# Effects of low glycemic index and fat restriction diet on weight control and cardiovascular factors: a cohort study based on populations in Southwest China

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**Research**

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# Abstract

Background: Evidence from trials about benefits and risks of low glycemic index diets to loss weight and modify cardiovascular risk factors is preliminary. It is unclear to health benefits of choosing a suitable food source and limiting fat. The aim of this study was to prospectively assess the effect of low glycemic index and fat restriction diet on weight control and cardiovascular risk factors of overweight/obesity individuals in Southwest China.

Methods: Overweight/obese men (n=101) and women (n =153) were received low glycemic index with fat restriction diet intervention, dietary advice consistent with dietary portfolio principles between February and July in 2019. Specific dietary intervention lasted 3 months. Changes in weight, body composition, and blood chemistry profile were obtained.

Results: After adjusting for potential confounders, the physical indicators were significantly different at baseline and after 3-momth intervention. All detected indexes were not significantly different between the male and female individuals. Compared with baseline before intervention, participants showed varying degrees of improvement in body mass index, BMI, waist circumference, percentage of body fat, visceral fat, cholesterol and triglycerides.

Conclusions: For overweight/obesity individuals in Southwest China, regardless of the gender, low glycemic index and fat restriction diet might be helpful to control weight and cardiovascular risk.

Trial registration: CHiCTR, ChiCTR1900020934, Registered 22 January 2019, http://www.chictr.org.cn/edit.aspx?pid=35414&htm=4.


# Introduction

Along with the fast development of Chinese economy, there generally appeared the poor diet with high glycemic index (GI) such as high amount of sugar and greater intake of finely processed grains and starchy carbohydrates, which is associated with obesity development and extremely unhealthy for the human body[1]. Study revealed that overweight or obesity have become so common in southwest of China, where major minority nationalities inhabited[2]. While among the various risk factors for developing cardiovascular disease (CVD), obesity, decreased physical activity, and poor diet stand out[3,4]. CVD is a leading cause of death in southwest China and it has become a huge burden on healthcare worldwide[5,6]. To address the growing burden of overweight/obesity, referring the current recommendation based on the domestic and international research results, either low-carbohydrate (LC), low-fat calorie-restricted, or Mediterranean diet may be effective[7,8].

There have been reports of LC diets for dietary intervention at home and abroad, due to their ability to induce rapid weight loss[9,10], which includes the Zone diet, South Beach diet, Atkins diet and etc. A recent meta-analysis defined LC diet as a diet with a total energy intake (TEI) from carbohydrates of less than 45%[11]. The “glycemic index” is one attribute of carbohydrate containing foods and is quantified

according to the amount 50 g of its carbohydrate compared with 50 g of glucose increases blood glucose during 2 hours. A prospective controlled trial showed that the beneficial effects of the GI restricted diet can be improved modestly by reducing its carbohydrate content[12]. Besides weight loss, increasing evidence suggested that a LC diet might result in improvement in traditional CVD risk factors such as blood pressure, lipids and glucose[13,14]. Present, as the main source of energy in southwestern region is carbohydrates, it is important to further understand how glycemic index relates to the prevalence of overweight/obesity and cardiovascular risk factors.

Moreover, food source also plays an important role in modifying the linkage between carbohydrate intake and people's health. Low carbohydrate diets are frequently associated with postprandial hyperlipidemia if dietary fat, instead of dietary protein, in these diets is mainly used to replace carbohydrates[15]. However, optimal carbohydrate-to-fat (C/F) ratio for patients with overweight/obesity is still unclear due to sparse and inconsistent data from relevant researches. Hence, we examined the effects of a 3-month low GI and fat restriction dietary intervention on weight loss and CVD risk factors of overweight/obesity individuals in southwest China.

## Methods

# Participants

Participants were the overweight or obese healthy adults from the Health Examination Center of the People's Hospital of Sichuan province, range 18–65 years old, and had body mass index (BMI) range of 24–39 Kg/$m^2$. All the subjects signed an informed consent form. The trial was approved by the Human Ethics and Research Ethics committees of Sichuan Provincial People's Hospital.

Exclusion criteria included: (1) Severely obese persons (BMI ≥ 40Kg/$m^2$). (2) Evidence of acute coronary syndrome, cerebrovascular events or blood pressure that was not controlled (systolic pressure ≥ 160 mmHg and/or diastolic pressure ≥ 100 mmHg) in the previous 3 months. (3) Got in the acute attack stage. (4) Diabetes severe liver and kidney function damage, renal failure. (5) Inflammatory bowel disease or major chronic inflammatory diseases, acute or chronic infections, irritable bowel syndrome, severe gastrointestinal diseases. (6) Patients with malignant tumors or acute and chronic infections that needed to be treated. (7) Pregnancy or planning to become pregnant or breast feeding. (8) Actively following a special diet or weight-loss program. (9) Major surgery in the previous 6 months. All the subjects remained on their daily energy intake diet before the intervention.

# Protocol

Eligible participants recruited by advertisements between February and July in 2019 were sent questionnaires. Completed questionnaires, fasting blood, anthropometric, and blood pressure measurements were obtained at baseline and at subsequent physical examination at 3 months at the

Health Examination Center of the People's Hospital of Sichuan province. All participants provided signed consent.

Five health managers from the Hospital were trained by dietitians to standardize the grouping principle of the population, the content of health education, the supervision steps of return visit, etc., and were responsible for the guidance, consultation, supervision and publicity of the low GI and fat restriction diet during the study.

All the executive condition of subjects were monitored during the intervention and all the body composition changes after the intervention were recorded through various ways, such as telephone follow-up, internet interaction and WeChat. The changes of indexes before and after intervention were compared.

# Dietary Interventions: Low Gi And Fat Restriction Diet

All participants received a copy of Health Food Guide. The advice addressed benefits, strategies and barriers to change for each participant. The participants were recommended a limited energy diet of 300 to 500 kilocalories per day depending on their weight and level of daily activity, with carbohydrate energy ratio below 45 percent and fat energy ratio from 25 to 30 percent. All diets are replaced with one cup of soy milk (200 ml), 1 small dish of starch-free vegetables (not more than 150 g) and one/two boiled eggs for breakfast, as well as starch-free vegetables (< 200 g) and 100–150 g low-fat meat (i.e. beef, lean meat, skinless chicken, fish) for lunch and dinner.

Participants were also encouraged to choose low GI and low fat foods, avoid sweet drink, avoid internal organs and fat, reduce cooking oil and sugar, drink at least 1.8 litres of water per day, increase intake of starch-free vegetables and whole grain cereals, increase consumption of cholesterol-lowering functional foods including soy foods and viscous fiber sources such as oats and barley, and maintain a daily level of exercise[16]. Alcohol and caffeine were banned throughout the study. Regularly nutritional support from professional nutritionists were provided. Patients were fed for 3 months and then assessed. A full food selection card of the method and the recommended priority list is in Table 1 and Table 2 .

Table 1. Nutrition recommendations for weight management initiation

| Alternative meat dishes | Alternative vegetables | Avoid food |
|---|---|---|
| Grass carp, fish, white chain, bass, salmon, mullet, mandarin fish, river shrimp, squid, small yellow croaker, mutton (thin), quail, bone chicken, sea warm, cod, rabbit meat, skinless chicken, lobster, thin beef, eel, thin pork, egg, loach, clam, clam, crab, oyste. | Water celery, lettuce, cabbages, kale, green cabbage, rape, kelp, wax gourd, mushroom, mung bean sprouts, Chinese cabbage, cabbage, lettuce head, oyster mushroom, cucumber, leek, green onion, pea tip, celery, broccoli, Portuguese cabbage, gourd, vegetables, spinach, green bamboo shoots. | Viscera, cream, chicken skin, fat poultry, fat livestock, potatoes, rice, noodles, wine, beverages, candy, ice cream, nuts, sweet potatoes, fried food, etc. |
| 1.Try to choose foods near the top of the list.<br>2. Be sure not to take any other drugs (Chinese medicine, syrup, infusion, ginseng, etc.).<br>3. Drink at least 1800 ml of water every day, no alcohol, coffee, tea or other beverages.<br>4.Weigh in the morning, record the types, quantity, weight and waist circumference of daily intake of food, timely communicate with dieticians and adjust the diet in stages to achieve the ideal goal.<br>5. It is recommended to stick to exercise as much as possible according to the recommendation of exercise prescription and record it to promote the decomposition of fat. | | |

Table 2. Reference table of food GI values

| Food Name | GI | Food Name | GI |
|---|---|---|---|
| Carbohydrate | | Beans products | |
| Glucose | 100 | Soybeans (soaked, boiled) | 18 |
| sucrose | 65 | Mung bean | 27.2 |
| lactose | 46 | Lentils | 38 |
| Cereals/products | | vegetables | |
| Rice | 83.2 | Carrot | 71 |
| Glutinous rice | 87 | Pumpkin | 75 |
| Barley flour | 66 | Beet | 64 |
| Potato, starch and products | 62 | Fruits and products | 36 |
| Potato | 54 | Apple | 36 |
| Sweet potato | 32.6 | Pear | 43 |
| Lotus root starch | 14 | Grape | 27.6 |
| Seeds | 13 | Dairy products | 48 |
| Peanut | 2.2 | Milk | 11.9 |
| Sunflower seed | 61 | Yogurt (with sugar) | 40.3 |
| Pine nut kernel | 87.9 | Low-fat milk | 61 |
| Fast food | 7 | The beverage category | 57 |
| Hamburger | | Cola | |
| White bread | | Ice-cream | |
| Soda biscuit | | Juice | |
| *Glycaemic index (GI) was calculated using glucose as standard.<br>LGI, low-GI; HGI, high-GI | | | |

# Biochemical And Dietary Analyses

Biochemical analyses were performed in the routine laboratory of People's Hospital of Sichuan province. Acquisition subjects before and after intervention in the height, weight, BMI, body fat percentage (PBF), visceral fat area (VFA), waist circumference (WC), waist-hip ratio (WHR), quality of skeletal muscle (SMC) and basal metabolic level. Body composition detection was used the body composition detector (Inbody 770, Korea). The test subjects should empty their bowels and urine on an empty stomach, take off their jackets, remove watches, necklaces and other metal objects, stand barefoot on the foot plate electrode, hold the electrode part of the hand handle with both hands, and be operated by the health administrator who has received unified training. Participants' body height was measured without shoes in light indoor clothing on the same height scales (Omron HNH-318, Japan) at each physical examination. Blood pressure was the mean of 3 readings using an automatic sphygmomanometer (Jiantailang HBP-9020, China).

# Statistics

SPSS 17.0 software was used for statistical analysis. The experiment adopted group design and self-matching design, and adopted independent sample t-test and paired sample t-test. Chi-square test was performed, and means and 95% confidence intervals (CIs) are provided. $P < 0.05$ was considered statistically significant. Age, sex, smoking status, income, education, and baseline outcomes as covariates (Table 3).

Table 3. The characteristics of study participants

| Feature | Population | Male | Female | $F/\chi^2$ value | P value |
|---|---|---|---|---|---|
| Cases | 254 | 101(39.8) | 153(60.2) | / | / |
| Age (year) | 36.33 ± 9.65 | 36.31 ± 9.03 | 36.35 ± 10.06 | 0.001 | 0.975 |
| Education level | | | | | |
| Primary school or lower | 52(20.5) | 19(7.5) | 33(13.0) | | |
| Secondary school | 42(16.9) | 14(5.5) | 29(11.4) | | |
| High school | 101(39.8) | 38(15.0) | 63(24.8) | 5.27 | 0.261 |
| Above high school | 8(3.1) | 5(2.0) | 3(1.2) | | |
| Income per month(RMB) | | | | | |
| < 3000 | 40(15.7) | 11(4.3) | 29(11.4) | | |
| 3000–6000 | 63(24.8) | 28(11.0) | 35(13.8) | | |
| 6000–10000 | 50(19.7) | 13(5.1) | 37(14.6) | 14.04 | 0.007* |
| > 10000 | 49(19.3) | 19(7.5) | 30(11.8) | | |
| Smoking (cases) | | | | | |
| Never | 146(57.5) | 45(44.6) | 101(66.0) | | |
| Former | 39(15.4) | 17(16.8) | 22(14.4) | 13.202 | 0.001* |
| Smoker | 69(27.2) | 39(38.6) | 30(19.6) | | |
| Excessive alcohol consumption (cases)# | | | | | |
| No | 228(89.8) | 91(90.1) | 137(89.5) | 0.021 | 0.532 |
| Yes | 26(10.2) | 10(9.9) | 16(10.5) | | |
| Sporting (cases) | | | | | |
| < 1 times/week | 144(56.7) | 57(56.4) | 87(56.9) | | |
| 1–3 times/week | 80(315) | 31(30.7) | 49(5.9) | 0.196 | 0.907 |
| > 3 times/week | 30(11.8) | 13(12.9) | 17(11.2) | | |
| *P<0. 05 indicates a statistically significant difference. | | | | | |
| #excessive alcohol consumption (no vs. drinking either wine or beervs.drinking more than 25 g/day) | | | | | |

# Results

A total of 254 participants (101 men, 153 women, mean age: 36.33 ± 9.65 years, and BMI: 28.10 kg/$m^2$) completed the study, and the retention rate of patients who completed the 3-month active intervention was 68%. Figure 1 presents a CONSORT diagram.

General characteristics of individuals, overweight, obesity, and any of the cardiovascular risk factors of the low GI and low fat diet care shown in Table 4(end of the paper). No significant difference was identified before and after intervention regarding fasting blood glucose (FBG), cholesterol (including high density liptein cholesterol, HDL, and low density liptein cholesterol, LDL), and blood uric acid (BUA). However, other variables including weight, BMI, WC, WHR, body fat percentage, visceral fat, cholesterol and triglycerides were significantly decreased in patients who used the recommended dietary after our intervention. Overall, at 3 months, the differences in weight and WC were significant. Differences were reflected in the individual intervention responses.

Table 4

Comparisons before and after the intervention.

| Gender | Variable | Mean | SD | Mean difference before and after | Difference SD | T value | P value |
|---|---|---|---|---|---|---|---|
| Female | | | | | | | |
| | Baseline weight (Kg) | 68.71 | 11.69 | 5.13 | 3.05 | 20.79 | 0 |
| | After weight (Kg) | 63.58 | 10.86 | | | | |
| | Baseline BMI ($Kg/m^2$) | 28.10 | 7.91 | 3.23 | 8.02 | 4.98 | 0 |
| | After BMI ($Kg/m^2$) | 24.88 | 4.34 | | | | |
| | Baseline WC (cm) | 91.29 | 11.75 | 5.27 | 6.95 | 9.38 | 0 |
| | After WC (cm) | 86.02 | 12.78 | | | | |
| | Baseline WHR | 0.90 | 0.06 | 0.03 | 0.04 | 10.73 | 0 |
| | After WHR | 0.87 | 0.05 | | | | |
| | Baseline body fat percentage(%) | 34.87 | 5.16 | 3.04 | 3.66 | 10.27 | 0 |
| | After body fat percentage(%) | 31.83 | 4.88 | | | | |
| | Baseline visceral fat area ($cm^2$) | 97.45 | 23.06 | 12.52 | 10.22 | 15.10 | 0 |
| | After visceral fat area ($cm^2$) | 84.69 | 19.86 | | | | |
| | Baseline metabolism(Kcal) | 1334.28 | 214.06 | 12.85 | 105.66 | 1.50 | 0.135 |
| | After metabolism(Kcal) | 1321.43 | 224.21 | | | | |
| | Baseline skeletal muscle,MM (g) | 25.48 | 6.44 | 0.15 | 1.41 | 1.30 | 0.194 |
| | After skeletal muscle,MM (g) | 25.34 | 6.46 | | | | |
| | Baseline cholesterol(mmol/L) | 4.66 | 1.22 | 0.42 | 0.81 | 3.90 | 0 |

*P<0. 05 indicates a statistically significant difference.

| Gender | Variable | Mean | SD | Mean difference before and after | Difference SD | T value | P value |
|---|---|---|---|---|---|---|---|
| | After cholesterol(mmol/L) | 4.24 | 1.01 | | | | |
| | Baseline triglyceride(mmol/L) | 2.18 | 2.20 | 0.41 | 0.78 | 3.98 | 0 |
| | After triglyceride(mmol/L) | 1.77 | 1.82 | | | | |
| | Baseline LDL-C(mmol/L) | 2.73 | 0.94 | 0.15 | 0.67 | 1.65 | 0.104 |
| | After LDL-C(mmol/L) | 2.59 | 0.79 | | | | |
| | Baseline HDL-C(mmol/L) | 1.30 | 0.43 | -0.04 | 0.28 | -0.94 | 0.351 |
| | After HDL-C(mmol/L) | 1.33 | 0.44 | | | | |
| | Baseline FBG(mmol/L) | 4.87 | 0.70 | 0.01 | 0.80 | 0.06 | 0.955 |
| | After FBG(mmol/L) | 4.86 | 0.57 | | | | |
| | Baseline BUA,UA(umol/L) | 322.71 | 82.57 | -4.78 | 55.66 | -0.65 | 0.519 |
| | After BUA,UA(umol/L) | 327.49 | 89.85 | | | | |
| Male | | | | | | | |
| | Baseline weight (Kg) | 87.12 | 15.95 | 5.72 | 3.28 | 17.56 | 0 |
| | After weight (Kg) | 81.40 | 14.50 | | | | |
| | Baseline BMI($Kg/m^2$) | 31.71 | 12.95 | 3.68 | 12.28 | 3.01 | 0.003 |
| | After BMI($Kg/m^2$) | 28.03 | 4.96 | | | | |
| | Baseline WC (cm) | 99.65 | 12.01 | 4.50 | 2.67 | 16.89 | 0 |
| | After WC (cm) | 95.16 | 11.17 | | | | |
| | Baseline WHR | 0.94 | 0.06 | 0.04 | 0.03 | 12.67 | 0 |

*P<0. 05 indicates a statistically significant difference.

| Gender | Variable | Mean | SD | Mean difference before and after | Difference SD | T value | P value |
|---|---|---|---|---|---|---|---|
| | After WHR | 0.90 | 0.06 | | | | |
| | Baseline body fat percentage(%) | 31.83 | 5.35 | 3.23 | 2.69 | 12.05 | 0 |
| | After body fat percentage(%) | 28.60 | 5.29 | | | | |
| | Baseline visceral fat area ($cm^2$) | 105.72 | 28.30 | 15.67 | 9.54 | 16.50 | 0 |
| | After visceral fat area ($cm^2$) | 90.05 | 26.22 | | | | |
| | Baseline metabolism(Kcal) | 1633.05 | 222.40 | 36.63 | 123.13 | 2.99 | 0.004 |
| | After metabolism(Kcal) | 1596.42 | 221.77 | | | | |
| | Baseline skeletal muscle,MM(g) | 29.99 | 6.14 | -0.24 | 1.38 | -1.77 | 0.08 |
| | After skeletal muscle,MM (g) | 30.24 | 6.03 | | | | |
| | Baseline cholesterol(mmol/L) | 4.93 | 1.06 | 0.20 | 0.74 | 1.89 | 0.064 |
| | After cholesterol(mmol/L) | 4.69 | 1.20 | | | | |
| | Baseline triglyceride(mmol/L) | 2.26 | 1.47 | 0.46 | 1.24 | 2.64 | 0.011 |
| | After triglyceride(mmol/L) | 1.81 | 1.26 | | | | |
| | Baseline LDL-C(mmol/L) | 3.05 | 0.96 | 0.03 | 0.69 | 0.30 | 0.766 |
| | After LDL-C(mmol/L) | 2.98 | 0.99 | | | | |
| | Baseline HDL-C(mmol/L) | 1.34 | 0.71 | 0.01 | 0.27 | 0.30 | 0.769 |

*P<0. 05 indicates a statistically significant difference.

| Gender | Variable | Mean | SD | Mean difference before and after | Difference SD | T value | P value |
|---|---|---|---|---|---|---|---|
| | After HDL-C(mmol/L) | 1.33 | 0.68 | | | | |
| | Baseline FBG(mmol/L) | 5.14 | 0.74 | 0.27 | 0.51 | 3.72 | 0.001 |
| | After FBG(mmol/L) | 4.87 | 0.61 | | | | |
| | Baseline BUA,UA(umol/L) | 418.79 | 101.13 | 5.92 | 78.72 | 0.53 | 0.597 |
| | After BUA,UA(umol/L) | 413.12 | 89.88 | | | | |
| *P<0. 05 indicates a statistically significant difference. | | | | | | | |

# Discussion

In this trial, which enrolled overweight and obese participants, composing the healthful diet of low GI and fat-restriction foods did controll weight wit increased HDL cholesterol levels, reduced LDL cholesterol levels or plasma triglyceride levels by 1 to 2 mmol/L and etc. Figure 2 shows improvements in waist circumference, blood lipids and other indicators of body weight and cardiovascular risk factors. They also demonstrate the advantages in effectively promoting low GI and fat-restriction diet to the overweight/obese population, using recommendations that, when followed, increase weight loss without cardiovascular risk. It indicates an urgent need for innovative approaches to support the implementation of current dietary advice[17].

Our findings are supported by clinical trials of typical low-carbohydrate diets, that showed compared to currently-recommended low-fat diets, low-carbohydrate diets produced greater weight loss and more favorable changes in body composition, high-density lipoprotein cholesterol, and triglycerides[18 – 20], while similar or lesser reductions in low-density lipoprotein cholesterol, blood pressure, blood glucose or insulin[18, 21]. Previous cohort studies in adults had shown that GI score was inversely associated with HDL cholesterol[22]. It is also meaningful that every diet studied in previous trials and this trial lowered LDL cholesterol levels of the participants from baseline when they were eating provided diets.

Moreover, our study suggested that dietary GI maight be more relevant to women than to men. Women generally lose weight more slowly and display differences in postprandial glucose and fat oxidation, which might influence the rate of weight loss. These explain the difference in indicators between male and female participants before and after intervention.

We chose a 3-months duration of the intervention periods based on results of previous studies, which suggested that 3-months was sufficient to detect changes in our outcomes. A controlled trial of 6 weeks found significant beneficial effect of low-fat diet on serum cardiovascular risk factors[23]. These results do not suggest that the effects of our diets become apparent only after a longer duration of intervention.

# Dietary Pattern

In this study, we hypothesized that a low glycemic index would cause weight loss and body composition improvement, and we would also observe the impact on CVD risk factors. A study reported implementation of a low GI diet in overweight children was feasible on the basis of a 12-week nutritional intervention by giving brief instructions on categorizing food[24]. Thus, if a low GI and low fat diet did relate to anthropometric or cardiovascular disease outcomes, we hope this relationship would be seen in the present group of southwest Chinese.

Replacing starches with low GI foods in daily meals was relatively difficult to implement in the early stage but well accepted by nearly all subjects. Learning to choose foods with a lower glycemic index and changing the eating habits a little, people coud improve the quality of their diet and stick to it for a long time.

Actually, previous dtudies in other populations showed mixed results[25 – 27]. A meta-analysis of 28 trials found that lowering glycemic index did not affect HDL cholesterol or triglyceride levels, while could lower LDL cholesterol level only if fiber content was also increased[28]. In fact, the effect of dietary fiber on lowering LDL cholesterol was well recognized. A high-carb diet with a low glycemic index mentioned in the article might contain more fiber and less dietary cholesterol. Therefore, we speculated whether the emergence of different clinical research results of the effect of low GI diet on CVD risk factors was related to different levels of dietary fiber and fat content. In our intervention analysis study, the diet of the subjects chosed low-GI foods, and the energy supply ratio of fat was strictly controlled below 30%, which excluded the effect of fat on CVD risk factors to a certain extent.

# Nutrients Composition

Analysis indicated that approximately 60%-70% effects of dietary on CVD risk factors were not explained by differences in weight loss, and plausibly due to different macronutrient concentrations in the diet[27]. This finding is important, because it indicated that obese adults who lose weight on a low-carb diet could improve cardiovascular status and blood lipid levels to the same or higher levels than a low-fat diet.

The recommended LC diet is composed of carbohydrates with low GI food, while the amount of carbohydrates is still uncertain. It is worth considering comprehensively GI is just one of the attributes of a carbohydrate food. Further, nutrients often cluster. The effects of glycemic index, if any, might actually result from other nutrients, such as fiber, potassium, and polyphenols, which favorably affect health. Even

though the consumption of low GI foods is advocated, the independent benefits of GI are uncertain, especially when persons are already consuming a health diet rich in whole grains, vegetables, and fruits. In a recent prospective cohort study for 25 years exploring association between carbohydrate consumption and mortality, diets composed of 50–55% carbohydrates, regardless their plants or animal source, were associated with lowest risk of mortality[29]. When comparing LC diets, higher mortality rates were associated with animal-based protein and fats, while lower mortality rates were noticed among individuals who consumed diets with plant-based protein and fats. The advantages of increased plant food consumption should be emphasized. The optimal macronutrient composition the carbohydrate-to-fat (C/F) ratio for patients with obesity was still unclear. Therefore, while considering the intake of food GI, we also need to pay attention to the diet pattern, especially the composition of fat, fiber and phytonutrients in the diet.

Besides, previous epidemiological studies had demonstrated that saturated fatty acids and trans fatty acids was associated with an increased risk of CVD, while polyunsaturated and monounsaturated fats could reduce the risk[30]. In this study, we only focused on the total amount of fat during the intervention. Although foods with high saturated fat content (such as cream, chicken skin, fat poultry, fat livestock, etc. in Table 1) were restricted, we did not distinguish the intake of saturated fatty acid (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) respectively, which might interfere with the results of the study.

# Adverse Events

Those who were given advice might suffer gastrointestinal side effects. Although the diets prescribed were recommended for long-term health, it was possible that the acute increase in fiber from cereals, fruits, and vegetables and control in carbohydrate might cause some abdominal discomfort. Sudden reductions in carbohydrate intake might lead to symptoms like dizziness, fatigue and exercise intolerance, which tended to improve spontaneously in few days to weeks after such diet. These problems would not reappear when participants became accustomed to such diets. Although the participants were explicitly told in the informed consent before the research, some participants who could not tolerate these symptoms gave up persistence and fell off in the first few weeks.

# Adherence In The Present Study

Usual eating habits were resistant to change without specific personal and environmental supports. The success of dietary recommendations were affected the intensity of the intervention. Further emphasis of compelling reasons was required on the longer-term health advantages of sustaining a good diet, as had been confirmed in long-term follow-up of part of the anticipants. Educational programs on food choices for health maintenance might also be helpful. Meanwhile, more emphasis should be placed on overcoming obstacles related to food preparation methods and food choices when dining out. In this trail,

as long as the participants are willing, each meal coud be sent to the nutritionist by taking pictures, receiving supervision and comments, effectively solving the problem of diet compliance. Timely diet advice and monitoring feedback significantly increased interaction and persistence.

# Strengths

This was the first study in southwest China that investigated how low GI and fat restriction diet relate to overweight/obesity and markers of cardiovascular disease. One particular strength of our study was that it encouraged specific food consumption by providing both dietary advice and supervision. It was also in the context of glycemic index and fat portfolio-restricted dietary approaches, and determined the effects on body weight and risk factors for CVD. Participants received extensive knowledge of the low GI diets. Through online instant feedback intervention, its completion rate and diet adherence rate were high. Uniform guidelines were used in all consultations, and nutritionists did not turn a blind eye to the intervention process. Dietary sessions for the whole trial were intermittently observed for consistency by independent registered dietitian consultants who were not the regular part of the study staff.

The significance of this study was to study the effects of diet on weight and CVD risk by choosing foods with low glycemic index and fat restriction. However, further research is needed to determine the optimal composition of fat/carbohydrate and saturated/unsaturated fat, etc., which could be the optimal dietary composition to reduce the risk of cardiac metabolism. This study also had important public health implications in the setting of a high prevalence of excessive refined carbohydrate consumption and an epidemic of obesity and CVD worldwide.

# Study Limitations

Although this study had multiple strengths, there were some limitations. First, we only focused on the total amount of fat during the intervention. Although foods with high saturated fat content were restricted(such as cream, chicken skin, fat poultry, fat livestock, etc. in Table 1), we did not distinguish the intake of SFA, MUFA and PUFA respectively, which might interfere with the results of the study. Further analysis needs to be done in the future.

A second limitation was the provision of food guide, which might have beneficial effects in increasing intake of the desired foods for the participants. However, the changes observed in risk factors were not significant. As the participants were generally healthy at baseline, changes might have been more difficult to detect, which limited to see the effect. Besides, the clinical significance of small changes in some novel CVD risk factors is unknown.

Last, the sample size we recruited to participate in this cohort study was not large enough, lacking of control groups, and the observation time was short. The impact on long-term effects was unknown. The results of this study were not generalizable to the general population of the whole southwest China.

Literature was still lacking for well-designed randomized controlled trials to compare low-fat versus low-carbohydrate diets without confounding effects of from the behavioral aspects of eating. The ideal amount of carbohydrates, fats, and protein in an optimal diet for weight loss without CVD risk is still uncertain. Further research on the effects of a low GI diet on weight loss and CVD risk is warranted.

# Conclusion

In conclusion, at least in the short term, our finding suggested the low GI and fat restriction diet was significantly effective for weight loss without cardiovascular risk. Choosing low-GI foods was beneficial for weight loss and lower body fat, particularly in women. This advice could optimize clinical outcomes within current nutrition guidelines. Research on this type of diet can provide personalized guidance and basis for public health nutrition advice for weight loss and CVD prevention. Larger studies to evaluate low GI and fat restriction diet on weight reduction, weight maintenance, cardiovascular disease risk reduction and long-term out-comes are warranted.

# Declarations

**Ethics approval and consent to participate:**

The study design was approved by the Human Ethics and Research Ethics committees of Sichuan Provincial People's Hospital(Approval Number:2017-153). Written informed consent was obtained from the participants in the survey.

**Consent for publication:** The authors agree to publish in this journal.

**Availability of data and materials:** The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Competing interests:** The authors declare no conflicts of interest. This study is not related to any particular products of a company, and the results do not recommend any particular products.

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**Author Contributions:** We were grateful to all study participants for their active cooperation. We acknowledged contribution of our survey team members, interviewers, the leaders, and volunteers for their continuous effort in the field survey. Liu Yuping(Liu YP) designed the research. Sun Ping(Sun P) conducted research. Shuai Ping(Shuai P) analyzed data or performed statistical analysis. Qiao Qichuan(Qiao QC) completed follow-up and data collection. Li Tingxin(Li TX) performed the entire process of intervention , wrote this article and had primary responsibility for final content. All authors provided critical revisions and approved the final version of the manuscript.

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**Consent for publication:** Not applicable.

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# Figures

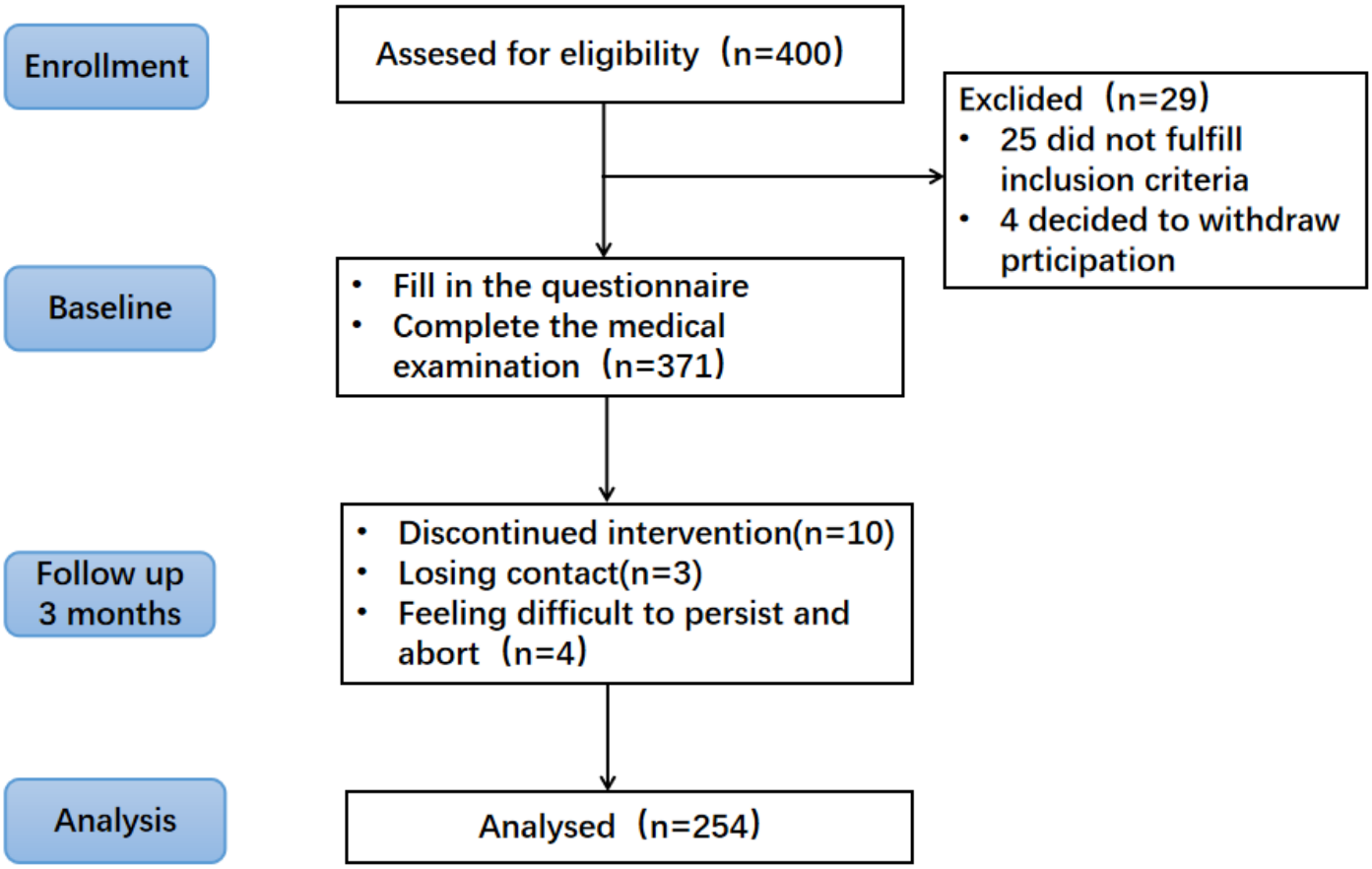
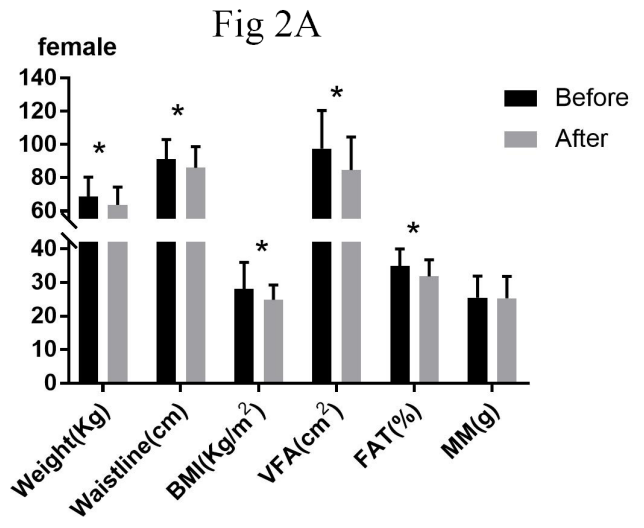
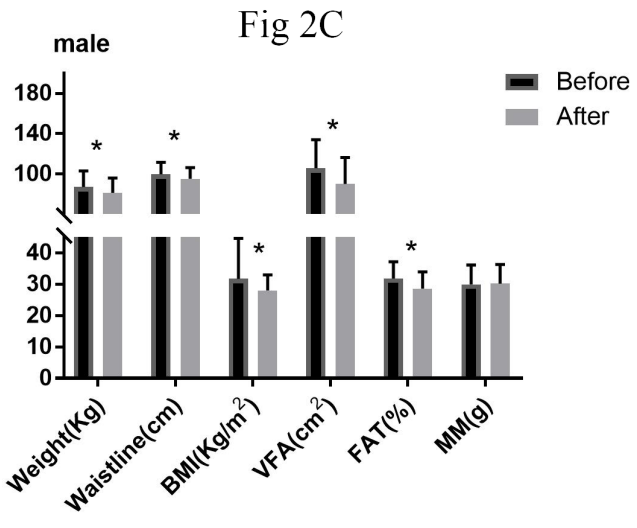
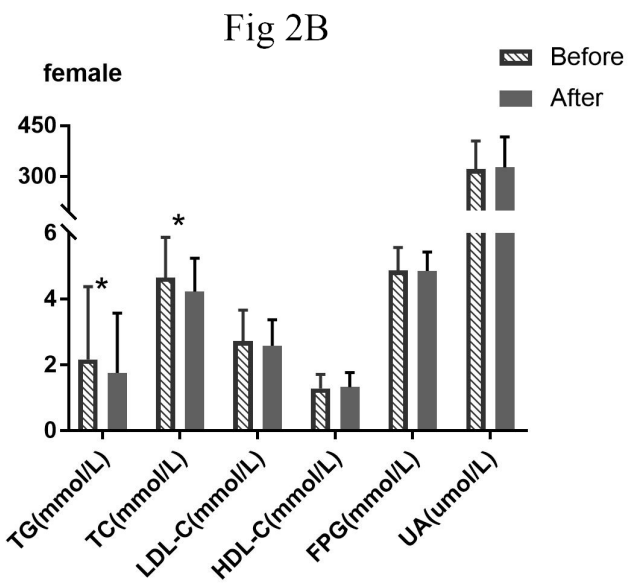


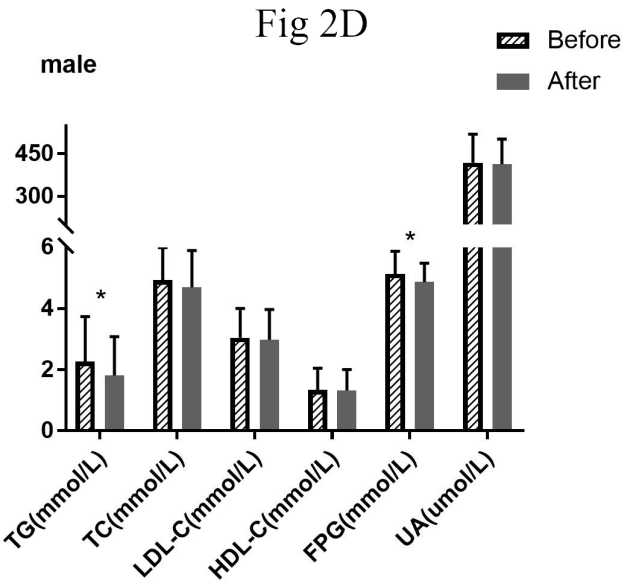

**Figure 2**

The CONSORT flow diagram of this study.




## Figure 4

Changes of body weight, body composition, blood lipids, fasting blood glucose, blood uric acid and other indicators of different gender participants before and after the intervention.