

Original Article

Bundled behavioural strategies for long-term weight maintenance in Chinese patients with overweight or obesity

Junren Kang MD, Yuanyuan Bao BS, Ji Fu MD, Hailong Li MD, Kang Yu MD

Department of Clinical Nutrition, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China

Background and Objectives: Behavioural strategies can promote adherence to intensive lifestyle treatments for obesity. This study aimed to explore effective behavioural strategies for weight maintenance in Chinese patients with overweight or obesity. **Methods and Study Design:** Retrospective analysis of weight maintenance data was conducted. Patients with overweight or obesity, who had received a 3-month weight loss and behavioural intervention, were asked to complete questionnaires to monitor compliance with behavioural strategies after the weight loss. They continued to follow a daily calorie restriction for 12 months to maintain their weight. The primary outcome was to evaluate the association between a total weight loss (TWL) of more than 5% and compliance with behavioural strategies during the 6-month weight maintenance phase. **Results:** A total of 131 patients completed the questionnaire. The top three easy-to-perform behaviours were eating vegetables and protein first and carbohydrates later, self-weighing each day and having regular eating times. Of 131 patients, 61 (46.5%) and 42 (32.1%) were followed up for 6 months and 12 months respectively. Reducing high-fat food intake ($p = 0.002$) and eating an average frequency of 5 times a day ($p = 0.034$) were associated with a TWL of more than 5% during 6 months weight maintenance. Reducing high-fat food intake was associated with a TWL of more than 5% during 12 months weight maintenance ($p = 0.029$). **Conclusions:** Chinese patients with overweight or obesity who experienced a TWL of more than 5% were more likely to reduce high-fat food intake during long-term weight maintenance.

Key Words: behavioural interventions, obesity, lifestyle intervention, weight loss, weight maintenance

INTRODUCTION

Globally, the incidence of obesity has risen significantly, and China ranks first for both men and women with obesity worldwide.¹ Common treatments for obesity, such as intensive nutrition and lifestyle interventions, pharmacotherapy and bariatric surgery, are recommended, and intensive nutrition and lifestyle strategies are basic, effective and safe interventions.^{2,3} Intensive nutrition and lifestyle strategies can lead to weight loss and remission of metabolic syndrome.⁴⁻⁶ On the other hand, Weight regain after intensive nutrition induced weight loss is a common phenomenon and weight maintenance is a major challenge in the management of obesity.^{7,8} During intensive nutrition and lifestyle modification, patients with obesity with better adherence can achieve greater weight loss maintenance.^{9,10} Weight loss maintenance were found to be strongly related to adherence to an intensive nutrition and lifestyle intervention in large-sample randomized controlled trials with a 12-month follow-up.¹¹⁻¹³ Behavioural strategies for developing habits can enhance adherence to intensive nutrition and lifestyle treatments.¹⁴ Several habit-based weight loss studies, such as 10 top tips (10TT), have shown that habit-based behavioural strategies can improve the self-regulatory capacity and the effect of weight loss maintenance in patients with

obesity.¹⁵⁻¹⁸ Behavioural strategies were more cost-effective without psychological adverse effects and extra medical costs.^{16,19} However, because of the differences between Chinese and Western dietary habits,²⁰ these intervention methods are not widely used in China, and little work has focused on behavioural strategies for weight loss maintenance in Chinese patients with overweight or obesity. Behavioural strategies that are suitable for long-term weight loss maintenance may be more meaningful. Therefore, we developed a retrospective study that enrolled patients with overweight or obesity after weight loss for 3 months and weight maintenance for 12 months to explore which behavioural strategies are effective and suitable for weight maintenance in Chinese patients with overweight or obesity.

Corresponding Author: Dr Kang Yu, Department of Clinical Nutrition, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, No. 1, Shuai Fu Yuan Dongcheng District Beijing, China
Tel: +861013801130457; Fax: +861069154097
Email: yuk1997@sina.com

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METHODS

Patient characteristics

This was a retrospective analysis of a 12-month weight loss maintenance data. In our previous study, a total of 131 patients with overweight or obesity received 3 months of weight loss treatment, which included behavioural strategies.⁶ The protocol for the weight loss intervention had been previously reported.⁶ After the 3-month weight loss, they completed questionnaires monitoring their compliance with these strategies. And they were followed up at the clinic every month during 12-month weight maintenance phase.

During the weight maintenance phase, they were provided approximately 70% of their total energy requirements and behavioural strategies for 12 months. The targeted percentages of energy derived from fat, protein, and carbohydrates were 20%, 20%, and 60%, respectively. They received a face-to-face clinical interview monthly for dietary adherence and adverse events such as constipation and hair loss. Body mass index (BMI), fat-free mass (FFM), fat mass (FM) and total body mass (TM) were also measured with multi-frequency segmental bioelectrical impedance analysis (BIA, H-Key 350, SEEHIGHER, CHINA).

Inclusion criteria: (1) 18-70 years old; (2) had a 3-month of weight loss treatment including behavioural strategies; (3) completed the questionnaires consciously after the 3 months weight loss period; and (4) followed by a daily calorie restriction for 6 months to maintain weight. Patients were excluded if they had been lost to follow up. The study was conducted in accordance with the Declaration of Helsinki, approved by the Institutional Review Board and full Institutional Review Board approval statement was obtained. All clinical investigations were conducted according to the principles expressed in the World Medical Association Declaration of Helsinki. Written informed consent was obtained from all participants.

Behavioural strategies

The bundled behavioural strategies were included in weight loss and maintenance treatment in our clinical practice. These strategies consisted of reducing high-fat food consumption, having regular eating times, having an average eating frequency of 5 times a day, eating vegetables and protein first and carbohydrates later, increasing the number of chewing cycles, self-weighing every day, avoiding prolonged periods of sitting, and having daily exercise training. We also developed behavioural strategies questionnaires to monitor compliance with the behavioural program (Figure 1). All patients were asked to complete the behavioural strategies questionnaires at the clinic after the 3-month weight loss.

Outcomes

The primary objective was to explore effective and suitable behavioural strategies for weight loss maintenance in Chinese patients with overweight or obesity. The primary outcome was to evaluate the association between a total weight loss (TWL) of more than 5% and compliance with behavioural strategies during the 6-month weight maintenance phase. The secondary outcome was to evaluate the association between a TWL of more than 5% and compliance with behavioural strategies during the 12-month weight maintenance phase. The initial weight was defined as the weight before weight loss. The % TWL was defined as the difference between the initial weight and final weight divided by the initial weight. Weight regain after nutrition and lifestyle interventions was defined as the progressive regaining of weight to the initial body weight after successful weight loss, due to a lack of consensus on its definition. Weight loss of at least 5% can decrease hepatic steatosis and other obesity comorbidities as stated in clinical practice guidelines; therefore, a weight loss of 5% was used as the cut-off value in this study.²¹⁻²³

Data collection

Question	Descriptions for the behavioral strategies	Yes / No
Do you have regular eating times?	Try to have regular time of breakfast, lunch or dinner in everyday, including weekends and weekdays. The variability in the timing of breakfast, lunch or dinner is within half an hour.	
Do you try to reduce your intake of high-fat food?	Try to reduce high-fat food containing significant amounts of saturated animal fats and trans fats, such as fried food, broth, cream, pastry, chocolate, milk tea and so on.	
Do you have an average eating frequency of 5 times a day?	The average eating frequency is defined as 5 times a day, including breakfast, lunch, dinner and two extra meals with fruit or yogurt at 10 AM and 4 PM.	
Do you eat vegetables and protein first and carbohydrates later?	The food order is vegetables and protein followed 15 min later by carbohydrate.	
Do you try to increase your number of chewing cycles?	The numbers of chewing cycles are 20-30 times	
Do you weigh yourself each day?	Try to measure your body weight in the morning after an 8-hour fast using a calibrated scale.	
Do you try to avoid prolonged sitting time?	Sedentary behavior is operationally defined as any waking activity characterized by an energy expenditure of 1.5 metabolic equivalents (METs) or less.	
Do you exercise daily?	Try to have daily exercise training with moderate exercise intensity for more than 30 min, such as gymnastics, jogging, table tennis, cycling, badminton, swimming, aerobics, etc.	

Figure 1. The simple survey questionnaire of bundled behavioral strategies

The behavioural strategies questionnaires were completed by trained dietitians through face-to-face interviews at the clinic after the 3-month weight loss phase. All clinical characteristics at the 6th and 12th month of weight maintenance phase, such as age, sex, initial body weight BMI, FFM, FM and TM, were collected from an independent electronic database. All dietitians had several training sessions to minimize bias. Data were abstracted and inputted independently by 2 trained investigators within 72 hours of the survey to ensure consistency and integrity. Disagreements on information were resolved by consensus or retrieving further information from the electronic database.

Statistical analysis

For the sample size calculation, the %TWL reported after a 6-month weight maintenance phase in a randomized clinical trial was 6%,¹² we had calculated that sample size (permissible error 0.06, two-sided $\alpha=0.05$, $\beta=0.1$) was about 61. The differences in compliance with behavioural strategies between patients with or without more than 5% weight loss were compared with the Pearson chi-square test or Fisher's exact test. The differences in body weight, BMI and lean body weight between different time points in weight maintenance phase were analysed using paired *t* tests for normally distributed variables or nonparametric tests for nonnormally distributed variables. The differences in percentage of TWL, TWL of more than 5% and weight regain were compared by the chi-square test or Fisher's exact test. All statistical tests were two-sided, and *p* values <0.05 were considered statistically significant. Statistical analysis was performed using SPSS software (Version 19, SPSS Inc., IBM, NY, USA).

RESULTS

Baseline characteristics

Data from the electronic database of patients with overweight or obesity receiving 12 months weight maintenance from July 1st, 2018 to July 1st, 2023 were reviewed (Figure 2). Baseline characteristics for 131 patients are displayed in Table 1. The patients with type 1 or 2 diabetes, cardiovascular events, or cancer were excluded.⁶ At baseline, 131 patients lost an average of 6.8 ± 4.3 kg after weight loss for 3 months, and the mean %TWL was 7.8 ± 4.4 %. A total of 75.6% of the patients lost more than 5% of their initial body weight.

All 131 patients completed the questionnaire monitoring compliance after weight loss for 3 months. A total of 67.2% (*n*=88) of them had reduced intake of high-fat food, 71.0% (*n*=93) had regular eating times, 51.9% (*n*=68) had an average eating frequency of 5 times a day and 90.8% (*n*=119) ate vegetables and protein first and carbohydrates later. A total of 45.0% (*n*=59) of them had an increased number of chewing cycles, 82.4% (*n*=108) weighed themselves each day, 18.3% (*n*=24) had tried to avoid prolonged sitting times and 10.7% (*n*=14) exercised daily. The top three easy-to-perform behaviours were eating vegetables and protein first and carbohydrates later, self-weighing each day and having regular eating times (Table 2).

The 6 months weight maintenance phase

Of the 131 patients with overweight or obesity originally investigated, 61(46.5%) were followed up during 6 months weight maintenance phase. Demographic characteristics were presented in Table 1. They underwent an average of 15 (range, 5-29) clinical interviews. The mean age was 34.2 ± 10.6 years, and 73.8% were female. The mean body weight was 78.1 ± 15.9 kg, a total of 61

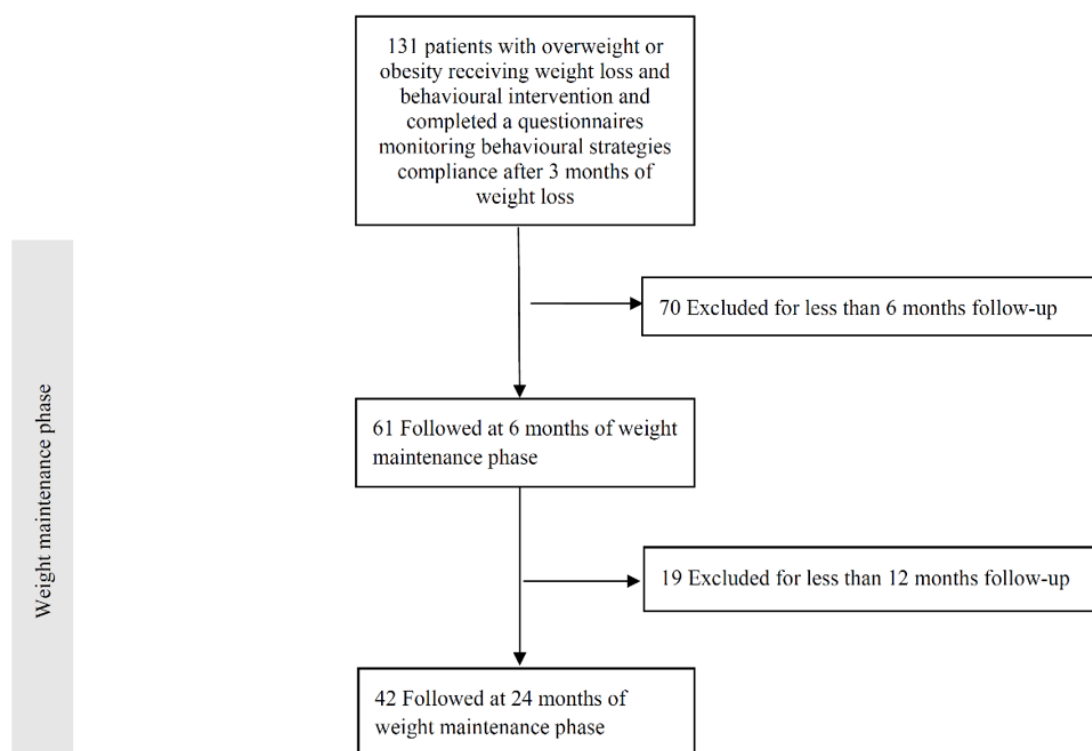


Figure 2. Study flow diagram

Table 1. Patient characteristics

Characteristics	Before weight loss	Baseline	At the 6th month of weight maintenance phase	At the 12th month of weight maintenance phase
N	131	131	61	42
Age, y, mean \pm SD	30.7 \pm 4.7	30.7 \pm 4.7	34.2 \pm 10.6	35.2 \pm 11.5
Sex, n (%)				
Male	24 (18.3)	24 (18.3)	16 (26.2)	12 (28.6)
Female	107 (81.7)	107 (81.7)	45 (73.8)	30 (71.4)
Weight (kg)	84.8 \pm 16.4	78.0 \pm 14.8 *	78.1 \pm 15.9 *	79.8 \pm 15.3 *
BMI (kg/m ²)	30.7 \pm 4.7	28.2 \pm 4.3 *	27.9 \pm 4.6 *	28.7 \pm 4.9 *
FFM (kg)	51.8 \pm 9.9	50.7 \pm 9.6 *	51.9 \pm 10.1 *	52.4 \pm 9.4 *
FM/TM (%)	38.8 \pm 6.2	35.0 \pm 6.9 *	33.7 \pm 7.0 *	34.2 \pm 8.0 *
Weight loss (kg)		6.8 \pm 4.3	7.9 \pm 7.1	6.3 \pm 9.2
Weight regain (%)			5 (8.1) **	12 (28.6) **
%TWL (%)		7.8 \pm 4.4	9.0 \pm 6.7	7.0 \pm 9.3
5% weight loss, n (%)		99 (75.6)	38 (62.3)	25 (59.5)

BMI: Body Mass Index; FM: fat mass; TM: total mass; FFM: fat free mass

* $p < 0.05$ vs. "Before weight loss"

** $p < 0.05$ vs. "Baseline".

Table 2. The compliance with the bundled behavioral strategies

The behavioral strategies	n (%)
Having regular eating times ³³	93 (71.0)
Reducing high-fat food ²⁹	88 (67.2)
Having average eating frequency of 5 times a day ¹⁸	68 (51.9)
Eating vegetables and protein first and carbohydrate later ³⁷⁻³⁹	119 (90.8)
Increasing the number of chewing cycles ^{35, 36}	59 (45.0)
Self-weighing each day ¹⁹	108 (82.4)
Avoiding prolonged sitting time ⁴⁰	24 (18.3)
Having daily exercise training ³¹	14 (10.7)

patients lost an average of 7.9 \pm 7.1 kg after weight loss for 3 months and weight maintenance for 6 months. The mean %TWL was 9.0 \pm 6.7 % and 62.3% lost more than 5% of initial body weight, while 8.1% of patients regained their initial body weight.

Reducing high-fat food intake ($p = 0.002$), eating an average frequency of 5 times a day ($p = 0.034$) were associated with a weight loss of more than 5% during the 6 months weight maintenance phase. There were no significant differences in other behavioural strategies between patients with or without more than 5% weight loss (Table 3).

The 12 months weight maintenance phase

Of the 131 patients, 42 (32.1%) were followed up during the 12 months weight maintenance phase. The mean age was 35.2 \pm 11.5 years, and 71.4% were female. The mean body weight was 79.8 \pm 15.3 kg, a total of 42 patients lost an average of 6.3 \pm 9.2 kg after weight loss for 3 months and weight maintenance for 12 months. The mean %TWL was 7.0 \pm 9.3% and 59.5% lost more than 5% of initial body weight, while 28.6% of patients regained their initial body weight (Table 1).

Reducing high-fat food intake ($p = 0.029$) was associated with a weight loss of more than 5% during the 12 months weight maintenance phase. There were no significant differences in other behavioural strategies between patients with or without more than 5% weight loss (Table 4).

DISCUSSION

In the current study, we demonstrated behavioural strategies effective and suitable for long-term weight maintenance in Chinese patients with overweight or obesity. Eating an average frequency of 5 times a day and reducing high-fat food intake were associated with a weight loss of more than 5% during the 6-month weight maintenance phase. The patients with more than 5% weight loss were more likely to reduce high-fat food intake during the 12-month weight maintenance.

The incidence of obesity has increased significantly among Chinese adults, accompanied by an increase in metabolic diseases, such as hypertension and diabetes.²⁴⁻²⁷ Nutrition and lifestyle treatments are effective and safe for the treatment of obesity;^{5, 6, 13} moreover, they also have a positive effect on the remission of type 2 diabetes in long-term follow-up.^{27,28} Behavioural strategies may be beneficial for increased adherence and weight loss maintenance.¹⁵⁻¹⁸ Because of the differences between Chinese and Western dietary habits,²⁰ these intervention methods are not widely used in China. Behavioural strategies that are suitable for the lifestyles of Chinese patients may be more meaningful.

During the weight loss maintenance phase, reducing high-fat food intake was associated with a weight loss of more than 5%, which was consistent with previous literature.²⁹ It was mainly because that reducing the consumption of high-fat foods could effectively prevent excess saturated fat and caloric intake.²⁹

Table 3. The association between the behavioral interventions and 5% weight loss or more during the 6 months weight maintenance phase

	Patients with 5 % weight loss or more, (n=38)	Patients with less than 5 % weight loss, (n=23)	<i>p</i>
Behavioral interventions, n (%)			
Having regular eating times	30 (78.9)	17 (73.9)	0.756
Reducing high-fat food	34 (89.5)	12 (52.2)	0.002
Having average eating frequency of 5 times a day	26 (68.4)	9 (39.1)	0.034
Eating vegetables and protein first and carbohydrate later	35 (92.1)	20 (87.0)	0.664
Increasing the number of chewing cycles	23 (60.5)	9 (39.1)	0.121
Self-weighing each day	34 (89.5)	16 (69.6)	0.084
Avoiding prolonged sitting time	7 (18.4)	4 (17.4)	0.919
Having daily exercise training	7 (18.4)	2 (8.7)	0.462

Table 4. The association between the behavioral interventions and 5% weight loss or more during the 12 months weight maintenance phase

	Patients with 5 % weight loss or more, (n=25)	Patients with less than 5 % weight loss, (n=17)	<i>p</i>
Behavioral interventions, n (%)			
Having regular eating times	19 (76.0)	11 (64.7)	0.498
Reducing high-fat food	22 (88.0)	9 (52.9)	0.029
Having average eating frequency of 5 times a day	16 (64.0)	6 (35.3)	0.115
Eating vegetables and protein first and carbohydrate later	24 (96.0)	14 (82.4)	0.286
Increasing the number of chewing cycles	12 (48.0)	7 (41.2)	0.757
Self-weighing each day	21 (84.0)	12 (70.6)	0.446
Avoiding prolonged sitting time	3 (12.0)	3 (17.6)	0.672
Having daily exercise training	2 (8.0)	2 (11.8)	0.683

Eating frequency was inversely associated with obesity. Using data from the 2009–2010 and 2011–2012 National Health and Nutrition Examination Survey (NHANES), Zhu Y et al.¹⁸ found that obese people with a higher eating frequency more often ate food with lower energy density and had a lower BMI and waist circumference. The average eating frequency was 4.38 times a day for women and 4.48 times a day for men. In our study, the average eating frequency was defined as 5 times a day, including breakfast, lunch, dinner and two extra meals with fruit or yogurt at 10 AM and 4 PM. We found that a frequency of 5 times a day was positively associated with more than 5% of TWL during the 6-month weight maintenance phase. This may be because it is recommended that fruit or yogurt be included in extra meals, and obese patients eat fewer fruits than usual. As time passes, compliance has decreased, and eating frequency was not associated with a weight loss of more than 5% during the 12-month weight maintenance phase.

Other behavioural strategies, such as regular exercise training,^{30, 31} self-weighing each day,^{19, 32} eating at regular times,^{33, 34} increasing the number of chewing cycles,^{35, 36} eating vegetables and protein first and carbohydrate later^{37–39} and avoiding prolonged sitting time⁴⁰ were not associated with a weight loss of more than 5% during the weight maintenance phase.

Regular exercise training could prevent weight gain^{2, 30} and help adults choose healthier diets.³¹ Prolonged sitting time may increase all-cause mortality and the risk of metabolic diseases, such as diabetes and coronary heart disease.⁴⁰ In this study, patients were used to a sedentary lifestyle; only 10.7% of the patients performed daily ex-

ercises, and 18.3% of the patients had tried to avoid prolonged sitting times. Therefore, no association was observed between these two behavioural strategies and 5% weight loss in this study.

Regular eating times could help in the development of healthy eating habits and prevent obesity in cross-sectional studies.^{33, 34} A study involving 1106 adults from 2017–2019 found that different meal timings between weekends and weekdays were positively associated with BMI and that BMI increased significantly with meal timings greater than 3.5 hours. Another study found that adults with irregular living habits tended to skip breakfast and eat fewer fruits and vegetables; therefore, they had lower adherence to the Mediterranean diet and a higher BMI.³⁴ Increasing the number of chewing cycles could decrease appetite after meals and increase diet-induced thermogenesis in cross-sectional studies.³⁵ A study of 4,451 Japanese children aged 5 to 6 years showed that eating too fast was associated with overweight ($p < 0.001$).³⁶ Although these behavioural strategies were effective in cross-sectional studies, they did not lead to a weight loss of more than 5% during long-term weight maintenance. The effectiveness has decreased over time and the long-term impact on weight maintenance needs further verification in prospective studies.

In our study, 94.3% of the patients with obesity were able to eat vegetables and protein first and carbohydrates later. Several studies have found that the adjustment of eating order could help to control blood glucose in diabetes.³⁷ Other studies with prediabetes patients³⁸ or type 1 diabetes³⁹ have come to similar conclusions. However, this eating order was not related with 5% of weight loss.

Weight loss maintenance is a major challenge in the management of obesity and there is significant individual variation.⁴¹ Weight regain depends on various physiological mechanisms, including changes in resting energy expenditure and metabolic adaptation,⁴² hormonal adaptations,⁴³ variations in cellular stress and inflammatory responses,⁴¹ expression of stress-related genes⁴⁴ and so on. The behavioural strategies have intended to promote adherence to weight loss and many people choose not to take it up during long term follow-up.^{45, 46} The eating frequency was related with more than 5% of TWL during the 6-month weight maintenance phase, but not in the 12-month weight maintenance phase. And reducing high-fat food intake was associated with a TWL of more than 5% during 12-month weight maintenance. The behavioural strategies that directly prevent excess caloric intake might be more effective for long-term weight maintenance.²⁹ Multidisciplinary approaches, including diet, healthy lifestyle publicity and education, family-based behavioural support, and effective follow-up should be reinforced during the weight maintenance phase.^{47, 48}

Our study had several limitations. First, it was a retrospective study, and there may be bias when patients after weight loss for 3 months recall their actions. Further prospective studies should be conducted. Second, all patients were asked to complete the behavioural strategies questionnaires at baseline but not at the 12th month weight maintenance phase. The inability to assess changes in behavioural strategies was also a weakness. As an exploratory cohort study, the association between TWL of more than 5% and behavioural strategies was evaluated. We developed this pilot study to explore behavioural strategies that are suitable for Chinese patients with overweight or obesity, and the methods of assessing the behavioural strategies also had limitations. Evaluation of the efficacy of behavioural strategies or changes in response to the intervention will be conducted in our future prospective studies. Third, in this study, body composition was measured with BIA, which is not the gold standard for body composition. Dual-energy X-ray absorption or computed tomography scans may be used in our future study. Fourth, the missing rate of data was higher during the 12 months weight maintenance phase, partly due to the COVID-19 pandemic and the demographic characteristics may also provide some idea of the potential for bias. Large samples and long-term outcomes are needed.⁴⁹

Nonetheless, to our knowledge, this is the first pilot study to explore behavioural strategies that are suitable for weight loss maintenance in Chinese patients with overweight or obesity. These behavioural strategies were cost-effective and tended to improve the effect of weight loss and maintenance. The efficacy of behavioural strategies should be examined in future prospective studies. Behavioural strategies that are suitable for people with obesity in different cultures and with living habits should be developed.

Conclusions

Chinese patients with overweight or obesity who experienced a weight loss of more than 5% were more likely to reduce high-fat food intake during long-term weight maintenance.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflict of interest.

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