TITLE: The effects of exercise on postpartum weight retention in overweight and obese women

RUNNING TITLE: Maternal obesity and exercise

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ABSTRACT

Obesity is a global phenomenon with unfavourable clinical and economic outcomes. The prevalence of maternal obesity has risen at similar rates to global obesity and has two distinct population pathways. Firstly, pregnancy has been identified as a risk factor for the development of obesity due to extreme gestation gain and/or prolonged postpartum weight retention. Secondly the number of pre-gravid obese women has increased dramatically over recent years, making this a high-risk medical group. As such, effective interventions are necessary to prevent and reduce the incidence of excessive gestational weight gain and persistent postpartum weight retention, particularly in overweight and obese women. The focus of this review is on the postpartum period, which includes the first twelve months following childbirth. Exercise has many potential benefits for these women, but, despite considerable interest in the effects of physical activity on maternal body mass, few exercise-based randomised controlled trials exist. Two studies have implemented low to moderate intensity walking programmes as weight management interventions, with limited success. Two, more recent studies have used resistance exercises and active videogames to promote weight loss, however while both types of interventions resulted in significant weight loss, these reductions were not significantly different from the corresponding control groups. As such, a proof of principle with regards to exercise and weight retention in overweight and obese women is not available. More investigation is warranted in this important research area and future studies should be based on accessible, progressive, appropriate and effective exercise strategies.

Keywords: physical activity, gestation, post-natal, body mass, obesity

Introduction

Pregnancy is a risk factor for the development of obesity [1], as it often precipitates long-term weight gain [2]. Despite clear guidelines for appropriate gestational weight gain (GWG) [3], a large percentage of women develop excessive GWG [4], which is regularly coupled with prolonged postpartum weight retention [5]. Pre-pregnancy body mass is one of the most influential regulators of GWG and previous research has shown that overweight and obese women are most likely to exceed the recommended range [3]. The prevalence of pre-gravid overweight and obese women has increased dramatically in recent years [6] and is associated with numerous negative maternal and foetal health implications [7, 8]. Moreover, healthcare has been purported to cost 23% more for overweight women and 37% more for obese women compared with normal weight women [9]. As

such, effective, appropriate interventions to limit excessive GWG and prevent postpartum weight retention are required, especially for overweight and obese women.

The majority of previous interventions involve dietary manipulation, with or without a concurrent exercise programme, which are offered during pregnancy, following parturition or throughout both periods. Determining the specific effects of either pregnancy or postpartum exercise interventions is important, as the motivation to be physically active may be different following parturition than during pregnancy. Combined interventions make it difficult to interpret the relative impact of each factor and altering both dietary and physical activity habits may be too much for new and expectant mothers during an already overwhelming time. Exercise has numerous potential benefits, including weight management [10], reduced morbidity [11] enhanced well-being [12], increased energy [13] and improved sleep [14]. However a recent systematic review and meta-analysis from our group [15], showed a lack of research on exercise interventions for weight management during and following pregnancy. The aim of this review is to focus solely on studies employing exercise based interventions to regulate body mass following childbirth in overweight and obese women.

Historical perspective

Research into maternal obesity has been ongoing since the mid twentieth century; the relationship between maternal obesity and exercise was initially considered in 1977 and the first studies investigating the effects of exercise on postpartum weight retention were published in the 1990's. In the last two years, three systematic reviews, with meta-analyses [15, 16, 17], have focused on exercise-based interventions for postpartum weight management; one on exercise based interventions during and following childbirth in normal, overweight and obese women [15], one on combined diet and exercise interventions following parturition in non-specified women [16] and one on combined diet and exercise interventions during pregnancy and postpartum in overweight and obese women [17]. Table 1 shows the characteristics of the studies included in each review. Choi et al. [17] only included combined exercise and diet intervention in their review, however Elliott-Sale et al. [15] and Nascimento et al. [16] included four exercise-only studies; Bertz et al. [18] was included in both reviews, Maturi et al. [19] was excluded by Nascimento et al. [16] as "the primary outcome was not available" and Dewey et al. [20] and McIntyre et al. [21] were not included by Elliott-Sale et al. [15] as these studies were not applicable based on their search criteria, *i.e.*, exercise interventions designed to manage maternal weight. Lim et al. [22] published a systematic review and meta-analysis on effective strategies for weight loss in postpartum women and included 22 exercise only interventions. However, only two of their included studies were designed to influence body weight and were RCT's. As such, their conclusions must be viewed with caution. These reviews highlight the paucity of exercise-based intervention studies but signifies a considerable interest in this research area.

Table 1. Summary of review papers examining the effects of exercise on postpartum weight management (ordered by study ID).

Reviews	Included studies	Exercise only interventions	Diet & exercise interventions
Elliott-Sale et al. [15]	Bertz et al. [18] Maturi et al. [19]	Bertz et al. [18] Maturi et al. [19]	None
Nascimento et al. [16]	Bertz et al. [18] Colleran & Lovelady [23] Craigie et al. [24] Davenport et al. [25] Dewey et al. [20] Leermakers et al. [26] Lovelady et al. [27] McIntyre et al. [21] O'Toole et al. [28] Ostbye et al. [29] Walker et al. [30]	Bertz et al. [18] Dewey et al. [20] McIntyre et al. [21]	Colleran & Lovelady [23] Craigie et al. [24] Davenport et al. [25] Leermakers et al. [26] Lovelady et al. [27] O'Toole et al. [28] Ostbye et al. [29] Walker et al. [30]
Choi et al. [17]	Craigie et al. [24] Lovelady et al. [27] Ostbye et al. [29] Walker et al. [30]	None	Craigie et al. [24] Lovelady et al. [27] Ostbye et al. [29] Walker et al. [30]

Bertz et al. [18] investigated the combined and separate effects of a 12-week dietary and/or exercise behaviour modification programme on postpartum weight retention in singleton term delivery, overweight and obese women (Body Mass Index [BMI] 25-35 $kg \cdot m^{-2}$). The women were recruited at 10-14 weeks following parturition and were randomly allocated to either a control (C), dietary (D), exercise (E) or diet and exercise (DE) group. Changes in body weight were measured at baseline, following the 12-week intervention and one year after baseline. **Groups E and D received 1.5 h and 1 h of individual behaviour modification counselling at baseline and halfway through the intervention at 6 weeks (total of 3 h of counselling for E group and 2 h for D group), while the DE group received both the D and E treatments for a combined total of 5 h of counselling**. The D modification programme was designed to reduce dietary energy intake by 500 $kcal \cdot d^{-1}$ with 50-60% of energy derived from carbohydrates, < 30% from **fat** and 10-20% from protein. The E modification programme was based on a progressive walking intervention that accumulated to a 45-minute brisk walk, four days a week, at 60-70% of maximum heart rate. Participants also received bi-weekly text message throughout the 12 weeks that encouraged them to adhere to the intervention and to report body weight in the D group, number of walks in the E group and both measures for the DE group. Usual care was provided to the control group. Following the 12 week intervention, body weight was significantly reduced in the D group only (-8.3 ± 4.2 kg, $p < 0.001$), which was maintained at the 1 year follow-up (-10.2 ± 5.7 kg, $p < 0.001$). The E and DE groups resulted in modest, non-significant, reductions in body weight following the intervention period and at nine months after treatment (E: -2.4 ± 3.2 kg, $p = 0.910$ and -2.7 ± 5.9 kg, $p = 0.741$; DE: -6.9 ± 3.0 kg, $p = 0.110$ and -7.3 ± 6.3 kg, $p = 0.234$) compared with the C group (-0.8 ± 3.0 kg and -0.9 ± 6.6 kg). Maturi et al. [19] examined the effects of a 12 week, walking-based exercise programme on body mass in postpartum women. Breastfeeding women were recruited 6-24 weeks following birth of a singleton foetus and were randomly assigned to either a walking or routine care group. The walking intervention was progressive, from baseline values (mean 3,249 steps) to a minimum of 10,000 steps per day by the 12^{th} week. Steps were counted using pedometers and were recorded on calendars. Participants in the walking group received an individual counselling **session**, on the benefits of physical activity, with a researcher at baseline and then fortnightly via telephone. In addition, women were contacted weekly by text message with a reminder to be active and were provided with a leaflet on weight loss on week eight of the intervention. Following the intervention, women in the walking group lost on average 2.1 kg ($p = 0.001$) compared with 0 kg ($p = 0.94$) in the control group; between group difference $p = 0.001$. Table 2 highlights the similarities and differences between the two studies [18,19].

Table 2. Study characteristics showing similarities and difference between studies.

	Bertz et al. [18]	**Maturi et al. [19]**
n number	E = 18 and C = 17	I = 32 and C = 34
Intervention	Walking	Walking
Delivery mode	Individual	Individual
Frequency	4 days a week	Every day
Duration	Discrete – 45 minutes per session	Ongoing throughout the day
Intensity	60-70 % maximum heart rate	Minimum of 10,000 steps
Tracking system	Self-reported diaries	Pedometers
Adherence rates	83 %	Described as "excellent"
Number of drop-outs during intervention	E = 2 and C = 2	I = 3 and C = 1
Age at baseline (y)	E = 33.2 ± 3.7 and C = 32.2 ± 4.6	I = 25.7 ±4.6 and C = 24.8 ± 3.7
Education - more than high school (%)	E = 88 and C = 87	I = 88 and C = 82
Weeks postpartum	10-14	I = 12.8 ± 5 and C = 12.73 ±5.86
Baseline BMI ($kg \cdot m^{-2}$)	25-35 pre randomisation	I = 26.2 ± 3 and C = 25.1 ± 2
Gestational weight gain (kg)	Not reported	I = 15.96 ± 4.56 and C = 14.3 ± 5.3
Parity	Mean: E = 1 and C = 2	% N: 1^{st} - I = 28 and C = 31, 2^{nd} – I = 3 and C = 2 and 3^{rd} or more – I = 1 and C = 1
Breastfeeding at baseline (%)	E = 94 and C = 93	I = 100 and **C** = 100
Working at baseline (%)	Not reported	I = 7 and C = 8
Baseline steps per day	E = 8874 ± 2732 and C = 8361 ± 3742	I = 3249 ± 1041 and C not specified
Increase in steps per day following the intervention	E = 1422 and C = 1962 – no exercise main effect	I = 6711 (p = < 0.001) and C not specified
Dietary intake	Dietary energy intake not significantly different between groups pre or post intervention (p > 0.05)	Food intake not significantly different between groups pre or post intervention (p > 0.05)

I – intervention group, C – control group, E – exercise group

Our previous meta-analysis [15] showed that the exercise protocols employed by Bertz et al [18] and Maturi et al. [19] did not cause a significant decrease in postpartum weight retention, although there was a trend towards a reduction in body mass (WMD -1.74 kg, CI -3.59 to 0.10, p = 0.06). Both studies [18,19] used walking based exercise programmes and had many similar characteristics, demographics and methodology. The main differences between the studies related to the tracking systems used and the pre and post-intervention number of daily steps. Bertz et al. [18] used a subjective tracking system, while Maturi et al. [19] used an objective, quantitative measure. As such, although reporting high adherence rate (83%) there may have been compliancy issues in the Bertz et al. [18] study. George and Shalansky [31] noted that adherence to a particular treatment could be affected by a number of issues, including an individual's perceived barriers to adherence and the required lifestyle changes to facilitate the suggested treatment, especially if a lifelong habit needs to be changed. Whilst these factors were observed in heart failure patients, it is plausible to suggest that the same might be true for overweight or obese women undertaking a new exercise regimen during the postpartum period, where similar challenges are faced. New mothers consistently report a large number of perceived barriers to exercise including; a shortage of time, the need for childcare, a lack of social support, tiredness and low self-confidence [32-36]. Moreover, overweight and obesity is caused by many complex chronic issues, requiring substantial changes to behaviour and lifestyle [37]. Using equipment such as a pedometer [19], rather than self-reported

diaries [18], removes the need for subjective recall, reduces the burden to complete an onerous measure on a regular basis and decreases the potential for discrepancy between expected and actual achievement. Therefore, I suggest that, in order to accurately report adherence rates in a population that may have compliancy issues, future research should only utilise objective, low interaction measures. Bertz et al. [18] reported pre intervention values of between 8000-9000 steps per day, whilst Maturi et al. [19] reported baseline values of 3000-4000 steps per day. The high number of daily steps presented by Bertz et al. [18] may indicate an overestimation of physical activity levels prior to the intervention or may suggest that the participants in this study were already moderately active and as such the prescribed exercise regimen was not sufficient to elicit a more positive response. In addition, the number of daily steps following the intervention was not significantly different, despite walking 4 days per week for 45 minutes, which may again imply issues with adherence in this group. Conversely, Maturi et al. [19] demonstrated a significant increase in daily steps following their walking programme, in previously sedentary participants. Consequently, I would suggest that future studies evaluate the components (frequency, intensity and duration) of their interventions with respect to baseline physical activity levels in order to maximise the potential benefit of the exercise regimen. In addition, mid-treatment evaluation should be incorporated to provide the opportunity to adjust the exercise programme if necessary.

Current perspective

Search strategy: PubMed, MEDLINE, OVID, BioMed Central, Oxford Journal, Springer Link, ScienceDirect and Web of Science were searched in November 2015 (our previous search was conducted in September 2013), using terms such as “exercise interventions”, “weight management”, “weight loss”, “weight retention” “postpartum”, “overweight” and “obesity” as MeSH headings or All Fields. Only studies published in English and performed on human participants were considered and no date restriction was applied. A change in body mass (kg) was set as the primary outcome measure, defined as post-intervention body mass minus pre-intervention body mass, with a negative change implying weight loss. All randomised, and quasi-randomised, controlled trials were considered, which compared an exercise-based weight management intervention, with routine care or another type of intervention, conducted during the postpartum period (12 months following childbirth). The term “intervention” included all modes of interventions *e.g.*, counselling, technology-based programmes, exercise classes, as long as they were designed to manage maternal weight and included an “exercise” component. Any type of physical activity, consisting of planned, structured and repetitive body movement done to improve one or more component of physical fitness, was considered as “exercise”. Two new, additional papers were identified [38, 39].

LeCheminant et al. [38] examined the effects of resistance training (RT) versus flexibility training (FT) on body composition in women with more than 2.27 kg of postpartum weight retention. Women were randomly assigned to a four month, bi-weekly RT or FT group and were otherwise free living. The RT programme consisted of 1-3 sets of nine exercises, with 8-12 repetitions performed per set, with a 90 second rest between sets, on two non-consecutive days. The exercises were leg extension, seated leg curl, leg press, bicep curl, shoulder press, chest press, lat pull-down, seated row and abdominal curl-ups and were delivered in a progressive manner, ensuring continuous overload for all participants. Supervision was provided at various stages throughout the 18 weeks. The FT group were unsupervised and performed four static stretches per major muscle group, with each stretch lasting approximately 10-30 seconds. Height and weight were measured before (0 months) during (2 months) and after (4 months) the intervention, in addition to a DXA scan, to assess fat mass, fat-free mass and body fat percentage, at 0 and 4 months. Both the RT and FT groups showed a significant decrease in BMI, weight, fat mass and body fat percentage following the intervention. However, there were no group by time interactions for completers, with control of baseline, time postpartum and parity, for any of the body composition measures. Sixteen participants withdrew from the study (nine from the RT group and seven from the FT group), meaning that a total of 44 out of 60 participants completed the study. Women completed approximately 93% and 80% of sessions in the RT and FT groups respectively. Of the 21 RT completers, five reported mild knee pain.

Tripette et al. [39] used active video games (AVG) to promote weight loss following childbirth in Japanese women (BMI 24.5 ± 3.4 $kg \cdot m^{-2}$). Postpartum women were randomised to an AVG or no intervention group and body mass, height, BMI, waist to hip ratio, whole body fat and lean mass were assessed prior to and following the 40-day intervention period. Women in the AVG were supplied with a Nintendo Wii console and accessories and were asked to play for 30 minutes every day, which was equivalent to 10 $MET \cdot h \cdot wk^{-1}$ of exercise. Following the intervention, women in both groups showed a significant decrease in weight, BMI and body fat mass however, there was no group effect for any body composition measure. Playtime data was only available for 11 of the 17 exercising women; frequency 23 ± 9 days (4.0 ± 1.6 $d \cdot w^{-1}$) and duration 1420 ± 737 minutes (62 ± 25 minutes per session). These data show that participants played less frequently but for longer than instructed. None of the AVG group withdrew from the study, however three women reported sustaining injuries and seven women experienced muscle soreness as a result of playing. A pilot study from our group [**40**] found similar results in eight postpartum women who exercised for 45 minutes, on alternate days, for 12 weeks using the Wii Fit. The women were supplied with three training programmes, each containing an aerobic, training plus, muscle and yoga component, which they were allowed to alternate but not combine. Three programmes were provided to reduce boredom and promote adherence and the women were asked to engage maximally with each activity and session. Weight, size (height, regional circumferences, BMI) and composition (fat mass, lean mass) were measured before and after the intervention and participants were asked to supply their pre-pregnancy body weight. Body composition was assessed using full-body dual-energy x-ray absorptiometry scans and food diaries, including three 3-day weighed food intakes, were used to confirm that participants had not altered their energy intake. Prior to the intervention, weight was 8.2 kg greater than self-reported pre-pregnancy values. Following the intervention, weight was significantly lower than baseline values and was similar to self-reported pre-pregnancy levels. The average rate of weight loss during the intervention was 0.40 ± 0.03 kg per week. Reductions in BMI (approximately 2 $kg \cdot m^{-2}$), waist, hip and bust circumference (3-6%) accompanied the weight loss. None of the participants withdrew from the study and all participants completed 100% of the prescribed sessions. There were no reported injuries throughout the study.

These studies show that it is feasible to engage postpartum women in exercise-based weight management studies. In particular, the video-based studies [39, 40] seem appropriate for new mothers as they can be performed at home, at a convenient time, without childcare. However, as these interventions are unsupervised, participants need to be fully familiarised with the exercises and given clear instructions on the frequency, duration and choice of activities to prevent injury and to maximise the enjoyment and sustainability of this type of exercise. Although LeCheminant et al. [38] and Tripette et al. [39] did not show a significant group effect on body weight or composition, the change in physical activity habits associated with the exercise groups reflect a positive behaviour change, which is necessary for tackling obesity. In addition, the exercise programmes resulted in other health benefits; exercising participants were significantly stronger (bench press, leg press and abdominal curl-ups) [38], had better exercise self-efficacy [38], were less sedentary and more active (light-intensity activity time) [38] and had greater trunk flexibility [39] than non-exercising participants. Several methodological limitations were noted including; small sample size [38], insufficient tracking system for exercise adherence [39], inadequate energy intake measures [39], short study duration [39] and the absence of a control group [40]. Future studies must address these limitations while exploiting the strength of these studies; the successful application of an RT programme in a novel population [38], the objective measurement of strength [38], body composition [38, 39, 40] and physical activity [38] and the use of technology to engage new mothers and overcome many of their perceived barriers to exercise [39, 40].

Conclusion

Due to the paucity of randomised controlled trials in this research area, it is impossible to offer a proof of principle with regards to exercise and postpartum weight management in overweight and obese women. Further research is essential to design safe and effective exercise programmes for this high risk group. Ideally, new studies should begin during pregnancy, when exercise has been shown to be an effective weight management tool [15], and extend into the postpartum period, to exploit the enthusiasm of pregnant women

to do their best for their unborn baby. Future exercise regimens must capitalise on the "teachable moment" associated with childbirth, promoting behaviour change that is manageable, during this busy time, and sustainable, beyond the postpartum period. The American College of Obstetrics and Gynaecologists recommends resuming or initiating exercise regimens following childbirth [41] and suggest that, in the absence of medical or surgical complications, physical activity can be undertaken within days of delivery, without adverse effects. Previous studies have shown the efficacy of regular aerobic exercise on maternal cardiovascular fitness without influencing milk production or composition or infant growth [42], thus suggesting the appropriateness and value of cardiovascular exercise during the postpartum period. However, the dearth of studies in this area prevents a definite conclusion and highlights the need for more studies.

Therefore, based on the available literature, I would recommend progressive, supervised exercise programmes, in a cool environment, relative to entry fitness, BMI and gestational stage for women with uncomplicated pregnancies. Based on previous findings, these exercise programmes should be of moderate intensity, for up to 20-30 minutes each day and should include both aerobic and strength conditioning activities [41]. Furthermore, adequate hydration and nutrition should be maintained, hyperthermia, supine exercises, contact sports, high altitude exertion, scuba diving and high impact activities avoided [43] and pelvic muscle exercises incorporated in all exercise regimens. Following pregnancy, exercise interventions should follow similar guidelines, with a more progressive, higher intensity approach.

CONFLICT OF INTEREST

None.

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