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RESEARCH PAPER

A pilot intervention to reduce postpartum weight retention and central adiposity in first-time mothers: results from the mums OnLiNE (Online, Lifestyle, Nutrition & Exercise) study

P. van der Pligt,[1] K. Ball,[1] K. D. Hesketh,[1] M. Teychenne,[1] D. Crawford,[1] P. J. Morgan,[2] C. E. Collins[3] & K. J. Campbell[1]

[1]Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Deakin University, Geelong, VIC, Australia
[2]Priority Research Centre for Physical Activity and Nutrition, School of Education, The University of Newcastle, NSW, Australia
[3]School of Health Sciences, Faculty of Health and Medicine, The University of Newcastle, NSW, Australia

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Correspondence
P. van der Pligt, Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Deakin University, Geelong, VIC, Australia.
Tel.: +61 03 9244 6135
E-mail: p.vanderpligt@deakin.edu.au

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Abstract

Background: Postpartum weight retention (PPWR) increases the risk for obesity and complications during subsequent pregnancies. Few interventions have been successful in limiting PPWR in mothers. The present study assessed the effectiveness of the mums OnLiNE (Online, Lifestyle, Nutrition & Exercise) intervention with respect to reducing PPWR and improving diet, physical activity and sedentary behaviour.
Methods: A subsample of first-time mothers enrolled in the Extended Melbourne Infant Feeding Activity and Nutrition Trial (InFANT Extend) completed the nonrandomised mums OnLiNE intervention. Women in the intervention (I) group (n = 28) received access to an online calorie tracking program, smartphone app, three telephone counselling calls with a dietitian and written material. Women in two comparison groups (CI and C2) (n = 48; n = 43) were from the control (C1) and intervention (C2) arms of InFANT Extend and received no additional support. Weight and waist circumference were measured objectively. Written surveys assessed diet and physical activity. Sedentary behaviour was self-reported. Linear and logistic regression assessed changes in outcomes between groups from 9 to 18 months postpartum.
Results: Mean PPWR decreased in the (I) group (−1.2 kg) and the C2 group (−1.2 kg), although the changes were not significant. Mean waist circumference for all groups exceeded recommendations at baseline but decreased to below recommendations for women in the (I) group (78.3 cm) and significantly for the (I) group (−6.4 cm) compared to C1 (−1.1 cm; P = 0.002) and C2 (−3.3 cm; P = 0.001). Changes in diet, physical activity or sedentary behaviour were not significant.
Conclusions: The online intervention reported in the present study shows promise with respect to reducing waist circumference in postpartum women. Further evidence of strategies that may improve weight and related behaviours in this target group is needed.

Introduction

The largest increase in being overweight and obese for women occurs during childbearing age [1,2] and increased rates of maternal obesity have been frequently linked with weight retention following pregnancy [1], otherwise known as postpartum weight retention (PPWR). Furthermore, an increased body mass index (BMI) between

pregnancies is associated with an increased risk of multiple, adverse obstetric [3–5] and neonatal [6,7] outcomes during subsequent pregnancies.

Although PPWR is variable [8], weight gained as a result of pregnancy often tracks into the long term [9]. At 12 months, PPWR has been found to predict maternal overweight 15 years later [10] and it also contributes to the development of maternal obesity and associated morbidity [11]. Because PPWR tends to be centrally rather than peripherally deposited [12,13], this is particularly harmful for women, increasing the risk of the development of cardiovascular disease [13–15] and type 2 diabetes mellitus [16,17]. Yet these risks are significantly reduced if women return to their pre-pregnancy weight by 6 months postpartum [16,17], providing an important rationale for supporting women to limit PPWR. Therefore, understanding how we can best support women to attain a healthy weight in the postpartum is a key priority for obesity prevention in women.

The postpartum period has been described as an ideal stage during which to engage with women when planning weight self–management behaviours [18] and women have reported having a high motivation for weight-loss during this life-stage [8]. Of the relatively few interventions aimed at reducing PPWR conducted to date [19], the results have been mixed [20]. However, multiple systematic reviews of postpartum interventions have provided information about what is likely to assist women in limiting PPWR [20–22]. The results have consistently shown that interventions targeting both diet and physical activity (as opposed to just one of these components) and including one-on-one counselling as part of the intervention delivery are more effective [20,22].

Furthermore, interventions delivered via e-mail, telephone or the Internet might be less burdensome for new mothers and more practical than traditional face-to-face methods. Such modes of delivery for weight-loss support have been successful when implemented as part of interventions in the non-obstetric population [23,24]. Yet, these have seldom been trialled during the postpartum period and they may be particularly well suited to new mothers, who are often challenged for time as a result of caring for their newborn. Therefore, the the present study aimed to assess whether a 9-month combined online and telephone delivered intervention would assist first-time mothers in limiting PPWR and central adiposity and improve their diet, physical activity and sedentary behaviour during the postpartum period.

Materials and methods

The mums OnLiNE (Online, Lifestyle, Nutrition & Exercise) pilot intervention study was conducted from June 2012 to December 2013 and was nested within the cluster-randomised controlled trial (RCT), Extended Melbourne Infant Feeding Activity and Nutrition Trial (InFANT Extend). Details of the InFANT Extend methods are provided elsewhere [25]. Ethics was approved by the Deakin University Human Research Ethics Committee [modification of 2011-029 (2007-175) (11/02/2011)].

Study population

An overview of the recruitment stages is presented in Fig. 1. Recruitment to the mums OnLiNE study was staggered over 12 months. The women approached were from the 31 first-time parent groups already enrolled to the intervention arm of InFANT Extend and were approximately 9 (and no more than 12) months postpartum. To be eligible, women needed to be 18 years or older and be first-time mothers with singleton pregnancies. In total, 208 eligible women were approached for recruitment. Women were visited by a researcher at a group session as part of the InFANT Extend study and informed about the mums OnLiNE intervention. Two Facebook advertisements, 2 weeks apart, were posted to each InFANT Extend group. Written invitations, a plain language statement and consent forms were sent via mail. Women were sent a reminder letter in the mail and via e-mail approximately 1 month later as a final invitation to take part in the study.

Two comparison groups were computer generated from a sample of 162 women who were taking part in the larger InFANT Extend RCT and were matched to the intervention group with respect to baseline BMI and education. Sixty women from the InFANT Extend control arm formed comparison group 1 (C1) for the mums OnLiNE study and sixty women from the InFANT Extend intervention arm formed comparison group 2 (C2). A slightly larger (relative to the mums OnLiNE intervention group) sample of 60 women for each comparison group was generated to account for potential attrition (i.e. the possibility of women becoming pregnant).

Intervention

Bandura's social cognitive theory (SCT) [26], with evidence-based behaviour change components, underpinned the intervention design including self-monitoring, feedback and goal setting. Women in the intervention group received: (i) a brochure including physical activity recommendations for Australian adults; (ii) a pedometer; (iii) a tape measure and instructions for self-monitoring of waist circumference (WC); (iv) a SMART goal setting chart for weight and/or lifestyle behaviour related goals; (v) a pocket calorie counter book including nutritional

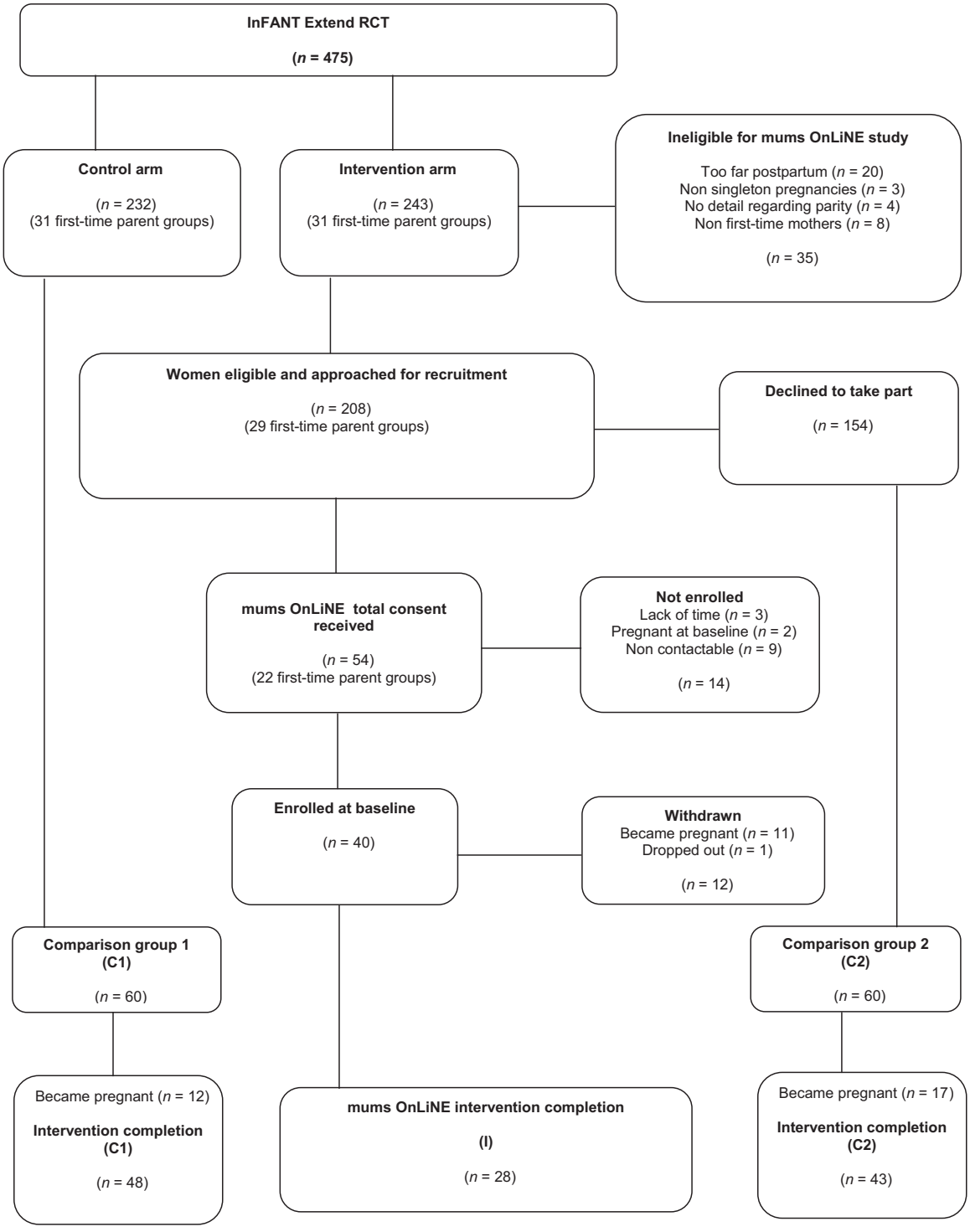

Figure 1 Overview of women completing the mums OnLiNE (Online, Lifestyle, Nutrition & Exercise) study. InFANT Extend, Extended Melbourne Infant Feeding Activity and Nutrition Trial; RCT, randomised controlled trial.

information for Australian food products; and (vi) a detailed instruction manual to assist using the online CALORIEKING program (www.calorieking.com.au). Resources were adapted for postpartum women based on those previously used in a weight-loss intervention for adult males [27].

Women received access to the freely available CALORIEKING website for 9 months and used this program at their discretion. CALORIEKING comprises an online, behaviour therapy website, which provides tools to assist individuals to improve their diet and physical activity levels [27]. Approximately 1 month following commencement of the intervention, an iPhone only app became available to access the program. Women who chose to install the app were required to pay AUD$4.49 to download this from the iTunes store. Women also received three-one-on-one telephone counselling calls with the dietitian, at baseline, as well as at 3 and 6 months. Telephone calls lasted approximately 30 min each and were tailored specifically to the individual. They were based on motivational interviewing and health coaching strategies where participants were assisted in integrating new knowledge into their personal behaviour change plans [28] in an effort to create immediate action and increase the likelihood of a healthy behaviour change [28]. Individual goals were set and discussed during the telephone calls. Some examples of individual, planned behaviour change included strategies to increase fruit and vegetable intake or reduce snacking on high-fat, high-sugar foods, reducing sitting time when at home or work, increasing incidental exercise and exploring options to increase planned walking or structured exercise. Women could use individual resources and goal setting charts as they chose. Provision of group support was provided to all women with optional access to an online discussion board for the study duration, designed specifically to facilitate connection with the dietitian, as well as to encourage social interaction with other mothers participating in the mums OnLiNE program.

Comparison groups

Comparison group 1 (C1) and 2 (C2) were women taking part in the 3-year, Melbourne InFANT Extend RCT. Women in C1 were from the control arm of InFANT Extend and received usual care as part of the Maternal and Child Health system in Victoria, Australia. They also received mailed newsletters regarding general information about their baby's health (e.g. dental health and sun protection) [29]. Advice from Maternal and Child Health Nurses, including general lifestyle advice (e.g. child sleeping and feeding practices), is given as part of this standard group practice. Women in C2 were from the intervention arm on InFANT Extend and received 6 × 2 h group sessions, delivered quarterly by a Dietitian from when infants were 3 months of age up until 18 months [29]. Sessions were interactive, based on anticipatory guidance and were focussed on child feeding, active play, screen time alternatives, parent modelling, child-focussed physical activity and sedentary behaviours [29]. Group discussion between mothers was facilitated by the Dietitian, which included a discussion around the uptake of key messages presented at the sessions (e.g. 'colour every meal with fruit and veg', 'eat together play together' and 'parents provide, kids decide'). Women also received a purpose-designed DVD that they could watch between each group session, as well as written information of each topic covered in the group sessions.

Primary outcomes

Anthropometry was carried out by trained research staff at baseline and intervention completion via standard procedures. Height was measured using a calibrated Victar stadiometer. Weight, in light clothing and with shoes removed, was measured once using Tanita digital scales (Model 1582; Tanita Corporation, Tokyo, Japan) and recorded to the nearest 0.01 kg. Maternal BMI was calculated as [weight (kg)/height $(m)^2$] [30,31]. Postpartum weight retention was calculated as the difference between weight at baseline and self-reported pre-pregnancy weight. This method has been used for calculating PPWR in multiple studies of varying design [12,32] and is considered a standard method for calculating PPWR [33]. Waist circumference was measured using a Lufkin Executive Thinline tape measure (W606PM; Lufkin, Sparks, MD, USA). Measurements were taken in light clothing with shoes removed. When anthropometry could not be carried out and for those women who were only able to start the program more than 1 month after objective data collection, weight and WC were self-reported.

Secondary outcomes

Survey data were drawn from two mail-out surveys completed as part of InFANT Extend (baseline (9 months postpartum); intervention completion (18 months postpartum)). At baseline, dietary intake was assessed using a modified foof frequency questionnaire, as adapted from the Cancer Council of Victoria's (CCV) Dietary DQES [34]. The modified version consisted of 19 questions that assessed frequency of intake of different foods over the past 12 months, as well as usual intake of a number of different foods and beverages. At intervention completion, the validated CCV DQES [34] assessed dietary intake over the past 12 months. It comprised a list of 74 items with 10 frequency response options assessing frequency of intake from 'never' to '3 or more times per day' [34]. One item asked women to report their usual intake each of fruit (serves per day) and vegetables (excluding potatoes) (serves per day). Intake responses were compared with Australian adult recommendations for daily fruit and vegetable intake (two serves of fruit and five serves of

vegetables per day) [35]. Several separate items asked women to report their usual intake of different noncore foods. Responses were converted into daily equivalent frequencies (i.e. number of times consumed per day) according to the CCV protocol and divided into several different food categories [34].

Physical activity was assessed using the Australian Institute of Health and Welfare's Active Australia Survey (AAS),[36,37] a valid and reliable tool for use in Australian populations [36,38,39]. Women estimated the total duration (number of times and total hours and minutes) that they spent walking continuously (for at least 10 min) for recreation, exercise or to get from place to place, as well as participating in vigorous and moderate physical activity (which excluded household chores, gardening or yard work), in the week prior to completing the questionnaire. To avoid the possibility of errors as a result of over-reporting, the time spent in a single intensity of activity was truncated in accordance with the survey protocol [37,40]. Physical activity levels were defined as either meeting recommendations (i.e. sufficient activity) or not. Women were classified as being 'sedentary' in accordance with the AAS if their combined total time spent walking, in moderate activity and in vigorous activity, was equal to zero [37].

Two further survey items item not included in the AAS assessed sedentary behaviour. Women were asked to report the usual time (hours and minutes) on a weekday and separately on a weekend day, that they spent sitting watching television or videos/DVDs. An average daily time (min day^{-1}) was calculated by summing the time reported for weekdays [multiplied by five (weekdays per week)] with the time reported for weekend days [multiplied by two (2 weekend days per week)] and dividing that score by seven. Reported durations and total viewing time were truncated to 1080 min day^{-1} (18 h) [25].

Statistical analysis

Assessment of outcomes was reported as the change from baseline to intervention completion for the intervention (I) group compared to that of (C1) and (C2). Data were analysed using SPSS, version 21 (IBM Corp., Armonk, NY, USA). For regression analyses assessing the intervention effect, STATA, version 12 (StataCorp, College Station, TX, USA) was used to allow controlling for clustering by the first-time mothers' group. Descriptive analyses were used to describe the sample at baseline. All continuous outcome measures were checked for normality and detection of outliers using three standard tests (normality histograms, normality Q-Q scatter plots and homoskedacicity scatter plots). One way-analysis of variance was used to assess the differences in characteristics at baseline. For analysis of the intervention effect, when outcomes were continuous, linear regression was conducted and either binomial or multinomial logistic regression was conducted when outcomes were categorical. All analyses adjusted for a range of specified confounders, including maternal gestational weight gain, PPWR, age and household income. $P < 0.05$ was considered statistically significant for all analyses.

Results

Participants

An overview of women who completed the mums OnLiNE intervention is presented in Fig. 1. Fifty-four women (26% of eligible) provided their written consent to take part. In total, 40 women were recruited to the (I) group from 21 different InFANT Extend first-time mothers' groups. Of the 40 participants, 11 were subsequently withdrawn because they became pregnant during the intervention and one was lost to follow-up. In total, 28 women from 16 different InFANT Extend first-time mothers' groups completed the intervention (70% retention). During the study, 12 women in (C1) and 17 women in (C2) became pregnant. Data for these women were excluded from the analyses.

In total, objective weight and WC data for twelve women were available at both baseline and intervention completion. When objective anthropometric measures were unavailable or women declined to be measured either at baseline or at intervention completion, weight and WC were self-reported. All recorded anthropometry measures for the (C1) and (C2) groups were measured objectively. Complete survey data were available for 27 women in the (I) group, 34 women in the (C1) group and 32 women in the (C2) group. Missing anthropometric and survey data were excluded from all analysis on a case-by-case basis for each variable.

Baseline characteristics of the mums OnLiNE intervention group ($n = 40$) and the two matched control groups ($n = 60$ and $n = 60$) are presented in Table 1. At baseline, women on average were overweight [mean (SD) BMI = 26.0 (4.64) kg m^{-2}]. Mean (SD) PPWR at baseline was significantly lower for the (C2) group [0.5 (6.41) kg] compared to the (C1) group [3.7 (6.87); $P = 0.025$] but not compared to the (I) group [2.4 (5.30) kg].

Primary outcomes

Changes in anthropometry are presented in Table 2. Based on data that included self-reported anthropometry, there was no significant between group difference with respect to either mean weight or PPWR change for the (I) group compared to the (C1) and (C2) group.

Table 1 Maternal characteristics at baseline

	Mean (SD)			
	(I) (n = 40)	(C1) (n = 60)	(C2) (n = 60)	P-value
Maternal age (years)	33.2 (3.54)	32.4 (4.23)	32.9 (4.38)	0.656
BMI (kg m^{-2})[†]	26.0 (4.64)	25.4 (5.24)	24.9 (4.71)	0.568
Pre-pregnancy BMI (kg m^{-2})	25.1 (4.28)	24.0 (4.50)	24.7 (4.70)	0.481
Weight (kg)	70.3 (14.71)	69.8 (14.49)	67.9 (13.32)	0.663
Gestational weight gain (kg)	14.7 (5.76)	14.5 (7.49)	13.2 (5.08)	0.453
Postpartum weight retention (PPWR) (kg)	2.4 (5.30)	3.7 (6.87)[‡]	0.5 (6.41)[‡]	**0.025**[‡]
Waist circumference (cm)	84.9 (11.92)	83.7 (12.19)	82.4 (11.18)	0.598
	n (%)			
Marital status*				
Married	33 (82.5)	42 (70.0)	47 (78.3)	
De facto	6 (15.0)	12 (20.0)	12 (20.0)	
Separated/divorced	1 (2.5)	3 (5.0)	1 (1.7)	
Never married	–	3 (5.0)	–	
Birth country				
Australia	31 (77.5)	47 (78.3)	46 (76.7)	
UK	1 (2.5)	1 (1.7)	2 (3.3)	
Other	8 (20.0)	12 (20.0)	12 (20.0)	
Weekly household income*				
$1–1499	13 (32.5)	23 (38.3)	22 (36.7)	
$1500–1999	12 (30.0)	12 (20.0)	17 (28.3)	
$2000 or more	8 (20.0)	14 (23.3)	21 (35.0)	
Unsure/undisclosed	7 (18.0)	11 (18.3)	–	
Education[†]				
No qualification/up to year 12	4 (10.0)	6 (10.0)	6 (10.0)	
Trade/apprenticeship/certificate/diploma	7 (17.5)	17 (28.3)	17 (28.3)	
University degree/higher degree	29 (72.5)	37 (61.7)	37 (61.7)	
Employment status*				
Part time work	2 (5.0)	6 (10.0)	3 (5.0)	
Studying full time/unemployed	–	–	1 (1.7)	
Keeping house/raising children full time	38 (95.0)	54 (90.0)	56 (93.3)	
Smoking currently*				
Yes	2 (5.0)	4 (6.7)	3 (5.0)	
No	38 (95.0)	56 (93.3)	57 (95.0)	

(I), intervention group; (C1), control group 1 (InFANT RCT control group); (C2), control group 2 (InFANT RCT intervention group).
*Demographics at 3 months postpartum.
[†]Body mass index (BMI) and Education ($P > 0.05$) for comparison of means between the intervention group and two control groups.
[‡]Significant difference in PPWR (kg) between the C1 and C2 group; bolded p value (level significant)

However, there was a significant decrease in mean WC measures for the (I) group (−6.4 cm) compared to the change in WC for the (C1) group (−1.1 cm) [β-coef (95% CI) = 5.59 (2.26–8.93); (P = 0.002)] and (C2) group (−3.3 cm) [β-coef (95% CI) = 6.38 (2.69–10.07); (P = 0.001)]. When the analyses excluded all women who had self-reported either weight or WC at baseline or follow-up, significant differences in mean weight were observed in the (I) group (−3.2 kg) compared to the (C1) group (+0.9 kg) for weight [β-coef (95% CI) = 2.31 (0.46–4.14); (P = 0.016)] and PPWR (−0.7 kg and 0.0 kg, respectively) [β-coef (95% CI) = 2.16 (0.13–4.18)] but not the (C2) group (−1.2 kg). The significant difference in WC remained, when the (I) group (−5.2 cm) was compared with both the (C1) (−1.1 cm) [β-coef (95% CI) = 5.19 (1.04–9.34); (P = 0.016)] and (C2) (−3.3 cm) groups [β-coef (95% CI) = 6.12 (1.31–10.95; P = 0.014)].

Secondary outcomes

Changes in dietary intakes are presented in Table 3. There was no significant between group difference in change in fruit intake (serves per day) or the proportion of women who were meeting recommendations for fruit intake.

Table 2 Anthropometric outcomes and comparison of anthropometry between the intervention and control groups*

	Baseline Mean (SD)			Follow-up Mean (SD)			(C1)†		(C2)†	
	(I)	(C1)	(C2)	(I)	(C1)	(C2)	β-coef (95% CI)	*P*-value	β-coef (95% CI)	*P*-value
Including self-report data										
	(*n* = 28)	(*n* = 48)	(*n* = 43)	(*n* = 27)	(*n* = 41)	(*n* = 33)				
Weight (kg)‡	71.0 (14.77)	69.7 (14.52)	70.0 (14.09)	69.4 (14.78)	70.6 (14.82)	67.3 (11.6)	1.27 (−0.55, 3.08)	0.167	0.21 (−1.6, 2.07)	0.817
PPWR (kg)§	2.9 (5.99)	3.3 (6.72)	1.6 (5.64)	1.7 (4.98)	3.3 (7.46)	0.4 (4.02)	1.27 (−0.59, 3.12)	0.176	0.31 (−1.53, 2.16)	0.736
	(*n* = 26)			(*n* = 26)	(*n* = 39)	(*n* = 27)				
Waist circumference (cm)¶	84.7 (12.03)	83.9 (12.37)	84.9 (11.60)	78.3 (10.02)	82.8 (14.26)	81.6 (11.21)	**5.59 (2.26, 8.93)**	**0.002**	**6.38 (2.69, 10.07)**	**0.001**
Excluding self-report data‖										
Weight (kg)‡	65.71 (12.57)	69.7 (14.52)	70.0 (14.09)	62.55 (10.35)	70.6 (14.82)	67.3 (11.6)	**2.31 (0.46, 4.15)**	**0.016**	1.44 (−0.42, 3.31)	0.125
PPWR (kg)§	1.37 (4.76)	3.3 (6.71)	1.6 (5.64)	0.70 (4.65)	3.3 (7.46)	0.4 (4.02)	**2.16 (0.13, 4.18)**	**0.037**	1.35 (−0.733, 3.44)	0.198
Waist circumference (cm) ¶	79.96 (10.46)	83.9 (12.37)	84.9 (11.60)	74.75 (7.59)	82.8 (14.26)	81.6 (11.21)	**5.19 (1.04, 9.34)**	**0.016**	**6.12 (1.31, 10.93)**	**0.014**

(I), intervention group; (C1), control group 1 (InFANT RCT control group); (C2), control group 2 (InFANT RCT intervention group); 95% CI, 95% confidence interval.

*Linear regression.

†Results compared to the mums online intervention (I) group for (C1) and (C2).

‡Intervention effects for weight (kg) when adjusted for age, income and postpartum weight retention (PPWR) and clustering by first-time mothers' group.

§Intervention effects for PPWR (kg) when adjusted for age, income and gestational; weight gain and clustering by first-time mothers' group.

¶Intervention effects for waist circumference (cm) when adjusted for age, income and PPWR and clustering by first-time mothers' group.

‖Anthropometric data for women with objective weight and waist circumference measures at baseline and intervention completion (I) group (*n* = 12) included; (C1) group (*n* = 41) included; (C2) group (*n* = 33) and adjusted accordingly as for the analysis including self-report data; bolded p value (level significant).

Table 3 Dietary intake comparison between the intervention and control groups from baseline to follow-up*‡

	Baseline			Follow-up			C1†		C2†	
	(I)	(C1)	(C2)	(I)	(C1)	(C2)	OR/RRR (95% CI)	*P*-value	OR/RRR (95% CI)	*P*-value
		n (%)			*n* (%)					
Fruit intake (serves per day)				(*n* = 27)		(*n* = 32)	0.24 (0.02, 2.86)	0.258	2.21 (0.38, 13.00)	0.380
None/less than 1 serve	1 (3.6)	8 (16.7)	5 (11.6)	2 (7.4)	5 (10.4)	3 (9.4)				
1 serve per day	11 (39.3)	11 (22.9)	15 (34.9)	10 (37.0)	10 (26.3)	12 (37.5)				
2 or more serves	16 (57.1)	29 (60.5)	23 (53.5)	15 (53.6)	23 (60.5)	17 (53.2)				
Vegetable intake (serves per day)				(*n* = 27)		(*n* = 32)	3.72 (0.99, 13.95)	0.051	3.30 (0.75, 14.45)	0.113
None/less than 1 serve	0	1 (2.1)	4 (9.3)	0	0	0				
1–2 serves	9 (32.2)	24 (50.0)	15 (34.9)	4 (14.8)	17 (44.7)	12 (37.5)				
3–4 serves	17 (60.7)	21 (43.8)	19 (44.2)	19 (70.3)	17 (44.7)	17 (53.1)				
5 or more serves	2 (7.1)	4 (4.2)	5 (11.6)	4 (14.8)	4 (10.6)	3 (9.4)				
Fruit intake meets recommendations				(*n* = 27)		(*n* = 32)	1.82 (0.62, 5.34)	0.274	0.89 (0.23, 3.03)	0.847
Yes	16 (57.1)	29 (60.4)	23 (53.5)	15 (55.6)	29 (60.4)	17 (53.1)				
No	12 (42.9)	19 (39.6)	20 (46.5)	12 (42.9)	19 (39.6)	15 (46.9)				
Vegetable intake meets recommendations				(*n* = 27)		(*n* = 32)	0.55 (0.11, 2.73)	0.465	0.29 (0.06, 1.41)	0.126
Yes	2 (7.1)	2 (4.2)	5 (11.6)	4 (14.8)	2 (4.2)	3 (9.4)				
No	26 (92.9)	46 (95.8)	38 (88.4)	23 (85.2)	46 (95.8)	29 (90.6)				
Fruit and vegetable intake meets recommendations				(*n* = 27)		(*n* = 32)	0.47 (0.08, 2.75)	0.400	0.49 (0.12, 1.96)	0.312
Yes	1 (3.6)	1 (2.1)	2 (4.7)	3 (11.1)	1 (2.1)	2 (6.3)				
No	27 (96.4)	47 (97.9)	41 (95.3)	24 (88.9)	47 (97.9)	30 (93.8)				
	n (%)			*n* (%)			RRR (95% CI)	*P*-value	RRR (95% CI)	*P*-value
Crisps				(*n* = 27)	(*n* = 38)	(*n* = 32)	1.15 (0.36, 3.65)	0.812	3.48 (1.15, 10.52)	**0.027**
Never/1–3 times per month	21 (75.0)	28 (58.4)	26 (60.5)	22 (81.5)	28 (73.7)	17 (53.2)				
1–4 times per week	7 (25.0)	20 (41.6)	14 (32.6)	5 (18.5)	9 (23.7)	14 (43.8)				
5–6 times per week	–	–	1 (2.3)	–	1 (2.6)	1 (3.1)				
Once per day or more	–	–	2 (4.7)	–	–	–				
Chocolate/lollies				(*n* = 27)	(*n* = 38)	(*n* = 32)	0.78 (0.21, 2.87)	0.71	1.03 (0.20, 5.25)	0.974
Never/1–3 times per month	10 (35.8)	8 (16.7)	12 (27.9)	6 (22.2)	8 (21.1)	9 (28.2)				
1–4 times per week	6 (21.4)	27 (56.3)	24 (55.8)	12 (44.4)	23 (60.5)	18 (56.2)				
5–6 times per week	7 (25.0)	5 (10.4)	5 (11.6)	3 (11.1)	2 (5.3)	1 (3.1)				
Once per day or more	5 (17.8)	8 (16.7)	2 (4.7)	6 (22.2)	5 (10.5)	4 (12.5)				
Cakes/biscuits				(*n* = 27)	(*n* = 38)	(*n* = 32)	0.93 (0.31, 2.80)	0.903	0.53 (0.18, 1.59)	0.261
Never/1–3 times per month	9 (32.1)	17 (35.4)	21 (48.9)	9 (32.2)	13 (27.1)	8 (18.6)				
1–4 times per week	12 (42.9)	28 (58.4)	19 (44.2)	16 (57.2)	22 (45.8)	23 (53.5)				
5–6 times per week	4 (14.3)	1 (2.1)	1 (2.3)	2 (7.1)	–	1 (2.3)				
Once per day or more	3 (10.7)	2 (4.2)	2 (4.7)	–	3 (6.3)	–				

Table 3. Continued

	n (%)			n (%)			RRR (95% CI)	P-value	RRR (95% CI)	P-value
Pies/sausage rolls				(n = 27)	(n = 38)	(n = 32)				
Never/1–3 times per month	23 (82.1)	43 (89.6)	38 (88.3)	25 (92.6)	32 (84.2)	31 (96.9)	4.50 (0.77, 26.43)	0.096	0.18 (0.00, 10.38)	0.404
1–4 times per week	5 (17.8)	5 (10.4)	4 (9.3)	2 (7.4)	6 (15.8)	1 (3.1)				
5–6 times per week	–	–	–	–	–	–				
Once per day or more	–	–	1 (2.3)	–	–	–				

(I), intervention group; (C1), control group 1 (InFANT RCT control group); (C2), control group 2 (InFANT RCT intervention group); OR, odds ratio; RRR, relative risk ratio; 95% CI, 95% confidence interval.

*Logistic regression.

†Results compared to the mums online intervention (I) group for (C1) and (C2).

‡Intervention effects for dietary outcomes adjusted for age and income and clustering by first-time mothers' group.

(I) group (n = 28); (C1) group (n = 48); (C2) group (n = 43) unless otherwise stated.

Change in vegetable intake (serves per day) for the (I) group (7.1% and 14.8%) was borderline significant compared to the (C1) group (4.2% and 10.6%) [relative risk (95% CI) = 3.72 (0.99–13.95); P = 0.051]. There was no significant difference in the proportion of women who were meeting recommendations for vegetable intake or combined fruit and vegetable intake in the (I) group compared to the (C1) or the (C2) group. For noncore food groups (crisps, chocolate/lollies, cakes/biscuits, pies/sausage rolls), the proportion of women consuming crisps 'never/1–3 times per week' remained relatively unchanged in the (I) group (75.0% and 81.5%). This was significantly different compared to the (C2) group in which the proportion of women consuming crisps 'never/1–3 times per week' decreased (60.5% and 53.2%) [relative risk (95% CI) = 3.48 (1.15–10.52); P = 0.027)]. There was no significant difference in the proportion of women consuming any of the other noncore foods between groups.

Changes in physical activity and sedentary behaviour are presented in Table 4. There was no significant difference in mean time (minutes) spent walking, moderate, vigorous activity or total activity in the (I) group compared to the (C1) or the (C2) group. The majority of women in all three groups reported meeting physical activity recommendations at both baseline and follow-up. For television/DVD/video time, there was no significant difference in mean time (minutes) on weekdays, weekend days or total time between groups.

Discussion

The present study assessed whether a 9-month, theoretically-grounded behaviour change intervention would assist women in limiting PPWR and central adiposity and improve lifestyle behaviours following childbirth. Overall, the intervention improved WC measures and, when self-reported weight was excluded from the analysis, the intervention was effective in limiting PPWR when data were compared with the (C1) group. However, it should be acknowledged that removing self-reported data from the anthropometric results left a significantly small sample size for comparison. Despite small changes in maternal anthropometry, the mums OnLiNE intervention was unable to significantly improve diet, physical activity or sedentary behaviours in first-time mothers.

With studies having previously shown that under-reporting of weight and BMI tends to be common amongst overweight adults [41–43], previous research has shown that women of reproductive age who seek participation in clinical research, self-report their height and weight accurately [44], with good correlation between reported and measured BMI [44]. Although it was not clear why the improved anthropometric measures were

Table 4 Physical activity and sedentary behaviour patterns and comparison between the intervention and control groups from baseline to follow up*†

	Baseline			Follow-up			C1‡		C2‡	
	(I)	(C1)	(C2)	(I)	(C1) (*n* = 38)	(C2) (*n* = 33)				
	Mean (SD)			Mean (SD)			β-coef (95% CI)	*P*-value	β-coef (95% CI)	*P*-value
Total PA (min week^{-1})	349.46 (273.92)	405.08 (345.23)	288.02 (275.07)	363.21 (248.83)	387.29 (307.48)	289.52 (230.90)	−30.17 (−147.18, 86.84)	0.606	−58.40 (−165.57, 48.77)	0.278
Walking (min week^{-1})	206.61 (161.14)	259.96 (193.89)	211.63 (193.80)	207.68 (149.58)	264.46 (221.03)	180.78 (154.54)	31.91 (−54.99, 118.80)	0.463	−49.91 (−116.12, 16.30)	0.136
Moderate (min week^{-1})	29.29 (47.29)	40.64 (85.83)	27.21 (62.08)	55.36 (89.79)	54.05 (115.72)	28.06 (53.63)	−20.13 (−73.64, 33.38)	0.452	−19.27 (−63.56, 25.03)	0.385
Vigorous (min week^{-1})	113.57 (163.09)	107.40 (171.74)	49.19 (76.16)	100.18 (111.94)	82.37 (103.64)	75.31 (79.36)	−21.56 (−68.37, 25.23)	0.358	−17.46 (−58.13, 23.20)	0.391
Total TV/DVD/video time (min day^{-1})	177.17 (158.27)	154.96 (172.09)	195.66 (154.25)	111.56 (60.01)	113.67 (75.53)	135.91 (83.96)	3.84 (−31.53, 39.21)	0.828	14.03 (−24.55, 52.61)	0.467
Television/DVD/video time weekday (min day^{-1})	185.89 (186.30)	159.06 (194.61)	209.19 (198.9)	111.61 (63.32)	99.34 (73.71)	132.27 (103.89)	−11.02 (−44.29, 22.26)	0.508	12.06 (−33.73, 57.85)	0.598
Television/DVD/video time weekend day (min day^{-1})	155.36 (92.40)	144.69 (147.86)	161.86 (81.28)	111.43 (62.64)	149.47 (171.59)	145.00 (64.81)	44.73 (−8.09, 97.56)	0.095	20.15 (−14.48, 54.79)	0.247
		n (%)			*n* (%)		OR (95%CI)	*P*-value	OR (95%CI)	*P*-value
PA meets recommendations		(*n* = 46)			(*n* = 37)	(*n* = 31)				
Yes	21 (75.0)	32 (69.6)	23 (53.5)	22 (78.6)	24 (64.9)	21 (67.7)	0.45 (0.14, 1.49)	0.191	0.60 (0.20, 1.82)	0.368
No	7 (25.0)	14 (30.4)	20 (46.5)	6 (21.4)	13 (35.1)	10 (32.3)				

(I), intervention group; (C1), control group 1 (InFANT RCT control group); (C2), control group 2 (InFANT RCT intervention group); 95% CI, 95% confidence interval.

*Intervention effects for physical activity (PA) and sedentary behaviour outcomes adjusted for age and income and clustering by first-time mothers' group.

†Linear and logistic regression.

‡Results compared to the mums online intervention (I) group for (C1) and (C2) (I) group (*n* = 28); (C1) group (*n* = 48); (C2) group (*n* = 43) unless otherwise stated.

observed when self-reported data were excluded from the analyses, body dissatisfaction could be one factor that led to over-reporting of weight or WC among women in the present study. Body dissatisfaction during the postpartum period has been previously documented [45–47], where women have been found to assume negative feelings towards increases in their weight at the waist and hips particularly [48], with changes commonly occurring as a result of pregnancy weight gain.

Measures of WC are important in this population group because PPWR tends to be centrally rather than peripherally deposited [12, 13]. Of concern, mean WC measures across all three groups at baseline were above the WHO recommendation of ≤ 80 cm, a cut-off point for the reduced risk of metabolic complication [49]. Assessment of WC was a methodological strength of the present study and the significant reduction in WC measurements in the (I) group compared to women in both control groups was an important finding, despite the small sample size. Even modest reductions in WC have been shown to reduce risk factors for poor cardio-metabolic health, such as hyperglycaemia, high blood pressure and blood triglyceride levels [39]. Therefore, in the interest of maternal health and assessment of chronic disease risk, future postpartum interventions should focus on the monitoring of WC, in addition to PPWR.

Despite promising anthropometric changes, there was no significant improvement in any secondary outcome for women who completed the mums OnLiNE intervention compared to women in both control groups. It may be possible that, for women in the intervention group, slight decreases in total energy intake occurred, which could explain the small amounts of weight-loss or reduced WC measures irrespective of fruit, vegetable or noncore food intake. However, energy intake was not an outcome of the present study despite self-monitoring of energy intake and expenditure being a main feature of the CALORIEKING program. Therefore, overall energy deficits were unable to be determined that may have given some insight into observed weight-loss. Regardless, the purpose of the program was to enable women to log their own diet and physical activity and gain feedback as part of the self-monitoring component of the theoretical underpinning of the intervention. In this case, the program was used for self-monitoring purposes and not for outcome evaluation.

Regarding physical activity assessment, the AAS asked women to report durations and intensities of physical activity retrospectively for the previous 7 days only. It is likely that physical activity levels fluctuated with seasonal changes or with women returning to work. The results may therefore not be reflective of changes in physical activity across the entire 9-month intervention period. Although possible improvements in physical activity duration and/or intensity at different times throughout the intervention period may in part explain the observed improvements in PPWR and WC, this could not be assessed. Women were concurrently enrolled in the InFANT Extend RCT and additional assessment of physical activity would have increased participant burden and subsequently may have reduced participation in the mums OnLiNE intervention.

Furthermore, the activity of mothers in the present study may be somewhat underestimated because the AAS does not assess domestic activity such as completing household chores. Domestic physical activity and housework have previously been considered as key components with respect to determining total physical activity and trends in physical activity for mothers [50] and so measurement of domestic physical activity in this population group is an important consideration for future interventions.

Consistent with the literature assessing physical activity in new mothers [51], walking was the most prevalent type of activity for women in the present study. Walking is a highly suitable, functional and low cost activity for new mothers and, even when conducted at a low intensity, regular walking for short periods (approximately 25 min) has been found to reduce risk factors for chronic disease, as well as postpartum BMI [51]. Although women in the present study were encouraged to use their pedometer and log daily steps on the website and/or smartphone application, daily step targets were not an outcome that was assessed in the present study. Moreover, it was difficult to assess whether all women would use the pedometer because, for some women, a reduction in sedentary time was a key focus of individual goal setting, whereas participation in higher intensity sports (e.g. netball) or other activities such as swimming was a target goal for other women. Women in the intervention group only received a pedometer as part of a theoretically-based intervention for self-monitoring and, as such, daily steps could not be compared with the control group. Nonetheless, monitoring of daily steps have been shown to be an effective tool for promoting physical activity and limiting PPWR [52] and could be an important tool for physical activity assessment in future interventions.

Importantly, the risk for morbidity and mortality is higher for those engaging in greater amounts of sedentary behaviour, independent of regular moderate to vigorous physical activity [53–55], yet the available literature assessing postpartum sedentary behaviour is limited. Notwithstanding, an assessment of sedentary time is highly relevant in this population group. For example, an assessment of television viewing by Oken *et al.* (2007) [56] found that, in their sample of women, for each hour of daily television viewing, the adjusted odds ratio for

retaining substantial weight (>5 kg) was 1.24. Although the results from the mums OnLiNE intervention showed that there was no change in television/DVD/video time during the 9-month study period, it may be that future interventions should target sedentary behaviours other than television/DVD/videos. Considering that new mothers have fewer opportunities to leave the home during the postpartum period [57], sedentary activities such as accessing computers and other electronic devices (e.g. tablets and smartphones) may contribute substantially to sedentary time among this population group. A more thorough understanding of new mothers' sedentary behaviour patterns and an assessment of barriers to reducing sedentary time are important for investigating postpartum weight management.

Similar to other postpartum interventions [20], there was a low uptake (18%) of the OnLiNE study. This was despite the intervention being designed to maximise accessibility and flexibility via the use of online and telephone delivery, with convenience being a priority. Although a low uptake may have partly been a result of many women already participating in the InFANT Extend intervention, it also reflects the difficulty in engaging with women during the postpartum period. Moreover, in the present study and across all three groups, of those women who were excluded from the follow-up analysis, all but one participant was excluded as a result of becoming pregnant for a second time and having to subsequently be withdrawn from the study. Therefore, initiating an intervention 9 months following the birth of a woman's first child may be too late, with many women evidently becoming pregnant shortly after. As such, development of strategies to recruit women successfully and at an appropriate time during the postpartum period should be a focus for future research.

This was the first intervention of its kind to combine both online or smartphone app capability with telephone-based support to promote healthy behaviour change in new mothers, which was a key strength of the study. An additional strength was the theoretical underpinning of the intervention. Few interventions targeting PPWR have been underpinned by behaviour change theories [19,58], which is surprising because successful technology-based weight-loss interventions have frequently utilised SCT in their development [24,59,60]. Furthermore, despite difficulty recruiting women to the mums OnLiNE intervention, retention rates were high (70%). This may have been a result of the one-on-one motivational interviewing. Motivational interviewing reflects patient-centred approaches that foster practitioner–patient partnerships [61] and, as a component of the mums OnLiNE intervention, likely contributed to rapport building between the women and the dietitian, thereby facilitating retention to the study. Furthermore, the intervention would be applicable in a real-world setting where the low dose and relatively low cost of implementation would infer feasibility in delivering the program to a wider population of new mothers.

A limitation of the present study was the inability to evaluate use of the CALORIEKING website and smartphone application (e.g. the number of times accessed or login durations) as a result of research budget restraints. Evaluating associations between engagement and intervention outcomes in future studies could inform the design of subsequent technology-based interventions targeting new mothers. Furthermore, the uptake and number of telephone calls with the dietitian was not evaluated as part of the present study. However, a qualitative process evaluation has been conducted and insight into usefulness of telephone calls will be reported elsewhere. A cost effective analysis of the intervention would be an important future consideration informing public health utility and we acknowledge that the uptake and use of intervention components would need to be assessed as part of this. Moreover, the self-reported dietary intakes [62] and physical activity data [63] methods utilised in the present study are known to be vulnerable to systematic and random measurement error recall bias and biased estimates of behaviour.

Finally, despite efforts to recruit a larger sample of women, the present study was not powered sufficiently to detect meaningful changes in anthropometry between the intervention and control groups. Given pragmatic restraints, the present study was designed as a pilot intervention study. Future studies with larger sample sizes, adequately powered to detect meaningful differences in maternal adiposity, are needed to broaden knowledge of effectiveness of postpartum interventions [22].

The mums OnLiNE intervention was unable to change the assessed healthy lifestyle behaviours in postpartum women, yet the observed change in WC bode well for potential effectiveness of interventions implemented by combined online and telephone delivery. Undoubtedly, new mothers require additional support to encourage improved dietary habits and also to promote engagement in regular physical activity and reduce sedentary behaviour. Further intervention studies are needed to assist new mothers in attaining healthy postpartum weight and lifestyle behaviours, in the interest of reducing the risk of maternal obesity and related morbidity.

Transparency declaration

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

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Conflict of interests, source of funding and authorship

The authors declare that they have no conflicts of interest.

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PV, KC, KB, KH and DC contributed to the original study idea and intervention design. PV conducted the study recruitment, intervention delivery and analyses. MT, KB, KH and KC assisted with guidance on data analyses. CC advised on the initial components as part of the intervention design. PM also contributed to the design of the intervention and advised on the online and written material as part of the intervention. All authors contributed to the development and revision of the manuscript.

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