Asian Nursing Research 15 (2021) 136–143

Contents lists available at ScienceDirect

Asian Nursing Research

journal homepage: www.asian-nursingresearch.com

Research Article

Evaluation of a Mobile-based Maternal Feeding Education Program for Overweight Prevention in Infants

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ARTICLE INFO

Article history:
Received 25 October 2020
Received in revised form
27 January 2021
Accepted 2 February 2021

Keywords:
education
feeding behavior
infant
mothers
overweight

SUMMARY

Purpose: The purpose of this study was to evaluate a mobile-based maternal feeding education program for overweight prevention in infants based on breastfeeding attitude, breastfeeding self-efficacy, breastfeeding duration, recognition of hunger and satiety cues of infants, and knowledge regarding providing solids foods.

Methods: A nonequivalent control group pretest-posttest design was used for the study. Participants included 15 primiparas in the experimental group and 14 primiparas in the control group in all the follow-up tests. Using self-reported questionnaires in electronic format, data were collected four times (before the intervention, 1 month after childbirth, 3 months after childbirth, and 6 months after childbirth). Using SPSS 24 version, independent *t*-test and repeated-measures analysis of variance were used to test the effects of the mobile-based maternal feeding education program.

Results: The experimental group showed significantly more positive breastfeeding attitude ($F = 5.28$, $p = .008$), higher breastfeeding self-efficacy ($F = 3.50$, $p = .041$), and increased breastfeeding duration ($t = -2.09$, $p = .046$) than the control group. In addition, the experimental group showed significantly improved knowledge regarding providing solid foods to the infants ($F = 4.86$, $p = .009$) in comparison with the control group. However, for education on recognizing hunger and satiety cues of infants, the mobile-based maternal feeding education program was not effective ($F = 0.23$, $p = .878$).

Conclusion: According to the results of this study, the mobile-based maternal feeding education program has the potential to contribute to overweight prevention in infants.

Introduction

Infancy is a developmental stage when the formation of feeding patterns and eating habits causing overweight in childhood [1]. In this regard, rapid weight gain might easily develop in infancy, and rapid weight gain during infancy is significantly associated with the development of overweight and obesity in childhood after infancy [2]. In previous studies, overweight infants had 3.1-fold and 17.5-fold increased likelihood of overweight and obesity in preschool age and adolescence, respectively [3,4]. Therefore, infancy was considered to be a critical period for the early prevention of overweight and obesity in children [5]. In particular, as overweight in infancy resulted from excessive energy intake and overnutrition via feeding [5], Cloutier et al. [6] emphasized the need for a maternal feeding education program for overweight prevention in infancy.

According to a model for the development of an early childhood obesity prevention program, the maternal feeding education program for the prevention of excessive weight gain in infants might increase the maternal positive attitude and self-efficacy in breastfeeding and providing food to the infants by helping recognize and respond sensitively to the hunger and satiety cues of the infants [6]. Infantile feeding and eating patterns for the prevention of excessive weight gain were formed on the basis of the maternal feeding behaviors [6]. In existing family-based and parental programs for overweight prevention of infants, educational content has mainly focused on improving positive breastfeeding attitudes, breastfeeding self-efficacy, sensitivity to recognize hunger and satiety cues of infants, and knowledge about the correct solid foods to be given to infants [7–10]. Therefore, as an early life intervention for the prevention of overweight in infants, maternal feeding

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https://doi.org/10.1016/j.anr.2021.02.001
p1976-1317 e2093-7482/

education programs should focus on addressing the key factors responsible for the formation of maternal feeding patterns.

According to previous studies, the maternal feeding education programs for the prevention of excessive weight gain of infants were mainly provided by postpartum home visits and face-to-face meetings [8–10]. However, in the Korean health care system, a postpartum home visiting program is not provided for parenting education and health care of mothers and their infants. In addition, Korean mothers traditionally limit contact with other people for approximately 3 months postpartum. Therefore, maternal education based on a home visiting program and face-to-face meetings might be inappropriate intervention strategies during postpartum periods in Korean society.

However, mobile-based parental education programs have been actively developed because most Korean people use smartphones [11,12]. Mobile websites might contain various educational contents, such as pictures, figures, and videos required for modeling a parental education program [13]. The success rates and satisfaction levels with the online education programs were high because of the availability of repeated learning and practice by frequently using mobile websites [13]. In addition, for mothers with newborns who cannot receive education at a fixed place and time [14], mobile-based education programs can prove to be highly user friendly, helping the mothers receive education at a place and time convenient for them.

Therefore, the purpose of this study was the development and evaluation of a mobile-based maternal feeding education program for the prevention of overweight in infants. We proposed the following hypothesis. The mothers who participated in the intervention would have an increased (1) positive breastfeeding attitude, (2) breastfeeding self-efficacy, (3) breastfeeding duration, (4) sensitivity to recognize hunger and satiety cues of their infants, and (5) knowledge regarding providing solid foods for overweight prevention in infants.

Methods

Study design

A nonequivalent control group pretest-posttest design was used to test the effects of the mobile-based maternal feeding education program for overweight prevention in infants.

Participants

The participants of the study were first-time pregnant mothers with more than 36 weeks gestational age, recruited from two different obstetrics and gynecology clinics located in Daejeon (metro city), South Korea. We used a convenience sampling method to select the clinics and participants. From each of the clinics, participants for the experimental and control groups were selected according to the inclusion and exclusion criteria. The inclusion criteria were as follows: (1) mothers who gave consent to participate, (2) mothers who were primary caregivers of their infants, and (3) mothers of infants born after more than 37 weeks and weighing more than 2500g at birth. The exclusion criteria were as follows: (1) mothers with twin infants, (2) mothers of infants with congenital deformities (e.g., cleft palate) and other health issues related to feeding difficulties, and (3) mothers who had participated in other maternal feeding education programs for overweight prevention in infants within 1 year of this study.

Using the G-3.1.2 power program, 24 was the required sample size with a medium effect size of 0.25 [15], a significance level of 0.05, statistical power of 0.80, two groups, four measures, and two-way repeated-measures analysis of variance (ANOVA). When considering a 20% dropout rate similar to a previous study with mobile-based health education [11], 29 might be the appropriate number for the final sample size. From July to August 2019, 19 and 14 mothers for the experimental and control groups, respectively, were selected. After the pretest, four mothers in the experimental group refused to participate in this study because of increased burden of caring for infants. Thus, 15 mothers in the experimental group were involved in all follow-up tests. Among the 14 mothers in the control group, there were no dropouts during the study process (Figure 1).

Ethical consideration

All the procedures and methods of this study were approved by the institutional review board of the research institute at the Chungnam National University, where a researcher of this study was involved (Approval no. 201903-SB-034-01). The researcher and a trained research assistant explained the purpose, procedures, methods of the study, informed the participants that the participation was voluntary and they could leave the study at any stage, and that the study respected individual rights and all information collected from the participants would be used confidentially and only for this study. Written informed consent was obtained from all the participants. Approximately 20 US dollars (20,000 won in Korea) was provided at every stage of evaluation, including pretest and follow-up tests.

Measures

To verify homogeneity of characteristics in the experimental and control groups, characteristics of infants and mothers were evaluated with risk factors for overweight in infancy. Characteristics of infants involved sex (female or male), gestational age (weeks), birth weight (grams), and delivery type (vaginal delivery or cesarean section). In addition, maternal characteristics involved current age (years), marital status (married or other), educational level (high school, 2-year and 4-year college, or more than 4-year college), perceived current socioeconomic status of family (high, middle, or low), weight gain during pregnancy (kilograms), smoking experience during pregnancy (yes or no), diagnosed with diabetes mellitus during pregnancy (yes or no), and diagnosed or treated for depression by certified psychiatrist during pregnancy (yes or no).

To evaluate the effects of the mobile-based maternal feeding education program, breastfeeding attitude, breastfeeding self-efficacy, and breastfeeding duration were assessed. In addition, recognition of hunger and satiety cues of infants and knowledge regarding providing solid foods for overweight prevention in infants were assessed with the mothers.

Breastfeeding attitude

Breastfeeding attitude was assessed using the Iowa Infant Feeding Attitude Scale, originally developed by De la Mora and Russell [16] and translated and validated in Korean by Ra and Chae [17]. The instrument consisted of 17 items, and responses toward each item were available on a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). Possible total scores ranged from 15 to 85 points, where a higher score indicates a more positive breastfeeding attitude. Cronbach's α is .86 in a study by De la Mora and Russell [16] and .72 in a study by Ra and Chae [17]. Cronbach's α in this study was .64–.82 according to the follow-up test of experimental and control groups.

Breastfeeding self-efficacy

Breastfeeding self-efficacy was assessed using the Breastfeeding Self-efficacy Scale-Short Form, originally developed by Dennis [18] and translated and validated in Korean by Ra and Chae [19]. The

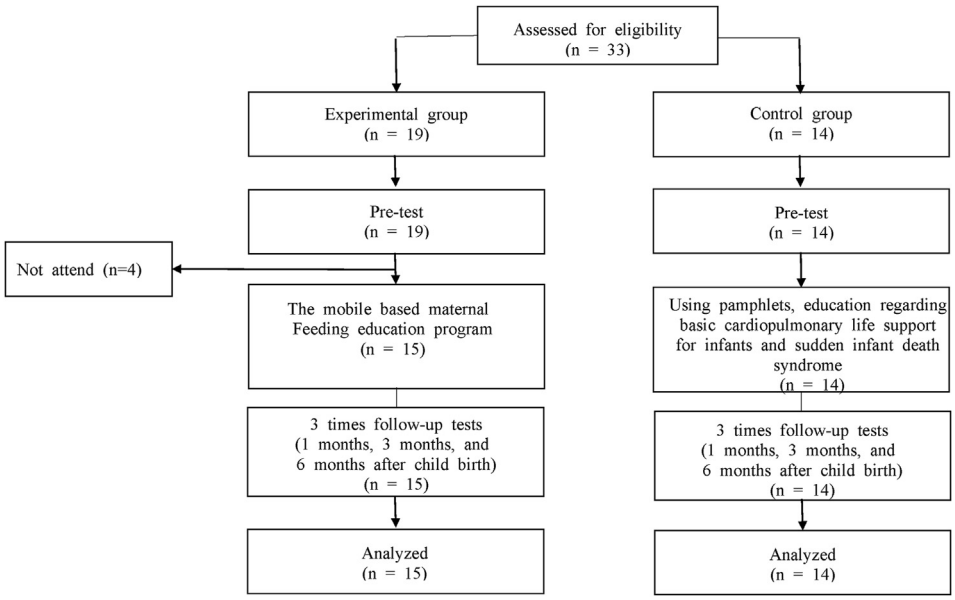

Figure 1. Flow diagram for participants.

instrument consisted of 14 items, and response toward each item was available on a 5-point Likert scale (1 = *never confident* to 5 = *always confident*). Possible total scores ranged from 14 to 70 points, where a higher score indicated higher breastfeeding self-efficacy. Cronbach's α is .96 in a study by Dennis [18] and .94 in a study by Ra and Chae [19]. Cronbach's α in this study was .84–.92 according to the follow-up test of experimental and control groups.

Breastfeeding duration

Breastfeeding duration was assessed from a single question. Participants were asked to indicate for how many days they had breastfeed until 6 months (180 days) after childbirth.

Recognition of hunger and satiety cues by infants

Recognition of hunger and satiety cues by infants was assessed through four items of the Infant Feeding Questionnaire, originally developed by Baughcum [20] and translated and validated in Korean by Ra, Jeong, and Kim [21]. Response toward each item was available on a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). The mean score per item ranged from 1 to 5 points, where a higher score indicated increased recognition of hunger and satiety cues by infants. Cronbach's α is .70 in a study of Baughcum [20] and 75 in a study by Ra et al [21]. Cronbach's α in this study was .70–.85 according to follow-up test of experimental and control groups.

Knowledge regarding providing solid foods for overweight prevention in infants

Knowledge regarding providing solid foods for overweight prevention in infants was assessed with four items in the instrument, which evaluated infant feeding knowledge of mothers [22]. One correct response for each item scored 1 point, and higher score (ranged 0–4 points) indicated increased knowledge regarding providing the solid foods, which would not cause overweight in infants.

Intervention procedures

Development of mobile-based maternal feeding education program for overweight prevention of infants

Themes, subthemes, and content development of the education program

For the development of themes, subthemes, and the content of the education, a literature review was conducted. According to the review, maternal feeding behaviors associated with overweight in infants was formula feeding with/without breastfeeding [1,23]; regular feeding pattern in fixed schedules and overfeeding without considering hunger and satiety cues of infants [1,24]; early providing of solid foods (<4 months) [25]; and providing of sweet beverage, juices, and high calories snacks with solid foods [1,24]. Thus, breastfeeding, responsive feeding considering hunger and satiety cues of infants, and providing appropriate solid foods were categorized as the themes. In addition, according to the themes, the subthemes and the content were developed, which included textbooks, currently developed educational material that is open to the public, and educational articles (Table 1).

Then, five pediatricians and five professors in child health nursing confirmed the contents' validity. They suggested the need for educational content for understanding childhood overweight or obesity (e.g., causes, problems because of childhood overweight or obesity, and prevention methods). Consequently, themes, subthemes, and contents of education regarding childhood overweight or obesity were added. Finally, according to content validity from five pediatricians and five professors in child health nursing, the content validity index was calculated as 3.2–4.0 points.

Mobile website construction

For mobile website construction, the researcher developed storyboards including short and core subtitles, pictures, figures, and videos according to the contents. Also, narrations were developed for each storyboard. Pictures, figures, and videos were used from the web with the permission of the copyright holder. If permission was not provided for using of pictures, figures, and video, illustrations replaced them. A total of 58 storyboards were developed, with 53 containing educational content, two for instruction on the program, and three for summary and wrap-up. Three professors in child health nursing and one pediatrician confirmed the content validity of the storyboards and narration.

In initial meetings, two web designers and the researcher designed the web pages, including layout, background color, letter

Table 1 *Themes, Subthemes, and Contents of the Mobile-Based Maternal Feeding Education Program.*

Themes	Subthemes	Contents
Childhood overweight/obesity	1. Characteristics of childhood overweight/obesity	1) Characteristics of childhood overweight/obesity. (Increased number and size of fat cells) 2) The need for childhood overweight/obesity prevention in early life, including infancy.
	2. Diagnosis of childhood overweight/obesity	1) Diagnostic criteria for childhood overweight/obesity. 2) Interpretation methods of children's weight status based on the developmental growth curve.
	3. Causes of childhood overweight/obesity.	1) Causes of childhood overweight/obesity.
	4. Problems associated with childhood overweight/obesity.	1) Physical, psychological, social health problems associated with childhood overweight/obesity.
Breastfeeding	1. Beneficial effects and methods of breastfeeding.	1) Beneficial effects of breastfeeding for growth and development in infancy. 2) Methods of breastfeeding initiation and maintaining and precautions for breastfeeding. 3) Postures for breastfeeding. 4) Methods to stop breastfeeding. 5) Understanding the satiety cues of breastfed infants.
	2. Overweight prevention during breastfeeding in infancy.	1) Overweight prevention effects of breastfeeding, compared with formula feeding, and mixed feeding with formula feeding and breastfeeding. 2) Composition of breast milk for overweight prevention in infants. 3) Improving self-regulation ability via breastfeeding for the prevention of obesity in infants. 4) Overweight prevention effects based on breastfeeding duration.
Responsive feeding	1. Responsive feeding according to hunger and satiety cues of infants.	1) Overweight prevention effects of responsive feeding according to hunger and satiety cues.
	2. Hunger and satiety cues.	1) Understanding of hunger cues in infants. 2) Understanding of satiety cues in infants.
	3. Similar cues compared with hunger cues.	3) Causes associated with similar cues (crying and irritation) in comparison with hunger cues.
	4. Caring according to causes of similar cues, in comparison with hunger cues.	4) Caring according to causes of similar cues (crying and irritation), in comparison with hunger cues.
Providing solid food	1. General methods and precautions for providing solid food.	1) Need for solid food and precautions related to providing solid food. 2) Methods for the provision of solid food according to age in months.
	2. Providing solid food for overweight prevention in infants.	1) Significance of solid food for obesity prevention in infants. 2) Association between the early provision of solid food and overweight in infants. 3) Limiting food for overweight prevention in infants when providing solid food. 4) Methods of providing solid food for overweight prevention in infants.

style and colors, and symbols according to the educational contents. Designed web pages were revised several times by the researcher and the web designers, and narration was finally recorded by a professional audiobook narrator for every web page.

Contents of mobile web were mainly categorized into three sections, including the introduction of the program, educational contents, and summary and wrap-up. In the introduction section of the program, the purpose of the program, using methods from the web, and the contact number of the researcher were presented. In the educational contents section, detailed education was provided according to the themes, subthemes, and educational content. Finally, in the summary and wrap-up section, summary and key points were presented according to the themes. Considering the attention span of 10–15 minutes in adults [26], all the educational content was provided within 10-minute blocks (4–9 minutes).

To make the website user friendly, icons representing the main three sections were placed on the homepage. In addition, touch icons for accessing detailed educational contents were provided. To revisit the information, icons for returning to previous pages of the educational contents were provided. In addition, icons for narration were placed to assist repeated hearing of the narration. On every last page, icons representing the educational contents were placed for accessing the subthemes. In addition, on every last page, icons for asking questions and giving opinions were also provided according to the themes. The researcher and two research assistants with doctoral degrees in nursing managed the website and answered any questions and comments from the participants. The web address is https://www. Healthybaby. online.

Through a model operation with three professors in child health nursing, five registered nurses with more than five years of working experience in pediatric wards, two web designers, and five first-time mothers of infants, the benefits, accuracy, comprehension of the website components, functionality, purpose, interactivity, confidentiality, and reliability of the website were evaluated (4.5~4.9 points/5 points) [11].

Implementation and data collection

For the experimental group, the feeding education program for overweight prevention in infants was provided through mobile from 38 weeks gestation to 6 months after childbirth. To ensure better understanding and recall by repetition, the researcher and

the research assistants encouraged the mothers to access the website at least once every 2 days, considering that memory from once accessed learning might be maintained up to 24 hours [27]. In addition, they confirmed the mothers' attendance every day and measured their access rates from the initial introduction section to the final summary and wrap-up section to guarantee completion of the entire educational content. For mothers who accessed the same educational contents for 3 days in a row and/or discontinued accessing the educational contents for 3 days, the researcher and research assistants sent text messages to encourage them to access the entire educational contents in the program.

Pamphlets containing information pertaining to basic cardiopulmonary life support for infants and prevention of sudden infant death syndrome were distributed to the control group participants. Using self-reported electronic questionnaires, data collection was conducted four times: before participation in the intervention and 1 month, 3 months, and 6 months after childbirth.

Statistical analysis

Statistical analysis was conducted using SPSS 24 version (IBM Corp., Armonk, NY, USA). Chi-square and independent *t*-tests were used for testing homogeneity characteristics of the participants and baseline breastfeeding attitude, breastfeeding self-efficacy, recognition of hunger and satiety cues of infants, and knowledge regarding providing solid foods for overweight prevention in infants between experimental and control groups, in the pretest. In addition, an independent *t*-test was conducted for comparing the mean values of breastfeeding duration until 6 months (180 days) after childbirth, between the experimental and control groups, in the final follow-up test (6 months after childbirth). A repeated-measures ANOVA was used to compare the changes in mean values of breastfeeding attitude, breastfeeding self-efficacy, recognition of hunger and satiety cues of infants, and knowledge regarding providing solid foods for overweight prevention in infants between the two groups in a pretest and three times in the follow-up test. A p-value <0.05 was considered to be statistically significant. A Bonferroni test was conducted for a post hoc test of the repeated-measures ANOVA. For statistical significance, the Bonferroni corrected p-value needed to be<.0083 (.05 of original significance level/6 of number of test).

Table 3 *Homogeneity of Outcome Variables Between Experimental and Control Groups.*

Variables	Exp (n = 15), M±SD	Cont (n = 14), M±SD	*t*	*p*
Breastfeeding attitude	57.20 ± 4.41	57.79 ± 2.91	0.43	.675
Breastfeeding self-efficacy	44.80 ± 6.99	41.50 ± 12.97	−0.86	.397
Recognition of hunger and satiety cues of infants	2.93 ± 0.40	2.89 ± 0.61	−0.21	.832
Knowledge regarding providing of solids foods	1.60 ± 0.63	1.93 ± 0.73	1.30	.205

Note. Cont. = control group; Exp. = experimental group; M = mean; SD = standard deviation.

Results

Homogeneity of characteristics of infants and mothers and outcome variables between experimental and control groups

There were no statistically significant differences in the characteristics (of infants and mothers) between the experimental and control groups (Table 2). In addition, in the pretest, there were no statically significant differences in breastfeeding attitude, breastfeeding self-efficacy, breastfeeding duration until 6 months (180 days) after childbirth, recognition of hunger and satiety cues of infants, and knowledge regarding providing solid foods for overweight prevention in infants between the two groups (Table 3) (See Table 4).

Effects of mobile-based maternal feeding education program for overweight prevention in infants

Regarding breastfeeding attitude, statistically significant differences were noticed across time points ($F = 11.84$, $p < .001$) and interactions between the groups and times ($F = 5.28$, $p = .008$),

Table 2 *Homogeneity of Characteristics of Infants and Mothers Between Experimental and Control Groups.*

Variables		Exp (n = 15) n (%)/M ± SD	Cont (n = 14) n (%)/M ± SD	t/χ^2	*p*
Infants' characteristics					
Sex	Boy	6 (40.0)	4 (28.6)	0.42	.518
	Girl	9 (60.0)	10 (71.4)		
Gestational age (wk)		39.22 ± 1.22	39.04 ± 1.02	−0.44	.661
Birth weight (g)		3,066.00 ± 264.60	3,080.93 ± 283.08	0.15	.884
Delivery type	Vaginal delivery	10 (66.7)	6 (42.9)	1.66	.198
	Cesarean section	5 (33.3)	8 (57.1)		
Maternal characteristics					
Current age (yr)		32.07 ± 4.15	31.14 ± 4.07	−0.69	.499
Marital status	Married	15 (100)	14 (100)		
	Others	0 (0.0)	0 (0.0)		
Educational level	High school,	0 (0.0)	2 (14.3)	3.19	.363
	2-yr and 4-yr college	14 (93.3)	10 (71.4)		
	More than 4-yr college	1 (6.7)	2 (14.3)		
Perceived current socioeconomic status of family	High	2 (13.3)	0 (0.0)	2.17	.338
	Middle	11 (73.4)	11 (78.6)		
	Low	2 (13.3)	3 (21.4)		
Weight gain during pregnancy (kg)		10.94 ± 2.77	12.24 ± 4.19	0.99	.329
Smoking experience during pregnancy	Yes	0 (0.0)	0 (0.0)		
	No	15 (100)	14(100)		
Diagnosed or treated for diabetes mellitus during pregnancy	Yes	1 (6.7)	3 (21.4)	1.33	.249
	No	14 (93.3)	11 (78.6)		
Diagnosed or treated for depression during pregnancy	Yes	0 (0.0)	0 (0.0)		
	No	15 (100)	14(100)		

Note. Cont. = control group; Exp. = experimental group; M = mean; SD = standard deviation.

Table 4 *Effects of the Mobile-Based Maternal Feeding Education Program.*

Variables	Group	Before intervention	1 mo after child birth	3 mo after child birth	6 mo after child birth	Source	F/t	p
		M±SD						
Breastfeeding attitude	Exp. (n = 15)	57.20 ± 4.41	52.87 ± 3.23	60.20 ± 4.89	61.27 ± 5.13	Group	1.09	.305
						Time	11.84	<.001
	Cont. (n = 14)	57.79 ± 2.91	55.36 ± 2.27	57.14 ± 4.42	57.21 ± 4.12	Group × time	5.28	.008
Breastfeeding self-efficacy	Exp. (n = 15)	44.80 ± 6.99	43.87 ± 6.20	47.67 ± 7.10		Group	5.34	.029
						Time	5.64	.007
	Cont. (n = 14)	41.50 ± 12.97	37.07 ± 9.38	38.43 ± 11.45		Group × time	3.50	.041
Breastfeeding duration (over 180 d)	Exp. (n = 15)	-	-	-	134.27 ± 46.75		−2.09	.046
	Cont. (n = 14)	-	-	-	94.36 ± 55.95			
Recognition of hunger and satiety cues of infants	Exp. (n = 15)	2.93 ± 0.40	3.17 ± 0.34	3.38 ± 0.43	3.70 ± 0.34	Group	0.17	.685
						Time	27.71	<.001
	Cont. (n = 14)	2.89 ± 0.61	3.25 ± 0.61	3.43 ± 0.42	3.80 ± 0.32	Group × time	0.23	.878
Knowledge regarding appropriate providing of solids foods	Exp. (n = 15)	1.60 ± 0.63	2.60 ± 0.63	2.73 ± 0.59	3.20 ± 0.56	Group	3.31	.080
						Time	22.01	<.001
	Cont. (n = 14)	1.93 ± 0.73	2.29 ± 0.61	2.36 ± 0.50	2.50 ± 0.52	Group × time	4.87	.009

Note. Cont. = control group; Exp. = experimental group; M = mean; SD = standard deviation.

although there was no significant between-group difference ($F = 1.09$, $p = .305$). According to the Bonferroni test, although breastfeeding attitude score at 1 month after childbirth was significantly lower compared with the baseline score (95% confidential interval [CI]: −4.80 to −1.96, $p < .001$), breastfeeding attitude scores were significantly higher at 3 months (95% CI: 2.48–6.64, $p < .001$) and 6 months after childbirth (95% CI: 3.21–7.04, $p < .0.001$) than the score at 1 month after childbirth.

Furthermore, for breastfeeding self-efficacy, statistically significant differences were noted between the groups ($F = 5.34$, $p = .029$) across time points ($F = 5.64$, $p = .007$) and interactions between the groups and times ($F = 3.50$, $p = .041$). According to the Bonferroni test, breastfeeding self-efficacy score at 1 month after childbirth was significantly lower when compared with the baseline score (95% CI: −4.61 to −0.75, $p = .008$). According to the Bonferroni test, breastfeeding self-efficacy score at 1 month after childbirth was significantly lower when compared with the baseline score (95% CI: −4.61 to −0.75, $p = .008$). However, the breastfeeding self-efficacy score significantly increased at 6 months after childbirth (95% CI: 2.17–7.04, $p = .001$) than the score at 1 month after childbirth. In addition, breastfeeding self-efficacy score at 6 months after childbirth increased significantly than the score at 3 months after childbirth (95% CI: 0.59–3.46, $p = .008$).

Regarding breastfeeding duration until 6 months (180 days) after birth, the mean breastfeeding duration of the experimental group (134.27 ± 46.75 days/180 days) significantly increased compared with the control group (94.36 ± 55.95 days/180 days; $t = -2.09$, $p = .046$).

With regard to recognition of hunger and satiety cues of infants, although there was a statistically significant difference across time points ($F = 27.71$, $p < .001$), there was not a statistically significant difference between the groups ($F = 0.17$, $p = .685$) and interaction between the groups and times ($F = 0.23$, $p = .878$). According to the Bonferroni test, the score of recognition of hunger and satiety cues of infants significantly increased from the baseline score after the intervention.

Regarding knowledge of providing solid food for overweight prevention in infants, statistically significant differences were noted across time points ($F = 22.01$, $p < .001$) and interactions between the groups and times ($F = 4.87$, $p = .009$), although there was no significant difference between the groups ($F = 3.31$, $p = .080$). According to the Bonferroni test, knowledge scores regarding appropriate providing of solid foods at 1 month (95% CI: 0.36–1.00, $p < .001$), 3 months (95% CI: 0.48–1.09, $p < .001$), and 6 months after childbirth (95% CI: 0.84–1.33, $p < .001$) increased significantly compared with the baseline score. In addition, the knowledge score regarding providing appropriate solid foods at 3 months (95% CI: 0.478–1.09, $p < .001$) and 6 months after childbirth (95% CI: 0.84–1.33, $p < .001$) increased significantly compared with the score at 1 month after childbirth.

Discussion

This study identified the effects of a mobile-based maternal feeding education program developed for overweight prevention in infants. According to the results in this study, the experimental group showed significantly more positive breastfeeding attitude, higher breastfeeding self-efficacy, and increased breastfeeding duration than the control group. In previous maternal education programs using various educational materials including pamphlets and lectures [28,29], breastfeeding education had a significant effect on increased positive breastfeeding attitude, breastfeeding self-efficacy, breastfeeding practice, and longer breastfeeding duration.

According to a conceptual framework explaining maternal breastfeeding practice based on social cognitive theory [30], social support such as advice and educational programs from health care providers can improve knowledge, positive attitude, and self-efficacy toward breastfeeding, leading to increased breastfeeding behaviors. On the same lines, Meedya et al [31] also reported that breastfeeding attitude and self-efficacy were significant modifiable factors influencing breastfeeding intention and duration. In detail, as breastfeeding attitude was a strong predictor of feeding choice, the breastfeeding attitude had maximum effect on the breastfeeding intention of mothers [32]. In addition, maternal breastfeeding attitude was influenced by relationships with significant people in close social networks, including family members and health care providers [33]. In detail, hearing about the benefits of breastfeeding from various sources such as health care providers was associated with increased positive breastfeeding attitude, which led to improved breastfeeding intention [34]. Furthermore, as increased breastfeeding self-efficacy was significantly associated with longer breastfeeding duration for 6 months after childbirth [31], maternal breastfeeding self-efficacy was influenced by increased knowledge, positive breastfeeding attitudes, and social support such as guidance from health care providers that plays an important role in the onset and continuation of breastfeeding [33]. In this context, Parsa et al [35] emphasized the importance of social support for a more positive breastfeeding attitude and increased breast self-efficacy, leading to successful breastfeeding after

childbirth. Therefore, the mobile-based maternal feeding education program might improve positive breastfeeding attitude and breastfeeding self-efficacy, which can lead to increased breastfeeding duration with high breastfeeding intention, by providing advice and knowledge regarding breastfeeding methods and benefits of breastfeeding, such as overweight prevention in infants. In particular, the intention to breastfeed by Korean mothers might be influenced by significant family members such as their mothers and mothers-in-law. This is in line with Korean culture, where, as in other Asian countries, parenting practices for young children tend to be followed with advice from grandparents [19]. However, Korean grandparent's knowledge about breastfeeding was less than that of Korean mothers of infants and undergraduate students [36]. Therefore, the mobile-based maternal feeding education program will be helpful in improving breastfeeding attitudes and breastfeeding self-efficacy from increased accurate knowledge, which could lead to increased intention to breastfeed among Korean mothers.

In addition, the experimental group showed significantly increased knowledge regarding providing solid foods for overweight prevention in infants than the control group. According to a previous study, a video-based maternal feeding education for overweight prevention in infants was also effective for improving maternal infant feeding knowledge and behaviors [22]. As parents and primary caregivers, mothers are key people for structuring early feeding; according to the family ecological model, parental practices for obesity prevention of their children were determined by child and parental factors [37]. Among the parental factors, increased parental agreement on weight management of their children with high knowledge about behaviors to reduce obesity risk was a significant factor [37]. In this context, the mobile-based maternal feeding education program containing information regarding providing solid foods for overweight prevention in infants might contribute to maternal feeding practice by improving maternal agreement and behaviors.

However, regarding the improvement of recognition of hunger and satiety cues by infants, the mobile-based maternal feeding education program was not effective. To sensitively recognize the hunger and satiety cues, it is important that infants send clear cues to their mothers, and mothers should distinguish the characteristics of each cue and interpret them accurately [38].

Mothers should acquire the skills to recognize their infant's unique hunger and satiety cues expressed by body movement, facial expressions, and vocalization [39]. However, the mobile-based maternal feeding education program only included education about common and classic hunger and satiety cues. In addition, maternal recognition of their infant's hunger and satiety cues might be improved with high-quality interaction between mothers and infants, which is influenced by various factors, including socioeconomic status, environment, and perception of the infant's weight [39]. Therefore, to develop sensitive recognition of their infant's hunger and satiety cues, mothers might need repeated and varied experiences of interaction with their infants as well as knowledge-based education. In this context, the effectiveness of the mobile-based maternal feeding education program for providing information regarding hunger and satiety cues of infants might be limited.

The study had certain limitations. Owing to the small sample size, statistical power was insufficient. Participants were recruited from only two obstetrics and gynecology clinics located in a metro city. Therefore, further studies are needed with sufficient participants from multiple obstetrics and gynecology clinics from diversely populated urban and rural areas. Next, this study did not test the effects of mobile-based education against other educational material. Therefore, in future studies, which compare educational effects according to educational material, the effects of mobile-based education should be verified. Finally, this study did not confirm the effects related to adiposity of infants. Therefore, further studies might be required for test effects on adiposity of infants, with longer follow-up periods.

Conclusion

The results of this study showed that a mobile-based maternal feeding education program for overweight prevention in infants was effective in improving positive breastfeeding attitudes, breastfeeding self-efficacy, breastfeeding duration, and knowledge regarding providing appropriate solid foods to infants. Furthermore, mobile-based education is an extremely user-friendly method as mothers can access necessary information such as healthy maternal feeding practices without any physical contact and at a place and time convenient for them.

Funding resource

This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea Government, Ministry of Science, ICT & Future Planning (2017R1C1B1003762).

Conflict of interest

The author declares that they have no conflict of interest.

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