

Weight loss maintenance: A review on dietary related strategies

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Background: Weight regain after weight loss is a common problem for all those obese or overweight who have had a recent weight loss. Different cures such as diet therapy, behavioral therapy, exercise or a mixture of them have been advised as solutions. The purpose of this review is to find the best diet or eating pattern to maintain a recent weight loss. **Materials and Methods:** We searched in PubMed and SCOPUS by using the following key words: Overweight, obesity, weight maintenance, weight regain, and diet therapy. Finally, we assessed 26 articles in the present article. **Results:** Meal replacement, low carbohydrate-low glycemic index (GI) diet, high protein intake, and moderate fat consumption have shown some positive effects on weight maintenance. However, the results are controversial. A Dietary Approach to Stop Hypertension (DASH)-type diet seems helpful for weight maintenance although the need for more study has remained. Some special behaviors were associated with less weight regain, such as, not being awake late at night, drinking lower amount of sugar-sweetened beverages, and following a healthy pattern. Some special foods have been suggested for weight maintenance. However, the roles of specific foods are not confirmed. **Conclusion:** Healthy diets recommend low carbohydrate, low GI, and moderate fat foods, but it is not clear whether they are useful in preventing weight gain. It seems that consuming fewer calories helps people to keep weight loss. Further research to find strategies in obesity management focusing on successful maintenance of weight loss is needed.

Key words: Diet, feeding behavior, weight loss

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INTRODUCTION

Obesity and overweight are considered to be the fifth cause of death all over the world. In 2008, the number of overweight adults was 1.5 billion, of which 200 million of them were obese men and nearly 300 million were obese women.^[1]

Regaining nearly half of the lost weight after one year is usual and most of dieters acquire their first weight within three to five years.^[2] Experts believe that if a person sustains even 5-10% of his / her weight loss, it is considered a great achievement.^[3] Actually weight maintenance is defined as weight change up to 3% of the actual body weight after weight loss.^[4]

After fat loss, thermogenesis reduces, and results in resistance to lose fat. A drop in hormones levels, such as leptin and thyroid hormones, causes the risk of increased energy intake after weight loss. In this period, adipocytes face cellular stress and consequently renewed fat storage.^[5]

The determinants of the ability of weight maintenance are genetic, behavior, and environment. Among them,

diet is the most important factor that influences the stability of body weight.^[6,7] Some studies have shown that calorie intake less than the requirement and changing the calorie distribution from macronutrients may have a role to play.^[8] Also eating behaviors such as higher dietary disinhibition and binge eating result in weight relapse.^[2]

It has been shown that a greater resting metabolic rate (RMR) at baseline, increased dietary restraint, and low frequency of dieting,^[8] are associated with weight regain. A meta-analysis in 2001, revealed that using a very low energy diet (VLED) for weight loss or losing more than 20 kg are two predictors of weight maintenance,^[9] however, one study that assessed the method of weight loss, declared that patients on VLED gain more weight after the end of the weight loss period, but a self-directed approach was more successful in this regard.^[10] Low intake of takeaway and fast foods,^[11] reduction of food consumption, adherence to a low-fat diet,^[12] and lower sugar-sweetened beverage consumption^[13] are some of the behaviors of maintaining the weight loss. Adopting these behaviors as a habit needs supportive strategies by virtue of phone or email.^[14]

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As the studies are inconclusive, it seems necessary to plan programs in order to facilitate weight maintenance for long periods. Although there are some review studies regarding the effects of different foods and diets on weight reduction, we are not aware of any review article regarding the effects of foods and diets on preventing weight regain after weight loss. It seems that weight maintenance is as important as weight reduction nowadays. Therefore, we conducted a review of the available evidence to assess the effect of different diets on weight maintenance after weight loss.

MATERIALS AND METHODS

To identify studies regarding weight maintenance, with an emphasis on dietary interventions, a complete search of articles was carried out by using PubMed and SCOPUS. The studies were restricted to those in English. The key words included 'overweight', 'obesity', 'weight maintenance', 'weight regain', and 'diet therapy'. Articles from 1974 to 2013 were included. We found 75 articles. We excluded studies published only as abstracts and those involving behavioral therapy or exercise *per se*. Finally we evaluated 26 studies.

Meal replacement

One of methods that have been used a lot for preventing weight gain is meal replacement. It is safe, efficient, cost-effective, and without any side effects.^[3,15] In this method the level of compliance is better, the receipt of nutrient intake is sufficient, and the drop-out rate is low.^[15,16] The calorie density of these meals is controlled and they are also nutrient-dense. Main meals and snacks can be replaced by

these nutritionally balanced low-fat meals. Table 1 shows the meal replacement trials for weight maintenance.

LeCheminant and his colleagues used a liquid form of very low energy diet (VLED) for weight loss. Subsequently, they randomized participants to receive a structured meal plan combined with either two-meal replacements or orlistat and physical activity. There was no significant difference in weight change between the groups during weight maintenance.^[3]

In another study, obese adults were assigned to Medifast's meal replacement (low fat, low GI, with a balanced ratio of CHO/Pro) (MD) or a self-selected, isocaloric, food-based meal plan for weight loss and weight maintenance. The amount of weight regain was more in the MD group, but the percentage of participants who kept up their weight in this group was more than in the other group.^[15]

In a prospective intervention, 100 patients randomly went on one of the two dietary interventions for weight loss: Group A, which consisted of an energy-restricted diet, and group B, which included an isocaloric diet, through which two meals per day were replaced. Next, the patients were ordered the same calorie diets and had only one replacement per day for four years. The body weight reduced in both groups in the weight-loss period, but group B had a greater change and maintained their weight better.^[16]

Meal replacement — based dietary intervention compared to a structured diet and exercise program for both weight

Table 1: Meal replacement and weight maintenance

Author, year, Design country	Design	Sample	Intervention for weight loss	Intervention for weight maintenance	Outcome	results
LeCheminant, 2005, the US ^[3]	Randomized clinical trial	Ninety-two 19-70-year-old adults	Very low energy diet (VLED)	Structured meal plan combined with either two meal replacements or orlistat plus physical activity (6 months)	Weight, body composition	no significant difference in weight alteration between groups in weight maintenance period
Davis, 2010, the US ^[15]	Randomized controlled trial	Ninety 18-65 year-old adults	Portion-controlled meal replacements (MD) or an isocaloric plan using guidelines from the USDA Food Guide Pyramid (BF) (16 weeks)	Meal replacements (24 weeks)	Weight, waist circumference, body composition	MD group regained 4.8±5.8 kg of baseline weight loss in comparison to the FB group that regained 0.8±4.8 kg (Sig between groups)
Ditschuneit, 2001, Germany ^[16]	Prospective dietary intervention trial	100 persons ≥18 years old	Group A (regular foods) or group B (two meal replacement) (3 months)	Replacement of one meal and one snack for all subjects (4 years)	Weight, blood pressure	body weight decreased in both groups but group B had a greater alteration
Kreider, 2011, the US ^[17]	Randomized comparative effectiveness trial	Ninety 18-55-year-old women	Meal replacement- based low calorie diet program (MRP) with encouragement to increase physical activity or a more structured meal plan-based low-calorie diet and supervised exercise program (SDE)	The same one with adequate calories	Weight loss, health, and fitness related data	both programs had favorable effects on weight loss promotion and maintenance

loss and maintenance had no distinctive influences on appetite, fullness, diet satisfaction, and quality. The structured diet group lost significantly more weight and maintained greater weight loss, but they reported more physical activity too that may have affected the results.^[17]

There are some limitations when using this method. First of all, participants in most studies are volunteers and so more motivated. Second, they may not be able afford meal replacements.^[16] Finally, using the same meals every day can bring out dietary fatigue.^[3]

Different macronutrient compositions in the diet

Some researchers have tried changing macronutrient percents to find the most effective dietary mixture for weight maintenance. These kinds of diets include, low carbohydrate, low glycemic index (GI), low fat with high MonoUnsaturated Fatty Acid (MUFA), and high protein. However, there is much contradictory data in this area.

Low carbohydrate diet, high MUFA diet, high carbohydrate-low GI diet, high carbohydrate-low GI diet plus intensive support or nurse support, and low CHO / Pro diet have no major effects on the maintenance of weight loss in comparison with a low-fat diet, high protein-low GI diet, high MUFA diet plus intensive support or nurse support, and high CHO / Pro diet, respectively.^[18-21]

Larsen and his colleagues showed that the rate of maintenance of weight loss were higher among participants who were assigned to the low-protein diets and to the high-GI diets compared to the high-protein diets and low-GI diets. Significant weight gain was seen in a low protein-high GI group, but in a high protein — low GI diet weight reduction after weight loss continued. However, there was no interaction between the protein and GI.^[22] In another study, changing the diet GI did not significantly affect weight maintenance, but the low GI group consumed fewer calories.^[23]

Following an investigation by Wang *et al.*, it was identified that persons who have high levels of leptin, IL-6, and CRP, should use a high-protein diet to prevent weight regain. Unfortunately the sample size of this study was small.^[24]

An energy-restricted diet, with moderate fat, may have more advantages for weight maintenance rather than a low-fat one.^[25] When following a low-energy diet (LED), levels of the gut-derived satiety signals decrease, so finding precise solutions for appetite control are necessary. Although a moderate-fat, high in MUFA, with a low GI diet in comparison with low-fat diet leads to an increase in GLP-2 and PYY in the MUFA group, no differences between the diet groups in appetite ratings, *ad libitum*

energy intake or body weight were seen during weight maintenance.^[26]

In one recent study, the patients were randomized to a low carbohydrate breakfast (LCb) or an isocaloric diet with a high carbohydrate and protein breakfast (HCPb). In the weight maintenance period, the LCb group regained weight, but the HCPb group continued weight loss and they had lower craving score for sweet, high fat, carbohydrate or starch, and fast foods. Weight change had a positive relationship with the craving score.^[27] Table 2 contains the dietary composition changes that may affect weight loss maintenance.

Dietary behaviors

Comparison of patients who have maintained their weight loss more than re-gainers shows that the subjects in first group stay late less at night, have increased physical activity after weight loss, drink less sugar sweetened beverages, eat less calorie from protein, and they have more emotional support. Losing more weight during weight loss, monitoring weight, and choosing healthy foods are supposed to be important factors for successful weight maintenance.^[13] The calorie intake of those who do not gain weight is less than obese and overweight people.^[28] Other habits consist of using less fat and refined grains, while consuming more fiber, whole grains, vegetables, and fruits.^[29]

Perceived hunger and cognitive control is different among weight regainers compared to others.^[30] Karhunen showed that greater increase in flexible control of eating and greater decrease in uncontrollable eating and psychological distress may play some roles in successful weight maintenance.^[31] Patients with less initial weight and more weight loss can prevent weight gain.^[32] When you consume more calcium it results in less weight increment.^[33] Weight loss maintainers in the National Weight Control Registry reported consuming different foods in the basement of the food pyramid, but they had less variety among all the food groups.^[34]

Other dietary changes

The Dietary Approaches to Stop Hypertension (DASH) diet is one of the diets that have been studied for weight maintenance. This diet includes consuming more vegetables, fruits, and low-fat dairy products. Following this diet helps patients to achieve^[35,36] and maintain weight loss and this effect has been related to dairy products rather than fiber.^[37]

Although gelatin has a short effect on hunger suppression, in comparison with milk protein it has no further effect on preventing weight gain.^[38]

It seems that a six-week re-feeding period after weight loss is more efficient in weight maintenance and improves dietary restraint in comparison to four weeks.^[39]

Table 2: Macronutrient component and weight maintenance

Author, year, country	Design	Sample	Intervention for weight loss	Intervention for weight maintenance	Outcome	results
Due, 2008, Denmark ^[18]	Parallel, randomized clinical trial	169 subjects aged 18-35 years	Low-calorie diet	A diet providing a Moderate amount of fat and >20% of fat as MUFA, a low-fat diet or a control diet	Change in Body weight and body composition	weight return were happened in both groups but it was non-significant between groups
Delbridge, 2009, Australia ^[19]	Parallel, randomized clinical trial	141 subjects aged >18 to <75 years	Very low energy diet (VLED)	High CHO low GI or a high protein low GI diet	Body weight and body composition	no difference between HP and HC groups in weight or BMI alterations during weight maintenance period
Dale, 2009, New Zealand ^[20]	Randomized controlled trial	200 women aged 25-70 years	Intensive support and a high-CHO low-GI diet or nurse support and a high-CHO diet low GI or intensive support and a high MUFA diet or nurse support and a high MUFA diet	The same diet	Hunger, satiety, weight, body fat	All diets had same effects for weight regain prevention
Layman, 2009, the US ^[21]	Multicenter randomized clinical trial	130 subjects aged 40-56 years	Low carbohydrate/protein ratio or high carbohydrate/protein ratio diets	The same diet	Weight and body composition	After 12 months, loss of fat mass in high protein diet group was greater
Larsen, 2010, Europe ^[22]	Multicenter, randomized clinical trial	1209 adults between 18 and 65 years	Low-calorie-diet	low Pro-low GI or low Pro-high GI or high Pro-low GI or high Pro-high GI or control diets	Body weight	Only low Pro-high GI group had significant weight regain
Philippou, 2009, UK ^[23]	Randomized controlled trial	42 subjects between 18 and 65 years	Low-calorie-diet	High glycemic index (HGI) or low glycemic index (LGI) diet	Weight, BMI, body fat	no difference in body weight, hunger or fullness in weight maintenance period between groups
Wang, 2011, Europe ^[66]	Randomized controlled trial	48 women 34-44 years old	Low-calorie-diet	low Pro-low GI or low Pro-high GI or high Pro-low GI or high Pro-high GI or control diets	Obesity related blood proteins	LH, CRP, IL6, haptoglobin, leptin, vascular endothelial growth factor-D, Insulin-like growth factor binding protein 3, had significant interaction with dietary protein level, IL8, macrophage migration inhibiting factor, Matrix metalloproteinase 9 and coagulation factor VII had significant interaction with dietary GI level for the prediction of weight during weight maintenance period
Azadbakht, 2007, Iran ^[25]	Randomized, prospective trial	89 subjects 40-50 years old	Energy-controlled diet with moderate fat or low fat energy-controlled diet	The same diet	Weight, BMI	moderate-fat diet was more successful in weight maintenance
Sloth, 2009, Denmark ^[26]	Randomized controlled trial	154 participants aged 18-35 years	low-energy diet	low-fat or high MUFA - low GI or average Danish diet	Body weight, body composition	significant increase in body weight, BMI and fat mass during weight maintenance (non significant between groups)
Jakubowicz, 2012, Israel ^[27]	Randomized, treatment controlled, open clinical trial	193 subjects aged 20-65 years	Low carbohydrate diet with a low calorie, and low carbohydrate breakfast (LCb) or high carbohydrate- and protein-enriched breakfast diet (HCPb)	The same diet	Waist circumference, Appetite scores	during the follow-up period HCPb participants lost additional weight, but subjects in the LCb group regained weight

Special foods

Some studies have assessed the effects of special foods on weight maintenance. For example, weight regain did not occur in individuals who had consumed green tea and caffeine mixture with an adequate or high-protein diet. Only, in the group with an adequate protein intake, a higher hunger score and lower satiety was seen.^[40] Based on a recent meta-analysis, green tea has no significant effect on the weight loss maintenance.^[41] It may have some consequences in habitual low caffeine consumers.^[42]

Weight changes after capsaicin consumption was not significantly different from a placebo. Respiratory quotient and resting energy expenditure was higher in the capsaicin group, but it had no relationship with weight regain and after treatment it returned to the normal level.^[43] Table 3 shows the results of using special diets or foods and prevention of weight regain.

DISCUSSION

The findings from this review show that neither meal replacement nor macronutrient composition manipulation, have any positive effects on weight maintenance. Sustaining lost weight needs some dietary pattern changes, including, healthy food choices and healthy lifestyle behaviors.^[44] Although long-term maintenance of dietary changes is difficult,^[45] it seems that more intake of fiber, MUFA, low-GI carbohydrates, as well as protein, result in less weight regain.^[18-27] However, a diet high in low glycemic index, fruits, vegetables, whole grains, protein foods, nuts, canola,

and olive oil can be helpful for weight maintenance. The relevant mechanisms consist of reducing the appetite and hunger by virtue of hormonal signals, improvement in body composition, and making individuals more satiated.^[46] Therefore, education on healthy eating behavior, in addition to a diet such as DASH, may help obese individuals to keep up their weight.

Meal replacement has been used for weight loss as a successful strategy.^[47] Its advantages are, easier adherence, reduced food choices, as well as controlled calorie and nutrient content, but it may be boring for a long period.^[3,4] Nevertheless, its effectiveness in weight maintenance is a subject under discussion. It can be the consequence of a different macronutrient composition or the number of meals that were replaced.

Dietary composition may have a role in preventing weight regain after weight loss. Low carbohydrate diets have been used a lot for weight loss, but their effects in long-term weight control are controversial. Poor dietary compliance is one of the most common problems associated with these diets. They also have to be supplemented because of nutrient deficiency.^[48] Soenen demonstrates that a higher protein intake, which is related to lower weight gain and lower carbohydrate intake has no additional results.^[49] The relationship between more protein intake and less weight regain has been shown previously.^[50]

It has been shown that micronutrient dietary supplement consumption results in a lower body weight and resting

Table 3: Diet, Food, and weight maintenance

Author, year, country	Design	Sample	Intervention for weight loss	Intervention for weight maintenance	Outcome	results
Champagne, 2011, the US ^[37]	Randomized controlled trial	828 participants aged 28-83 years	DASH diet	The same diet	Weight, BMI	More adherence to DASH diet was related to significantly less weight regain
Hochstenbach-Waelen, 2010, The Netherlands ^[38]	Single-blind parallel study	81 subjects aged 18-65 years		Sustained milk protein diet (SMP) or supra-sustained milk protein diet (SSMP) or supra-sustained gelatin-milk protein diet (GMP)	Body weight, body composition, dietary behavior	no significant weight regain were seen in all 3 diet groups
Hursel, 2009, The Netherlands ^[40]	Randomized, placebo-controlled, double-blind parallel trial	80 subjects 42-46 years old	Very low energy diet (VLED)	Green tea-caffeine mixture treatment+adequate protein (AP) or green tea-caffeine mixture treatment+relatively high protein (HP) or placebo or HP+ placebo	Body weight, body composition, attitude toward eating, post absorptive appetite profile	significant body weight regain occurred in the AP+placebo group, larger hunger and lower satiety in the green tea-caffeine mixture+AP group
Lejeune, 2003, The Netherlands ^[43]	Randomized double-blind placebo-controlled study	91 participants aged 18-60 years	Very low energy diet (VLED)	Capsaicin or placebo	Body weight, BMI, body composition, attitude toward eating, post absorptive appetite profile	body-weight regain were not significantly different between groups, increase in resting energy expenditure in weight maintenance period was significantly more in the capsaicin group

metabolic rate in men and lower hunger level in females,^[51] but there are no sufficient studies to assess their roles in preventing weight regain after weight loss. Only the Nachtigal cohort study revealed that long-term use of vitamins B6 and B12, and chromium were significantly associated with lower weight gain.^[52]

Whether more dairy intake is a predictor of successful weight maintenance, is unclear.^[33] Food variety is evaluated by virtue of the dietary diversity score (DDS).^[53] Some studies declare that lower DDS^[54-56] is related to lower body mass index (BMI); just one study has shown that their association is inverse.^[57,58] As energy intake increases along with DDS,^[59] the lower food group variety causes lower energy intake;^[34] so it is essential to eat just a special kind of food. Dietary habits that can help obese persons to keep their lost weight are self-efficiency, cognitive control, monitoring weight, correct dietary choices, high levels of physical activity, eating more low calorie-dense foods, and lower portion size.^[6,7,28-30,32] Unfortunately, most of the individuals who have lost weight successfully, give up healthy behaviors after the weight loss period.^[12] Although the special foods do not have a confirmed role in weight maintenance, other foods with a high amount of isoflavones may be effective in weight maintenance. Soy products are foods with a high amount of isoflavones.^[60-63] However, we have not documented researches in this field. Therefore, it is suggested to be considered in future researches. Some specific behavior also may be effective in weight maintenance. Previous publications have shown that sleep deprivation may be associated with obesity and central adiposity.^[64] Therefore, whether or not sleep duration is related to weight maintenance needs to be made clear in the future. Other behaviors also need to be assessed in this regard.

Diets such as DASH or addition of components like gelatin, capsaicin, and green tea have been tried for weight maintenance, but they need more investigation to clarify their long-term effects. Although the DASH diet has numerous health results, its effect on weight loss and maintaining it is still under dispute. As its recommended servings are similar to those that have been discussed earlier, a lot more research is needed in this area.

Diets with a meal replacement approach have some limitations, which have been mentioned previously. In comparison with the change of dietary macronutrient composition, they have no additional benefits, even though obeying the second one seems more convenient, because they do not need to change a person's food habits. Nutritional counseling can help overweight subjects to learn dietary behaviors for weight gain prevention. It is more effective when a kind of healthy diet such as DASH is followed. Lin's study indicates that lower saturated fat intake and higher

plant protein are associated with less weight regain.^[65] The DASH dietary approach may change the macronutrient composition of a diet to some extent, however, it does not have the limitations of the meal replacement pattern.

We should note the limitation of these studies such as self-reported data, more proportion of men than women in the study, their design, no representative sample, dropout rate, motivated participants, and low dietary compliance.

CONCLUSION

Long-term maintenance of the lost body weight can be described as a success. Although meal replacement has beneficial effects on weight loss, it cannot guarantee weight maintenance. Healthy diets recommend low carbohydrate, low GI, and moderate fat foods, but it is not clear whether they are useful in preventing weight gain. It seems that consuming fewer calories helps people to maintain the weight loss. Some special behaviors are also associated with better weight loss maintenance. Consuming a lower amount of sugar sweetened beverages, not being awake late at night, and consuming more healthy foods are some examples of such behaviors. No special food can definitely promote weight maintenance. Therefore, there is a necessity to develop further research to find strategies in obesity management, focusing on the successful maintenance of weight loss.

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