power for detecting clinically important effects of the intervention on postbaseline EPDS or HAM-D scores, which would account for at least 10% of the total variance in these scores [43]. All analyses used SAS statistical software.

Results

Figure 1 summarizes participation flow and trial retention. Eighty-eight participants met study criteria and were randomized: 46 to exercise and 42 to the usual care group. Both groups were similar on all baseline characteristics, with the exception of differences in frequency of cesarean birth (21% intervention group *vs.* 32.6% control group), and primiparity (33% *vs.* 41%) (Table I).

The proportions of subjects who completed the self-report outcome measures at all the assessments were similar in the two trial arms (30/46, 65% in the intervention group *vs.* 29/42, 69% in control group, $p=0.70$). Those participants who missed some postbaseline assessments had similar characteristics to the 'completers' ($p > 0.25$ for all demographic and clinical variables shown in Table I, data not shown). The mean baseline scores of both EPDS (14.0 among the completers *vs.* 12.7 among subjects who failed to complete at least one postbaseline depression assessment, $p=0.14$) and HAM-D (11.9 *vs.* 10.1, $p=0.11$).

During the 12-week training phase, participants in the exercise condition engaged on average in 165 min

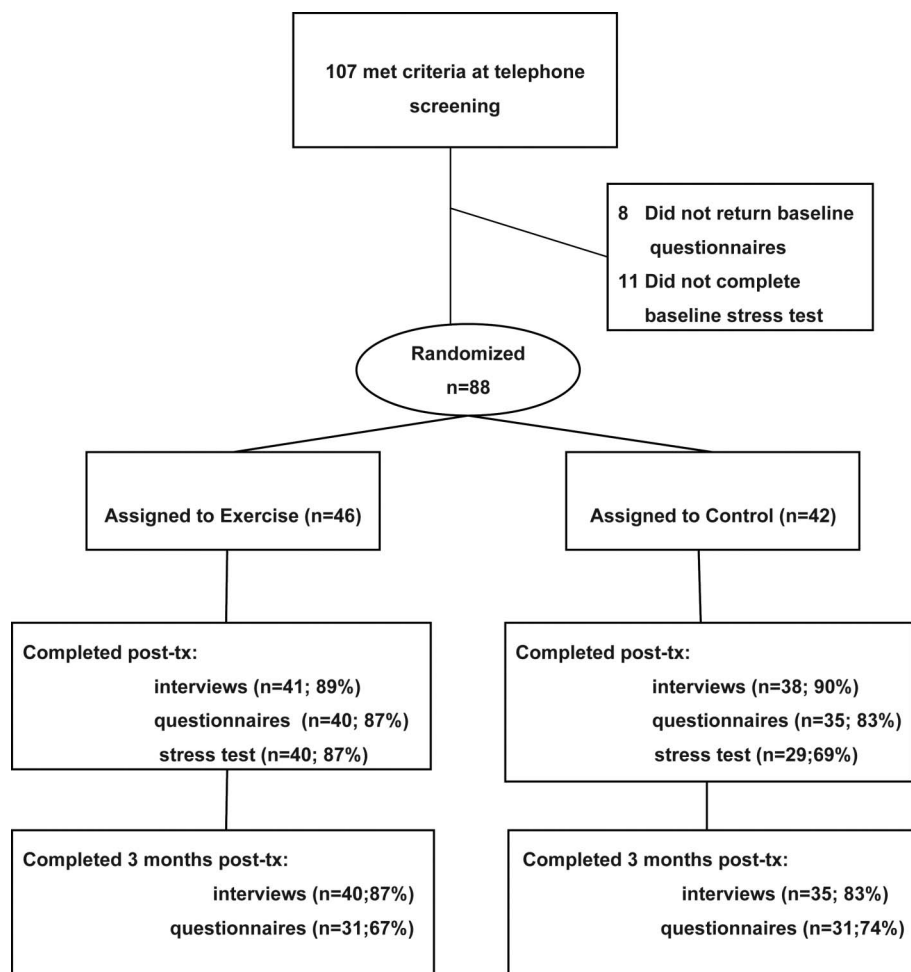


Figure 1. Patient recruitment and randomization.

Table I. Patient characteristics at study entry.

	Mean (SD)	
	Exercise (n = 46)	Control (n = 42)
Demographics		
Age (years)	34.3 (3.4)	32.7 (4.8)
Education (years)	16.0 (1.7)	15.1 (2.2)
Years w/current partner	7.3 (4.0)	6.1 (3.6)
Primiparous	41.3%	33.3%
Race: white	80.4%	76.2%
Clinical variables		
Weeks since delivery	11.0 (7.2)	12.1 (8.1)
Cesarean delivery	32.6%	21.4%
Maximal METS on stress test	10.7 (1.7)	11.0 (1.7)
Outcome measures		
EPDS	13.6 (3.6)	13.6 (3.9)
HAM-D	12.1 (4.2)	11.1 (3.8)

EPDS, Edinburgh postpartum depression scale; HAM-D, Hamilton depression scale; SD, standard deviation.

of exercise (SD = 117.9) per week, including aerobic, strength, and flexibility exercises. Adherence to the prescribed aerobic component of the exercise program (at least 60 min week) was 76.1% (35 out of 46

participants), with an average of 124 min (SD = 96.3) per week during the 12-week program. This is considerably higher than the average of 54.6 min (SD = 55.8) of exercise reported by the control group during the 12-week period. Walking exercise modality most frequently reported by women in the exercise group (85%) and control arm (55%). Adherence to strength exercise recommendations was moderate with 52.4% of women assigned to the intervention exercising at the recommended frequency. Participants in the exercise condition attended a median of 4 (out of 4) sessions with the exercise physiologist, with 80.4% (n = 37) attending at least three sessions. Correlations between the EPDS and the HAM-D at each assessment point were statistically significant at the $p < 0.01$ level (ranging from $r = 0.46-0.58$).

For each outcome, Figure 2 compares the changes over time in the mean scores in the two trial arms, among those subjects who completed a given depression assessment. For both outcomes, the mean scores in each group decrease considerably from baseline to both post-trial assessments, with only minor differences between the 3 and 6 months. For EPDS, the unadjusted changes in both groups are

similar. In contrast, the post-treatment decrease from the baseline HAM-D in the exercise group is much larger than in the control group (Figure 2). In both groups, there was only minimal improvement in physical fitness (METs) (mean increase from baseline to 3 months of 0.62 in the intervention group and 0.51 in the control group).

The comparisons in Figure 2 are calculated only for subjects who completed a given depression assessment, without adjusting for baseline differences in depression severity and other covariates, and without accounting for possible effect modification. To account for these factors, our primary analyses relied on the multivariable linear mixed model. The left part of Table II summarizes the results of multivariable mixed model-based intention-to-treat analyses. For each outcome, in the absence of any significant interaction, the first row shows the adjusted estimate of the exercise intervention effect pooled across the two assessment times and all subjects, with the 95% confidence intervals (CI). However, if one interaction was significant at $p < 0.10$ the first row provides details on the significant interaction that justified estimating separately the effects of the intervention in subgroups determined by baseline depression score or time, as appropriate. This estimate represents difference in

the mean depression score between the intervention and control groups after adjustment for the baseline depression severity, primiparity, and cesarean delivery, with negative estimates indicating bigger improvements in the exercise group.

For EPDS, there are no interactions between assessment time and either intervention ($p = 0.88$), or baseline EPDS ($p = 0.46$). In contrast, there is a very significant interaction ($p = 0.0002$) between the intervention and the baseline EPDS (dichotomized at 13), indicating that the differences between the two trial arms vary significantly depending on the baseline severity of the postpartum depressive symptoms. Accordingly, the next two rows of Table II show the estimated effects of the intervention on the EPDS score separately for the subgroups with less and more severe depression symptoms at baseline. For women with baseline EPDS ≤ 13 , the exercise intervention is associated with higher postbaseline EPDS scores (adjusted mean difference between intervention and control group of 2.77 points, 95% CI: 0.50–5.05, $p = 0.02$). In contrast, for women with higher severity of baseline postpartum depressive symptoms, patients in the intervention group have significantly lower post-baseline EPDS than those in the control group. Indeed, as shown in the 3rd row of Table II, among the women with baseline EPDS > 13 , the

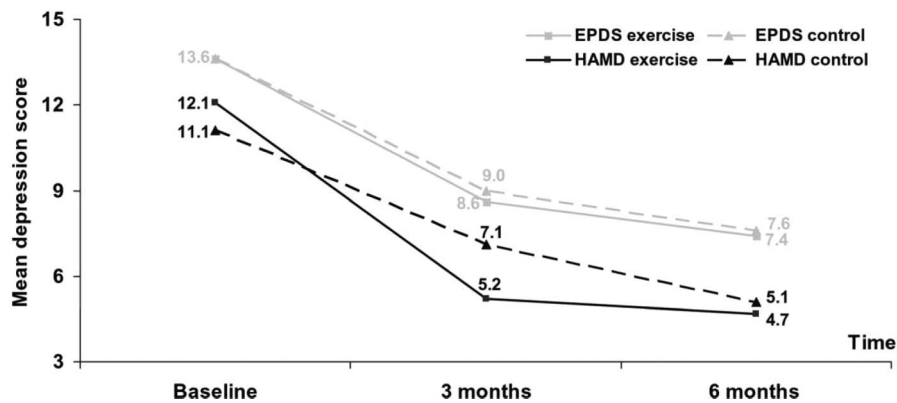


Figure 2. Mean changes on outcome measures. Total subjects who completed the depression tests: (1a) EPDS test, exercise group: $N = 46, 40, 31$ at baseline, 3 months, respectively, 6 months; (1b) EPDS test, control group: $N = 42, 35, 31$; (2a) HAM-D test, exercise group: $N = 46, 41, 40$; (2b) HAM-D, control group: $N = 42, 38, 34$.

Table II. Analyses of the effect of the intervention on the mean change in EPDS and HAM-D scores.

Depression score	Group	Time	Intention-to-treat analysis Intervention effect slope (95% CI)	Efficacy analysis Intervention effect slope (95% CI)
EPDS	All subjects	Pooled (3 & 6 months)	$p = 0.0002$ interaction (baseline EPDS* intervention)	$p = 0.0001$ interaction (baseline EPDS* intervention)
	Baseline EPDS ≤ 13	Pooled (3 & 6 months)	+2.77 (+0.50, +5.05)	+2.47 (+0.12, +4.82)
	Baseline EPDS > 13	Pooled (3 & 6 months)	-4.06 (-6.61, -1.51)	-4.54 (-7.01, -2.08)
HAM-D	All subjects	Pooled (3 & 6 months)	$p = 0.0977$ interaction (time* intervention)	-1.29 (-2.56, -0.01)
	All subjects	3 months	-1.83 (-3.41, -0.24)	-
	All subjects	6 months	-0.26 (-1.78, +1.26)	-

*Interaction term between the 2 variables.

mean adjusted EPDS score at postbaseline assessments in the exercise group was more than 4 points lower than in the control group (mean difference of 4.06 points, 95% CI: 1.51–6.61, $p < 0.001$).

The lower half of Table II shows the main results for HAM-D scores. The effect of intervention on the HAM-D scores did not vary depending on the baseline severity ($p = 0.56$ for the interaction between intervention and baseline HAM-D score, dichotomized at 17), and there was no interaction between baseline HAM-D and assessment time ($p = 0.54$). However, for HAM-D scores, the test of the effect modification between the assessment time and intervention reached our criterion for statistical significance of the interaction ($p = 0.098$ for the two-tailed test). Furthermore, the interaction between the assessment time and intervention was in the *a priori* expected direction, as we hypothesized that the intervention effect would be stronger at the post-treatment assessment (3 months) than 3 months later (i.e., at 6 months). Accordingly, the last two rows of Table II report the adjusted between-groups differences in HAM-D scores, separately for each assessment time. At post-treatment assessment, the mean HAM-D score is significantly lower, by almost 2 points, in the exercise than in the control group (adjusted mean between-groups difference of 1.83 points, 95% CI: 0.24–3.41, $p = 0.02$). In contrast, at 3 months post-treatment the difference between the two groups is very small and loses its statistical significance (last row of Table II).

The right part of Table II shows the results of multivariable mixed model-based efficacy analyses, with data for the exercise group limited to 35 ‘compliers’, i.e., subjects who engaged in at least 1 h per week of cardiovascular exercise. For EPDS, the pattern of results is similar to the ITT analyses. Specifically, there is a highly significant interaction between treatment and baseline score ($p = 0.0001$). As for ITT analyses, the exercise intervention is associated with significantly higher EPDS post-treatment scores among women with baseline scores ≤ 13 , whereas among subjects with higher severity of depressive symptoms at baseline (3rd row in the right part of Table II) it is associated with statistically and clinically significantly lower EPDS post-treatment scores, by about 4.5 points. In the efficacy analyses of HAM-D scores, neither the interaction between the intervention and assessment time ($p = 0.47$), nor the interaction between the intervention and baseline score ($p = 0.47$) or the interaction between baseline score and time ($p = 0.17$) is significant, so that the right part of Table II presents the adjusted intervention effect, pooled across both times and all subjects. The corresponding mean HAM-D postbaseline score among compliers in the exercise group is marginally

significantly lower, by about 1.3 points, than in the control group.

Discussion

This trial demonstrates that home-based exercise is an effective and feasible intervention for alleviating symptoms of depressed mood in the postpartum. Although previous studies have shown exercise to be effective in reducing depressive symptomatology in other populations [18,44], this is the first to show the benefits of exercise for depressed mood in the postpartum.

The findings suggest that exercise enhances the rate of recovery. Immediately following the 12-week intervention, women in the exercise group showed an almost two point reduction from baseline on HAM-D scores, compared with the control group, whereas at 3 months post-treatment HAM-D scores had improved similarly for both groups. This early effect is of clinical relevance as duration and severity of depressive symptoms (even subclinical) negatively impacts maternal and infant adaptation [45,46].

There has been some caution raised against the use of depression scales containing somatic symptoms such as the HAM-D during the postpartum because of potential overlap with postpartum physical symptoms (i.e., fatigue and insomnia) [23,25]. We took steps to minimize such difficulties, as interviewers probed to specifically determine whether a particular somatic symptom was related to postpartum circumstances (i.e., insomnia due to infant feedings) or depression. Similar to Ross et al. [47] we did not score the former as symptoms. Other findings suggest that somatic symptoms may be important in diagnosing subgroups of women with PPD [1,48]. On the basis of an examination of the HAM-D during pregnancy and the postpartum Ross et al. [47] recently concluded that postpartum women may be less likely to describe their distress as depression but more likely to articulate their symptoms as somatic. Importantly, depressive somatic symptoms have been shown to be less responsive to antidepressant therapy and have been associated with relapse and greater functional impairment [49–52].

In our trial, the effect of exercise for improving depressed mood assessed with the EPDS varied as a function of pretreatment depression severity. Women with higher initial depression, i.e., EPDS scores above 13, showed significantly greater reductions at both post-treatment assessments compared with controls with similar initial EPDS scores. In other words, the decline for women with higher initial EPDS scores was much larger in the intervention compared with the control group. The mean reduction in scores on the EPDS was at least 4 points for women with initially higher EPDS scores, which has been suggested to be a reliable clinically significant

change [53]. Although our findings suggest that exercise was most beneficial for women with higher baseline EPDS scores, baseline HAM-D scores indicate that the majority of our sample was likely experiencing mild or subclinical depression, as only 17% of the sample and 33% of the subgroup scoring more than 13 on the baseline EPDS had initial scores of at least 17 on the HAM-D.

Our findings showing a lower reduction in depressed mood EPDS scores in the exercise group relative to the usual care group, among women who entered the study less depressed ($EPDS \leq 13$), was unexpected. It is possible that women who were less depressed may have been less motivated to engage in a self-management activity such as aerobic type exercise. Our data (not shown) provide partial support for this explanation as estimates of energy expenditure for self-reported exercise were significantly higher for the women in the exercise group who scored higher on the EPDS at study entry compared with women who were less depressed in the intervention condition. Future studies are needed to examine the dose-response relation of exercise and reduction in postpartum depressive symptoms.

Efficacy analyses, restricted to women who adhered to the exercise program showed even larger benefits of the intervention. In this subgroup, the exercise program resulted in significantly larger reductions on both the HAM-D scores and the EPDS scores for initially more depressed women, at the end of the intervention as well as 3 months later. Adherence to the aerobic component of the exercise program was high and comparable with other trials using the home-based format [54] and exercise in depressed persons [44]. This suggests that home-based moderate intensity exercise programs with ongoing professional contact are feasible with postpartum depressed women.

The mechanisms associated with decreased depression levels with exercise are unknown. Various theories have been proposed including increases in self-efficacy [55], distraction from stress [15], alterations in brain norepinephrine and endorphin release and central serotonin levels [56,57]. Moreover, results are mixed as to whether improvements in depressed mood are mediated by increases in physical fitness [58–60]. Our results suggest that the improvements in mood were not related to changes in physical fitness levels and support the findings from three meta-analyses on exercise and depression indicating that exercise gains are not necessary to achieve reductions in depressed mood [58,61,62]. Although improvements in fitness have been observed in some trials of exercise and depressed mood [20], others including the recent study by Craft et al. [63] in a sample of depressive women comparing a home-based intervention (with minimal therapist contact) to a supervised exercise

intervention showed similar reductions in depressed mood in both exercise conditions and no improvements on cardiovascular fitness or body composition for either intervention. Like Craft et al. [63], we agree that it is possible that 3 months of exercise may not be a sufficient length of time to see significant improvements in cardiovascular fitness.

Our study has important strengths, including use of recommended outcome assessments for PPD, randomization, blinding of interviewers, low attrition, and an extended follow-up. The limitations of this study include a relatively well-educated, predominantly white sample of women motivated to volunteer in an exercise study. Similar to other exercise trials [44,64], blinding of participants regarding group assignment was not possible. As previously noted, none of the women in our study scored greater than 20 on the HAM-D at study entry, thus it is unknown whether our findings extend to more severely depressed women.

Our study included a relatively wide range of weeks since delivery (4–38 weeks). It may be expected that longer time since delivery would be correlated with higher duration of PPD and as a consequence, with higher probability of a spontaneous remission of symptoms. If so, then inclusion of women who have delivered several months prior to study entry could have attenuated the effect of the intervention. We did not have data on the exact onset of depression. However, while PPD typically appears 4–6 weeks postdelivery, its onset is often gradual and symptoms appear to be more long-lasting than depression at other times [2,65–67], with ~50% of women remaining symptomatic for up to 24 months [2,66,67]. Indeed all study participants at entry into the trial met the inclusion criterion of baseline $EPDS \geq 10$, which is indicative of depressed mood. Furthermore, time since delivery was not a confounder in our analyses because as shown in Table I, its distributions in the usual care and intervention groups were very similar. Moreover, time since delivery was only very weakly correlated with baseline depression scores ($r=0.14$ with EPDS and $r=0.15$ with HAM-D, $p > 0.15$ for both correlations). Finally, when added to our final multivariable mixed models, the interactions between time since delivery and the intervention were completely nonsignificant, indicating that the effect of the intervention did not depend on the time since delivery. All of these results suggest that the conclusions regarding the effectiveness of our intervention apply to women with a relatively wide range of time since delivery, as long as they meet our study entry criteria ($EPDS \geq 10$).

This study did not include an attention-placebo control group, further limiting the generalizability of the results as part of the differences observed may be attributable to the exercise therapist's attention and/or women's expectations about the benefits of the

exercise intervention. Visits with the exercise therapist were limited to discussing exercise progress and addressing exercise barriers, however some women may have perceived this as emotionally supportive. There remains substantial controversy in behavioral (e.g., exercise) and psychotherapy treatment trials regarding what constitutes a credible 'attention-placebo' condition [68,69]. It has been argued that the addition of an attention-placebo group is of dubious validity unless it is perceived by the subject as potentially valuable and its inertness has been determined, which is difficult with behavioral methods [68]. We felt that including a usual care control group was important to control for the natural course of the depressive symptoms, which decreased substantially over time in both trial arms.

Our findings have important clinical implications as they provide initial evidence for an effective nonpharmacological intervention for the alleviation of mild to moderate postpartum depressed mood. This is important as many women are reluctant to take medication in the postpartum period, particularly if they are breastfeeding [8]. Moderate-intensity home-based exercise is well accepted by women experiencing depressive symptoms in the postpartum and is a low-cost intervention that can be delivered widely within the health care system.

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References

1. Stowe ZN, Nemeroff CB. Women at risk for postpartum-onset major depression. *Am J Obstet Gynecol* 1995;173:639–645.
2. O'Hara MW. The nature of postpartum depressive disorders. In: Murray L, Cooper PJ, editors. *Postpartum depression and child development*. New York: Guilford Press; 1997. pp 3–31.
3. Hipwell AE, Goossens FA, Melhuish EC, Kumar R. Severe maternal psychopathology and infant-mother attachment. *Dev Psychopathol* 2000;12:157–175.
4. Murray L, Cooper P. Effects of postnatal depression on infant development. *Arch Dis Child* 1997;77:99–101.
5. Teti DM, Gelfand DM, Messinger DS, Isabella R. Maternal depression and the quality of early attachment: an examination of infants, preschoolers, and their mothers. *Dev Psychol* 2008;31:364–376.
6. Nonacs R, Cohen LS. Postpartum mood disorders: diagnosis and treatment guidelines. *J Clin Psychiatry* 1998;59(Suppl 2):34–40.
7. Appleby L, Warner R, Whitton AC, Faragher B. A controlled study of fluoxetine and cognitive-behavioural counselling in the treatment of postnatal depression. *BMJ* 1997;314:932–936.

8. Cooper PJ, Murray L, Wilson A, Romaniuk H. Controlled trial of the short- and long-term effect of psychological treatment of post-partum depression. I. Impact on maternal mood. *Br J Psychiatry* 2003;182:412–419.
9. O'Hara MW, Stuart S, Gorman L, Wenzel A. Efficacy of interpersonal psychotherapy for postpartum depression. *Arch General Psychiatry* 2000;57:1039–1045.
10. Cohen LS. Pharmacologic treatment of depression in women: PMS, pregnancy, and the postpartum period. *Depress Anxiety* 1998;8(Suppl 1):18–26.
11. Alvidrez J, Azocar F. Distressed women's clinic patients: preferences for mental health treatments and perceived obstacles. *Gen Hosp Psychiatry* 1999;21:340–347.
12. Cooper-Patrick L, Powe NR, Jenckes MW, Gonzales JJ, Levine DM, Ford DE. Identification of patient attitudes and preferences regarding treatment of depression. *J Gen Intern Med* 1997;12:431–438.
13. Camacho TC, Roberts RE, Lazarus NB, Kaplan GA, Cohen RD. Physical activity and depression: evidence from the Alameda County study. *Am J Epidemiol* 1991;134:220–231.
14. Farmer ME, Locke BZ, Moscicki EK, Dannenberg AL, Larson DB, Radloff LS. Physical activity and depressive symptoms: the NHANES I epidemiologic follow-up study. *Am J Epidemiol* 1988;128:1340–1351.
15. Gauvin L, Spence JC. Physical activity and psychological well-being: knowledge base, current issues, and caveats. *Nutr Rev* 1996;54:S53–S65.
16. Paffenbarger RS Jr, Lee IM, Leung R. Physical activity and personal characteristics associated with depression and suicide in American college men. *Acta Psychiatr Scand Suppl* 1994;377:16–22.
17. Lawlor DA, Hopker SW. The effectiveness of exercise as an intervention in the management of depression: systematic review and meta-regression analysis of randomised controlled trials. *BMJ* 2001;322:763–767.
18. Blumenthal JA, Babyak MA, Moore KA, Craighead WE, Herman S, Khatri P, Waugh R, Napolitano MA, Forman LM, Appelbaum M, et al. Effects of exercise training on older patients with major depression. *Arch Intern Med* 1999;159:2349–2356.
19. Blumenthal JA, Sherwood A, Babyak MA, Watkins LL, Waugh R, Georgiades A, Bacon SL, Hayano J, Coleman RE, Hinderliter A. Effects of exercise and stress management training on markers of cardiovascular risk in patients with ischemic heart disease: a randomized controlled trial. *JAMA* 2005;293:1626–1634.
20. Midtgaard J, Rorth M, Stelter R, Tveteras A, Andersen C, Quist M, Moller T, Adamsen L. The impact of a multi-dimensional exercise program on self-reported anxiety and depression in cancer patients undergoing chemotherapy: a phase II study. *Palliat Support Care* 2005;3:197–208.
21. Armstrong K, Edwards H. The effectiveness of a pram-walking exercise programme in reducing depressive symptomatology for postnatal women. *Int J Nurs Pract* 2004;10:177–194.
22. Daley AJ, Macarthur C, Winter H. The role of exercise in treating postpartum depression: a review of the literature. *J Midwifery Womens Health* 2007;52:56–62.
23. Cox JL, Holden JM, Sagovsky R. Detection of postnatal depression. Development of the 10-item Edinburgh Postnatal Depression Scale. *Br J Psychiatry* 1987;150:782–786.
24. Hamilton M. Development of a rating scale for primary depressive illness. *Br J Soc Clin Psychol* 1967;6:278–296.
25. Harris B, Huckle P, Thomas R, Johns S, Fung H. The use of rating scales to identify post-natal depression. *Br J Psychiatry* 1989;154:813–817.
26. Murray L, Carothers AD. The validation of the Edinburgh post-natal depression scale on a community sample. *Br J Psychiatry* 1990;157:288–290.

27. Zerkowicz P, Milet TH. Screening for post-partum depression in a community sample. *Can J Psychiatry* 1995;40:80–86.
28. Dennis CL. The effect of peer support on postpartum depression: a pilot randomized controlled trial. *Can J Psychiatry* 2003;48:115–124.
29. Freeman MP, Hibbeln JR, Wisner KL, Brumbach BH, Watchman M, Gelenberg AJ. Randomized dose-ranging pilot trial of omega-3 fatty acids for postpartum depression. *Acta Psychiatr Scand* 2006;113:31–5.
30. Small R, Lumley J, Donohue L, Potter A, Waldenstrom U. Randomised controlled trial of midwife led debriefing to reduce maternal depression after operative childbirth. *BMJ* 2000;321:1043–1047.
31. Hamilton MA. The Hamilton rating scale for depression. In: Sortorius N, Ban TA, editors. *Assessment of depression*. Berlin: Springer-Verlag; 1986. pp 143–152.
32. Simon GE, Revicki D, VonKorff M. Telephone assessment of depression severity. *J Psychiatr Res* 1993;27:247–252.
33. Bruce RA, Kusumi F, Hosmer D. Maximal oxygen uptake and nomographic assessment of functional aerobic impairment in cardiovascular disease. *Am Heart J* 1973;85:546–562.
34. American College of Sports Medicine. *Resource manual for guidelines for exercise testing and prescription*. 2nd ed. Philadelphia: Lea & Febiger; 1993.
35. American College of Sports Medicine. *The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in health adults*. *Med Sci Sports Exec* 1998;30:975–991.
36. American College of Sports Medicine. *ACSM's guidelines for exercise testing and prescription*. 7th ed. Philadelphia: Lippincott Williams & Wilkins; 2006.
37. King AC, Haskell WL, Taylor CB, Kraemer HC, DeBusk RF. Group- vs. home-based exercise training in healthy older men and women. *JAMA* 1991;266:1535–1541.
38. King AC, Kiernan M, Pman RF, Kraemer HC, Hull M, Ahn D. Can we identify who will adhere to long-term physical activity? Signal detection methodology as a potential aid to clinical decision making. *Health Psychol* 1997;16:380–389.
39. Diggle PJ. An approach to the analysis of repeated measurements. *Biometrics* 1988;44:959–971.
40. Molenberghs G, Thijs H, Jansen I, Beunckens C, Kenward MG, Mallinckrodt C, Carroll RJ. Analyzing incomplete longitudinal clinical trial data. *Biostatistics* 2004;5:445–464.
41. Boutitie F, Gueyffier F, Pocock SJ, Boissel JP. Assessing treatment-time interaction in clinical trials with time to event data: a meta-analysis of hypertension trials. *Stat Med* 1998;17:2883–2903.
42. Littell RC, Milliken GA, Stroup WW, Wolfinger RD. *SAS[®] system for mixed models*. Cary NC: SAS Publishing; 1996.
43. Cohen J. *Statistical power analysis for the behavioral sciences*. 2nd ed. Hillsdale NJ: Erlbaum Associates; 1988.
44. Dunn AL, Trivedi MH, Kampert JB, Clark CG, Chambliss HO. Exercise treatment for depression: efficacy and dose response. *Am J Prev Med* 2005;28:1–8.
45. Brennan PA, Hammen C, Andersen MJ, Bor W, Najman JM, Williams GM. Chronicity, severity, and timing of maternal depressive symptoms: relationships with child outcomes at age 5. *Dev Psychol* 2000;36:759–766.
46. Weinberg MK, Tronick EZ, Beeghly M, Olson KL, Kernan H, Riley JM. Subsyndromal depressive symptoms and major depression in postpartum women. *Am J Orthopsychiatry* 2001;71:87–97.
47. Ross LE, Gilbert Evans SE, Sellers EM, Romach MK. Measurement issues in postpartum depression part 2: assessment of somatic symptoms using the Hamilton rating scale for depression. *Arch Womens Ment Health* 2003;6:59–64.
48. Guedeney N, Fermanian J, Guelfi JD, Kumar RC. The Edinburgh postnatal depression scale (EPDS) and the detection of major depressive disorders in early postpartum: some concerns about false negatives. *J Affect Disord* 2000;61:107–112.
49. Karp JF, Scott J, Houck P, Reynolds CF III, Kupfer DJ, Frank E. Pain predicts longer time to remission during treatment of recurrent depression. *J Clin Psychiatry* 2005;66:591–597.
50. Menza M, Marin H, Opper RS. Residual symptoms in depression: can treatment be symptom-specific? *J Clin Psychiatry* 2003;64:516–523.
51. Nierenberg AA, Keefe BR, Leslie VC, Alpert JE, Pava JA, Worthington JJ III, Rosenbaum JF, Fava M. Residual symptoms in depressed patients who respond acutely to fluoxetine. *J Clin Psychiatry* 1999;60:221–225.
52. Paykel ES, Ramana R, Cooper Z, Hayhurst H, Kerr J, Barocka A. Residual symptoms after partial remission: an important outcome in depression. *Psychol Med* 1995;25:1171–1180.
53. Matthey S. Calculating clinically significant change in postnatal depression studies using the Edinburgh postnatal depression scale. *J Affect Disord* 2004;78:269–272.
54. Tully MA, Cupples ME, Chan WS, McGlade K, Young IS. Brisk walking, fitness, and cardiovascular risk: a randomized controlled trial in primary care. *Prev Med* 2005;41:622–628.
55. Scully D, Kremer J, Meade MM, Graham R, Dudgeon K. Physical exercise and psychological well being: a critical review. *Br J Sports Med* 1998;32:111–120.
56. Chaouloff F. Effects of acute physical exercise on central serotonergic systems. *Med Sci Sports Exerc* 1997;29:58–62.
57. Fox KR. The influence of physical activity on mental well-being. *Public Health Nutr* 1999;2:411–418.
58. Craft LL, Landers DM. The effect of exercise on clinical depression and depression resulting from mental illness: a meta-analysis. *J Sport Exerc Psychol* 1998;20:339–357.
59. Doyne EJ, Ossip-Klein DJ, Bowman ED, Osborn KM, Dougall-Wilson IB, Neimeyer RA. Running *versus* weight lifting in the treatment of depression. *J Consult Clin Psychol* 1987;55:748–754.
60. Martinsen EW, Hoffart A, Solberg O. Comparing aerobic with nonaerobic forms of exercise in the treatment of clinical depression: a randomized trial. *Compr Psychiatry* 1989;30:324–331.
61. Craft LL, Perna FM. The benefits of exercise for the clinically depressed. *Prim Care Companion J Clin Psychiatry* 2004;6:104–111.
62. Stathopoulou G, Powers MB, Berry AC, Smits JAJ, Otto MW. Exercise interventions for mental health: a quantitative and qualitative review. *Clin Psychol: Sci Pract* 2006;13:179–193.
63. Craft LL, Freund KM, Culpepper L, Perna FM. Intervention study of exercise for depressive symptoms in women. *J Womens Health (Larchmt)* 2007;16:1499–1509.
64. Sherman KJ, Cherkin DC, Erro J, Miglioretti DL, Deyo RA. Comparing yoga, exercise, and a self-care book for chronic low back pain: a randomized, controlled trial. *Ann Intern Med* 2005;143:849–856.
65. Stowe ZN, Hostetter AL, Newport DJ. The onset of postpartum depression: implications for clinical screening in obstetrical and primary care. *Am J Obstet Gynecol* 2005;192:522–526.
66. Dennerstein L, Varnavides K, Burrows G. Postpartum depression. A review of recent literature. *Aust Fam Physician* 1986;15:1470–1472.
67. Milgrom J, McCloud P. Parenting stress and postnatal depression. *Stress Med* 1996;12:177–186.
68. Horvath P. Placebos and common factors in two decades of psychotherapy research. *Psychol Bull* 1988;104:214–225.
69. Ojanen M. Can the true effects of exercise on psychological variables be separated from placebo effects? *Int J Sport Psychol* 1994;25:63–80.

Current knowledge on this subject

- Postpartum depression (PPD) affects 10–16% of women, with symptoms lasting up to 1 year postdelivery. Despite its prevalence and negative consequences for the mother and her infant, PPD is often not recognized or treated.
- Although pharmacological agents can be effective for treating postpartum depression, concerns remain regarding the adverse effects of pharmacological therapy on the breastfed newborn.
- Women may also opt against psychotherapeutic interventions for treating depression because of financial and social stigma associated with this treatment modality.
- There are few alternative nonmedical options available to women for the treatment of depression in the postpartum.

What this study adds

- Exercise is a feasible nonpharmacological intervention that can improve depressed mood in the postpartum.
- Improvements in mood were not related to changes in physical fitness levels, suggesting that exercise gains are not necessary to achieve reductions in depressed mood.