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Comparison of weight loss induced by dietary and pharmaceuticals in individuals with overweight and obesity: a retrospective study

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Research Article

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Abstract

This study aims to evaluate the impact of low-carbohydrate diet, balanced dietary guidance and pharmacotherapy on weight loss among individuals with overweight or obesity over a period of 3 months. The study involves 339 individuals with overweight or obesity and received weight loss treatment at the Department of Clinical Nutrition at the Second Affiliated Hospital of Zhejiang University, School of Medicine, between 1 January 2020 and 31 December 2023. The primary outcome is the percentage weight loss. Among the studied patients, the majority chose low-carbohydrate diet as their primary treatment (168 (49·56 %)), followed by balanced dietary guidance (139 (41·00 %)) and pharmacotherapy (32 (9·44 %)). The total percentage weight loss for patients who were followed up for 1 month, 2 months and 3 months was 4·98 (3·04, 6·29) %, 7·93 (5·42, 7·93) % and 10·71 (7·74, 13·83) %, respectively. Multivariable logistic regression analysis identified low-carbohydrate diet as an independent factor associated with percentage weight loss of ≥ 3 % and ≥ 5 % at 1 month (OR = 0·461, $P < 0·05$; OR = 0·349, $P < 0·001$). The results showed that a low-carbohydrate diet was an effective weight loss strategy in the short term. However, its long-term effects were comparable to those observed with balanced dietary guidance and pharmacotherapy.

Obesity and overweight are complex chronic metabolic diseases that result from a combination of factors, including genetics, psychosocial factors, endocrine dysfunction and unhealthy lifestyle choices such as physical inactivity and energy-dense diets. These conditions can lead to the abnormal accumulation of adipose tissue, increasing the risk of various chronic diseases like CVD, insulin resistance, type 2 diabetes, dyslipidemia, hypertension, fatty liver disease and cancer[1,2]. WHO's Global Health Estimates show that the global prevalence of overweight and obesity has been steadily increasing year after year for the past 50 years[3]. BMI is a convenient and widely used tool for screening adults for overweight and obesity[3]. In China, overweight and obesity are defined as 24 kg/m^2 ≤ BMI < 28 kg/m^2 and BMI ≥ 28 kg/m^2, respectively[4]. According to the expert consensus on obesity prevention and treatment in China (2022), more than half of Chinese adults suffer from overweight (34·3 %) and obesity (16·4 %) using Chinese BMI classification[5,6]. It is estimated that by 2030, the combined prevalence of overweight and obesity worldwide will reach a new high of 65·5 % in China[7,8]. Given the rapidly increasing and potential health hazards of obesity, effective intervention strategies are urgently needed.

The Centers for Disease Control and Prevention advises that losing 5–10 % of body weight can help improve the metabolic syndrome[9]. The Obesity Management Guidelines recommend lifestyle interventions, obesity pharmacotherapy and bariatric surgery as common weight loss approaches[10]. Bariatric surgery has established evidence for treating adults with severe obesity (BMI > 35 kg/m^2) and complications[11]. However, people are hesitant to choose bariatric surgery due to its invasiveness and long-term complications. Medication serves as an adjunct to behavioural intervention. For instance, in the treatment of prediabetes or type 2 diabetes, medications like semaglutide, liraglutide and metformin promote weight loss by suppressing appetite and carbohydrate absorption[9,12]. Semaglutide has been reported to reduce body weight in adults with obesity by 17–18 % over 68 weeks[13]. The weight loss effect of metformin on non-insulin-dependent type 2 diabetes patients, especially patients with obesity, is significant, but its effect on healthy people with obesity is uncertain[14,15]. Lifestyle interventions are considered the optimal choice for achieving weight loss. Dietary therapy is an essential component of lifestyle interventions. Numerous dietary patterns such as balanced-carbohydrate diet (carbohydrate ≥ 50 % of total energy), low-carbohydrate diet (carbohydrate < 30–40 % of total energy), low-glycemic index diets and Mediterranean-style diets have been reported to promote weight loss[16].

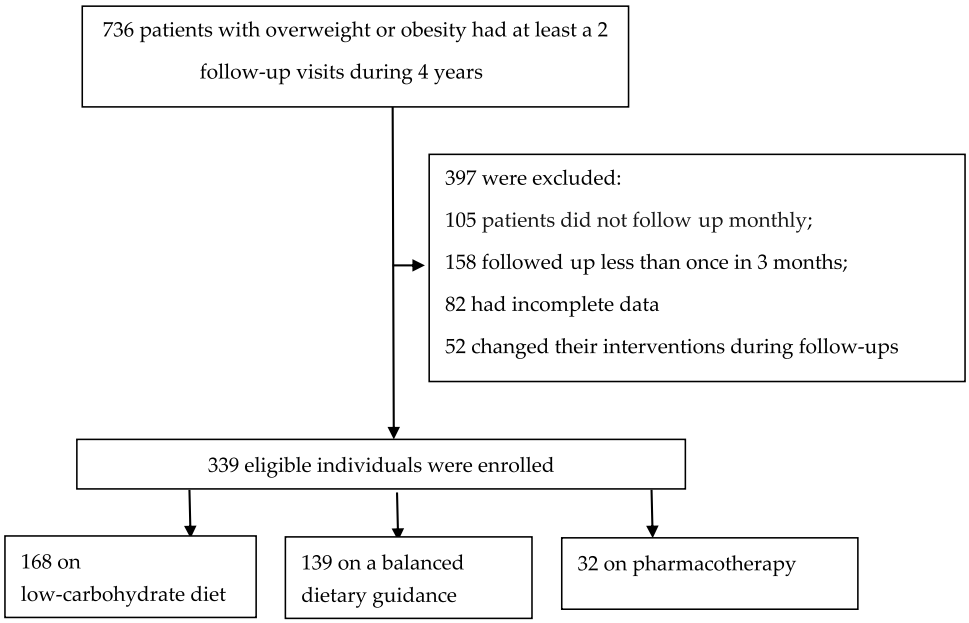

Fig. 1. Flow chart of the study.

In this study, we collected data from individuals with overweight and obesity who visited the clinical nutrition department twice or more within 3 months and received balanced dietary guidance, a low-carbohydrate diet or pharmaceuticals to lose weight. We retrospectively evaluated the extent and effectiveness of weight loss using different therapies to provide evidence for clinicians, nutritionists and other health professionals making unified clinical decisions when prescribing weight loss strategies.

Materials and methods

Participants

This retrospective study examined the weight loss effect in individuals with overweight or obesity at the Department of Clinical Nutrition at the Second Affiliated Hospital of Zhejiang University School of Medicine between 1 January 2020 and 31 December 2023.

Inclusion criteria: (1) patients were all adults (aged 18 years or older); (2) patients had at least two follow-up visits with a BMI of 24 or higher; (3) the primary goal of these patients was to lose weight and (4) patients were enrolled regardless of whether they had other symptoms of metabolic syndrome.

Exclusion criteria: (1) patients who had less than two follow-up visits in a 3-month period; (2) patients with incomplete data on weight and other body composition and (3) patients who changed their interventions methods during the follow-up period.

Finally, 339 individuals were enrolled in this study. The low-carbohydrate diet group consisted of 168 individuals, the balanced dietary guidance had 139 individuals and pharmacotherapy had thirty-two individuals. (Fig. 1). Among the low-carbohydrate diet group, 139 individuals completed the 1-month visit, seventy-seven individuals completed the 2-month visit and forty-one individuals attended the 3-month visit. In the balanced dietary guidance, 114 completed the 1-month visit, fifty-four completed the 2-month visit and sixteen attended the 3-month visit. In pharmacotherapy group, twenty-one individuals completed the 1-month visit, nineteen individuals completed the 2-month visit and eight individuals attended the 3-month visit (online Supplementary Fig. S1). All three groups were comparable in terms of age, sex, history of obesity, history of psychiatric disease, marriage and duration of overweight or obesity at each follow-up period (online Supplementary Table S1–S3).

Methods

After each individual visit, the doctor would assess the total energy requirement based on their BMR measured by the InBody 720 (InBody USA). Three different weight loss interventions were offered, with detailed descriptions of their advantages and disadvantages. Individuals were then given the option to voluntarily choose one of these interventions based on their weight loss objectives and economic status. Individuals who received balanced dietary guidance were provided with a menu that consisted of a composition of 50–65 % carbohydrates, 20–30 % fat and 10–20 % protein. The protein mainly came from beans, bean products, nuts, milk, poultry, aquatic products and lean livestock meat. Fats were mainly derived from unsaturated fatty acids, while reducing the intake of saturated fatty acids. Carbohydrates mainly came from whole grains. The composition of a low-carbohydrate diet was 20–30 % carbohydrates, 40–45 % fat and 30–40 % protein. Patients were advised to eat two meal replacement bars per d instead of staple foods to help reduce carbohydrate intake and ensure adequate nutrient intake. Each individual was provided with a detailed recipe specifying the quantity of foods they should consume each day. They were instructed to keep track of their daily diet by taking photos or utilising the Boohe App. Each month, a dietitian conducted a face-to-face visit to assess adherence and individual motivation through a 24-h dietary recall or review of dietary records, aiming for an ideal weight. For those with overweight or obesity, pharmacotherapy involved individuals with overweight or obesity taking semaglutide (1 mg per week) or/and metformin (0·5 g three times a day) to control their body weight and other metabolic-related indicators. Additionally, they were encouraged to incorporate regular exercise (150–300 min per week) into their daily routine, including both aerobic and anaerobic activities.

The weight and other body composition were measured through multi-frequency bioelectrical impedance analysis using the InBody 720 device (Bio Space Co.). The parameters included BMI, visceral fat area, skeletal muscle mass, body fat mass, percent body fat and waist-to-hip ratio. Personal information such as age, sex, height, health complications, marital status, family history, history of psychiatric disorders or treatment, number of visits with a dietician and the duration of overweight or obesity were collected.

This study utilised Chinese-specific BMI cut-off values, defining overweight as a BMI of ≥ 24 kg/m^2 and obesity as a BMI of ≥ 28 kg/m^2[4,10]. Three to five weeks (average 1 month) after the initial visit, the first time point was designated. The second time point occurred seven to nine weeks (average 2 months) after the first visit, and the third time point occurred 11–13 weeks (average 3 months) after the initial visit.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving patients were approved by the Second Affiliated Hospital of Zhejiang University (ethical approval number 20231215). This study was a retrospective study, and the hospital agreed to waive the informed consent application. Trial registration: Clinical trial registration: URL: https://www.clinicaltrials.gov. Unique identifier: NCT06182618.

Outcomes

The primary outcome was the percentage weight loss at 1, 2 and 3 months after commencing a low-carbohydrate diet, balanced dietary guidance and pharmacotherapy (semaglutide or/and metformin). The percentage weight loss was calculated as 100 × ((Weight at Baseline Visit – Weight at Follow-up Visit)/ Weight at Baseline Visit) [17]. Since the monthly percentage weight loss was non-normally distributed data (online Supplementary Table S4), it was converted into a categorical variable (significant weight loss and insignificant weight loss). 3 % and 5 % weight loss were defined as the end points of significant weight loss[17,18]..

Statistical analysis

The Shapiro–Wilk test (online Supplementary Table S1) was used to assess the normality of continuous variables. The baseline demographic data and body composition parameters were presented as mean values (SD), median (interquartile range) or numbers (percentages). For unmorally distributed data, the Wilcoxon signed-rank test and Kruskal–Wallis *H* test were utilised for comparison. For normally distributed data, the independent-sample *t* test and one-way ANOVA were used to compare different groups. Categorical variables were compared using the χ^2 test. Variables with a *P*-value of less than 0·2 were included in the multivariable logistic regression analysis model[19]. Multivariable logistic regression analysis was conducted to investigate the impact of the baseline demographic data and body composition parameters on significant weight loss. The statistical significance was set at $\alpha = 0{\cdot}05$. All statistical analyses were performed using IBM SPSS Statistics 25 (IBM SPSS).

Results

Baseline characteristics

A total of 339 patients who were prescribed dietary and pharmaceuticals for weight loss and had at least two follow-up visits within 3 months were included in the analysis. The low-carbohydrate diet was the most prevalent treatment (168 (49·56 %)), followed by balanced dietary guidance (139 (41·00 %)) and pharmacotherapy (32 (9·44 %)). Their median age was 28 (25, 33) years, with males accounting for 38·94 %. Twenty-six (7·67 %) patients had a family history of obesity and twenty (5·90 %) subjects had a history of psychiatric disease. Age, sex, history of obesity, history of psychiatric disease, marriage, duration of overweight or obesity were similar among the three groups ($P > 0{\cdot}05$) (Table 1).

Percentage weight loss with different therapeutic methods at various time points

The total percentage weight loss for patients who were followed up for 1 month, 2 months and 3 months was 4·98 (3·04, 6·29) %, 7·93 (5·42, 7·93) % and 10·71 (7·74, 13·83) %, respectively. At 1 month, Kruskal–Wallis *H* test revealed that patients who received the low-carbohydrate diet achieved a percentage weight loss of 5·26 (3·90, 6·70)) % compared with a percentage weight loss of 3·95 (2·53, 5·68) % and 3·72 (2·34, 5·97) % for patients receiving balanced dietary guidance and pharmacotherapy ($P < 0{\cdot}001$). At 2 months, patients who received the low-carbohydrate diet (8·86 (6·45, 10·84) %) and pharmacotherapy (8·16 (5·79, 9·68) %) achieved a higher percentage weight loss than those who received balanced dietary guidance (6·77 (3·72, 8·65) %) ($P < 0{\cdot}01$). At 3 months, there was no significant differences among groups for the percentage of weight loss ($P = 0{\cdot}362$) (Fig. 2 and online Supplementary Table S5).

Predictors of achieving 3 % or more weight loss on univariate analysis and multivariable logistic regression analysis at 1-month point

The results of the univariable analyses showed that patients who received a low-carbohydrate diet were significantly more likely to lose 3 % of their body weight than those who received a balanced dietary guidance. Patients with dyslipidemia were associated with higher odds of successful wright loss (3 % or more). Entering *P*-value less than 0·20 variables in a multivariable logistic regression model retained 'a low-carbohydrate diet' as an independently significant predictor of 3 % or more weight loss (OR = 0·465, $P < 0{\cdot}05$) (Table 2).

Predictors of achieving 5 % or more weight loss on univariate analysis and multivariable logistic regression analysis at 1-month point

In the univariable analyses, patients in a low-carbohydrate diet had a higher chance of achieving 5 % or more weight loss at 1-month point. Meanwhile, the greater the BMI, the higher the likelihood of losing 5 % or more weight. Variables with a *P*-value of less than 0·20 were included in the multivariable logistic regression analysis model. The analysis identified low-carbohydrate diet (OR = 0·358, $P < 0{\cdot}05$) and BMI (OR = 1·336, $P < 0{\cdot}05$) as independent factors associated with percentage weight loss of ≥ 5 % at 1 month (Table 3).

Predictors of achieving 3 % or more weight loss on univariate analysis and multivariable logistic regression analysis at 2-month point

At 2 months, univariable analyses and multivariable logistic regression analysis showed that there was no significant predict

Table 1. Characteristics (Numbers and percentages; median values and interquartile ranges)

	Low-carbohydrate diet		Balanced dietary guidance		Pharmacotherapy		Total			
	n	%	*n*	%	*n*	%	*n*	%		
Variables, *n* (%)	168	49·56	139	41·00	32	9·44	339	100·00	*H*/$\chi 2$	*P*
Demographic information										
Age (years)										
Median	28·5		29		26		28		3·096	0·213
IQR	25, 34		26, 34		20·25, 33		25, 33			
Sex: male, *n* (%)	62	37·13	54	38·57	16	50·00	132	38·94	1·886	0·390
Family history of obesity, *n* (%)	14	8·38	10	7·14	2	6·25	26	7·67	0·270	0·874
Psychiatric disease, *n* (%)	11	6·59	9	6·43	0	0·00	20	5·90	4·098	0·129
Marriage: married, *n* (%)	62	37·13	64	45·71	10	31·25	136	40·11	3·495	0·174
Duration of overweight or obesity, *n* (%)										
< 5 years	101	60·48	86	62·32	20	62·50	207	61·06		
5–10 years	37	22·16	31	22·46	12	37·50	80	23·60	8·353	0·079
> 10 years	29	17·37	21	15·22	0	0·00	50	14·75		

IQR, interquartile range.

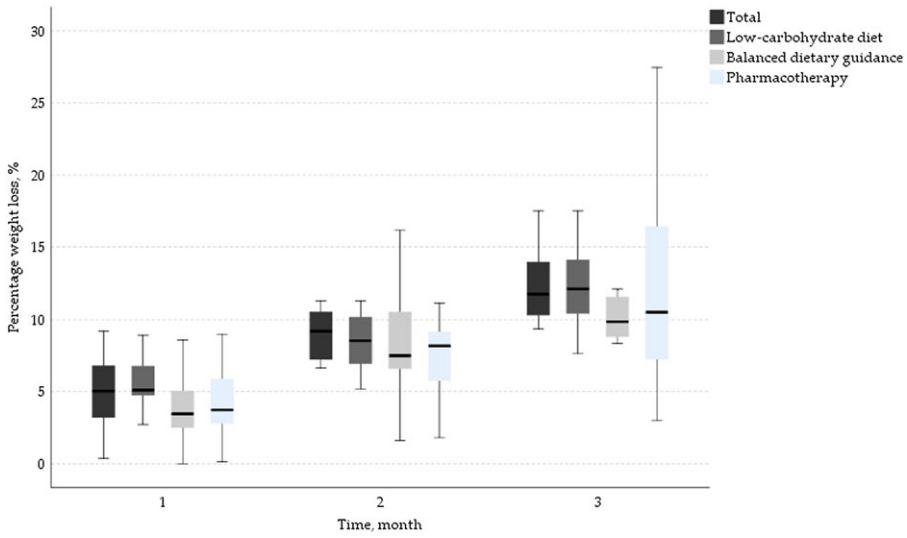

Fig. 2. Percentage weight loss with different therapeutic methods at various time points.

trend in 3 % or more weight loss for demographic information, duration of overweight or obesity, body composition parameter, therapeutic methods and obesity-related co-morbidities ($P > 0{\cdot}05$) (Table 4).

Predictors of achieving 5 % or more weight loss on univariate analysis and multivariable logistic regression analysis at 2-month point

In the univariable analyses, low-carbohydrate diet, baseline body fat mass and percent body fat were significantly associated with the odds of percentage weight loss of ≥ 5 % at 2-month point. By entering *P*-value less than 0·20 variables in a multivariable logistic regression model, none of the variables retained in the model ($P > 0{\cdot}05$) (Table 5).

Predictors of achieving 3 % or more and 5 % or more weight loss on univariate analysis and multivariable logistic regression analysis at 3-month point

Multivariate logistic regressions adjusted showed that demographic information, duration of overweight or obesity, body composition parameter, therapeutic methods and obesity-related co-morbidities with a *P*-value less than 0·20 in the univariable analyses had no significant effect on percentage weight loss of ≥ 3 % and ≥ 5 % at 3-month points (online Supplementary Table S6/Table S7).

Table 2. Predictors of achieving 3% or more weight loss on univariate analysis and multivariable logistic regression analysis at 1-month point (Coefficient and standard errors; odds ratios and 95 % confidence intervals)

Univariate analysis		B	SE	Wald	OR	95 % CI	*P*
Balanced dietary guidance		–	–	–	–		–
Variables	Low-carbohydrate diet*	−0·916	0·292	9·819	0·400	0·226, 0·710	0·002
	Pharmacotherapy	0·448	0·486	0·852	1·566	0·604, 4·056	0·356
	Age	−0·010	0·017	0·321	0·990	0·958, 1·024	0·571
	Sex	−0·275	0·285	0·930	0·760	0·434, 1·328	0·335
	History of obesity	0·613	0·498	1·516	1·846	0·696, 4·896	0·218
	Psychiatric disease	−1·666	1·043	2·553	0·189	0·025, 1·459	0·110
	Marriage: married	0·092	0·289	0·100	1·096	0·622, 1·930	0·751
	Hypertension	0·528	0·491	1·153	1·695	0·647, 4·439	0·283
	Dyslipidemia*	1·177	0·554	4·513	3·246	1·095, 9·618	0·034
	Type 2 diabetes	1·007	0·575	3·066	2·737	0·887, 8·449	0·080
	Prediabetes	−0·111	0·488	0·051	0·895	0·344, 2·330	0·820
	Hyperuricemia	0·080	0·541	0·022	1·083	0·375, 3·126	0·883
	MAFLD	0·525	0·331	2·520	1·690	0·884, 3·230	0·112
	POCS	0·570	0·643	0·785	1·768	0·501, 6·235	0·376
	Number of visits with dietician	0·079	0·099	0·631	1·082	0·891, 1·314	0·427
	Duration of overweight or obesity	0·020	0·193	0·010	1·020	0·699, 1·489	0·919
	Weight	0·014	0·009	2·787	1·015	0·997, 1·032	0·095
	BMI*	0·068	0·034	4·039	1·07	1·002, 1·143	0·044
	BMR	0·000	0·001	0·034	1·000	0·999, 1·001	0·853
	VFA	0·004	0·004	1·374	1·004	0·997, 1·011	0·241
	SMM	0·013	0·022	0·362	1·013	0·971, 1·057	0·548
	BFM	0·031	0·016	3·630	1·032	0·999, 1·066	0·057
	PBF	0·035	0·022	2·559	1·036	0·992, 1·082	0·110
Multivariable logistic regression analysis							
Variables retained in the model	Low-carbohydrate diet*	−0·765	0·308	6·155	0·465	0·254, 0·852	0·013
	Psychiatric disease	−1·612	1·055	2·336	0·199	0·025, 1·577	0·126
	Dyslipidemia	0·825	0·585	1·989	2·281	0·725, 7·176	0·158
	Type 2 diabetes	0·853	0·638	1·788	2·348	0·672, 8·202	0·181
	MAFLD	0·430	0·370	1·351	1·537	0·745, 3·174	0·245
	Weight	0·051	0·043	1·367	1·052	0·966, 1·145	0·242
	BMI*	0·085	0·103	0·677	1·089	0·889, 1·332	0·410
	BFM	−0·136	0·115	1·391	0·873	0·696, 1·094	0·238
	PBF	0·110	0·097	1·295	1·117	0·923, 1·351	0·255
	Constant	−5·473	4·389	1·555	0·004		0·212

MAFLD, metabolic associated fatty liver disease; PCOS, polycystic ovary syndrome; VFA, visceral fat area; SMM, skeletal muscle mass; BFM, body fat mass; PBF, percent body fat.
*$P < 0·05$.

Discussion

In 2013, the American Heart Association (AHA), American College of Cardiology (ACC) and The Obesity Society (TOS) jointly released guidelines suggesting that achieving sustained weight loss of 3–5 % is likely to improve blood lipids, reduce blood glucose and blood pressure, and lower the risk of developing type 2 diabetes[20]. Weight loss of 5 % or more (up to 10 %) can further improve metabolic-related indicators like blood pressure, blood glucose, HbA1C, TAG and cholesterol. This weight loss can also improve associated conditions like fatty liver disease, type 2 diabetes, obstructive sleep apnoea and osteoarthritis and even reduce the risk of certain cancers[17,21–23]. The ideal rate of weight loss for patients with obesity is 0·5–1 kg per week, or 2–4 kg per

Table 3. Predictors of achieving 5% or more weight loss on univariate analysis and multivariable logistic regression analysis at 1-month point (Coefficient and standard errors; odds ratios and 95 % confidence intervals)

Univariable analysis		B	SE	Wald	OR	95 % CI	*P*
	Balanced dietary guidance						
Variables	Low-carbohydrate diet*	–1·034	0·250	17·064	0·356	0·218, 0·581	0·000
	Pharmacotherapy	0·304	0·459	0·438	1·355	0·551, 3·328	0·508
	Age	–0·001	0·015	0·002	0·999	0·970, 1·029	0·962
	Sex	0·043	0·250	0·030	1·044	0·640, 1·703	0·863
	History of obesity	0·334	0·481	0·482	1·397	0·544, 3·588	0·487
	Psychiatric disease	–0·275	0·519	0·280	0·760	0·275, 2·102	0·597
	Marriage: married	0·115	0·251	0·208	1·122	0·685, 1·836	0·648
	Hypertension	0·209	0·467	0·200	1·232	0·494, 3·075	0·655
	Dyslipidemia	0·611	0·571	1·143	1·842	0·601, 5·646	0·285
	Type 2 diabetes	0·842	0·614	1·882	2·320	0·697, 7·724	0·170
	Prediabetes	–0·008	0·412	0·000	0·992	0·442, 2·226	0·984
	Hyperuricemia	–0·121	0·476	0·065	0·886	0·348, 2·253	0·799
	MAFLD	0·083	0·304	0·075	1·087	0·599, 1·972	0·784
	POCS	0·182	0·618	0·087	1·200	0·357, 4·029	0·768
	Number of visits with dietician	0·074	0·081	0·845	1·077	0·919, 1·262	0·358
	Duration of overweight or obesity	0·027	0·166	0·027	1·028	0·743, 1·422	0·868
	Weight*	0·015	0·007	4·082	1·015	1·000, 1·002	0·043
	BMI*	0·070	0·028	6·280	1·073	1·015, 1·133	0·012
	BMR	0·001	0·001	2·039	1·001	1·000, 1·029	0·153
	VFA	0·004	0·003	1·382	1·004	0·998, 1·009	0·240
	SMM	0·031	0·019	2·740	1·031	0·994, 1·070	0·098
	BFM	0·020	0·013	2·439	1·021	0·995, 1·047	0·118
	PBF	0·011	0·019	0·331	1·011	0·974, 1·049	0·565
Multivariable logistic regression analysis							
Variables retained in the model	Low-carbohydrate diet *	–1·027	0·266	14·855	0·358	0·213, 0·604	0·000
	Type 2 diabetes	1·230	0·668	3·395	3·421	0·925, 12·656	0·065
	Weight	0·217	0·405	0·286	1·242	0·561, 2·748	0·593
	BMI*	0·290	0·103	7·975	1·336	1·093, 1·634	0·005
	SMM	–0·377	0·676	0·310	0·686	0·182, 2·581	0·577
	BFM	–0·339	0·432	0·613	0·713	0·305, 1·664	0·434
	BMR	0·000	0·002	0·000	1·000	0·997, 1·003	0·987
	Constant	–9·050	4·016	5·079	0·000		0·024

MAFLD, metabolic associated fatty liver disease; PCOS, polycystic ovary syndrome; VFA, visceral fat area; SMM, skeletal muscle mass; BFM, body fat mass; PBF, percent body fat.
*$P < 0·05$.

month, which amounts to approximately 5–10 kg lost over 3 months. This translates to a weight loss of 3 % to 5 %, and it is based on dietary therapy[18]. In other words, dietary therapy may achieve similar weight loss outcomes as pharmacotherapy.

In this retrospective study, we found that after dietary and intervention for patients who were followed up for 1 month, 2 months and 3 months, the total percentage weight loss was 4·98 (3·04, 6·29) %, 7·93 (5·42, 7·93) % and 10·71 (7·74, 13·83) %, respectively. Patients on a low-carbohydrate diet achieved greater magnitude of weight loss than those on balanced dietary guidance and pharmacotherapy at 1 month. At 2 months, those taking anti-obesity medication lost similar weight compared with those on a low-carbohydrate diet, but more than those in the balanced dietary guidance group. When the intake of carbohydrates drops below 40 % of total energy content, it may lead to a reduction in energy supply in the diet. The reason for this decrease in energy intake when following a low-carbohydrate diet was not fully understood, but it may be linked to the simplicity or monotony of the diet.

Table 4. Predictors of achieving 3% or more weight loss on univariate analysis and multivariable logistic regression analysis at 2-month point (Coefficient and standard errors; odds ratios and 95 % confidence intervals)

Univariable analysis		B	SE	Wald	OR	95 % CI	*P*
	Balanced dietary guidance						
Variables	Low-carbohydrate diet	−0·864	0·496	3·041	0·421	0·160, 1·113	0·081
	Pharmacotherapy	0·163	0·678	0·058	1·177	0·311, 4·449	0·810
	Age	0·016	0·033	0·220	1·016	0·952, 1·084	0·639
	Sex	−0·405	0·479	0·717	0·667	0·261, 1·704	0·397
	History of obesity	0·397	0·689	0·332	1·487	0·386, 5·737	0·564
	Psychiatric disease	0·339	0·820	0·171	1·404	0·281, 6·999	0·679
	Marriage: married	0·170	0·477	0·127	1·185	0·466, 3·016	0·722
	Hypertension	−19·427	17974·857	0·000	0·000		0·999
	Dyslipidemia	0·960	0·872	1·210	2·611	0·472, 14·425	0·271
	Type 2 diabetes	−19·452	14210·363	0·000	0·000		0·999
	Prediabetes	0·508	0·617	0·678	1·662	0·496, 5·564	0·410
	Hyperuricemia	1·191	0·900	1·749	3·289	0·563, 19·209	0·186
	MAFLD	0·365	0·562	0·422	1·440	0·479, 4·330	0·516
	POCS	−19·411	23205·423	0·000	0·000		0·999
	Number of visits with dietician	0·243	0·170	2·026	1·275	0·913, 1·780	0·155
	Duration of overweight or obesity	−0·041	0·337	0·015	0·959	0·495, 1·859	0·902
	Weight	0·016	0·015	1·107	1·016	0·987, 1·046	0·293
	BMI	0·067	0·055	1·473	1·069	0·960, 1·191	0·225
	BMR	0·000	0·001	0·044	1·000	0·998, 1·002	0·833
	VFA	0·011	0·006	3·193	1·011	0·999, 1·023	0·074
	SMM	0·006	0·037	0·029	1·006	0·936, 1·082	0·865
	BFM	0·049	0·028	2·930	1·050	0·993, 1·110	0·087
	PBF	0·065	0·037	3·019	1·067	0·992, 1·148	0·082
Multivariable logistic regression analysis							
Variables retained in the model	Low-carbohydrate diet	−0·630	0·519	1·474	0·533	0·193, 1·472	0·225
	Hyperuricemia	1·143	0·975	1·374	3·136	0·464, 21·191	0·241
	Number of visits with dietician	0·183	0·172	1·137	1·201	0·858, 1·682	0·286
	VFA	0·008	0·011	0·443	1·008	0·985, 1·030	0·506
	BFM	−0·003	0·060	0·002	0·997	0·886, 1·122	0·961
	PBF	0·022	0·056	0·147	1·022	0·915, 1·141	0·702
	Constant	−1·312	1·870	0·492	0·269		0·483

MAFLD, metabolic associated fatty liver disease; PCOS, polycystic ovary syndrome; VFA, visceral fat area; SMM, skeletal muscle mass; BFM, body fat mass; PBF, percent body fat.

Studies had confirmed that it was the amount of energy consumed, rather than the nutrient composition, that determines weight loss[24,25]. A randomised clinical trial demonstrated that after 6 months of intervention, people following a healthy low-carbohydrate diet significantly decreased their total energy intake compared with those following a healthy low-fat diet[26]. Medications can reduce body weight of obese or overweight patients by suppressing appetite and delaying gastric emptying. These effects may occur through a combination of the effect of the drug on the hypothalamus and the gastrointestinal tract. Also anti-obesity medication can easily cause gastrointestinal adverse events such as nausea, dizziness and diarrhoea, leading to a reduction in food intake[21,27].

These factors may result in more rapid weight loss compared with patients who only follow balanced dietary guidance. Multiple studies had demonstrated the efficacy of semaglutide and metformin in achieving significant and rapid weight loss. A weekly dose of 1·7 mg or 2·4 mg of semaglutide led to a 5·9 % weight reduction after 3 months, while metformin 0·5 g three times daily resulted in a 5·1 % weight loss after 3 months[21,22]. Consequently, in clinical practice, doctors often recommended medications as a treatment option for patients with severe obesity

Table 5. Predictors of achieving 5% or more weight loss on univariate analysis and multivariable logistic regression analysis at 2-month point (Coefficient and standard errors; odds ratios and 95 % confidence intervals)

Univariable analysis		B	SE	Wald	OR	95 % CI	*P*
	Balanced dietary guidance						
Variables	Low-carbohydrate diet*	−0·995	0·426	5·451	0·370	0·160, 0·852	0·020
	Pharmacotherapy	−0·371	0·664	0·313	0·690	0·188, 2·536	0·576
	Age	0·002	0·028	0·003	1·002	0·949, 1·057	0·954
	Sex	−0·731	0·41	3·176	0·481	0·215, 1·076	0·075
	History of obesity	−0·135	0·675	0·04	0·874	0·233, 3·279	0·841
	Psychiatric disease	−0·171	0·809	0·045	0·843	0·173, 4·116	0·833
	Marriage: married	0·136	0·41	0·111	1·146	0·513, 2·559	0·739
	Hypertension	−19·901	17974·85	0	0·000		0·999
	Dyslipidemia	0·453	0·862	0·276	1·572	0·290, 8·519	0·600
	Type 2 diabetes	−0·629	1·089	0·333	0·533	0·063, 4·504	0·564
	Prediabetes	−0·047	0·599	0·006	0·954	0·295, 3·087	0·937
	Hyperuricemia	0·684	0·891	0·591	1·983	0·346, 11·359	0·442
	MAFLD	0·543	0·478	1·292	1·722	0·675, 4·395	0·256
	POCS	−19·883	23205·42	0	0·000		0·999
	Number of visits with dietician	0·236	0·141	2·796	1·267	0·960, 1·671	0·094
	Duration of overweight or obesity	−0·108	0·286	0·143	0·898	0·512, 1·573	0·706
	Weight	0·015	0·013	1·422	1·015	0·990, 1·040	0·233
	BMI	0·094	0·049	3·670	1·098	0·998, 1·209	0·055
	BMR	0	0·001	0·007	1·000	0·998, 1·002	0·933
	VFA	0·009	0·005	3·316	1·009	0·999, 1·019	0·069
	SMM	−0·005	0·031	0·026	0·995	0·936, 1·058	0·872
	BFM*	0·058	0·025	5·392	1·060	1·009, 1·113	0·020
	PBF*	0·093	0·034	7·652	1·097	1·027, 1·172	0·006
Multivariable logistic regression analysis							
Variables retained in the model	Low-carbohydrate diet	−0·818	0·452	3·282	0·441	0·182, 1·069	0·070
	Number of visits with dietician	0·189	0·144	1·713	1·208	0·910, 1·603	0·191
	Sex	−0·699	0·708	0·976	0·497	0·124, 1·990	0·323
	VFA	−0·003	0·010	0·108	0·997	0·977, 1·017	0·742
	BFM	0·061	0·097	0·387	1·062	0·878, 1·286	0·534
	PBF	0·006	0·081	0·006	1·006	0·858, 1·180	0·939
	BMI	−0·011	0·136	0·007	0·989	0·757, 1·291	0·934
	Constant	−0·017	3·438	0·000	0·983		0·996

MAFLD, metabolic associated fatty liver disease; PCOS, polycystic ovary syndrome; VFA, visceral fat area; SMM, skeletal muscle mass; BFM, body fat mass; PBF, percent body fat.
*$P < 0·05$.

or at least one obesity-related co-morbidity rather than dietary therapy. At 3 months, there were no significant differences in the percentage of weight loss among different therapies.

One potential reason was that, regardless of the type of weight loss therapy employed, a decrease in resting energy expenditure, also known as metabolic adaptation, occurs as weight was lost. During this adaptation process, weight loss may not be noticeable, and there was no clear evidence to indicate how long this metabolic adjustment will persist. Another reason could be that individuals with overweight or obesity tend to have lower levels of lipolysis and lipid oxidation compared with those with a normal weight. As weight loss progresses, these processes are further reduced, and once the weight loss reached a certain point, these reductions in lipolysis and lipid oxidation persist, leading to a slower rate of weight loss[28].

Univariate analysis indicated that the implementation of a low-carbohydrate diet, along with higher body composition parameters and obesity-related complications, played a significant role in

achieving notable weight loss at 1 and 2 months, but not at 3 months. Further multiple logistic regression analyses suggested that the low-carbohydrate diet was an independent predictor of a minimum 3 % and 5 % weight loss percentage when all characteristics were adjusted for at the 1-month mark. However, it did not have a significant impact on weight loss at 2 or 3 months. These findings align with reports that low-carbohydrate diets result in more effective body weight reduction in the short term but not in the long term[29]. Additionally, another randomised trial demonstrated that a low-carbohydrate diet resulted in a 6·8 % weight loss at 3 months, contrasting with a balanced diet that led to a 2·7 % weight loss – which differed from the findings of our study[30]. This could be attributed to factors such as a single diet, changes in plasma or central satiety factors, or other factors that affect appetite and dietary adherence. However, as the body gradually adapts to this dietary pattern over the long term, these factors weaken, and the magnitude of weight loss becomes similar to other interventions[20]. However, for long-term weight control, a trained interventionist or nutrition professional is essential, regardless of whether lifestyle intervention is used alone or in combination with adjunctive therapies such as medications[10,17].

This study has several limitations that must be acknowledged. First, as a retrospective study, we did not have access to detailed records of patients' energy intake and physical exercise levels, which could have introduced bias into the results. Second, we excluded patients who were not followed up monthly, which may have led to an overestimation of the effectiveness of weight loss. Additionally, there was a possibility of recall bias because the dosage and duration of medication were provided by patients during their communication with dieticians and may not have been accurate. Furthermore, the number of patients followed up for 3 months was relatively small, which may have limited the accuracy of the results. Our analyses only examined the effects within 3 months and did not consider the longer-term effects of weight loss. Finally, our analysis was incomplete due to the absence of laboratory indicators related to metabolic syndrome, which made it challenging to establish the connection between weight loss and changes in the risk factors for metabolic syndrome.

In conclusion, this retrospective study showed that a low-carbohydrate diet was an effective weight loss strategy in the short term (1 month). However, its long-term effects (2 and 3 months) were comparable to those observed with balanced dietary guidance and pharmacotherapy. Therefore, it is important to consider individual patient characteristics and long-term outcomes when selecting appropriate weight loss strategies. Future research should focus on longer-term follow-up and include more comprehensive assessments of patient lifestyle factors, lipid metabolism, blood glucose, intestinal flora, etc., to better understand the impact of different dietary interventions on weight loss and metabolic health.

Supplementary material. For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114524002629

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