Home-Based Active Video Games to Promote Weight Loss during the Postpartum Period

JULIEN TRIPETTE[1], HARUKA MURAKAMI[1], YUKO GANDO[1,2], RYOKO KAWAKAMI[1,3], AZUSA SASAKI[1], SATOSHI HANAWA[1], AIKO HIROSAKO[1], and MOTOHIKO MIYACHI[1]

[1]*Department of Health Promotion and Exercise, National Institute of Health and Nutrition, Shinjuku, Tokyo, JAPAN;* [2]*Sport Science Research Center, Waseda University, Tokorozawa, Saitama, JAPAN; and* [3]*Graduate School of Sport Sciences, Waseda University, Tokorozawa, Saitama, JAPAN*

ABSTRACT

TRIPETTE, J., H. MURAKAMI, Y. GANDO, R. KAWAKAMI, A. SASAKI, S. HANAWA, A. HIROSAKO, and M. MIYACHI. Home-Based Active Video Games to Promote Weight Loss during the Postpartum Period. *Med. Sci. Sports Exerc.*, Vol. 46, No. 3, pp. 472–478, 2014. **Purpose**: Weight retention during the postpartum period is critical for the later development of obesity in women. Traditional physical activity is frequently discontinued because of incompatibility with mothers' agenda (i.e., baby care). In the present study, active video games (AVG) are proposed for postpartum women to improve their body composition. **Methods**: Thirty-four postpartum women (body mass index = 24.5 ± 3.4 kg·m^{-2}) were randomized to an AVG group or a control group. Subjects assigned to the AVG group were given a Wii Nintendo console with the game Wii Fit Plus for 40 d. The two groups were tested for weight, body mass index, body fat mass, waist and hip circumferences, and other anthropometric parameters. Physical fitness, energy expenditure, energy intake, and adverse events were also investigated. **Results**: The AVG group lost more weight than the control group (−2.2 ± 0.9 vs. −0.5 ± 0.7 kg, $P < 0.001$). They also exhibited more important reductions of BMI, waist and hip circumferences, and body fat ($P < 0.05$). During the 40-d period, subjects expended an estimated 4682 ± 2874 kcal just by playing AVG. Daily energy intake was reduced by 206 ± 559 kcal. There were significant positive correlations between playing frequency, total playing time, total energy expenditure during the 40-d period, and decrease in daily energy intake respectively, and weight loss ($P < 0.05$). Playing time data suggested no conflict with baby care activities. **Conclusions**: AVGs could represent an interesting spare physical activity for postpartum women. In the present study, these games promoted physical activity, induced a reduction of energy intake, and subsequently minimized weight retention.
Key Words: WOMEN HEALTH, PHYSICAL ACTIVITY, EXERGAME, HEALTH PROMOTION, ENERGY EXPENDITURE, ENERGY INTAKE

The postpartum period, similar to pregnancy itself, is a critical period in women's lives. Mothers begin breastfeeding, adjust their lifestyle to maternity, and recover from pregnancy-related physiological changes. The first year postpartum is therefore associated with many challenges, among which weight loss can be viewed as a central issue for the welfare of mothers. Up to 25% of women indeed retain 4.5 kg or more of weight after 1 yr of maternity (1,13), and such retention can have significant health effects, as Willett et al. (38) reported an association between a weight gain of 5 kg (or higher) and later occurrence of coronary heart disease in women. Long-term effects of postpartum weight retention also include subsequent chronic overweight and obesity (1). For example, Rooney and Shauberger (34) reported that women who do not return to their prepregnancy weight by 6 months postpartum were 8.3 kg heavier at a 10-yr follow-up. These observations emphasize the importance of mothers' weight variation during the first year of maternity for the subsequent development of chronic disease.

Intervention strategies designed to help mothers to return to prepregnancy weight include both diet and exercise and have been the subject of several studies (9,10,16,19–21,25). Exercise has been shown to have a beneficial effect on weight loss, body composition, lipid profile, and physical capacity, without altering lactation performance (1). However, under real conditions, the level of physical activity (PA) still decreases during the postpartum period (33) because of lack of time and motivation and prioritization of baby care activities (6). Therefore, new intervention techniques adapted to mothers' agenda and new responsibilities must be investigated to allow effective weight loss management during the postpartum period. In particular, attention should be paid to activities that can be performed without discontinuation of baby surveillance and to which new mothers' could therefore adhere.

Home-based active video games (AVGs) are sometimes presented as an emerging enjoyable activity able to promote

Address for correspondence: Motohiko Miyachi, Ph.D., National Institute of Health and Nutrition, Department of Health Promotion and Exercise, 1-23-1 Toyama, Shinjuku, 162-8636, Tokyo, Japan; E-mail: miyachi@nih.go.jp.
Submitted for publication April 2013.
Accepted for publication August 2013.

0195-9131/14/4603-0472/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®

DOI: 10.1249/MSS.0000000000000136

PA (31). Several laboratory studies rated AVG as moderate PA (i.e., >3 METs [32]), and some intervention studies showed significant weight loss or reduction in body mass index (BMI) after several weeks of gaming (23,28,37). Interestingly, only one study conducted in young adults showed a significant decrease in body weight and body fat as well as a high level of enjoyment (37), but this protocol did not include postpartum women. On the other hand, many case reports described mild to severe injuries in AVG players, including muscle lesions, tendinitis, tendon tears, bone fractures, and severe joint injuries (3–5,11).

Because AVG have the potential to promote PA while meeting young mothers' new constraints (i.e., lack of time, baby surveillance, etc.), the present study was performed to assess the effectiveness of this new type of home-based activity to improve body composition in postpartum women. We hypothesize that AVG can induce reductions of weight, BMI, and fat mass. Secondary outcomes such as physical fitness were also examined as well as playing time, energy expenditure (EE), and energy intake (EI). Finally, potential side effects were also investigated.

METHODS

Ethics and recruitment. Thirty-four postpartum women from Tokyo Metropolitan Area, Japan, were recruited through advertising in magazines dedicated to maternity and mother care. Twelve subjects per group yielded a power of 0.8 based on a satisfying effect size of 1.5 for the difference in weight loss between groups, which is the primary outcome. Groups of 17 women were chosen to deal with potential dropouts. All participants provided a medical form signed by a physician indicating that they were healthy enough to participate in the study. All women recruited were Japanese, were between 3 months and 1 yr postpartum, and declared to be nonsmokers. A period of 3 months was chosen to allow sufficient recovery from childbirth. All participants experienced natural vaginal delivery (i.e., no C-section) and had no plans of becoming pregnant in the upcoming months. Women with a history of cardiovascular disease or with a BMI $\leq$ 22 kg·m^{-2} were excluded, as well as women who did not have audio–video equipment to which the AVG system could be connected, were unable to perform exercise, were engaged in regular PA, or participated in a weight loss program. At the initiation of the study, 65% of women declared exclusive or partial breastfeeding. The study protocol was approved by the ethical committee of the National Institute of Health and Nutrition. All subjects gave their written informed consent.

Groups and protocol. Participants were randomized to an AVG group or a no intervention control (CONT) group. The experimental period lasted 40 d. Baseline measurements were performed on the day before the intervention period (or "passive" period for the control subjects). Subjects came to the National Institute of Health and Nutrition for anthropometric measurements, blood pressure assessment, blood sampling, and physical fitness tests. Women assigned to the AVG group were provided with a Nintendo Wii console (Nintendo, Inc., Kyoto, Japan), one CD of Wii Fit Plus game, all the necessary peripherals (i.e., remote and "Nunchuk" controllers, as well as a balance board, i.e., a pressure pad), and an instruction manual indicating how to connect the console to their home TV system and how to save data properly for the study. On the same day, an e-mail message was sent to all participants with the instructions. Control subjects were asked not to change their lifestyle during the 40 upcoming days. Subjects in the AVG group were recommended to play AVG for 30 min on a daily basis. Because AVG mean intensity is close to 3 METs (29,32), this recommendation is equivalent to 10 MET·h·wk^{-1} of exercise, which is viewed as the minimal prescription to induce weight loss and improve of body composition in adults (30). Following this incentive, and to remain as close as possible to naturalistic conditions, no other recommendations were provided for the practice of other PA or dietary intake. The latter comment is also valid for the control group. Measurements were repeated at the end of the 40-d period. At the end of the protocol, participants were asked to return the Wii console. Daily EI was estimated at baseline and at the end of the experimental period in both groups. The time spent playing AVG, as well as EE, was evaluated for subjects assigned to the intervention group. Women were invited to report any adverse events or painful episodes using a questionnaire.

Anthropometric measurements. Body weight assessments were done using a digital scale (Tanita Corp., Tokyo, Japan), and height was measured using a stadiometer. BMI (kg·m^{-2}) was calculated. Waist and hip circumferences were measured around the abdomen at the level of the navel at the late expiratory phase using a tape measure and at the widest part of the hip–buttocks area, respectively, to calculate the waist/hip ratio. Finally, whole body fat (both mass and percentage), lean mass, and bone mineral density (BMD) were determined by dual-energy X-ray absorptiometry (Hologic QDR-4500; Hologic, Waltham, MA) with subjects in the supine position. This technique has been shown to be valid for body composition assessment in women (14).

Blood tests and blood pressure measurements. Before and after the intervention, venous blood samples were obtained after an overnight fast. Blood was processed for glucose (mg·dL^{-1}), glycated hemoglobin (HbA1c, %), triglycerides (TG, mg·dL^{-1}), total cholesterol (mg·dL^{-1}), high-density lipoprotein cholesterol (HDL-cholesterol; mg·dL^{-1}), and low-density lipoprotein cholesterol (LDL-cholesterol; mg·dL^{-1}). Blood pressure was measured after 10 min of rest in the supine position.

Physical fitness assessment. Subjects were asked to perform handgrip, vertical jump, and sit-and-reach tests to assess their physical capabilities. After a brief warm-up, each test was performed twice. Only the average scores are reported. Handgrip strength was measured using a handheld dynamometer. Vertical jump tests were performed using a vertical jump mat. Sit-and-reach tests were done using a

CLINICAL SCIENCES

digital flexibility testing device (T.K.K.5112; Takeikiki, Tokyo, Japan).

Playing time and EE estimation for the AVG group. The time spent playing AVG was evaluated using the Nintendo Wii Fit Plus data saving system, which displays the daily time spent in each type of activity. The system also estimates the daily EE (kcal) based on the metabolic chamber EE measurements reported by Miyachi et al. (29). In this article, the authors reported average MET values for each Wii Fit Plus activity in both females and males. Nintendo Inc. used these mean EE values (data not shown in the article) to develop a caloric counter and provide the player with a caloric expenditure estimation (kcal) after each activity. The Wii Fit Plus EE estimation is calculated from the time spend in one particular activity and the previous metabolic chamber EE evaluation. In this article, we report the number of days playing AVG within the 40-d intervention period, the total playing time over the intervention period, the mean duration of AVG playing for days during which the subjects actually played (hereafter "sessions"), and the number of kilocalories spent by playing AVG as estimated by the Wii Fit Plus game.

Dietary data. EI variations over the experimental period were investigated in the two groups using the Brief-type self-administered Diet History Questionnaire (BDHQ), which consists of a validated four-page questionnaire that elicits responses about the consumption frequency of 58 foods and beverages to estimate dietary intake in the preceding month. This test was developed for the assessment of dietary habits in the Japanese population. EI was calculated using an *ad hoc* computer algorithm specifically developed for BDHQ data processing. This questionnaire is described in more detail elsewhere (15). Questionnaires were completed on the same days as anthropometric and physical fitness tests (i.e., at baseline and at the end of the 40-d experimental period). ΔEI refers to the difference between the estimated daily EI at the end of the protocol and at baseline and is expressed in kilocalories.

Adverse events. Side effects such as pain, injuries, and muscle soreness were investigated using a questionnaire in the AVG group. Subjects were asked to answer "true" or "false" to the following items: 1) I experienced some pain or injuries related to the AVG practice; 2) I had muscle soreness during the intervention period; 3) I did not experience any pain or injury while playing AVG or during the intervention period. The subjects were then asked to describe any pain, injuries, and muscle soreness in the following open-ended section: "please comment about reported pain, injuries, and their duration."

Statistical analysis. Data are presented as mean ± SD. The analysis was performed in an intent-to-treat fashion; one control subject quit the study and did not have any measurements at 40 d. The unpaired *t*-test was performed to test the differences between groups for subject characteristics (cf. Table 1). Two-way repeated-measures ANOVA was used to determine the differences between groups and between baseline and postintervention measurements for anthropometric parameters and physical fitness results. The presence of a group–time interaction was investigated, and pairwise comparisons were performed when necessary. In the AVG group, the Pearson's correlation test was performed to investigate the relation between playing time/EE metrics (cf. number of days playing AVG, total time spent playing AVG, mean duration of one AVG session, and total EE estimated by Wii Fit Plus, respectively) and weight change (g). The relation between ΔEI and weight loss was investigated in both groups using the Pearson's correlation test too. Finally, the relationship between weight loss and breastfeeding status was investigated using the Spearman's correlation test in the AVG group. Statistical significance was set at $P < 0.05$. Analyses were conducted with IBM SPSS Statistics 20.0 (SPSS Japan, Inc., Tokyo, Japan).

RESULTS

Participant characteristics. As shown in Table 1, there were no significant differences between the two groups in age, height, weight, BMI, number of postpartum weeks when starting the protocol, blood glucose, HbA1c, triglycerides, total cholesterol, LDL-cholesterol, HDL-cholesterol, systolic blood pressure, or diastolic blood pressure. Glucose, total cholesterol, and LDL-cholesterol significantly decreased in both groups during the experimental period (baseline values are reported in Table 1; percentage of decrease for AVG and CONT groups: glucose = 8 ± 9 vs. 3 ± 6, total cholesterol = 4 ± 11 vs. 2 ± 7, and LDL-cholesterol = 5 ± 16 vs. 6 ± 9, respectively). The percentage of women breastfeeding at the initiation of the study (both exclusively and combined with formula or solid food) was 59% in the CONT group and 71% in the AVG group. Twenty-nine percent of the participants declared exclusively breastfeeding in each group. In the AVG group, no correlation was found between weight loss and women breastfeeding status ($R = 0.386$, $P = 0.304$).

TABLE 1. Baseline subject characteristics.

	AVG Group	CONT Group
Age (yr)	32.4 ± 5.2	32.5 ± 4.6
Height (cm)	158.1 ± 4.4	158.3 ± 6.7
Weight (kg)	61.7 ± 9.7	60.9 ± 9.0
BMI (kg·m^{-2})	24.7 ± 3.9	24.3 ± 2.9
No. postpartum months[a]	7 ± 3	7 ± 3
Whole-body BMD (g·cm^{-2})	1.08 ± 0.07	1.10 ± 0.05
Blood glucose (mg·dL^{-1})	82.1 ± 6.0	84.7 ± 9.7
HbA1c (%)	4.9 ± 0.2	5.0 ± 0.5
Triglycerides (mg·dL^{-1})	62.1 ± 28.3	64.9 ± 21.3
Total cholesterol (mg·dL^{-1})	185.6 ± 22.8	187.8 ± 33.1
LDL-cholesterol (mg·dL^{-1})	107.9 ± 19.2	111.9 ± 31.3
HDL-cholesterol (mg·dL^{-1})	65.3 ± 11.4	62.9 ± 14.7
Systolic blood pressure (mm Hg)	110 ± 10	109 ± 10
Diastolic blood pressure (mm Hg)	64 ± 8	62 ± 8

Values are mean ± SD. No differences were observed.
[a]Baseline measurements.
BMD, bone mineral density; HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

TABLE 2. Body composition changes in AVG and CONT groups over time.

	AVG Group			CONT Group					
	Baseline	40 d	Δ	Baseline	40 d	Δ	Group Effect	Time Effect	Interaction
Weight (kg)	61.7 ± 9.7	59.5 ± 9.5*	−2.2 ± 0.9	60.9 ± 9.0	60.4 ± 9.2*	−0.5 ± 0.7	NS	$P < 0.001$	$P < 0.001$
BMI (kg·m^{-2})	24.7 ± 3.9	23.8 ± 3.8*	−0.9 ± 0.3	24.3 ± 2.9	24.0 ± 3.1*	−0.2 ± 0.3	NS	$P < 0.001$	$P < 0.001$
Waist circumference (cm)	87.1 ± 9.5	84.2 ± 9.8*	−2.9 ± 1.6	87.8 ± 8.3	87.0 ± 9.1	−0.8 ± 2.3	NS	$P < 0.001$	$P = 0.003$
Hip circumference (cm)	97.4 ± 8.0	95.1 ± 7.7*	−2.3 ± 1.8	96.5 ± 4.3	96.0 ± 4.9	−0.4 ± 1.6	NS	$P < 0.001$	$P = 0.003$
Waist/hip ratio	0.89 ± 0.05	0.88 ± 0.06	−0.01 ± 0.03	0.91 ± 0.05	0.90 ± 0.06	0.00 ± 0.02	NS	NS	NS
Body fat mass (kg)	21.4 ± 7.2	19.9 ± 7.6*	−1.5 ± 1.1	20.2 ± 5.2	19.7 ± 5.6*	−0.5 ± 0.7	NS	$P < 0.001$	$P = 0.003$
Body fat percentage (%)	33.8 ± 5.5	32.4 ± 6.2	−1.4 ± 1.4	32.6 ± 4.3	32.0 ± 4.8	−0.7 ± 0.9	NS	$P < 0.001$	NS
Lean body mass (kg)	40.8 ± 3.3	40.4 ± 3.1	−0.4 ± 0.9	41.4 ± 5.0	41.4 ± 4.8	0.0 ± 0.7	NS	NS	NS
Whole body BMD (g·cm^{-2})	1.08 ± 0.07	1.10 ± 0.08	0.02 ± 0.00	1.10 ± 0.05	1.11 ± 0.04	0.01 ± 0.0.1	NS	$P < 0.001$	NS

Values are mean ± SD.
* Significant difference within group between baseline and 40-d measurements ($P < 0.05$).
BMI, body mass index; NS, not significant.

Anthropometric measurements. As shown in Table 2, there were significant group–time interactions in weight, BMI, waist and hip circumferences, and body fat mass, with a more marked decrease in the AVG group over the 40-d period ($P < 0.05$). No effect was observed for the waist/hip ratio. Body fat percentage decreased during the experimental period in the two groups but no significant interaction ($P = 0.09$) was observed. BMD increased in both groups, and no group effect was noted.

Physical fitness assessment. No group effect, time effect, or interactions were noted for handgrip strength (cf. baseline values: 25.3 ± 4.5 vs. 25.5 ± 3.5 cm for AVG and CONT groups, respectively; postintervention data not shown) and vertical jump (cf. baseline values: 34.6 ± 4.0 vs. 33.6 ± 4.0 cm for AVG and CONT groups, respectively; postintervention data not shown). There was a significant group–time interaction for trunk flexibility (cf. baseline values: 39.8 ± 7.5 vs. 38.1 ± 9.6 cm for AVG and CONT groups, respectively; and postintervention values: 42.5 ± 6.6 vs. 38.5 ± 9.2 cm for AVG and CONT groups, respectively; $P < 0.05$), which increased significantly during the experimental period in the AVG group only (cf. Δ: 2.8 ± 3.4 vs. 0.4 ± 3.0 cm for AVG and CONT groups, respectively).

Playing time and estimated EE for the AVG group. We were unable to extract saved data for six subjects for various reasons as follows: inadvertent suppression of data by the subject ($n = 1$), subjects forgot the password that gives access to saved data ($n = 2$), system was not returned ($n = 2$), and several players using the same data saving slot ($n = 1$). Therefore, data from 11 subjects were processed. Subjects played AVG 23 ± 9 d during the 40-d intervention period, corresponding to a playing frequency of 4.0 ± 1.6 d·wk^{-1}. Total playing time was 1420 ± 737 min per subject for the whole intervention period, resulting in an average session time of 62 ± 25 min. The estimated number of kilocalories spent by playing AVG was 4682 ± 2874 kcal.

EI variation. The mean ΔEI were −206 ± 559 and −27 ± 262 kcal in the AVG and CONT groups, respectively. ΔEI was positively correlated with weight loss in the AVG group ($R = 0.593$, $P = 0.015$), while no correlation was found in the CONT group.

Relation between playing time/frequency/EE and weight loss. Correlation tests were performed in 11 subjects (cf. above paragraph). A significant correlation was noted between the total time spent playing AVG and weight loss ($R = 0.624$, $P = 0.040$). The same observation was made for the number of days playing AVG (i.e., playing frequency) versus weight loss ($R = 0.639$, $P = 0.034$). No correlation was found between the mean duration of AVG session and weight loss. Thus, we found a good relation between the number of kilocalories spent while playing AVG and weight loss ($R = 0.703$, $P = 0.016$).

Adverse events, painful episodes, and muscle soreness. This section involves the AVG group only. Thirteen subjects completed the questionnaire. Three subjects reported injuries while playing AVG. These injuries were reported among the five subjects who exhibited the longest playing times (between 81 ± 22 and 93 ± 49 min·d^{-1}). Seven subjects mentioned muscle soreness during the intervention period at different body locations (Table 3). The mean duration of muscle soreness when clearly reported was 3.4 ± 2.1 d ($n = 4$). Detailed results are presented in Table 3.

DISCUSSION

The present results support the hypothesis that home-based AVG can decrease weight, BMI, and fat mass in postpartum women. We also observed decreases in both waist and hip circumferences and improvement in physical fitness as suggested by the increase in trunk flexibility in women who played AVG. On the other hand, significant adverse events can sometimes occur, which would require specific playing recommendations to preserve the above-mentioned health benefits.

TABLE 3. Adverse events in the AVG group.

n = 13	
Pain or injury while playing Wii Fit: 3 ○ 1 mild: low back pain (81 ± 22 min[b]) ○ 1 severe: ankle twist (91 ± 21 min[b]) ○ 1 required medical treatment: wrist tendinitis (85 ± 78[b]) No pain or injury reported: 4	Muscle soreness reported: 8[a] Location of pain: ○ Generalized: 1 ○ Abdominal: 2 ○ Calf: 1 ○ Upper arm: 1 ○ Thighs: 1 ○ Unknown: 2 Mean duration of pain: 3.4 ± 2.1 d ($n = 4$)[c]

[a]One subject reported muscle soreness in two different locations.
[b]Individual's mean duration of one AVG session.
[c]Only four subjects indicated clear duration for muscle soreness.
PA, physical activity.

Effects of AVG on body composition and physical fitness. Improvements in body composition after AVG interventions have already been reported in some other populations. Although inconsistent results have been reported in the literature (23,28,31,37), some articles indicated a positive effect on BMI after an intervention with AVG (23,28). Most of these studies were conducted in children or adolescents, but Trout and Zamora (37) also showed a significant reduction in weight and fat mass after an 8-wk intervention in young adults. Another study involving interactive video dance games showed a BMI reduction after 6 wk of intervention in young adult women (26). To date, the present study is the first to confirm such results in postpartum women.

The weight loss of 2.2 ± 0.9 kg observed in the AVG group for a 40-d intervention period is a very promising outcome in comparison to the weight loss of 0.5 ± 0.7 kg in the CONT group. This primary result was supported by further decreases in BMI, fat mass, and waist and hip circumferences (Table 2), highlighting the potential effectiveness of AVG intervention in postpartum women and the opportunity to use them to prevent later development of chronic overweight, obesity, or metabolic syndrome (12,17,35). Interestingly, the present anthropometric variations are in the same order as weight loss observed in previous intervention studies that used traditional PA for comparable or slightly longer durations (9,16,20,21,25). Both resistance and continuous training have indeed been shown to induce significant weight loss during the postpartum period (16). As AVG themselves (including the tested game, Wii Fit Plus) are a mixture of postural, aerobic, and strength exercise, it was not surprising that the same outcome was observed in the present study. Subjects playing AVG also showed increased trunk flexibility to the same extent as with traditional aerobic or resistance exercise (16).

The present study population consisted of healthy Japanese women who did not present with marked overweight or metabolic disorders (Table 1). As postpartum weight retention could be more of an issue in women with pregestational overweight or excessive gestational weight gain (13,17), and because there are large differences in gestational weight gain between countries (8), the present results must be confirmed in non-Japanese overweight populations.

Body composition improvement: suggested mediators. Changes in body composition may have been mediated in several different ways. First, it could have been due to an increase in AVG-related EE. During the intervention period, subjects in the AVG group exercised a total of 1420 ± 737 min and the total time spent playing AVG was significantly correlated with weight loss. In the present study, AVG actually allowed the subjects to exercise 4.0 ± 1.6 times a week (mean duration: 62 ± 25 min), representing an additional 35 ± 18 $\text{min}\cdot\text{d}^{-1}$ of moderate PA, since AVG have been classified as such in adults by previous studies (4,29,31). In addition, the playing frequency was positively correlated with weight loss, indicating that the more frequently you play AVG, the more weight you may lose. Over the experimental period, the AVG group expended 4682 ± 2874 kcal. Typically, a weight loss of 1 kg can be obtained through expenditure of 7000 kcal in normal nonpostpartum adult population (18). The additional 1.7 kg of weight loss in the AVG group (compared to the CONT group) would therefore theoretically require expenditure of 11,900 kcal. Other mediators could have participated in the observed amelioration of body composition. Second, AVG may indeed have a positive influence on dietary behavior. Our results indicated a positive correlation between the decrease in daily EI (i.e., ΔEI) and weight loss. In addition, because ΔEI was −206 ± 559 kcal in the AVG group, the total EI reduction over the 40-d period could be as much as 8240 kcal. Added to the reported mean AVG-related EE (i.e., 4682 ± 2874 kcal), the latter figure brings the 40-d total kilocalorie reduction to a roughly calculated 12,962 kcal, which is in the same order as the above estimated 11,900 kcal for a weight loss difference of 1.7 kg between the two groups. Thus, the positive correlation with playing frequency, but not with the mean duration of AVG session, also suggested that the observed weight loss in the AVG group could have been a consequence of some behavioral changes (including dietary behavior) rather than the result an increased EE only. Whether AVG can positively influence dietary habits or has no effect is still a matter of debate (7,22,24,27). However, a recent study conducted by Lyons et al. (22) described a lower of snack consumption on energy surplus in young adults playing AVG compared to TV watchers or sedentary video game players. The decrease in TV watching-related snacking could indeed have participated in the reduction of daily EI in the AVG group, but more studies are required to elucidate this point in the specific postpartum situation. Finally, AVG could also have a beneficial effect on non–AVG-related PA.

Higher EE, lower EI, or both, the associated behavior changes might have been promoted by the specific environment of Wii Fit Plus. This game encourages daily self-weighing and displays daily variations of weight, BMI, and expended kilocalories. These features may have promoted self-regulation of intake and expenditure, as suggested by Steinberg et al. (36) in a daily self-weighing intervention study using smart scales.

Side effects. Some adverse events were noted. From muscle soreness to more serious injuries (Table 3 and [3–5,11]), participants must be aware that AVG can be as "threatening" as traditional physical activities and exercise, highlighting the sporting characteristic of AVG. In the present study, the occurrence of injuries seemed to be related to the mean session duration (Table 3); the longer playing the time, the higher the risk of injury. As weight loss was positively correlated with both total playing time and frequency but not with the mean session duration, we may recommend frequent sessions lasting no more than 80 min to preserve the beneficial effects of this activity in postpartum women.

Limitations. This study had several limitations. First, we did not objectively measure the daily PA in subjects.

However, the Wii Fit Plus playing time counter allows a fair estimation of the time spend in AVG in the intervention group. The good correlations found between playing time metrics and weight loss also indicate significant participation of AVG in the observed weight loss. Although helpful, the use of the console data saving system can sometimes be problematic and can result in data loss, as in the present study or that conducted by Baranowski et al. (2). Future studies using the console data saving system should be aware of this recurrent issue. Second, the 40-d period used in this study did not allow us to draw conclusions for longer periods. Women's adherence could indeed decrease in longer intervention periods and alter the weight loss trend. Third, the BDHQ test is known to underestimate EI compared to other gold standards (15). However, the present study was designed to monitor EI changes over a given period and not absolute EI values. Therefore, we suppose that the BDHQ-related EI underestimation may not alter the ΔEI trend in a way that could invalidate the present discussion. Finally, we did not assess enjoyment or women's feelings about exercising at home rather than outside and having the possibility to concomitantly take care of the baby. Such outcomes could have been useful to better understand the adherence of subjects and further design exercise interventions specifically tailored for this population.

CONCLUSIONS

Weight management is among the primary health concerns for postpartum women. Playing home-based AVG, coupled with an EI reduction of nearly 200 $kcal \cdot d^{-1}$, allowed postpartum women to lose weight (2.2 ± 0.9 kg) and to improve their overall body composition in a relatively short time (40 d in the present study). Playing time results suggested strong adherence of women, indicating no conflict with their maternal agenda (i.e., baby care). While the relevance of using AVG to promote exercise among the overall population is still under debate, this type of activity could represent an interesting spare PA for postpartum women who have fewer opportunities to go outside. In this population, it could be used at least transiently when traditional PA is not possible to manage weight loss and reduce the risk of developing weight retention-related chronic diseases. Adverse events have been noted, emphasizing the need to approach AVG as a real PA to effectively obtain health benefits. We recommend frequent sessions to optimize body composition improvement. To avoid adverse event, playing time should not exceed 80 min for one session. Other intervention studies are needed to better evaluate the opportunities of using AVG as a spare PA in postpartum women as well as in other populations.

The authors would like to thank all the young mothers who participated in the study and Tatsuya Nishikata (NKS Data Agency) for his help in the management of subjects. The study was partially funded by Nintendo Inc., Japan. Julien Tripette is supported by the Fonds de Recherche du Québec – Santé (FRQS).

Nintendo staff did not participate in the design of the study or in the interpretation or discussion of results. The authors therefore declare no competing interests. The results of the present study do not constitute endorsement by the American College of Sports Medicine.

REFERENCES

1. Amorim Adegboye A, Linne Y, Lourenco P. Diet or exercise, or both, for weight reduction in women after childbirth. *Cochrane Database Syst Rev*. 2007;18(3):CD005627.
2. Baranowski T, Abdelsamad D, Baranowski J, et al. Impact of an active video game on healthy children's physical activity. *Pediatrics*. 2012;129(3):e636–42.
3. Beddy P, Dunne R, de Blacam C. Achilles wiiitis. *AJR Am J Roentgenol*. 2009;192(2):W79.
4. Biddiss E, Irwin J. Active video games to promote physical activity in children and youth: a systematic review. *Arch Pediatr Adolesc Med*. 2010;164(7):664.
5. Brown CN, McKenna P. A Wii-related clay-shoveler's fracture. *Sci World J*. 2009;9:1190.
6. Carter-Edwards L, Østbye T, Bastian LA, Yarnall KS, Krause KM, Simmons T-Jl. Barriers to adopting a healthy lifestyle: insight from postpartum women. *BMC Res Notes*. 2009;2(1):161.
7. Chaput JP. Do active video games increase food intake? *Am J Clin Nutr*. 2011;94(4):1155; Author reply 6.
8. Cheng HR, Walker L, Tseng YF, Lin PC. Post-partum weight retention in women in Asia: a systematic review. *Obes Rev*. 2011;12(10):770–80.
9. Colleran HL, Wideman L, Lovelady CA. Effects of energy restriction and exercise on bone mineral density during lactation. *Med Sci Sports Exerc*. 2012;44(8):1570–9.
10. Dewey KG, Lovelady CA, Nommsen-Rivers LA, McCrory MA, Lonnerdal B. A randomized study of the effects of aerobic exercise by lactating women on breast-milk volume and composition. *N Engl J Med*. 1994;330(7):449–53.
11. Eley KA. A Wii fracture. *N Engl J Med*. 2010;362(5):473–4.
12. Gore SA, Brown DM, West DS. The role of postpartum weight retention in obesity among women: a review of the evidence. *Ann Behav Med*. 2003;26(2):149–59.
13. Gunderson EP, Abrams B. Epidemiology of gestational weight gain and body weight changes after pregnancy. *Epidemiol Rev*. 1999;21(2):261–75.
14. Hansen NJ, Lohman TG, Going SB, et al. Prediction of body composition in premenopausal females from dual-energy X-ray absorptiometry. *J Appl Physiol*. 1993;75(4):1637–41.
15. Kobayashi S, Murakami K, Sasaki S, et al. Comparison of relative validity of food group intakes estimated by comprehensive and brief-type self-administered diet history questionnaires against 16 d dietary records in Japanese adults. *Public Health Nutr*. 2011;14(7):1200–11.
16. LeCheminant J, Hinman T, Pratt K, et al. Effect of resistance training on body composition, self-efficacy, depression, and activity in postpartum women. *Scand J Med Sci Sports*. 2012; doi: 10.1111/j.1600–0838.2012.01490.x. [Epub ahead of print].
17. Linne Y, Dye L, Barkeling B, Rossner S. Weight development over time in parous women—the SPAWN study—15 years follow-up. *Int J Obes Relat Metab Dis*. 2003;27(12):1516–22.
18. Livesey G, Elia M. Estimation of energy expenditure, net carbohydrate utilization, and net fat oxidation and synthesis by indirect calorimetry: evaluation of errors with special reference to the detailed composition of fuels. *Am J Clin Nutr*. 1988;47(4): 608–28.
19. Lovelady CA, Bopp MJ, Colleran HL, Mackie HK, Wideman L. Effect of exercise training on loss of bone mineral density during lactation. *Med Sci Sports Exerc*. 2009;41(10):1902–7.

20. Lovelady CA, Garner KE, Moreno KL, Williams JP. The effect of weight loss in overweight, lactating women on the growth of their infants. *N Engl J Med*. 2000;342(7):449–53.
21. Lovelady CA, Nommsen-Rivers LA, McCrory MA, Dewey KG. Effects of exercise on plasma lipids and metabolism of lactating women. *Med Sci Sports Exerc*. 1995;27(1):22.
22. Lyons EJ, Tate DF, Ward DS, Wang X. Energy intake and expenditure during sedentary screen time and motion-controlled video gaming. *Am J Clin Nutr*. 2012;96(2):234–9.
23. Maddison R, Mhurchu CN, Jull A, Prapavessis H, Foley LS, Jiang Y. Active video games: the mediating effect of aerobic fitness on body composition. *Int J Behav Nutr Phys Act*. 2012;9:54.
24. Mathieu ME, Kakinami L. Active video games could be the solution to the increased energy intake reported with sedentary video games. *Am J Clin Nutr*. 2011;94(4):1150–1; Author reply 1–2.
25. McCrory MA, Nommsen-Rivers LA, Molé PA, Lönnerdal B, Dewey KG. Randomized trial of the short-term effects of dieting compared with dieting plus aerobic exercise on lactation performance. *Am J Clin Nutr*. 1999;69(5):959–67.
26. Mejia-Downs A, Fruth SJ, Clifford A et al. A preliminary exploration of the effects of a 6-week interactive video dance exercise program in an adult population. *Cardiopulm Phys Ther J*. 2011; 22(4):5.
27. Mellecker RR, Lanningham-Foster L, Levine JA, McManus AM. Energy intake during activity enhanced video game play. *Appetite*. 2010;55(2):343–7.
28. Mhurchu CN, Maddison R, Jiang Y, Jull A, Prapavessis H, Rodgers A. Couch potatoes to jumping beans: a pilot study of the effect of active video games on physical activity in children. *Int J Behav Nutr Phys Act*. 2008;5(1):8.
29. Miyachi M, Yamamoto K, Ohkawara K, Tanaka S. METs in adults while playing active video games: a metabolic chamber study. *Med Sci Sports Exerc*. 2010;42(6):1149–53.
30. Ohkawara K, Tanaka S, Miyachi M, Ishikawa-Takata K, Tabata I. A dose–response relation between aerobic exercise and visceral fat reduction: systematic review of clinical trials. *Int J Obes*. 2007; 31(12):1786–97.
31. Peng W, Crouse JC, Lin JH. Using active video games for physical activity promotion: a systematic review of the current state of research. *Health Educ Behav*. 2013;40(2):171–92.
32. Peng W, Lin JH, Crouse J. Is playing exergames really exercising? A meta-analysis of energy expenditure in active video games. *Cyberpsychol Behav Soc Netw*. 2011;14(11):681–8.
33. Pereira MA, Rifas-Shiman SL, Kleinman KP, Rich-Edwards JW, Peterson KE, Gillman MW. Predictors of change in physical activity during and after pregnancy: Project Viva. *Am J Prev Med*. 2007;32(4):312–9.
34. Rooney BL, Schauberger CW. Excess pregnancy weight gain and long-term obesity: one decade later. *Obstet Gynecol*. 2002;100(2): 245–52.
35. Rooney BL, Schauberger CW, Mathiason MA. Impact of perinatal weight change on long-term obesity and obesity-related illnesses. *Obstet Gynecol*. 2005;106(6):1349–56.
36. Steinberg DM, Tate DF, Bennett GG, Ennett S, Samuel-Hodge C, Ward DS. The efficacy of adaily self-weighing weight loss intervention using smart scales and email. *Obesity*. 2013;21(9):1789–97.
37. Trout J, Zamora K. Dance Dance Revolution: a physiological look at an interactive arcade game. *ICHPERD J Res*. 2008;3(1):67–72.
38. Willett WC, Manson JE, Stampfer MJ, et al. Weight, weight change, and coronary heart disease in women. Risk within the 'normal' weight range. *JAMA*. 1995;273(6):461–5.