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Nutrition Education via A Mobile Application on Weight Loss and Quality of Life: A Randomized Controlled Trial

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ABSTRACT

Objective: To evaluate the effect of nutrition education supported by MOtiVE mobile application on weight loss and quality of life (QoL).

Methods: In this pilot randomized-controlled study, 79 overweight/obese patients who presented to University Hospital between March-September 2018 to consult a dietitian, were included. All the participants were provided with a weight-loss diet program. Then, participants were randomized to experimental and control groups. During the first interview, all participants completed the questionnaire and anthropometric measurements were done. BMI, the scores obtained from different QoL scales, and Healthy Eating Index (HEI) were the dependent variables. Daily messages were sent to cases for 3 months via MOtiVE mobile application. All the participants were asked to be present three months later for a follow-up appointment. Using SPSS 25.0, change in BMI, QoL scores, and other variables within both groups were assessed via Wilcoxon signed-rank test and McNemar chi-square test.

Results: 20 cases and 18 controls completed the study. The mean BMI decreased significantly in both groups being more predominant in cases (p=.001 for cases and p=.006 for controls). Waist circumference decreased (p=.029), self-esteem (p=.035) and healthy eating scores (p=.007) increased only in cases. Hence there were significant improvements in cases, in the final evaluation, there were no significant differences between the groups (p>.05)

Conclusion: Nutrition education supported by MOtiVE mobile application improved anthropometric measurements, self-esteem, quality of life, and healthy eating habits of the overweight/obese participants. Free mobile applications can be used in increasing motivation to adopt new behaviors to tackle obesity.

Keywords: Obesity, mobile applications, nutrition, education, quality of life,

1. INTRODUCTION

Obesity is a multifactorial and chronic disease characterized by excessive accumulation of fat in the body resulting from the interaction between genetic and environmental factors. According to World Health Organization in 2016, more than 1.9 billion adults were overweight and over 650 million were obese (1). Several studies showed that obese persons report a lower health-related quality of life (HRQoL) than their non-obese counterparts (2). In weight loss programs, the most important factor is lifestyle changes. Technology-based interventions are considered a valid tool for weight loss and seem to increase program adherence (3). Studies conducted on this issue have shown that such programs, although short-term, lead to positive changes in diet, physical activity level, glycemic control, anthropometric measurements, and biochemical parameters (4-7). In a systematic review of adults, Alnuaimi et al. (8) found that mobile applications are more effective than standard interventions in weight management and maintenance of weight loss. In a study by Nikolaou and Lean (9), it was found that mobile health apps are the fastest growing area in the e-health sector, among 100000 health apps in app stores, about 29000 of them are related to obesity (physical activity, diet, energy intake and expenditure etc.) but only 17 of them were developed by professionals. As a result, even though these applications are very common, they lack professional content expertise. MOtiVE is an application developed exclusively for this study by expert researchers. It is aimed to increase compliance with the diet by both informing the participants and increasing their motivation by sending compact information messages to the participants. The app can also track and report which participant opened which message to see if the messages reached the target. In several studies, low self-esteem and poor body image were determined to be associated with obesity (10, 11). Providing motivational support to achieve lifestyle changes can play a significant role in maintaining weight loss by increasing self-esteem. As far as we can see, when the study was conducted, this was the first study that aimed to provide nutrition education and motivation through a mobile application, thus aiming to improve

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anthropometric indices and quality of life measures. In parallel, the application was the first application developed in the field with these features in Turkish. The main purpose of the present study was to compare the effect of standard education on weight loss, quality of life (QoL), and healthy eating behavior with that of nutrition education supported by mobile applications.

2. METHODS

2.1. Trial Design

The present study was conducted with patients who presented to the Ege University Hospital Endocrine and Metabolic Diseases Outpatient Clinic in March-September 2018 to consult a dietitian and to receive routine nutrition therapy, aged between 18-64 years and with Body Mass Index (BMI) ≥ 25 kg/m^2. The participants were first given the standard nutrition training by the dietitian in the outpatient clinic, and then a person-specific diet program. After this, the patients who gave their consent to participate in the study were randomly assigned to the case and control groups. Then, anthropometric measurements of all the participants were performed and the data collection forms were filled in. The "MOtiVE" mobile application for smartphones designed specifically for this study was installed on the smartphones of the cases, and text, visual, or video messages were sent to them via this application for three months. The participants in the control group underwent the routine procedure. In line with the routine practice of the outpatient clinic, all the participants were told to be present three months later for control appointments. At the end of December 2018, at the end of the three-month follow-up period, the data collection process ended. In a systematic review conducted by Aguilar-Martınez et al (12), showed that most of the trials last for 2-4 months.

2.2. Participants and Recruitment

Of the patients, those who did not have a smartphone with an internet connection, underwent bariatric surgery, took medication, or practice a special diet for thyroid problems, diabetes, celiac, gout, and kidney diseases, and whose body fat analysis was not fulfilled due to the presence of a pacemaker, prosthesis, etc. were not included in the study.

When we consider 80% power with a %5 error and medium effect size (dz:.5) we had to have 27 participants in each group calculated via G-power. According to the results of a study conducted by Allen et al, 25 participants in each group was enough to reach 80% power (13). When we evaluate admissions to the outpatient clinic, we saw that each week we can have 4 or 5 new participants. Thus, considering this data, we decided to take 30 participants in each group. Considering the loss in follow-up we included 40 participants in each group. The flowchart of the study is given in Figure 1. At the end of the study, the loss in follow-up was more than expected. Thus, the study was concluded with 20 cases and 18 controls. In G-power post hoc power calculations yield 98% power for BMI difference in cases (two dependent means, dz:.89, alpha:.05, n=20).

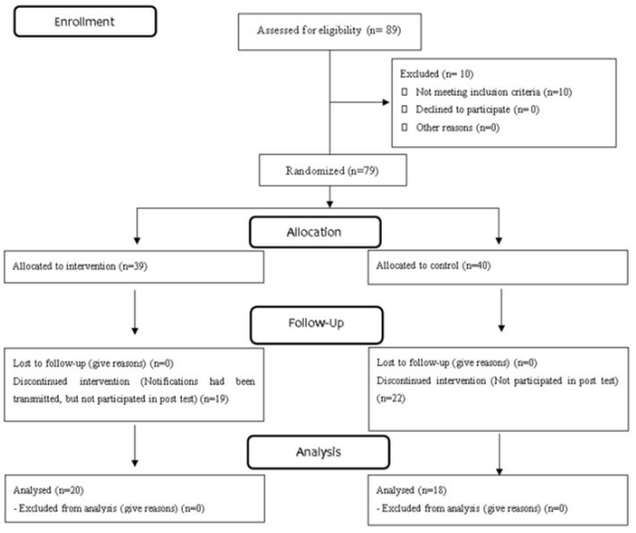

Figure 1. *The flowchart of the study*

In the present study, randomization was carried out in the following block allocation sequence: AABB, ABAB, BABA, BBAA, ABBA, BAAB.

Change in the BMI and other anthropometric indices and the scores obtained from the Weight Efficacy Lifestyle (WEL) test, Rosenberg Self-Esteem Scale (RSES), Obesity and Weight-Loss Quality of Life Instrument (OWLQoL), Healthy Lifestyle Behavior-II Scale (HLSB-II) and Healthy Eating Index (HEI) were the dependent variables.

2.3. Measurements

Anthropometric Measurements

The body height was measured with a stadiometer whereas the body weight, body fat percentage, and BMI were measured with the Tanita BC-418 Segmental Body Composition Analyzer. Waist circumference was measured with a non-elastic standard measuring tape, with the individual wearing light clothes, standing still, in an upright position, and with arms open sideward. WC was measured from the midpoint between the distal border of the lowest rib and the superior border of the iliac crest (14). Neck circumference was measured by placing the inelastic measuring tape around the neck from the point just below the laryngeal prominence.

WEL Test: It consisted of 20 questions about negative feelings, food accessibility, social pressure, physical disturbance, and positive activity. The higher the score is the better the weight efficacy lifestyle is (15, 16).

HEI: It was developed by the United States Department of Agriculture to investigate the quality of diet in Americans (17). The new HEI-2015, which was published in 2018, consists of 13 components related to diet. The increase in scores indicates a positive development (18). Nutritional values for individuals based on their 24-hour food consumption records were calculated using the BEBIS, Turkish dietary data system.

RSES: The first 10 items of the scale are used to measure self-esteem. Self-esteem increases as the score obtained from the RSES decreases (19, 20).

HLSB-II: The scale includes health responsibility, exercise, nutrition, self-actualization, interpersonal support, and stress management subscales (21, 22).

OWLQOL: The higher the score obtained from the scale, the higher the quality of life of the person is (23, 24).

All of the scales were validated in Turkish and found to be reliable to use in Turkish. Among the scales, WEL test, HLSB-II, HEI could be accessed freely through internet sources, thus no permission was obtained for these scales. Turkish version of the Rosenberg Self-esteem Scale is under the license of Turkish Children and Adolescent Psychiatry Association and the fee for the license was paid by the authors. Written permission was obtained from the authors of the OWLQoL-Turkish version.

2.4. MOtiVE Application for Mobile Phones

The program was developed by researchers with technical support from a software engineer, specifically for this study and it is compatible with both Android and IOS. The messages were developed in Turkish by the researchers using the latest guidelines by Ministry of Health and other authorities (25-27). The messages were sent to the participants in the case group once a day for three months. Messages sent to the phone screen every morning at 9:00 AM were either text, visual, or video messages. The visual messages designed to draw the attention of the reader included both a text and an illustration (Figure 2). There were 90 messages disseminated, 26 of them visual, 10 of them were videos, and the rest were text messages containing compact information.

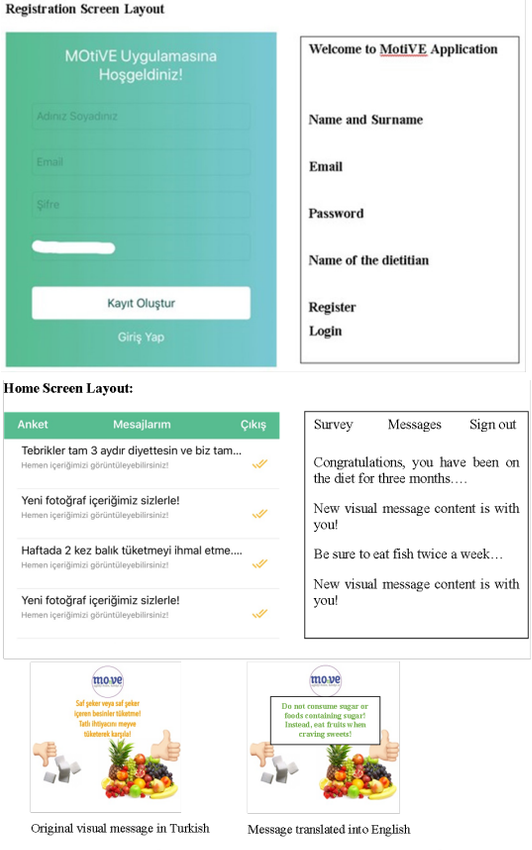

Figure 2. *Screenshots from MOtiVE and examples of messages*

By sending text messages like "*Sunday is the only day when most of us do not work. You will be more comfortable during the weekdays if you do your shopping and prepare meals on the weekend. Prepare your meatballs this Sunday and freeze them….*", practical solutions were offered to the participants. By sending text messages like "*Lifestyle changes improve your quality of life and enable you to lead a better quality of life. Improve your quality of life with diet and regular exercise. Thus, do not give up...*" the participants were motivated.

Video messages were uploaded to YouTube and a link address (e.g., What is an antioxidant? https://www.youtube.com/watch?v=TIaQq1CbNBM) was sent to the cases, which enabled them to access. The videos were also subtitled so that the watcher could get the message in noisy environments. The registration screen of the MOtiVE, home screen layout, and samples of messages sent for 90 days are given in additional files.

One of the features of the MOtiVE is to calculate how many days the participant was following the program and to send the message specific to that day to the person's phone. Thanks to this feature of the MOtiVE, it was possible to send a message like *"Congratulations, you have been on a diet for a full month…"* to the person who participated in the program for a month. Thus, the program was made person-specific. Another feature of the MOtiVE is that only one-way communication was possible to avoid bias. The application enabled only the researchers to send messages to the participants but did not allow the participants to communicate with the researchers. In this way, standardization was established between the participants in terms of determining their knowledge and interest. Another feature of the MOtiVE is to report whether the participants see the message of that day, which enabled the researchers to find out whether the participant has read the messages.

2.5. Statistical Analysis

In the analysis of the study data, IBM SPSS Statistics (version 25; IBM, New York, NY, USA) was used. Continuous variables were presented with mean ± standard deviation. At the baseline, the homogenous randomization of the participants to the case and control groups was investigated using the independent samples t-test (Mann Whitney-U test if the parametric condition could not be met) and chi-square tests. The efficacy of the intervention was assessed using Wilcoxon signed rank test separately in the case and control groups. $p<.05$ considered significant.

2.6. Ethical Issues

The study was conducted following the Declaration of Helsinki and ethical approval was obtained from Ege University Medical Research Ethics Committee (no:17-7.1/14, 08.08.2017) and the written consent was obtained from the patients. The study was recorded in clinical trials (no: ClinicalTrials.gov NCT04026971). This study adheres to CONSORT guidelines.

3. RESULTS

Of the participants (cases:20, controls:18), 90% in the case group and 83.4% in the control group were women. There was no significant age difference between cases and controls (34.7±14.0 years vs. 38.7±13.5 years; p=.349). The analysis performed to test whether the participants who took the final test had been homogenously randomized to the case and control groups at the baseline revealed that there were no significant differences between the groups in terms of their sociodemographic characteristics, anthropometric measurements, or the scores they obtained from the RSES, OWLQOL, HLSB-II scale, WEL test, and HEI and their sub-dimensions except for the nutrition subscale of the HLSB-II scale (p>.05). The participants in the control group obtained significantly higher scores from the nutrition subscale of the HLSB-II scale (Case group: 20.9±3.6, Control group: 23.6±4.2, p=.043). Therefore, it can be said that the participants were homogenously distributed to the case and control groups. According to the feedback provided by MOtiVE, all participants read all the messages.

Although weight, BMI and neck circumference measurements of the participants significantly decreased in both groups at the end of the 3 months, these differences were more dominant in the cases. Waist circumference decreased significantly only in cases. But in the final evaluation there were no significant differences between the groups. The changes in the anthropometric measurements of the participants at the end of the three-month follow-up were given in Table 1.

RSES scores significantly decreased in the cases which showed an increase in self-esteem. There were no significant changes in the WEL test scores of the participants in both groups. HLSB-II scale scores significantly increased only in the cases. As for the subscales of the HLSB-II scale, there were significant increases in the nutrition and stress management subscale scores in the cases. While the mean HEI scores of the controls did not change significantly at the end of the three months, those of the cases increased significantly. But in the final evaluation there were no significant differences between the groups. The comparison of all the data collection tools used in the present study is presented in Table 2.

Table 1. *Comparison of Anthropometric Measurements*

Measurements	Groups	n		Mean	SD	Median	Min.	Max.	p* within groups	p** First	p** Final
Weight, kg	Case	20	First test	91.4	18.0	89.3	67.7	129.0	**.001**	.682	.726
			Final test	88.5	17.1	87.2	66.3	120.9			
	Control	18	First test	89.4	17.9	86.2	67.1	128.9	**.006**		
			Final test	86.4	16.9	83.7	61.8	125.4			
BMI, kg/m^2	Case	20	First test	33.8	6.0	33.2	25.7	45.7	**.001**	.907	.953
			Final test	32.8	5.8	31.9	23.8	43.0			
	Control	18	First test	33.3	5.0	32.6	26.0	41.6	**.006**		
			Final test	32.2	4.7	32.5	23.8	40.4			
Body Fat Percentage, %	Case	20	First test	39.5	5.2	26.6	46.7	40.3	.489	.511	.569
			Final test	39.3	6.0	24.9	47.7	39.5			
	Control	18	First test	39.1	4.6	30.5	48.3	38.3	.556		
			Final test	38.7	4.9	29.3	46.0	39.1			
Waist circumference (cm)	Case	20	First test	108.2	15.1	86.0	141.0	109.5	**.029**	.770	.895
			Final test	106.1	15.1	82.0	135.5	107.0			
	Control	18	First test	108.3	12.7	87.0	130.0	108.5	.060		
			Final test	105.5	12.4	86.0	126.0	105.0			
Neck circumference (cm)	Case	20	First test	37.3	3.5	33.0	45.0	36.2	**.001**	.428	.371
			Final test	36.4	3.3	33.0	44.5	35.7			
	Control	18	First test	38.3	4.1	32.5	48.0	38.0	**.028**		
			Final test	37.5	4.3	32.0	48.0	36.5			

(*): Wilcoxon signed rank test, (**) Mann Whitney-U test. P values printed in bold indicate a significant difference.

Table 2: *Comparison of all the data collection tools used in the present study*

Scales	Groups	n		Mean	SD	Median	Min.	Max.	p*	p** First	p** Final
RSES	Case	20	First test	1.1	0.7	1.0	0.25	2.9	**.035**	.489	.407
			Final test	0.7	0.5	0.6	0.25	2.0			
	Control	18	First test	0.9	0.5	0.8	0.25	2.3	.723		
			Final test	0.9	0.6	0.7	0	2.3			
OWLQOL	Case	20	First test	55.2	16.6	58.0	28.0	87.0	.064	.568	.219
			Final test	45.3	21.5	38.5	20.0	95.0			
	Control	18	First test	51.3	21.0	50.0	11.0	95.0	.331		
			Final test	49.7	22.4	52.5	2.0	93.0			
HLSB-II	Case	20	First test	131.0	15.4	126.5	11.0	173.0	**.021**	.404	.396
			Final test	141.0	19.5	144.0	111.0	188.0			
	Control	18	First test	135.0	20.2	135.0	99.0	177.0	.981		
			Final test	135.0	19.3	129.5	109.0	167.0			
HLSB-II Health Responsibility	Case	20	First test	21.7	4.7	21.0	12.0	31.0	.294	.445	.977
			Final test	23.0	5.2	23.0	16.0	33.0			
	Control	18	First test	22.8	5.4	23.0	11.0	33.0	.896		
			Final test	22.8	5.3	22.0	14.0	33.0			
HLSB-II Exercise	Case	20	First test	15.7	4.2	15.5	8.0	24.0	.245	.481	.660
			Final test	17.0	5.6	17.5	8.0	29.0			
	Control	18	First test	14.8	5.4	14.0	8.0	25.0	.325		
			Final test	16.1	4.6	16.5	9.0	24.0			
HLSB-II Nutrition	Case	20	First test	20.9	3.6	21.0	15.0	31.0	**.001**	**.043**	.362
			Final test	25.0	4.2	25.5	17.0	36.0			
	Control	18	First test	23.6	4.2	23.5	18.0	33.0	.950		
			Final test	23.9	4.1	23.0	18.0	32.0			
HLSB-II Self-actualization	Case	20	First test	26.7	2.9	26.5	21.0	33.0	.124	.965	.363
			Final test	27.7	3.1	28.0	20.0	34.0			
	Control	18	First test	26.8	3.8	26.0	21.0	34.0	.457		
			Final test	26.6	4.2	26.0	19.0	34.0			
HLSB-II Interpersonal Support	Case	20	First test	26.9	3.5	27.5	21.0	33.0	.323	.713	.325
			Final test	27.5	4.1	29.0	21.0	35.0			
	Control	18	First test	27.7	4.1	28.0	21.0	36.0	.175		
			Final test	26.3	4.6	24.5	18.0	35.0			
HLSB-II Stress Management	Case	20	First test	18.9	2.9	18.5	15.0	25.0	**.036**	.791	.116
			Final test	20.7	3.2	21.0	14.0	28.0			
	Control	18	First test	19.0	3.3	19.5	13.0	26.0	.876		
			Final test	19.1	3.1	18.0	14.0	26.0			
WEL Test	Case	20	First test	51.0	13.7	48.0	24.0	89.0	.256	.492	.306
			Final test	47.7	16.9	46.5	20.0	91.0			
	Control	18	First test	47.2	16.8	48	20.0	83.0	.177		
			Final test	42.0	12.7	39.0	26.0	70.0			
HEI Score	Case	20	First test	49.2	9.8	52.0	30.0	65.0	**.007**	.230	.849
			Final test	56.1	11.4	56.5	34.0	72.0			
	Control	18	First test	53.7	8.2	54.0	43.0	68.5	.486		
			Final test	55.7	10.3	55.7	37.0	72.5			

(*) Wilcoxon signed rank test. (**) Mann Whitney-U test.
P values printed in bold indicate a significant difference.
HEI: Healthy Eating Index; HLSB-II: Healthy Lifestyle Behavior-II Scale; OWLQOL: Obesity and Weight-Loss Quality of Life; RSES: Rosenberg Self-Esteem Scale; WEL: Weight Efficacy Lifestyle

4. DISCUSSION

The use of internet-based applications to develop a healthy lifestyle is increasing. However, most of these programs have not been evaluated with appropriate and standardized methods and have different exposure times. Safran Naimark et al. (28) investigated the effect of an internet-based application on improving a healthy lifestyle in a randomized controlled trial. They collected data on nutrition knowledge, diet quality, and physical activity periods using online data collection forms. The cases used the Internet-based application designed based on healthy lifestyle

recommendations of the US Department of Agriculture and the Israeli Ministry of Health for 14 weeks. Of the 99 participants, 86% of them (n=85, 56 in the case group, 29 in the control group) completed the study. Besides significant weight loss (p=.03), knowledge score, diet quality score, and success score indicating success in maintaining a healthy life increased significantly in the cases. There was a significant correlation between the frequency of using the application and a high success score (p<.01). Similarly, in their randomized controlled study aimed at weight loss, Patrick et al. (29) sent SMSs and/or multimedia messages to the participants in the case group 2-5 times a day for 16 weeks. At the end of the 16th week, the weight loss in the cases was significantly higher (p=.02). It was concluded that SMSs and multimedia messages could promote behaviors supporting weight loss in obese adults. In the present study, all participants took nutritional training first with their diets and then randomized to cases and controls. That could be the reason for controls to lose weight significantly as well as cases, cases being more predominant. Besides weight loss, the present study showed significant improvements regarding self-esteem; healthy lifestyle behaviors, quality of life, and healthy eating habits were observed only in cases. Therefore, in line with Patrick et al.'s study, mobile applications can improve behaviors that support weight loss. Moreover, a recently published meta-analysis concluded that even though there are concerns about the study designs, mobile apps and wearables can be effective self-regulating tools for weight loss (30).

A meta-analysis including 14 randomized controlled trials to investigate whether internet-based interventions were effective in empowering patients concluded that these interventions yield positive improvements. On the other hand, in 3 studies using general self-efficacy scales and in 1 study using the RSES conducted to assess self-esteem, no changes were observed. The comparison of face-to-face interviews and internet-based interventions demonstrated that no significant differences were observed in self-esteem (31). In the present study, cases received messages in addition to routine nutritional therapy. Unlike the meta-analysis, a significant decrease in RSES scores thus, a significant increase in self-esteem was observed in cases in the present study. However, according to the analysis of the self-efficacy scores obtained from the WEL test, we also could not show significant changes in both groups. It is thought that internet-based interventions can be used to improve self-esteem, lifestyle behaviors, and quality of life of patients but not self-efficacy.

Although the use of a mobile application led to changes in health behaviors, the mechanisms by which these applications facilitate behavior change are generally not known. West et al. (32) conducted a cross-sectional study including 217 participants. The participants gave their feedback about their diet and nutrition applications in the last 6 months and most of the participants agreed that the application increased their dietary motivation, improved their self-efficacy, and increased their willingness to set dietary goals and to reach the target. Therefore, it was concluded that diet and nutrition-related practices focusing on the improvement of motivation, willingness, self-efficacy, attitude, knowledge, and goal setting might be particularly useful. Jacobs et al. (33) demonstrated the importance of adherence to intervention on weight loss in a large sample using a smartphone application *Noom* tracking individual self-monitoring and showed that after three months, a significant reduction in BMI was accomplished. They concluded that smartphone application use can induce weight loss associated with adherence. The present study was also aimed at improving healthy lifestyle behaviors by inducing motivation. At the end of the present study, there was a significant improvement in the mean scores of BMI as well as from the overall HLSB-II scale and only its nutrition and stress management subscales.

Limitations and Strengths

The mobile application MOtiVE and its unique features solely designed for this study can be considered the main strength of this study. Personal feedback about messages, personal timing, and sending messages according to enrollment time makes this program tailored to participants. All the participants read the messages, so the messages were considered to be attractive and not boring. Moreover, one-way communication ensured the standardization of knowledge and motivation. In the final evaluation, there were no significant differences between the groups in terms of anthropometric measurements. This can be expected since both groups received nutritional therapy and counseling. On the other hand, some of the quality measures significantly increased in cases, but not in controls, even though it did not reach a significant difference in the final evaluation. This can be due to loss in follow-up and relatively small sample. Even though there were significant losses during the follow-up period, the study reached 98% power to detect significant differences in BMI within cases.

5. CONCLUSIONS

In conclusion, it is thought that provision of mobile application-based nutrition education to overweight and obese individuals in addition to routine nutritional therapy may lead to improvements in anthropometric measurements, self-esteem, healthy lifestyle behaviors, quality of life, and healthy eating habits of the participants, and it might help to achieve the targeted weight loss. As the number of dietary and nutritional practices continues to increase, to ensure healthy lifestyle behavior changes, application developers together with health professionals should consider integrating the appropriate theoretical structures into the newly developed mobile applications because these types of mobile applications are easily accessible. Such applications should be created and made available to the public free of charge for the protection of public health, and the prevention and reduction of obesity.

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Design of the study: DP, SS, RM
Acquisition of data for the study: DP, SS
Analysis of data for the study: DP, RM
Interpretation of data for the study: DP, SS, RM
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