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ORIGINAL RESEARCH

Duration of Treatment in a Weight Loss Program Using a Mobile App is Associated with Successful Weight Loss During the COVID-19 Pandemic

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Purpose: We aimed to explore the independent factors associated with successful weight loss using a mobile app during the COVID-19 pandemic.

Patients and Methods: For this retrospective cohort study, we collected data from 45 adults in a weight loss program using a mobile app. We defined successful weight loss as a weight reduction by ≥ 5% of the baseline weight. Multivariate logistic analysis was used to assess potential factors influencing successful weight loss.

Results: All subjects showed a mean 4.1 ± 4.4 kg reduction of baseline weight after using the app for a mean duration of 11 weeks ($P < 0.001$). Subjects in the successful weight loss group displayed a longer duration of treatment (14.6 ± 6.5 weeks vs 6.9 ± 6.0 weeks, $P < 0.001$), greater number of dietary records (109.2 ± 84.7 vs 54.7 ± 58.8, $P = 0.002$), and greater number of outpatient visits (6.1 ± 2.7 vs 3.7 ± 2.3, $P < 0.001$) than those in the unsuccessful weight loss group. Multivariate logistic analysis showed that duration of treatment was an independent factor associated with successful weight loss (odds ratio = 1.23, 95% confidence interval: 1.08–1.41, $P = 0.003$).

Conclusion: In a weight management program using a mobile app during the COVID-19 pandemic, the duration of treatment was found to be an independent factor of successful weight loss.

Keywords: weight loss, mobile app, person-to-person feedback, COVID-19, diet tracking, real-life practice

Introduction

Overweight and obesity are risk factors for noncommunicable diseases, such as type 2 diabetes, cardiovascular disease, and some cancers.[1–4] Globally, the prevalence of obesity and overweight has significantly risen over the past three decades,[5] and the projected obesity trends are expected to enhance its economic burden.[6] In Taiwan, the prevalence of obesity in adults has also increased over the past two decades, and approximately half of adults in Taiwan have become overweight or obese.[7,8] Weight loss through lifestyle modification can significantly produce health benefits.[9–12] However, only a small proportion of patients with obesity undergoing lifestyle modification achieve clinically significant weight loss and weight loss maintenance.[13,14] To date, no country has succeeded in reversing the current obesity pandemic.[15]

Since coronavirus disease 2019 (COVID-19) was declared a global pandemic,[16] several studies conducted in different countries have shown lower diet quality, higher overeating frequency, less physical activity, and weight gain during the COVID-19 pandemic compared to before the COVID-19 pandemic.[17–20] Furthermore, obesity increases the risk of severe COVID-19 illness, hospitalization, and mortality.[21–24] However, weight management programs for obesity have been reduced during the COVID-19 pandemic to ensure the safety of patients and healthcare professionals.[25] Thus, remote approaches instead of face-to-face interactions for weight management are required.

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Prior to the COVID-19 pandemic, many studies demonstrated that telehealth and mobile health (mHealth) technologies are effective tools for weight loss treatment.[26] Weight loss treatment delivered by smartphone applications (apps) may lead to higher adherence and greater weight loss compared to that delivered by websites or paper diaries.[27] In the Asian population, the use of a mobile app applied to weight loss may also have benefits for improving diet quality and weight loss self-efficacy.[28,29] During the COVID-19 pandemic, the use of telehealth increased by almost 200% in the US.[30] Recently, a randomized clinical trial, using the mHealth app to promote ketogenic diet during the COVID-19 pandemic, found that self-reported dietary adherence is an important predictor of weight-loss success.[31] Thus, telehealth technologies may be a feasible choice for weight management during the COVID-19 pandemic.

Although a nation-wide lockdown was not implemented until May 18, 2021, a social distancing policy was implemented after a locally-transmitted COVID-19 infection was reported on January 21, 2020 in Taiwan.[32] Assembly and gathering were restricted according to public assembly guidelines published by the Taiwan Centers for Disease Control. Since September 1, 2020, the Taichung Veteran General Hospital (VGH) provided a weight management program, which combined self-monitoring of meal tracking and weight tracking as well as person-to-person individualized feedback, via a mobile app during follow-up in the Weight Control Outpatient Department in the Taichung VGH.

The present study retrospectively assessed data from real-life practice to examine the degree of weight loss during a mobile weight management program in the Taichung VGH during the COVID-19 pandemic and explored independent factors associated with successful weight loss.

Materials and Methods

Patients

We retrospectively collected the medical information of subjects who had undergone weight loss treatment at the Weight Control Outpatient Department in the Taichung VGH between September 2020 and May 2021. The inclusion criteria were: (1) age between 20 and 64 years; (2) initial body mass index (BMI) $\geq$ 24 kg/m^2; (3) patients registering the homecare app between September 2020 and May 2021. The exclusion criteria were: (1) changing any medications within 3 months before the first visit; (2) the use of anti-obesity drugs within 3 months before the first visit; (3) the use of glucagon-like peptide 1 agonists; (4) a history of bariatric surgery; (5) weight loss by > 5% in 6 months prior to baseline measurements; (6) a history of endocrine disorders; (7) a history of drug addiction or psychological disorders; (8) the use of systemic steroids; (9) pregnancy; and (10) no any meal photo uploaded onto the homecare app. Finally, we enrolled participants in our analyses only if they had at least two anthropometric measurements at different visits during the program (Figure 1).

Taichung VGH Homecare App

The Taichung VGH homecare app is a non-commercial app consisting of a patient interface and a professional interface. The patient interface allows subjects to record their blood pressure, blood glucose, body weight, and meal contents via a smartphone. Particularly, meal contents can be uploaded as photos with text annotations and patient users can obtain feedback messages from professional users. The professional interface is the backstage management system, accessible by professional users. Professional users monitor the records of blood pressure, blood glucose, body weight, and meal contents uploaded by participants. Notably, professional users can send person-to-person messages in response to meal photos through the professional interface.

Mobile Weight Management Program

The mobile weight management program was provided, beginning September 1, 2020. Patients in the first visit to the Weight Control Outpatient Department registered in the Taichung VGH homecare app. Patients were assigned to a personalized meal plan with a specific calorie and macronutrient goal based on their initial weight. This program used daily weight tracking, meal tracking, and personalized feedback for meal tracking on the homecare app. Patients were encouraged to participate in weight tracking every day and upload all food and beverages consumed throughout the program without a limit on the number of food logs entered daily. Patients logged meals, snacks, treats, and beverages,

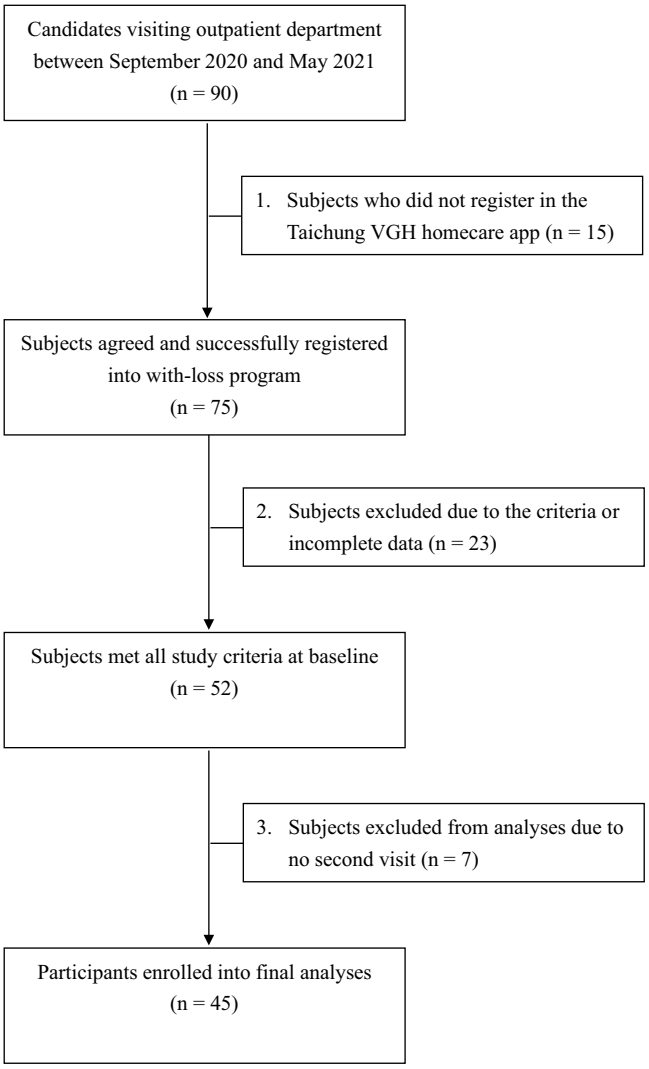

Figure 1 Flow diagram of the enrollment of study subjects.
Abbreviation: VGH, Veteran General Hospital.

including their photo, description, and quantity. Each photo of an individual meal, snack, treat, or beverage was considered a single food log entry.

Professional users, four physicians and one dietitian, checked the weight and meal tracking records on the professional interface and sent personalized feedback messages, including mental health support and diet education based on each meal photo, to the patient-user interface. Diet education included estimation of calorie, knowledge and estimation of macronutrients, and suggestions for dietary adjustments. Patient users received messages on the homecare app from professional users, and were encouraged to adjust their diet content based on recommendations to meet their personalized meal goals (Figure 2).

Outpatient follow-up visits were requested in an interval of less than 3 months, and anthropometric measures (body weight, waist circumference, hip circumference, body fat mass, skeletal muscle mass, body fat mass percentage, and fat-free mass) were evaluated on every follow-up visit. Patients who did not attend the next outpatient follow-up visits within 3 months were defined as being at end of weight loss treatment.

Assessment

Baseline data obtained from the medical records of the initial face-to-face interview included age, sex, and anthropometric measures (body height, body weight, waist circumference, hip circumference, body fat mass, skeletal muscle

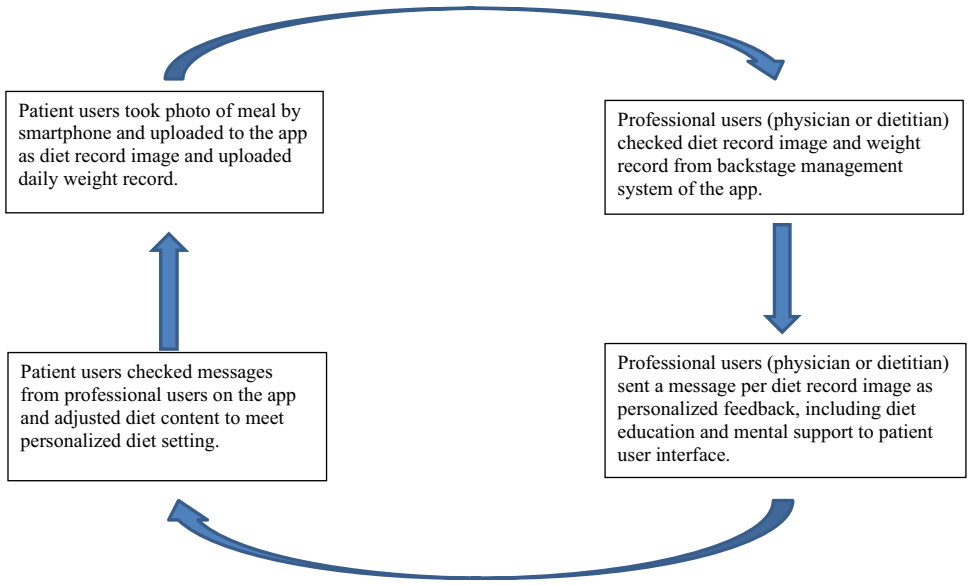

Figure 2 Circuit of mobile weight management program on the app.

mass, body fat mass percentage, and fat-free mass). Body weight, body fat mass, body fat mass percentage, skeletal muscle mass, and fat-free mass were measured at every follow-up visit with a calibrated bioelectrical impedance scale (InBody 230 multifrequency analyzer, Biospace Corp., Seoul, Korea). BMI was calculated through the following equation: weight (kg)/(height [m])^2. Waist circumference was measured to the midpoint between the lower border of the rib cage and the iliac crest. Hip circumference was measured at the level of the greatest protrusion of the buttocks when the subject was standing erect with feet together.

Type 2 diabetes was defined according to a recorded diagnosis of type 2 diabetes or use of antidiabetic drugs, an HbA1c level ≥ 6.5%, or a fasting glucose level ≥ 126 mg/dL before the date of the first visit. Prediabetes was defined according to a recorded diagnosis of prediabetes, an HbA1c between 5.7 and 6.4% or glucose between 100 and 125 mg/dL before the date of the first visit in subjects who did not meet the criteria for diabetes. Hypertension was defined according to a recorded diagnosis of hypertension or use of anti-hypertensive drugs.

Educational status, marital status, fertility status, history of weight loss, exercise habits, snacking habits, and times of eating out per week were all categorized and obtained at the first weight control outpatient visit.

Outcome Measures

The primary outcome was a successful weight loss, defined as a final weight reduction by ≥ 5% of the initial body weight.[33] Changes in other anthropometric measures were defined as follows: (the last observed anthropometric measurements) – (the first observed anthropometric measurements). Duration of treatment was defined as the interval between the date of the first and last observed in-person exams. The number of dietary records was defined as the number of meal photos tracked over the duration of treatment. The number of diet records per week was defined as follows: (the number of dietary records)/(duration of treatment). The number of days of weight recording was defined as the number of days of weight tracking over the duration of treatment. The completion ratio of daily weight recording was defined as follows: (days of weight recording/days of the duration of treatment) ×100%. The number of outpatient visits was defined as the number of outpatient visits over the duration of treatment. The interval of outpatient visits was defined as follows: (weeks of treatment duration)/(number of outpatient visits).

Statistical Analyses

All continuous data are presented as the mean ± standard deviation (SD). Categorical data are presented as numbers and percentages. A Mann–Whitney *U*-test was conducted to detect significant differences in continuous variables between

groups. A Wilcoxon Signed Rank test was conducted to detect significant differences in continuous variables before and after treatment. Chi-square tests were conducted to detect differences in categorical variables. Backward-stepwise logistic regression was used to identify the factors associated with successful weight loss (weight loss by ≥ 5%). Statistical analyses were performed using SPSS version 22.0 software (IBM Corp., Armonk, NY, USA).

Results

In a total of 45 subjects enrolled in the study, a mean weight reduction of 4.1 ± 4.4 kg (P < 0.001) was observed over a mean duration of 11.0 ± 7.3 weeks. There were 24 (53.3%) subjects in the unsuccessful weight loss group with weight loss < 5%, and 21 (46.7%) subjects in the successful weight loss group, including: 14 subjects (31.1%) with weight loss between 5% and 9.9%, 5 (11.1%) subjects with weight loss between 10% and 14.9%, and 2 (4.4%) subjects with weight loss ≥ 15% (Figure 3).

The characteristics of enrolled subjects are shown in Table 1. Subjects in the successful weight loss group had lower baseline body fat percentages compared to those in the unsuccessful weight loss group (37.5 ± 6.9% vs 41.6 ± 6.3%, P = 0.032). There were no significant differences in age (37.4 ± 11.2 years vs 43.1 ± 12.3 years, P = 0.108) and sex (47.6% female vs 75% female, P = 0.114) between the successful weight loss and the unsuccessful weight loss groups, respectively. There were no significant differences in baseline body weight, BMI, waist circumference, hip circumference, body fat mass, skeletal muscle mass, body fat mass percentage, fat-free mass, number of subjects with type 2 diabetes, prediabetes, hypertension, antidiabetic drug history, educational status, marital status, fertility status, history of weight loss, exercise habits, snacking habits, and times of eating out per week between these two groups.

The use of the mobile app and other aspects of the interventions are shown in Table 2.

Subjects in the successful weight loss group had longer duration of treatment (14.6 ± 6.5 weeks vs 6.9 ± 6.0 weeks, P < 0.001), higher number of dietary records (109.2 ± 84.7 vs 54.7 ± 58.8, P = 0.002), higher number of outpatient visits (6.1 ± 2.7 vs 3.7 ± 2.3, P < 0.001), and higher interval of outpatient visits (2.5 ± 1.1 weeks vs 1.8 ± 0.9 weeks, P = 0.003) than those in the unsuccessful weight loss group. There were no significant differences in the number of dietary records per week, days of weight recording, and completion ratio of daily weight recording between these two groups.

Table 3 shows the changes in the anthropometric measurements. Subjects in the successful weight loss group had higher weight loss in percentage (8.6 ± 3.4% vs 1.3 ± 2.4%, P < 0.001), higher weight loss (7.6 ± 3.4 kg vs 1.1 ± 2.4 kg, P < 0.001), higher BMI reduction (2.7 ± 1.1 kg/m^2 vs 0.4 ± 0.8 kg/m^2, P < 0.001), higher waist circumference reduction

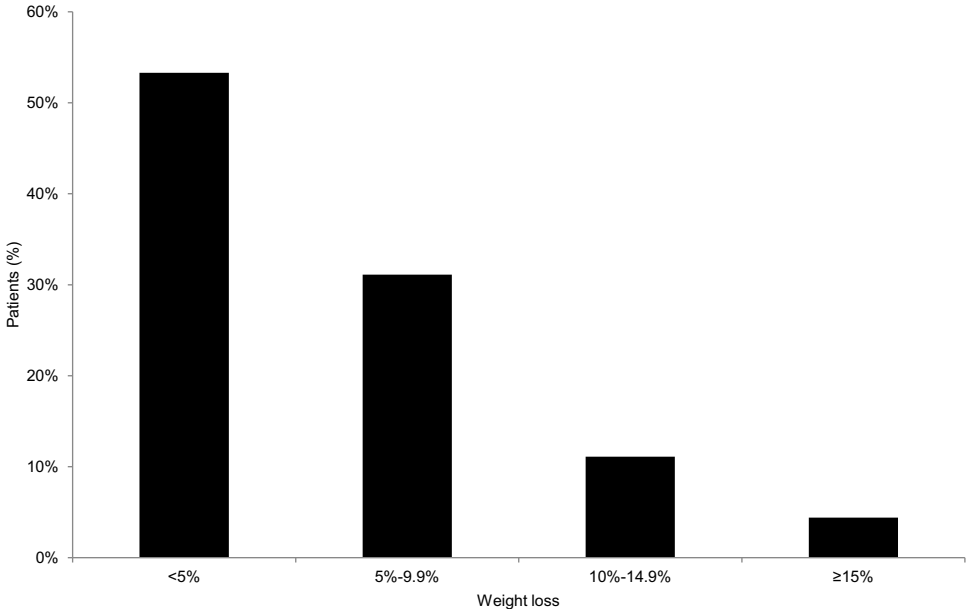

Figure 3 Proportions of patients categorized by weight loss of their baseline body weight.

Table 1 Baseline Characteristics of the Enrolled Patients

Baseline Characteristic	Total (n=45)	Weight Loss ≥ 5% (n=21)	Weight Loss < 5% (n=24)	P value
Age (years)	40.4 (12.0)	37.4 (11.2)	43.1 (12.3)	0.108
Female, n (%)	28 (62.2%)	10 (47.6%)	18 (75%)	0.114
Weight, kg	87.5 (19.2)	87.5 (17.3)	87.4 (21.1%)	0.909
BMI (kg/m^2)	31.7 (5.7)	31.3 (5.3)	32.0 (6.1)	0.690
BMI categories — no. (%)				
24≤BMI<27	8 (17.8%)	2 (9.5%)	6 (25%)	0.252
27≤BMI<30	10 (22.2%)	6 (28.6%)	4 (16.7%)	0.476
30≤BMI<35	17 (37.8%)	10 (47.6%)	7 (29.2%)	0.334
BMI≥35	10 (22.2%)	3 (14.3%)	7 (29.2%)	0.296
Waist circumference (cm)	100.9 (13.3)	100.3 (11.3)	101.6 (15.3)	0.900
Hip circumference (cm)	109.5 (10.7)	109.5 (9.4)	109.5 (11.8)	0.716
Body fat mass (kg)	35.1 (11.3)	33.2 (10.7)	36.7 (11.9)	0.260
Skeletal muscle mass (kg)	29.3 (6.9)	30.5 (6.5)	28.2 (7.1)	0.158
Body fat mass percentage (%)	39.7 (6.8)	37.5 (6.9)	41.6 (6.3)	0.032
Fat-free mass (kg)	52.4 (11.3)	52.9 (10.2)	50.7 (11.8)	0.145
Type 2 diabetes, n (%)	13 (28.9%)	4 (19.1%)	9 (37.5%)	0.302
Pre-diabetes, n (%)	25 (55.6%)	12 (57.1%)	13 (54.1%)	0.999
Hypertension, n (%)	7 (15.6%)	2 (9.5%)	5 (20.8%)	0.422
Antidiabetic drug history, n (%)	11 (24.4%)	4 (19.1%)	7 (29.2%)	0.660
Metformin, n (%)	9 (20%)	3 (14.3%)	6 (25%)	0.370
SGLT2 inhibitors, n (%)	7 (15.6%)	2 (9.5%)	5 (20.8%)	0.422
Insulin, n (%)	1 (2.2%)	1 (4.8%)	0 (0%)	0.467
SU, n (%)	2 (4.4%)	1 (4.8%)	1 (4.2%)	0.999
TZD, n (%)	1 (2.2%)	0 (0%)	1 (4.2%)	0.999
Educational status, n (%)				
Below college	11 (24.4%)	2 (9.5%)	9 (37.5%)	0.067
College or above	34 (75.6%)	19 (90.5%)	15 (62.5%)	
Marital status, n (%)				
Single	22 (48.9%)	12 (57.1%)	10 (41.7%)	0.461
Married	23 (51.1%)	9 (42.9%)	14 (58.3%)	
Fertility status, n (%)				
Having no child	26 (57.8%)	14 (66.7%)	12 (50.0%)	0.408
Having child	19 (42.2%)	7 (33.3%)	12 (50.0%)	
History of weight loss, n (%)				
Negative	8 (17.8%)	4 (19.0%)	4 (16.7%)	1.000
Positive	37 (82.2%)	17 (81.0%)	20 (83.3%)	
Exercise habit, n (%)				
Negative	17 (37.8%)	7 (33.3%)	10 (41.7%)	0.789
Positive	28 (62.2%)	14 (66.7%)	14 (58.3%)	
Snacking habit, n (%)				
Negative	22 (48.9%)	13 (61.9%)	9 (37.5%)	0.182
Positive	23 (51.1%)	8 (38.1%)	15 (62.5%)	
Times of eating out per week, n (%)				
≤7 times	31 (68.9%)	14 (66.7%)	17 (70.8%)	0.999
≥8 times	14 (31.1%)	7 (33.3%)	7 (29.1%)	

Note: Continuous data are expressed as means (SD) and categorical data are expressed as numbers (percentages).
Abbreviations: BMI, body-mass index; SD, standard deviation; SGLT2, sodium-glucose cotransporter 2; SU, sulfonylurea; TZD, thiazolidinedione.

(7.0 ± 3.7 cm vs 1.9 ± 3.2 cm, P < 0.001), higher hip circumference reduction (5.4 ± 3.4 cm vs 0.7 ± 3.3 cm, P < 0.001), higher body fat mass reduction (6.2 ± 3.0 kg vs 1.0 ± 1.1 kg, P < 0.001), higher skeletal muscle mass reduction (0.9 ±

Table 2 The Clinical Practice in the Weight Loss Program

	Total (n=45)	Weight Loss ≥ 5% (n=21)	Weight Loss < 5% (n=24)	P value
Duration of treatment (weeks)	11 (7.3)	14.6 (6.5)	6.9 (6.0)	<0.001
Number of dietary records	80.2 (76.3)	109.2 (84.7)	54.7 (58.8)	0.002
Number of dietary records per week	7.6 (4.6)	7.9 (4.3)	7.4 (4.3)	0.641
Days of weight record (days)	15.1 (33.8)	25.6 (41.8)	6 (21.8)	0.264
Completion ratio of daily weight record (%)	14.8% (27%)	21.9% (34.6%)	8.5% (16%)	0.540
Categories of completion ratio of daily weight record				
<10%, n (%)	31 (68.9%)	13 (61.9%)	18 (75%)	0.533
10%–49%, n (%)	9 (20%)	4 (19.0%)	5 (20.8%)	1.000
≥50%, n (%)	5 (11.1%)	4 (19.0%)	1 (4.2%)	0.169
Number of outpatient visits	4.8 (2.8)	6.1 (2.7)	3.7 (2.3)	<0.001
Interval of outpatient visits (weeks)	2.1 (1.0)	2.5 (1.1)	1.8 (0.9)	0.003

Note: Continuous data are expressed as means (SD) and categorical data are expressed as numbers (percentages).
Abbreviation: SD, standard deviation.

Table 3 Changes in Anthropometric Outcome Measures

Outcome Measure	Total (n=45)	Weight Loss ≥ 5% (n=21)	Weight Loss < 5% (n=24)	P value
Weight loss (%)	4.7 (4.7)	8.6 (3.4)	1.3 (2.4)	<0.001
Weight loss (kg)	4.1 (4.4)	7.6 (3.4)	1.1 (2.4)	<0.001
BMI reduction (kg/m^2)	1.5 (1.5)	2.7 (1.1)	0.4 (0.8)	<0.001
Waist circumference reduction (cm)	4.3 (4.2)	7.0 (3.7)	1.9 (3.2)	<0.001
Hip circumference reduction (cm)	2.9 (4.0)	5.4 (3.4)	0.7 (3.3)	<0.001
Body fat mass reduction (kg)	3.5 (3.4)	6.2 (3.0)	1.0 (1.1)	<0.001
Skeletal muscle mass reduction (kg)	0.4 (1.2)	0.9 (1.1)	0 (1.1)	0.018
Body fat percentage reduction (%)	2.4 (2.9)	4.4 (3.0)	0.7 (1.1)	<0.001
Fat-free mass reduction (kg)	0.7 (2.0)	1.5 (1.9)	0.1 (1.9)	0.021

Note: Data are expressed as means (SD).
Abbreviations: SD, standard deviation; BMI, body-mass index.

1.1 kg vs 0 ± 1.1 kg, P = 0.018), higher body fat percentage reduction (4.4 ± 3.0% vs 0.7 ± 1.1%, P < 0.001), and higher fat-free mass reduction (1.5 ± 1.9 kg vs 0.1 ± 1.9 kg, P = 0.021) than those in the unsuccessful weight loss group.

Multivariate logistic regression analyses demonstrated that duration of treatment was an independent factor associated with successful weight loss (odds ratio = 1.23, 95% confidence interval: 1.08–1.41, P = 0.003). The association was significant in both the crude and adjusted models (Table 4).

Discussion

The present study showed a mean weight loss of 4.7% of baseline body weight during an average 11 weeks of treatment using a mobile app. There were 46.7% of patients who had successful weight loss ≥ 5% of baseline weight. The duration of treatment was an independent factor associated with successful weight loss. Setting a weight loss goal is important for obesity management.[34] According to the Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society in 2013, a loss of ≥ 5% of the initial body weight can be a target for successful weight loss.[33] In line with our findings, the duration of treatment was reported as the only independent factor of successful weight loss defined by ≥ 5% baseline weight, and all other assessed variables were no longer significantly associated with successful weight loss after adjustment for duration of treatment based on the data retrospectively extracted from electronic medical records in The Wharton Weight Management Clinic.[35] Hu et al demonstrated that enrollment length in the digital Foodsmart platform was significantly associated with successful weight loss of 5% in a retrospective cohort.[36] Similarly, 52-week weight loss programs showed significantly greater

Table 4 Univariate and Backward Multivariate Logistic Analysis Showing Odds Ratios for Successful Weight Loss

	Univariate			Multivariate		
	OR	**(95% CI)**	**P**	**OR**	**(95% CI)**	**P**
Age (year)	0.96	(0.91–1.01)	0.118			
Sex (male vs female)	3.30	(0.94–11.63)	0.063			
Weight (kg)	1.00	(0.97–1.03)	0.988			
BMI (kg/m^2)	0.98	(0.88–1.09)	0.693			
Waist circumference (cm)	0.99	(0.95–1.04)	0.739			
Hip circumference (cm)	1.00	(0.95–1.06)	0.996			
Body fat mass (kg)	0.97	(0.92–1.03)	0.297			
Skeletal muscle mass (kg)	1.05	(0.96–1.15)	0.260			
Body fat mass percentage (%)	0.91	(0.83–1.00)	0.055			
Fat-free mass (kg)	1.03	(0.98–1.09)	0.281			
Type 2 diabetes (yes or no)	0.39	(0.10–1.54)	0.180			
Pre-diabetes (yes or no)	1.13	(0.35–3.67)	0.841			
Hypertension (yes or no)	0.40	(0.07–2.32)	0.307			
Antidiabetic drug history (yes or no)	0.57	(0.14–2.32)	0.433			
Metformin (yes or no)	0.50	(0.11–2.31)	0.375			
SGLT2 inhibitors (yes or no)	0.40	(0.07–2.32)	0.307			
SU (yes or no)	1.15	(0.07–19.60)	0.923			
Educational status (high vs low)	5.70	(1.07–30.43)	0.042	9.812	(0.93–103.88)	0.058
Marital status (married vs single)	0.54	(0.16–1.75)	0.302			
Fertility status (have child vs no child)	0.50	(0.15–1.68)	0.261			
Weight loss history (yes or no)	0.85	(0.18–3.92)	0.835			
Exercise habit (yes or no)	1.43	(0.42–4.83)	0.566			
Snacking habit (yes or no)	0.37	(0.11–1.24)	0.106			
Eat out per week (≥8 times vs ≤7 times)	1.21	(0.34–4.30)	0.763			
Number of diet record per participant (n)	1.01	(1.00–1.02)	0.028			
Number of diet record per week per participant (n)	1.03	(0.90–1.18)	0.675			
Days of weight record per participant (days)	1.02	(1.00–1.05)	0.092			
Completion ratio of daily weight record (%)	8.20	(0.59–113.19)	0.116			
Duration of treatment (weeks)	1.21	(1.07–1.37)	0.002	1.23	(1.08–1.41)	0.003
Number of outpatient visits (n)	1.48	(1.12–1.97)	0.007			
Interval of outpatient visits (weeks)	2.48	(1.13–5.46)	0.024			

Notes: Parameters that were significantly associated with successful weight loss in univariate logistic regression analysis were entered into the backward multivariate logistic regression analysis. Successful weight loss was defined as a weight loss ≥ 5% of baseline weight.
Abbreviations: BMI, body-mass index; SGLT2, sodium-glucose cotransporter 2; SU, sulfonylurea.

weight losses than 12-week programs based on a randomized controlled trial using life-style modification.[37] Notably, early attrition and drop out, defined as a participant not attending a scheduled visit, were negative predictors of successful weight loss during clinical trials.[38]

It was previously reported that a higher frequency of face-to-face attendance is a significant predictor of greater weight loss in conventional weight loss programs.[39–42] In contrast to the conventional weight loss programs, we observed a longer interval of outpatient visits and more outpatient visits in the successful weight loss group than in the unsuccessful weight loss group. None of above outpatient visit profile was independent factor after adjustment for the duration of treatment in the present study. Since self-monitoring and diet education are conducted via the mobile app, the goal of weight loss can be achieved without frequent face-to-face visits during the COVID-19 pandemic.

Dietary self-monitoring is an important component of weight loss programs.[43–45] This relationship between a dietary diary and weight loss has been revealed via use of online support.[46] In the Livongo Diabetes Prevention Program, food logging had the most important impact on weight loss.[47] Falkenhain et al also reported that self-reported dietary

adherence was the most important metric to predict weight loss during the COVID-19 pandemic, based on a secondary analysis of a randomized clinical trial using a mHealth ketogenic diet app intervention.[31] Although the number of dietary records in the ≥ 5% weight loss group was significantly greater than that in the < 5% weight loss group in the present study, the difference became nonsignificant after standardizing the number of dietary records by treatment time, ie the number of dietary records per week. Carter et al reported that a long duration was significantly associated with improvement of weight loss via electronic dietary self-monitoring using a mobile app.[48] In line with our findings, weight loss via an app using a photo feature as a dietary record method showed that a greater weight loss is mediated by increased duration and logged days.[49] Notably, several dietary-based programs for weight loss demonstrated that greater initial weight loss is associated with a lower study dropout rate.[50–54] Initial weight loss is a known predictor of successful weight loss and greater initial weight loss may be the motivating factor leading to longer treatment length and less attrition.[55]

High education is helpful in adopting a healthy diet and associated with a good repose to weight loss program.[56] Despite high education was associated with successful weight loss under univariable analysis, the association became nonsignificant after adjustment for the duration of treatment using mobile app in the present study. It has been reported that self-reporting weight has a potential social desirability bias.[57] The strength of our study was that the measurements of weight was performed using the same InBody machine for body-component analyses. However, the present study had several limitations: First, to promote adherence to the program, subjects were not followed by a fixed time schedule, and diet education via the app did not use a fixed formula in this study program. Therefore, our results cannot be applied to the weight-reduction programs with fixed-visit schedules. Second, the case number was relatively small in the present study. Third, changes in adherence-related profiles are important for successful weight loss. The self-weighing trajectories are reported to be significantly associated with weight-loss maintenance.[58] However, we did not perform these analyses due to limited case numbers and different visit intervals in each participant. Fourth, the present study had an observational design, which did not allow the determination of a causal effect. A randomized controlled trial is warranted to help determine causal direction.

Conclusion

We present a retrospective analysis of a weight management program using an app with self-monitoring dietary records, weight tracking, and person-to-person individualized feedback in real-world practice during the COVID-19 pandemic. The duration of treatment was an independent factor associated with successful weight loss. The numbers of dietary records and outpatient visits were not significantly associated with successful weight loss in multivariate logistic analysis.

Ethical Approval and Informed Consent

The study complied with the Declaration of Helsinki. The Institutional Review Board of the Taichung Veterans General Hospital approved the protocol (ethical approval code: CE21241B) and waived the need for informed consent due to the retrospective collection of data. Anonymous medical record data were obtained from the Clinical Informatics Research & Development Center of Taichung Veterans General Hospital after delinking the identification code.

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Disclosure

The authors report no conflicts of interest in this work.

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