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A pilot study evaluating the effects of a 12 week exergaming programme on body mass, size and composition in postpartum females

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Abstract

Introduction: *Pregnancy is associated with weight gain, the retention of which contributes to the prevalence of obesity and overweight in adult females. Many new mothers do not achieve the recommendations for physical activity (PA), citing factors such as a lack of time and access to childcare. Exergaming may address some of the barriers to PA and offer an alternative to traditional exercise, thus aiding in weight management. The aim of this pilot study was to evaluate the effects of an exergaming intervention on body composition in postpartum females.*
Methods: *Eight females who had given birth within 1 year completed a 12 week exergaming intervention, which required them to exercise at home for 45 minutes on alternate days, using the Wii Fit. Participants self-reported their pre-pregnancy body weight, and visited the laboratory prior to and following the intervention for evaluation of body weight, size (height, regional circumferences, body mass index [BMI]) and composition (fat mass [FM], lean mass [LM] and bone mineral content [BMC]). Body composition was evaluated via full body full-body dual-energy x-ray absorptiometry scan. Participants completed a three-day weighed food intake at three time-points.*
Results: *Baseline body mass was 8.2 kg greater than self-reported pre-pregnancy values (56.8 ± 5.1 kg). Following the intervention, body mass was significantly lower than baseline values and was similar to pre-pregnancy levels (59.9 ± 7.9 kg). Reductions in BMI (~2 kg·m^2), waist, hip and bust circumference (3-6%) accompanied the loss of body mass. Food diaries confirmed participants had not altered their energy intake.*
Discussion: *The results of this pilot study indicate that exergaming may offer an alternative to traditional exercise for preventing the retention of gestational weight gain and reducing associated health risks, whilst also maintaining lean mass and bone mineral content.*

Keywords: *active gaming, pregnancy, weight loss/management*

Introduction

Reducing the number of overweight and obese individuals[1] (body mass index ≥ 25 kg·m^2) is currently a public health priority[2]. Pregnancy, specifically the retention of gestational weight gain, contributes to the prevalence of overweight adult females[3-5]. The average body mass gain from pre-pregnancy to one year postpartum being between 0.5 to 4 kg[3,6,7], although 25% of women retain more than 4.5 kg of body mass following child-birth[6,8,9]. Overweight and obese females have a high risk of developing chronic diseases such as type II diabetes and cardiovascular disease[10,11]; therefore understanding the modifiable risk factors associated with prolonged gestational weight retention may be the key to reducing these risks and their consequences.

Regular physical activity (PA) and exercise play an integral role in weight management, reducing the risk of developing body mass-related health problems and lowering the mortality rate[12-14]. Concomitantly, sedentariness is known to be associated with body mass gain and increased mortality[15]. Previous literature has reported that postpartum females are generally less physically active than their childless counterparts[16], and it is estimated that over 50% do not achieve the minimum recommendations for PA (30 min·d^{-1} of moderate intensity exercise 5 d·wk^{-1}) as outlined by the American College of Sports Medicine[13]. Reduced PA levels could, therefore, contribute to postpartum body mass retention, and thus represent a potential target for intervention.

Although some studies have shown beneficial effects of regular exercise on body mass loss in the first year following parturition[17,18], initiating exercise in this period may not be feasible for many mothers. Perceived barriers to PA and exercise reported by new mothers include: tiredness and a lack of time, social support, childcare and confidence[19-23]. To date, few effective interventions which address these issues have been described in the literature[24].

Exergaming, also referred to dynamic interactive gaming (DIG), is a relatively novel concept describing video games that require individuals to physically interact, via body movements, in order to play[25,26]. Substituting inactive screen time (i.e. watching television) with exergaming may offer an alternative to traditional exercise and thus could aid in weight management[25-27]. Some research has begun to explore the effects of exergaming on PA and energy expenditure, and its utility in weight management in children and adults. Exergaming is reported to be enjoyable for adolescents and adults[28] and studies have shown that it increases energy expenditure and PA levels in comparison to traditional inactive video games[28-30]. Moreover, research has shown that exergaming interventions can reduce body mass and improve body composition in overweight and obese children[25,31], as well as increase their self-efficacy[31]. However, no research has so far examined the influence of exergaming on the body mass, size and composition of postpartum females. We suggest that exergaming has the potential to overcome some of the perceived barriers to exercise reported by postpartum females and could play an important role in weight management because it offers an opportunity to undertake PA at home, at a time when it is convenient, and does not necessitate childcare.

Pregnancy and lactation are associated with a loss of bone, characterised by a reduction in bone mineral density (BMD), which is usually reversed following childbirth and/or cessation of lactation[32,33]. However, recovery of BMD is not always complete[34] and a potential concern with a weight loss intervention in postpartum females is that the associated energy deficit may exacerbate the loss of bone[35]. Previous research has indicated that combined resistance and aerobic exercise slows bone loss during lactation[36]. Thus it is of interest to determine whether an exergaming intervention is effective at reducing body mass whilst preserving bone mineral content (BMC).

The aim of this pilot study was to examine changes in body mass, size and composition of postpartum females in response to a 12 week exergaming intervention. We also examined the feasibility of recruiting and retaining postpartum women. We hypothesised that the intervention would reduce body mass, improve body composition and preserve bone mineral content relative to baseline.

Methods

Participants

Eight healthy female participants volunteered for this study. All participants were less than one year postpartum prior to recruitment (19 ± 9 weeks, range 12 – 34 weeks). The mean $\pm$ SD age, mass and height was 31 $\pm$ 5 years, 65.0 $\pm$ 10.6 kg and 1.63 $\pm$ 0.08 m, respectively. Participants self-reported pre-pregnancy weight was 56.8 $\pm$ 5.1 kg. Participants had on average 2 $\pm$ 1 children prior to recruitment. For the present study six participants had singleton births while two participants had twins (five male and five female offspring), with the mean birth weight being 3.5 $\pm$ 0.4 kg. Six of the eight participants had been breast-feeding for 24 $\pm$ 17 weeks at the time of recruitment. Health screening and pregnancy history were recorded to assess suitability for the study and were used for the basis of the inclusion/exclusion criteria. All participants met the inclusion criteria: 18 – 40 years, viable pregnancy within the last 12 months, no postpartum complications, eumenorrheic with a menstrual bleed within the last 30 days, no large single dose of radiation exposure within the last 2 years and no musculoskeletal injuries. All of the participants reported low levels of habitual physical activity and none had been involved in regular exercise since at least the 2nd trimester of pregnancy. All participants were on maternity leave from their occupations for the duration of the study. All participants gave their written informed consent having read and understood the details of the study. Approval for the study was obtained from the institution's human ethics committee and conformed to the Declaration of Helsinki. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Research Design

At baseline (0 weeks) and following completion of the training programme (12 weeks) participants' height, weight, upper arm, thigh, bust, waist and hip circumference were recorded. In addition, participants underwent a full-body dual-energy x-ray absorptiometry (iDXA; Lunar iDXA, GE Healthcare, General Electric Company, Little Chalfont, UK) axial scan, performed by a qualified radiographer.

Participants were required to exercise at home using a Wii Balance Board (Nintendo Wii, Nintendo Co Ltd, Kyoto,

Table 1. Wii Fit training programmes provided to the participants.

	Programme 1	Programme 2	Programme 3
Training category	**Activity**	**Activity**	**Activity**
Aerobic	Step Basics (3)	Hula Hoop (4)	Step Plus (5)
	Rhythm Box (3.5)	Jogging (5)	Super Hula (3)
	Free Step (3)	Step plus (3.5)	Rhythm Box (3)
			Free Jog (5)
Training plus	Jog Plus (4)	Free Jog (3.5)	Skateboard (3)
	Obstacle (3)	Segway (2)	Rhythm Kung Fu (3)
	Rhythm Parade (3)	Birds Eye (2)	
		Cycling (2.5)	
Muscle	Single Arm Stand (5.5)	Torso & Waist Twists (2)	Parallel Stretch (2.5)
	Single Leg Reach (4)	Parallel Stretch (2.5)	Single Leg Reach (4)
	Balance Bridge (3.5)	Jack Knife (2)	Balance Bridge (3.5)
Yoga	Triangle (2.5)	Grounded V (3)	Warrior (2)
	Chair (2)	Half Moon (1.5)	Bridge (2)
	Half Moon (1.5) Warrior (2)	Triangle (2.5) Balance bridge (3.5)	Half Moon (1.5)

Values in the brackets represent the metabolic equivalents (METs) of the tasks provided by the game manufacturers. 1 MET is equivalent to 1 kcal·kg^{-1}·hr^{-1}.

Japan), every other day, for 12 weeks. The Wii Balance board is a controller containing sensors which measure an individuals' centre of pressure when stood on it. Participants were provided with a Wii Fit system for the duration of the study if they did not already own one (n=2). Participants were provided with three possible Wii Fit training programmes (Table 1), each containing an aerobic, training plus, muscle and yoga component. Participants were instructed to maximally engage with each activity. They were allowed to alternate between, but not combine, programmes. A selection of programmes was offered to reduce boredom and promote adherence. The duration of the programmes was 45 ± 8 minutes. Participants were fully familiarised with the programmes prior to commencing the intervention. Participants were asked to not to alter their habitual PA levels or engage in any exercise outside of the prescribed programme throughout the duration of the study, and retrospectively confirmed this at the completion of the programme.

Participants completed a three-day weighed food intake at three time-points (0, 6 and 12 weeks) during the study and kept a food diary for the entire 12 week period.

They were instructed not to alter their dietary habits in any way during the study. All participants provided enough information (food diaries and weighed food intake) to estimate energy intake and a breakdown of the macronutrients at all 3 time-points (week 1, week 6 and week 12). Data were analysed using Microdiet version 2 (Downlee Systems Ltd., High Peak, UK).

Research Protocol

On arrival to the laboratory, participants were instructed to remove their shoes, clothes and any metal objects from their person. They were asked to wear either a surgical gown or light clothing with no metal components such as zips or metal buttons. Height was measured using a portable stadiometer (Seca 213 Portable Stadiometer, Hamburg, Germany) to the nearest 0.1 cm. Weight was measured with a scale (Seca 876 Mobile Floor Scale, Hamburg, Germany) accurate to 0.2 kg. All circumferences were measured using a 150 cm fabric tape measure (Hoechstmass Balzer Gmbh, Sulzbach, Germany) and standard techniques[37]. The same experimenter and equipment was used for both testing session (0 and 12 weeks). Body mass index (body mass in kilograms divided by the height squared in meters, kg·m^2) was categorized into normal (BMI < 25 kg·m^2), overweight (BMI = 25–29 kg·m^2) and obese (BMI > 30 kg·m^2) using the WHO classification of BMI cut-offs [1].

Lean mass (LM), BMC and fat mass (FM) were measured using a total body iDXA axial scan. This system has recently been shown to produce highly reliable estimates of total and regional body composition [coefficient of variation <1% for repeated measures[38]]. A trained iDXA technician positioned the subject and performed the scans using standard procedures. Participants lay supine on the scanner and remained still while the fan-beam scanner moved inferiorly from the head to the feet. Total body LM, BMC and fat mass were measured in addition to left and right arms and legs,

Table 2. Circumference measurements (cm) by body region.					
	Body region				
	Waist	**Hip**	**Bust**	**Thigh**	**Arm**
Baseline	83.4 ± 10.6	102.9 ± 6.1	95.4 ± 8.9	49.3 ± 7.8	27.4 ± 2.7
Post	78.4 ± 6.7*	97.8 ± 5.6**	92.1 ± 9.0**	47.1 ± 4.7	26.3 ± 1.4
Data are group mean ± SD (*N* = 8). **P* < 0.05, ***P* < 0.01					

trunk and android (central) and gynoid (peripheral) regions. Values for the left and right arms and legs were averaged to create mean values for the arms and legs. Lean mass (kg) and BMC (g) were measured in absolute terms, whilst FM was measured in both absolute (kg) and relative terms (percentage of body region or total body mass; %).

Statistical Analysis

Descriptive and outcome statistics are presented as means ± SD. Data were analysed using SPSS version 18 (IBM SPSS statistics, New York, USA). All tests met the assumptions for parametric tests. Differences between baseline and post-intervention training values were analysed using a paired-samples *t*-test. Repeated measures ANOVA was used to detect differences between time points in body mass (pre-pregnancy, baseline and post-intervention) and energy intake (weeks 1, 6 and 12), with least squares difference *post hoc* analysis used to identify specific differences between time points. Statistical significance was accepted at *P* < 0.05. Data are also presented as the mean intra-individual percentage change from baseline to post-intervention for each outcome measure, which was calculated using the formula: *(post-intervention – baseline) / baseline × 100*.

Results

Body Mass

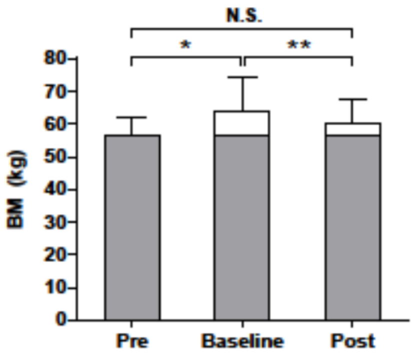

Figure 1. Body mass (BM; kg) recorded at pre-pregnancy (Pre), baseline and post-intervention (Post). Shaded segments on bars represent pre-pregnancy body mass and white segments on bars represents postpartum weight retention. Data are mean ± SD (*N* = 8). **P* < 0.05, ***P* < 0.01.

Participants' body mass was on average 8.2 ± 8.8 kg (14 %) greater at baseline compared to their self-reported pre-pregnancy body mass (Figure 1), and five of the eight participants had retained > 4.5 kg. Following the intervention, body mass decreased by 5.1 ± 3.9 kg (7%), such that post-intervention body mass was similar to self-reported pre-pregnancy values (Figure 1), and only 2 participants had still retained > 4.5 kg. The average rate of weight loss from baseline to post-intervention was 0.40 ± 0.03 kg per week.

Body Size

BMI at baseline was 24.4 ± 4.9 kg·m^2, with 6 participants categorised as normal (range 20.2 – 24.2 kg·m^2), one as overweight (27.7 kg·m^2) and one as obese (35.2 kg·m^2). Following the intervention, BMI was significantly lower (22.5 ± 3.9 kg·m^2; *P* = 0.01) compared to baseline. Two individuals classed as overweight and obese were close to moving down a BMI category, with post-intervention BMI values of 25.5 and 30.4 kg·m^2, whilst the other participants remained within the healthy range (19.4 – 23.4 kg·m^2). Waist, hip and bust circumference decreased from baseline to post-intervention (3 – 6%, Table 2 and Figure 2), but there were no differences in thigh or arm circumference.

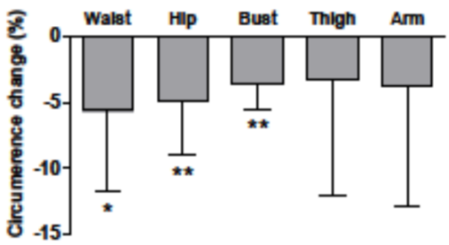

Figure 2. Percentage change from baseline to post-intervention for regional body circumferences. Data are group mean ± SD (*N* = 8). **P* < 0.05, ***P* < 0.01 indicates post-intervention values were significantly different from baseline.

Body Composition

Fat Mass

Total body FM decreased from baseline to post-intervention by 4.0 ± 3.0 kg (Table 3 and Figure 3A). When evaluated by body region, FM of the legs, trunk, android

Table 3. Baseline and post-intervention body composition data by region and for total body.

	Body region					
	Arms	**Legs**	**Trunk**	**Android**	**Gynoid**	**Total**
Fat mass (kg)						
Baseline	2.9 ± 7.9	9.6 ± 2.1	11.9 ± 4.5	2.0 ± 1.1	5.0 ± 1.3	25.3 ± 6.8
Post	2.6 ± 5.8#	8.1 ± 1.8**	9.7 ± 3.6**	1.4 ± 0.7**	4.1 ± 0.8*	21.3 ± 5.4**
Fat mass (%)						
Baseline	42.6 ± 3.9	42.1 ± 4.3	37.7 ± 6.2	40.3 ± 9.3	46.3 ± 6.4	38.8 ± 4.5
Post	40.4 ± 3.5	38.9 ± 4.3**	33.2 ± 6.7*	32.7 ± 8.7**	40.5 ± 6.4**	34.8 ± 3.6*
Lean mass (kg)						
Baseline	3.9 ± 0.5	13.0 ± 1.5	19.0 ± 1.8	2.8 ± 0.3	5.7 ± 0.8	38.9 ± 3.6
Post	3.7 ± 0.4	12.6 ± 1.3*	19.0 ± 2.0	2.8 ± 0.4	5.9 ± 0.7	38.0 ± 3.5
Bone mineral content (g)						
Baseline	297 ± 28	839 ± 98	670 ± 82	43 ± 6	224 ± 26	2306 ± 202
Post	299 ± 25	840 ± 96	629 ± 155	43 ± 6	225 ± 25	2312 ± 170

Data are group mean ± SD (N = 8). *$P < 0.05$, **$P < 0.01$, #$P = 0.054$

and gynoid regions decreased (15 – 28%), whilst there was also a trend for arm FM to decrease (Table 3 and Figure 3A). Total body relative FM decreased from baseline to post-intervention by 4.0 ± 3.4 % (Table 2 and Figure 3B). Relative FM of the legs, trunk, android and gynoid regions also decreased (5 – 18%), but there was no change in relative FM of the arms (Table 3 and Figure 3B).

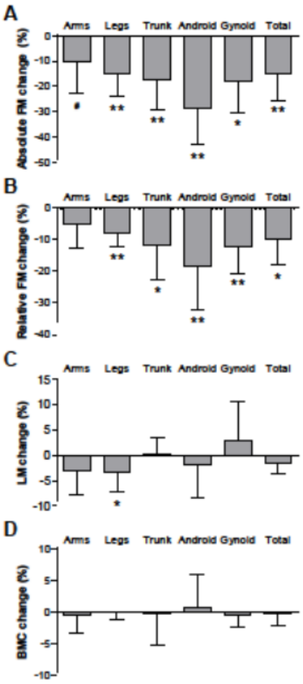

Figure 3. Percentage change from baseline to post-intervention for absolute FM (A), relative FM (B), LM (C) and BMC (D). Data are group mean ± SD (N = 8). *$P < 0.05$, **$P < 0.01$ indicates post-intervention values were significantly different, or tended to be different (#P = 0.054), from baseline.

Lean Mass

There was no difference in baseline and post-intervention total body LM (Table 3 and Figure 3C). Leg LM decreased by 0.4 ± 0.5 kg, but there were no differences in arm, trunk, android or gynoid LM (Table 3 and Figure 3C).

Body Mineral Content

No differences in baseline and post-intervention BMC were shown for the total body or any of the individual body regions (Table 3 and Figure 3D).

Dietary Analysis

Energy intake at the start of the intervention (2156 ± 97 $kcal \cdot d^{-1}$) was not significantly different from energy intake during (2090 ± 187 $kcal \cdot d^{-1}$) or at the end of the intervention period (2025 ± 159 $kcal \cdot d^{-1}$) (all $P > 0.05$), which were at 6 and 12 weeks respectively. Also the contribution of carbohydrate, fat and protein in the diet did not differ between the 3 time-points ($P > 0.05$). Carbohydrate, fat and protein provided 51%, 34% and 15% of total energy consumed at baseline compared to 49, 42 and 9% at the cessation of the exercise programme.

Discussion

This pilot study shows that it is feasible to recruit and retain postpartum women for an exergaming-based weight management study. This novel intervention showed reductions in total body mass and region-specific circumferences that were largely attributable to reduced body fat since LM and BMC were maintained. To the best of our knowledge, this is the first study of its kind and as such can be used to inform future randomised controlled trials using similar interventions.

Gestational weight gain is a known risk factor for becoming overweight and obese in adult females[3-5], and as such there is a need for effective interventions to prevent excessive and/or prolonged weight retention[17,18,24]. The present study examined changes in body size, mass and composition in response to a 12 week intervention using the Wii Fit in postpartum females. Prior to the intervention, baseline (postpartum) body mass was significantly greater (14%) than self-reported pre-pregnancy values. Following the intervention, body mass was significantly lower (7%) than baseline values and was similar to pre-pregnancy levels. Reductions in BMI (~2 $kg \cdot m^2$), waist, hip and bust circumference (3-6%) accompanied the loss of body mass.

This is the first study to investigate the effects of exergaming on body mass, size and composition in postpartum females. The present results showed that the reduction in body mass was due to a loss of fat mass and was reflected by a decrease in BMI, a common index of body size used to classify individuals as overweight or obese[1]. The reductions in BMI experienced by two participants in the present cohort were almost sufficient to move them down a category, from overweight and obese to healthy and overweight, following the intervention. The android region (28%) showed the greatest reduction in fat mass and this was accompanied by a 6% decrease in waist circumference. Android or abdominal fat is a well-known risk factor for metabolic disorders, cardiovascular disease and diabetes[39-41]. Thus the changes in body size and composition with the current intervention may confer substantial health benefits through a reduced risk of chronic cardiometabolic disease.

In general, lean mass was preserved over the course of the intervention, which might imply a preservation of physical function. The small reduction (0.4 kg) in leg lean mass may be attributed to the reduced functional loading on the lower limbs caused by the reduction in body mass. It would seem therefore that the intervention in its current form is inadequate for maintaining lean leg mass, and additional high-load resistance exercise may be warranted[42].

Neither total body nor regional BMC changed from baseline to post-intervention, which implies that the intervention was effective at preserving bone mass whilst also promoting weight loss. The maintenance of BMC may be viewed positively because other research has reported net site-specific losses in bone mineral density and mass of up to 7% in the spine, hip and forearm during the first 6 months postpartum[32,36]. The present results are therefore in line with previous research suggesting that exercise may help to preserve bone mass following pregnancy[36].

Previous research has shown a linear decline in body mass, by ~2 – 4 kg, from immediately postpartum to one year postpartum[43]. Women in the present study showed significant gestational weight gain (up to 8 kg) and retention (up to 34 weeks postpartum) at the time of recruitment and would therefore seem unlikely to have returned to their pre-pregnancy body mass within 12 months without intervention. The average rate of change in body mass from baseline to post-intervention during the present investigation was 0.42 ± 0.33 $kg \cdot wk^{-1}$, which exceeds the normal rate of change one might expect based on previous data[43] [~0.04 – 0.08 $kg \cdot wk^{-1}$]. Furthermore, the magnitude of reductions in body mass and waist circumference in our study (5.1 kg and 5 cm) were similar to those achieved (~2 – 5 kg and 4 – 11 cm) by low-to-moderate intensity aerobic exercise interventions of similar frequency (3 – 4 times per week) and duration (10-16 weeks)[17,18]. The control participants in these studies lost ≤ 0.1 kg and ≤ 1 cm over the same period[17,18]. Finally, dietary analysis confirmed that participants in the present study did not alter their dietary habits and thus it is unlikely that our results were confounded by a reduced energy intake. As such, we suggest that the changes shown in the present study are a direct result of our exergaming intervention, through increased PA levels and energy expenditure, and would not have occurred in the absence of intervention.

In the current study, the participants self-reported their pre-pregnancy weights. Given that their self-reported pre-pregnancy weights were statistically similar (mean gestational weight retention post-intervention ~3.1 kg) to their measured post-intervention body mass, and that females tend to under-report body mass by ~1.4 kg[44], it is unlikely that prospective measurement of body mass would have changed the present study's outcome, i.e. a return to pre-pregnancy body mass following the intervention.

New mothers frequently cite factors such as a lack of time, childcare, social support and confidence as reasons for not engaging in regular PA[19-23]. Our exergaming intervention may have enhanced participants' PA behaviours (e.g. frequency and intensity of PA, and adherence to the PA intervention) by addressing some of the reported barriers, since it could be performed at home, at a convenient time and without the need for childcare. Other possible contributors to enhanced PA behaviours may have included successful early experiences with the programmes and increased physical fitness through continued engagement, which might have improved their confidence to overcome the barriers to PA and to physically complete the activities[26]. Further benefits of exergaming as a tool to enhance PA behaviours might also include the potential for social support through the online community, the economic viability by comparison gym memberships or exercise class attendance, and the potential for adapting training programmes and thus potentially maintaining interest and adherence.

Some questions have been raised about whether exergaming is sufficient to meet current recommendations for PA and gain from the associated health benefits[27]. However, the results of this small pilot study support those from others studies showing similar improvements in overweight and obese children[25,31], and suggest it may provide worthwhile health benefits. There were anecdotal reports from the new mothers who took part in this study, suggesting that this mode of exercise was enjoyable, sustainable and addressed many of their perceived barriers to PA following childbirth. Further research is required to investigate the mechanisms for any alterations in PA, document changes PA and energy expenditure over a prolonged time period, and establish the health benefits of exergaming in postpartum females.

Conclusion

Postpartum females who participated in a novel 12 week exergaming intervention (consisting of aerobic, body-weight resistance exercise, flexibility and postural control exercises) showed reductions in total body mass and region-specific circumferences. These declines were largely attributable to reduced body fat since lean mass and BMC were maintained. Exergaming may offer an alternative to traditional exercise for preventing the retention of gestational weight gain and reducing associated health risks, whilst also maintaining bone mass.

Quick Points

- Exergaming is performed at home, at a time convenient for the participant, without the need for childcare and as such addresses most of the perceived barriers to exercise reported by new mothers.
- Many households already have an active gaming system (e.g. Wii Fit).
- Exergaming for 45 minutes, every other day for 12 weeks, resulted in significant weight loss; these results were seen without any change in diet.
- New mothers found this to be an enjoyable and sustainable mode of exercise.

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