Regular exercise to prevent the recurrence of gestational diabetes: a randomized controlled trial

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Short title: Cycling to break the cycle of diabetes

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- 24 **Précis:** Regular exercise commenced at 14 weeks of pregnancy does not prevent the
- 25 recurrence of gestational diabetes; however, it is associated with enhanced maternal fitness.

Abstract (291 words)

OBJECTIVE: To investigate the effect of a supervised home-based exercise program on the recurrence and severity of gestational diabetes mellitus (GDM), together with other aspects of maternal health, obstetric and neonatal outcomes.

METHODS: This randomized controlled trial allocated women with a history of GDM to an exercise intervention (14-week supervised home-based stationary cycling program) or to a control group (standard care) at 13 ± 1 weeks of pregnancy. The primary outcome was a diagnosis of GDM. Secondary outcomes included maternal fitness, psychological well-being and obstetric and neonatal outcomes. A sample size of 180 (90 in each group) was required to attain 80% power to detect a 40% reduction in the incidence of GDM.

RESULTS: Between June 2011 and July 2014, 205 women provided written consent and completed baseline assessments. Of these, 33 (16%) were subsequently excluded due to an elevated baseline oral glucose tolerance test (OGTT), leaving 172 randomized to exercise ($n = 85$) or control ($n = 87$). Three women miscarried before the assessment of outcome measures (control = 2; exercise = 1). All remaining women completed the post-intervention OGTT. The recurrence rate of GDM was similar between groups (control 40% [$n = 34$]; exercise 41% [$n = 34$]; $P = 0.95$) and the severity of GDM at diagnosis was unaffected by the exercise program, with similar glucose and insulin responses to the OGTT (glucose 2 h post OGTT 7.7 ± 1.5 versus 7.6 ± 1.6 mmol/L; $P > 0.05$). Maternal fitness was improved by the exercise program ($P < 0.01$) and psychological distress was reduced ($P = 0.02$). There were no differences in obstetric and neonatal outcomes between groups ($P > 0.05$).

CONCLUSION: Supervised home-based exercise commenced at 14 weeks of pregnancy did not prevent the recurrence of GDM; however, it was associated with important benefits for maternal fitness and psychological well-being.

Clinical trial registration: ClinicalTrials.gov, <https://clinicaltrials.gov>, NCT01283854.

Introduction

Women diagnosed with gestational diabetes mellitus (GDM) are at increased risk of pregnancy complications,¹ as well as developing type 2 diabetes and metabolic syndrome in later life.² For the fetus, elevated maternal glucose concentrations promote excessive growth and increased birth weight, increasing the risk of macrosomia, birth injury and admission to a neonatal care unit.¹ Later in life, these offspring have an increased prevalence of obesity, type 2 diabetes and metabolic syndrome, perpetuating the burden of diabetes across generations.²

Epidemiological data indicate that being physically active before and during pregnancy is associated with a reduced risk of GDM,³ while experimental studies have shown that regular exercise during pregnancy may attenuate the typical decline in glucose tolerance.⁴ However, few randomized controlled trials have investigated whether regular exercise can prevent GDM,⁵⁻⁷ and no trials have focused on women with a history of the condition who have a high risk of recurrence (~48%)⁸. Furthermore, compliance to prescribed exercise interventions has been reported as a limiting factor during pregnancy.⁷ Common barriers to exercise in this population include a lack of time associated with managing a household and caring for existing children, tiredness, physical limitations and concerns about safety.^{9,10} Supervised, home-based exercise training may overcome many of these barriers.^{4,11} Accordingly, the aim of this study was to investigate the effect of a 14-week supervised, home-based exercise program commenced at 14 weeks of pregnancy on the recurrence of GDM. The effect of the intervention on maternal cardiovascular fitness, body anthropometrics, psychological well-being and obstetric and neonatal outcomes were also examined.

Materials and Methods

This single-centered randomized controlled trial was conducted in Perth, Australia, and registered at www.clinicaltrials.gov (identifier: NCT01283854). The study was approved by the Women and Newborn Health Service Ethics Committee and conducted in accordance with the CONSORT Statement, with the first patient enrolled on 22 June 2011. Pregnant women with a history of GDM in a previous pregnancy were recruited through antenatal clinics, obstetricians, general practitioners, and ultrasound practices. Participants were eligible for inclusion if they were less than 14 weeks pregnant, over 18 years of age and able to participate in a 14-week exercise program. Women with pre-existing diabetes, elevated baseline oral glucose tolerance test (OGTT), multiple pregnancy or a medical condition that restricted exercise participation, those taking oral hypoglycemic agents, or those who were already engaged in a structured exercise program, were not eligible for the study. All participants provided written informed consent.

Eligible women were randomized between 12 and 14 weeks of pregnancy to an exercise intervention or control using a custom-designed computer program on a dedicated laptop that stratified by body mass index ($\text{BMI} < 30$; $30\text{--}34.9$ or $> 35 \text{ kg/m}^2$) and maternal age ($<$ or ≥ 35 y). Randomization was performed during the first visit to the laboratory, with the woman entering the stratification factors into the program to be informed of her allocation by the next screen. Participants randomized to exercise engaged in a 14-week stationary cycling program commencing seven days later. An upright cycle ergometer (Maxx Kh-805 Programmable Upright bike; Nordic Fitness) was delivered to each participant's home for her use during the intervention. All sessions were supervised by an exercise physiologist who would travel to the woman's home three times each week to monitor the duration and intensity of exercise.

Each session commenced with a 5-min warm-up consisting of pedaling at an intensity that equated to 55–65% of age-predicted maximum heart rate (HR_{max}) and a rating of perceived exertion (RPE) of 9–11 on the Borg scale.¹² This scale ranges from 6 (no exertion) to 20 (where exercise is perceived to be ‘very very hard’). The subsequent conditioning period was divided into 5-min periods of continuous moderate-intensity cycling (65–75% HR_{max} ; RPE 12–13) alternating with 5-min periods of interval cycling. Two types of intervals were used; one involved an increase in pedaling rate for 15-s, while the other involved an increase in cycling resistance for 30-s (target intensity 75–85% HR_{max} ; RPE 14–16) repeated every 2 min. A 5-min cool-down concluded each session (55%–65% HR_{max} ; RPE 9–11), followed by light stretching. The duration of each session was progressively increased by 5 min increments every two to three weeks, as tolerated, from 20–30 min to a maximum session duration of 60 min. The degree of progression was dependent on the baseline fitness level of the woman and her ongoing pregnancy symptoms.

Each participant was required to visit an independent local accredited pathology center (PathWest Laboratory Medicine, Perth, Australia) in the fasted state to complete a 75 g OGTT both pre- and post-intervention (at least 48 hours after the last exercise session). Diagnosis of GDM at the post-intervention OGTT was based on the criteria adopted in Western Australia at the time of the trial (fasting venous blood glucose ≥ 5.5 mmol/L [99 mg/dl] and/or a 2-h OGTT glucose ≥ 8.0 mmol/L [144 mg/dl]). Fasting glucose and insulin concentrations, together with glucose tolerance and insulin sensitivity, were determined from the 75 g OGTT. Insulin sensitivity was determined using the homeostatic model of assessment (HOMA-IR)¹³ and the insulin sensitivity index (ISI).¹⁴ Glycosylated hemoglobin (HbA1c), serum c-peptide and cholesterol concentrations were also measured from the

fasting venous blood sample. Post-intervention testing was completed within a week of cessation of the intervention, but at least 48 h after the last exercise session.

On a separate occasion, participants visited our laboratory for the assessment of secondary outcome measures pre- and post-intervention. Height, body mass, five peripheral skinfolds (biceps, triceps, subscapular, mid-thigh and calf), four limb girths (upper relaxed arm, upper flexed arm, thigh and calf), resting heart rate and blood pressure were measured. In addition, cardiovascular fitness was assessed based on the heart rate and oxygen consumption responses to submaximal exercise on a stationary cycle ergometer (Exertech Ex-10 front access cycle ergometer, Repco Cycle, Huntingdale, Australia). Briefly, this test involved progressive exercise until a heart rate equivalent to 75% of age-predicted maximum was attained.¹¹ Oxygen consumption was measured for the duration of the test (Universal ventilation meter, VacuMed, Ventura, USA; Ametek Applied Electrochemistry S-3A/1 and CD-3A, AEI Technologies, Pittsburgh, USA) with fitness expressed as both power output (W) and oxygen consumption at 75% of maximum heart rate. During the same session, the Edinburgh Postnatal Depression Scale (EPDS)¹⁵ was administered, along with the 21-item Depression Anxiety Stress Scale (DASS-21)¹⁶ to assess general psychological distress,¹⁷ while the Social Physique Anxiety Scale (SPAS)¹⁸ monitored social anxiety relating to physique.

Each participant also completed a 7-day food diary pre- and post-intervention for assessment of mean daily nutritional intake (total energy, carbohydrate, fat, protein, sugar and fiber; Foodworks, Xyris Software, Highgate Hill, Queensland, Australia). Physical activity (daily steps, time spent sedentary and in moderate intensity activity) was monitored for the same 7-day period using an accelerometer (ActiGraph, Pensacola, FL, USA). Changes in exercise

habit strength (patterning of action, automaticity, stimulus-response bonds, and negative consequences for non-performance) were assessed using the Exercise Habit Strength Questionnaire.¹⁹ After delivery, relevant obstetric and neonatal outcomes were extracted from hospital records.

Data from King Edward Memorial Hospital (Perth, Western Australia) indicated that the risk of GDM recurrence was 55% in our population, a figure consistent with the published literature.⁸ A sample size of 180 (90 women in each group) was required to attain 80% power to detect a 40% reduction in the incidence of GDM, from 55% to 33%, when performing a test of proportions at 5% significance level. Continuous data were summarized using means and standard deviation, or medians and interquartile ranges, depending on data normality, and were univariately compared using t-test or Mann-Whitney test. Categorical data were summarized using frequency distributions. The incidence of GDM and other categorical outcomes were compared using Chi-square test, except for low frequency outcomes which were compared using Fisher exact test. The glucose and insulin responses to the OGTT were compared using three-way (group x pre-post x time) repeated measures analysis of variance. Maternal fitness, body anthropometrics, psychological well-being, physical activity levels and daily nutritional intake were compared using two-way (group x time) repeated measures analysis of variance. Extreme under-reporters were identified using the Goldberg method as per Black²⁰ and excluded from the dietary analysis (8% of entries). Statistical analysis was conducted based on intention-to-treat using SPSS statistical software. All hypothesis tests were two-sided and conducted at a 5% significance level.

Results

A total of 318 women were assessed for eligibility for the study between 1 June 2011 and 31 July 2014 (Trial profile Figure 1) and 205 provided written consent to participate and completed baseline assessments at 13 ± 1 week of gestation. Of these 205 women, 33 were excluded from the trial due to an elevated OGTT at baseline, leaving 172 randomized to exercise ($n = 85$) or control ($n = 87$). The baseline characteristics of these women are shown in Table 1. The majority were of Caucasian ethnicity and lived in geographic areas in the top quintile for relative socio-economic advantage. There were no differences in glucose regulation between groups at baseline. Two women experienced pregnancy loss at 19 weeks gestation and one at 21 weeks (control = 2; exercise = 1). All remaining women completed the post-intervention OGTT (28 ± 1 week gestation); however, twelve women failed to complete the post-intervention assessment of fitness, body anthropometrics and psychological well-being (secondary outcomes). The final participant delivered on 26 January 2015, completing the period of data collection. Compliance to the exercise intervention was high (median 86% of sessions completed; interquartile range 79-95%). The mean heart rate during exercise was 130 ± 10 bpm ($70 \pm 5\%$ age-predicted maximum). Participants reported a mean session RPE of 13 ± 1 indicating that exercise intensity was perceived as “somewhat hard”. Exercise duration increased from 28 ± 4 min per session in the first week to 47 ± 11 min in the last week of the intervention.

The recurrence rate of GDM was similar between groups (40% control; 40.5% exercise; relative risk = 1.01, 95% confidence interval (0.70-1.46); $p=0.950$; Table 2) and there was no difference in the severity of GDM based on the overall degree of glucose tolerance or insulin response to the OGTT between groups post-intervention. HOMA-IR, ISI, HbA1c and serum C-peptide were also similar between groups post-intervention (Table 2). Advancing

pregnancy was associated with an increase in resting heart rate, blood triglycerides, LDL and HDL cholesterol, and a decrease in systolic and diastolic blood pressure ($P < 0.001$); however there were no differences between groups (Table 3). Similarly, body mass, sum of skinfolds and girths increased as pregnancy progressed ($P < 0.001$), with no difference between groups. Maternal cardiovascular fitness, based on the power output at 75% maximum heart rate, was increased in response to exercise ($P < 0.01$), resulting in higher fitness in the exercise group compared with controls post-intervention ($P < 0.01$). Oxygen consumption at 75% maximum heart rate also tended to increase after the exercise intervention ($P = 0.05$; Table 3).

There were no changes in EPDS scores over time and no differences between groups (Table 4). Similarly, the number of participants with EPDS scores ≥ 12 (indicating higher risk for depression in pregnancy) was similar between groups. In contrast, a significant difference in DASS-21 psychological distress scores was noted between groups post-intervention ($P = 0.04$), with a reduction in response to exercise, but no change in the control group. Social Physique Anxiety did not change over time and was similar between groups (Table 4). Daily nutritional intake was unaltered over time and was similar between groups pre- and post-intervention ($P > 0.05$; Table 5). With respect to daily physical activity levels, the mean number of steps taken decreased and the time spent sedentary increased as pregnancy progressed ($P < 0.05$; Table 5), but there were no differences pre- or post-intervention between groups. Time spent in moderate activity outside of the intervention was similar over time and between groups. Of note, women performing more than 20 min of moderate intensity physical activity (50th percentile) at study entry had a reduced incidence of GDM independent of their group allocation, compared with women performing less than 20 min of daily moderate activity (29% versus 49%; $P = 0.013$). The Habit Strength Questionnaire revealed an increase in the patterning of action and exercise automaticity from pre-

intervention to post-intervention in the exercise group but no change in controls ($P < 0.05$; Table 5). There were no differences in obstetric or neonatal outcomes between groups (Table 6) except that there were more male infants born to participants in the exercise group compared with controls ($P < 0.01$).

Discussion

A 14-week supervised, home-based exercise program commenced at 14 weeks of pregnancy did not reduce the recurrence of GDM, nor did it alter the overall degree of glucose intolerance or insulin sensitivity. However, the intervention was associated with improvements in maternal cardiovascular fitness, increases in exercise automaticity and a reduction in general psychological distress indicated by the DASS-21. Impaired glucose tolerance was identified before 14 weeks of pregnancy in 16% of women consenting to the study, suggesting that screening for GDM in women with a history of the condition may need to commence earlier than is currently practiced.

The lack of effect of the intervention on the recurrence of GDM is surprising given the epidemiological data to support a reduction in GDM risk with increasing physical activity,³ together with experimental studies reporting benefits of regular exercise during pregnancy for glucose tolerance.⁴ However, the few randomized controlled trials investigating the effect of exercise for GDM prevention have reported conflicting results, with some trials observing no effect of antenatal exercise (moderate intensity aerobic, strength and flexibility exercises performed three times a week for 45-60 min) on the incidence of GDM,^{5,7} while Cordero and colleagues⁶ reported reduced prevalence of GDM with a program of aerobic, strength and flexibility exercises performed three times per week from 10-14 weeks of pregnancy. The lack of benefit of our intervention for decreasing the recurrence of GDM was unlikely due to

low compliance given the fully supervised home-based design. The exercise prescription was based on previous work in women with and without GDM;^{4,11,21} however, it is possible that increasing the frequency of exercise may have altered the results, and the optimal duration and intensity of exercise for the prevention of GDM is not known. It is also unlikely that the lack of effect of exercise on GDM was due to compensatory changes in daily nutritional intake or physical activity levels outside of the intervention, given the lack of difference between groups; although it should be acknowledged that these measures were taken pre- and post-intervention only, and that self-reported food diaries are susceptible to under-reporting which is likely given the lower than expected energy intake seen here. It must also be noted that the exercise group gave birth to significantly more male infants. This coincidental occurrence may have influenced the rate of GDM given that women carrying a male fetus may have an increased risk of GDM.²²

The present intervention commenced at 14 weeks of pregnancy. Although this was initially considered a strength of the trial, it has recently been suggested that placental function and gene expression are programmed by the first trimester.²³ Accordingly, future research could focus on overcoming the challenges of recruiting earlier in pregnancy and even prior to conception. In support of this notion, women performing more than 20 min of moderate intensity physical activity at study entry had a reduced incidence of GDM independent of their group allocation. Consideration of the baseline physical activity levels of our sample also highlights that the women studied here may not be representative of the general population of pregnant women at risk of GDM. At study entry, the present sample accumulated a mean of 24 min of daily moderate intensity physical activity, which is higher than that reported in the general population of pregnant women in Australia.²⁴ Moreover, 57% of our sample lived in geographic areas of social advantage, 72% were under private

obstetric care and ~80% had a BMI < 30 kg/m². These indicators of socioeconomic status may influence awareness and commitment to health.^{9,25} In support of this notion, the GDM recurrence rate of 40% observed in our sample is lower than the expected recurrence rate based on our hospital data (55%). Indeed, volunteering for a 14-week exercise intervention itself may introduce self-selection bias, potentially suggesting a proactive approach to avoiding a second GDM diagnosis.

Despite a lack of effect of the exercise intervention on the recurrence or severity of GDM, the improvement in cardiovascular fitness is of great importance given the beneficial relationship between exercise during pregnancy and higher fitness and reduced cardiovascular risk factors later in life.²⁶ Meanwhile, the reduction in general psychological distress indicated by the DASS-21 in the exercise group is of interest given the adverse effects of maternal distress on development in utero.²⁷ Regardless of these benefits, there was no difference in obstetric and neonatal outcomes between groups, although the present study was not powered for these outcomes. The present intervention ceased at 28 weeks of pregnancy to coincide with assessment of the primary outcome measure; however, the effect of continuing an intervention of this nature until delivery remains to be determined.

In summary, supervised home-based exercise commenced after the first trimester of pregnancy does not reduce the recurrence of GDM or the degree of decline in glucose tolerance in women with a history of the condition at 28 weeks of pregnancy; however, it does benefit maternal fitness and psychological well-being. Future studies should seek to implement exercise interventions before conception, extend through to delivery, and focus on women with the lowest health, socioeconomic status and baseline physical activity levels.

294 Regardless of the lack of benefit observed here for the prevention of GDM, the benefits of
295 regular exercise for the management of GDM after diagnosis are well established.^{11,21}

Figure 1. CONSORT flow diagram

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Table 1. Baseline characteristics of women randomized to a 14-week supervised home-based exercise intervention or standard care [mean $\pm$ SD; n (%); median (interquartile range)].

Characteristic		Control (n = 87)	Exercise (n = 85)	P value
Maternal age (y)		33.8 $\pm$ 3.9	33.6 $\pm$ 4.1	0.750
Caucasian Ethnicity*		68 (78)	76 (89)	0.071
Parity	1	71 (82)	58 (68)	0.077
	≥ 2	16 (18)	27 (32)	
Body Mass Index	≤ 24.9 kg/m ²	48 (55)	37 (44)	0.138
	25–29.9 kg/m ²	19 (22)	30 (35)	
	≥ 30 kg/m ²	20 (23)	18 (21)	
Highest SEAIFA IRSD quintile		49 (56.3)	49 (57.6)	0.768
Smoking	Yes	-	4 (5)	0.096
	Unknown	4 (5)	6 (7)	
Fasting glucose (mmol/L)		4.3 $\pm$ 0.3	4.3 $\pm$ 0.4	0.780
Fasting insulin (mU/L)		5.8 $\pm$ 3.7	6.1 $\pm$ 3.2	0.623
HOMA-IR		1.1 $\pm$ 0.8	1.2 $\pm$ 0.7	0.549
Insulin sensitivity index (ISI)		9.8 $\pm$ 4.6	9.3 $\pm$ 5.2	0.553
HbA1c (%)		5.4 $\pm$ 0.3	5.4 $\pm$ 0.3	0.427
Serum C-peptide (nmol/L)		0.35 (0.29 – 0.51)	0.39 (0.29 – 0.52)	0.696

SEAIFA IRSD is the socio-Economic Indexes for Areas Index of Relative Socio-economic Advantage and Disadvantage (IRSD). Highest quintile represents the most advantaged. HOMA-IR is the homeostatic model of assessment insulin resistance.

*Other ethnicities include Asian, Eurasian, Hispanic and Polynesian.

Table 2. Gestational diabetes mellitus (GDM) diagnosis, measures of insulin sensitivity and glucose regulations after a 14-week supervised home-based exercise intervention or standard care [mean $\pm$ SD; n (%); median (interquartile range)].

Outcome	Post intervention	
	Control (n = 85)	Exercise (n = 84)
Diagnosed with GDM	34 (40.0)	34 (40.5)
Fasting glucose (mmol/L)	4.4 $\pm$ 0.5	4.5 $\pm$ 0.5
Fasting insulin (mU/L)	7.9 $\pm$ 4.4	9.1 $\pm$ 5.7
Glucose 2 h post OGTT (mmol/L)	7.7 $\pm$ 1.5	7.6 $\pm$ 1.6
HOMA-IR	1.25 (0.84 – 2.05)	1.56 (1.09 – 2.18)
ISI	5.6 (3.9 – 7.8)	5.0 (3.5 – 7.7)
HbA1c (%)	5.3 $\pm$ 0.3	5.3 $\pm$ 0.3
Serum C-peptide (nmol/L)	0.53 (0.37 – 0.71)	0.54 (0.41 – 0.71)

HOMA-IR, homeostatic model of assessment-insulin resistance. ISI, insulin sensitivity index.

HbA1c, glycosylated hemoglobin.

Table 3. Maternal health, body anthropometrics and cardiovascular fitness before and after a 14-week supervised home-based exercise intervention or standard care (mean $\pm$ SD; n (%)).

Outcome	Pre intervention		Post intervention	
	Control	Exercise	Control	Exercise
Resting heart rate (bpm)*	80 $\pm$ 8	78 $\pm$ 9	85 $\pm$ 9	84 $\pm$ 10
Systolic BP (mmHg)*	106 $\pm$ 13	106 $\pm$ 11	104 $\pm$ 12	103 $\pm$ 12
Diastolic BP (mmHg)*	64 $\pm$ 9	63 $\pm$ 8	61 $\pm$ 8	60 $\pm$ 8
Total cholesterol (mmol/L)*	4.9 $\pm$ 0.8	5.0 $\pm$ 0.8	6.3 $\pm$ 0.9	6.4 $\pm$ 1.1
HDL cholesterol (mmol/L)*	1.7 $\pm$ 0.3	1.7 $\pm$ 0.3	1.8 $\pm$ 0.3	1.8 $\pm$ 0.3
LDL cholesterol (mmol/L)*	2.7 $\pm$ 0.7	2.8 $\pm$ 0.7	3.6 $\pm$ 0.8	3.7 $\pm$ 1.1
Triglyceride (mmol/L)*	1.4 $\pm$ 0.6	1.2 $\pm$ 0.5	2.2 $\pm$ 0.8	2.2 $\pm$ 0.8
Body mass (kg)*	69.0 $\pm$ 16.2	70.5 $\pm$ 15.4	75.7 $\pm$ 16.0	76.9 $\pm$ 14.9
Weight gain (kg) at 28 wk	-	-	6.7 $\pm$ 2.6	6.4 $\pm$ 2.1
Body mass index (kg/m ²)*	25.7 $\pm$ 5.4	26.3 $\pm$ 5.1	28.2 $\pm$ 5.3	28.6 $\pm$ 4.9
Sum of four girths (cm)*	157 $\pm$ 20	159 $\pm$ 19	160 $\pm$ 19	161 $\pm$ 18
Sum of five skinfolds (mm)*	113 $\pm$ 40	122 $\pm$ 47	122 $\pm$ 43	131 $\pm$ 45
Maternal fitness (power output [W] at 75% maximum heart rate)	109 $\pm$ 21	112 $\pm$ 24	107 $\pm$ 19	120 $\pm$ 29 [†]
Maternal fitness (oxygen consumption [L/min] at 75% maximum heart rate)*	1.50 $\pm$ 0.21	1.55 $\pm$ 0.29	1.52 $\pm$ 0.24	1.65 $\pm$ 0.38

*Indicates significant main effect for time (P < 0.01). [†]Indicates significant difference between groups post-intervention (P < 0.05).

Table 4. Maternal psychological well-being assessed through the Edinburgh Postnatal Depression Scale (EPDS), Depression, Anxiety and Stress Scales (DASS-21) and Social Physique Anxiety Scale (SPAS) before and after a 14-week supervised home-based exercise intervention or standard care [median (interquartile range); n (%)].

Outcome	Pre intervention		Post intervention	
	Control	Exercise	Control	Exercise
EPDS	4 (1 - 6)	4 (2 - 6)	4 (2 - 7)	4 (1.5 - 6)
EPDS score ≥ 12	2 (2.3)	5 (5.9)	3 (3.5)	1 (1.2)
Missing	-	-	8 (9.4)	3 (3.5)
DASS-21	8 (4 - 11)	6 (4 - 12)	7 (4.5 - 11)	6 (2 - 10)*
SPAS total	28.5 (18 - 37)	32 (23 - 39.5)	26 (18 - 35)	29 (19 - 38)

* Indicates significant difference between groups post-intervention ($P < 0.05$).

Table 5. Daily nutritional intake, physical activity and exercise habit strength before and after a 14-week supervised, home-based exercise intervention or standard care [mean $\pm$ SD (%)].

Outcome	Pre intervention		Post intervention	
	Control	Exercise	Control	Exercise
Daily energy intake (kJ)	7627 $\pm$ 1779	7625 $\pm$ 1832	7808 $\pm$ 1709	7351 $\pm$ 1488
Carbohydrate intake (g)	198 $\pm$ 50 (43)	192 $\pm$ 51 (42)	201 $\pm$ 58 (42)	188 $\pm$ 48 (42)
Sugar intake (g)	79 $\pm$ 29	80 $\pm$ 34	87 $\pm$ 35	77 $\pm$ 27
Protein intake (g)	87 $\pm$ 24 (20)	91 $\pm$ 28 (20)	92 $\pm$ 19 (20)	88 $\pm$ 18 (21)
Fat intake (g)	70 $\pm$ 23 (33)	72 $\pm$ 22 (35)	72 $\pm$ 22 (34)	69 $\pm$ 19 (34)
Saturated fat (g)	27 $\pm$ 9	30 $\pm$ 9	29 $\pm$ 10	28 $\pm$ 9
Monounsaturated fat (g)	26 $\pm$ 10	26 $\pm$ 9	27 $\pm$ 9	25 $\pm$ 8
Dietary fibre (g)	23 $\pm$ 7	22 $\pm$ 10	24 $\pm$ 7	21 $\pm$ 6
Daily steps taken*	6488 $\pm$ 1988	6072 $\pm$ 1688	5910 $\pm$ 1767	5520 $\pm$ 1651
Sedentary time (min/day)*	1179 $\pm$ 81	1182 $\pm$ 78	1187 $\pm$ 91	1195 $\pm$ 82
Moderate activity (min/day)	24 $\pm$ 14	21 $\pm$ 14	24 $\pm$ 15	23 $\pm$ 16
Exercise habit strength				
Patterning of action*	20.07 $\pm$ 5.65	19.93 $\pm$ 5.38	20.23 $\pm$ 5.66	22.95 $\pm$ 3.85 ^{†‡}
Automaticity*	20.52 $\pm$ 5.65	19.32 $\pm$ 5.48	20.68 $\pm$ 5.40	21.33 $\pm$ 4.80 [‡]
Stimulus-response bonds	15.97 $\pm$ 4.73	16.49 $\pm$ 4.98	15.95 $\pm$ 4.44	16.62 $\pm$ 4.87
Negative consequences for non-performance	16.93 $\pm$ 5.82	17.72 $\pm$ 6.31	17.01 $\pm$ 5.30	18.33 $\pm$ 5.90

*Indicates significant main effect for time ($P < 0.01$). [†]Indicates significant difference between groups post-intervention ($P < 0.05$). [‡]Indicates significant difference within group pre to post-intervention ($P < 0.05$).

Table 6. Obstetric and neonatal outcomes of women randomized to standard care or a supervised home-based exercise program [mean $\pm$ SD; n (%)].

Outcome		Control	Exercise	P-value
Onset of labour	Spontaneous	28 (32.9)	25 (29.8)	0.457
	Induced/Augmented	30 (35.3)	33 (39.3)	
	No labour	27 (31.8)	26 (31.0)	
Mode of Delivery	Standard vaginal delivery	36 (42.4)	38 (45.2)	0.984
	Assisted vaginal delivery	12 (14.1)	11 (13.1)	
	Elective caesarean	26 (30.6)	25 (29.8)	
	Emergency caesarean	11 (12.9)	10 (11.9)	
Obstetric complications	Pre-eclampsia	1 (1.2)	2 (2.4)	1.000
	Post-partum hemorrhage	3 (3.5)	2 (2.4)	1.000
	Sepsis requiring antibiotics	3 (3.5)	3 (3.5)	1.000
Neonate outcomes	Preterm birth	4 (4.7)	3 (3.6)	1.000
	Gestational age at delivery (wk)	38.5 $\pm$ 1.3	38.9 $\pm$ 21.1	0.101
	Apgar score < 7 at 5min	1 (1.2)	1 (1.2)	1.000
	Special care nursery admission	14 (16.5)	8 (9.4)	0.180
	Birth weight (g)	3419 $\pm$ 518	3552 $\pm$ 469	0.082
	Head circumference (cm)	34.7 $\pm$ 2.2	35.0 $\pm$ 2.3	0.436
	Large for gestational age	10 (11.8)	12 (14.2)	0.336
	Small for gestational age	2 (2.4)	-	
	Male neonate	35 (41.2)	54 (64.3)	0.003

Note: p-values for categorical variables are Chi-square test or Fisher exact test in the case of low frequency outcomes.