Chapter

The Role of Dietary Interventions in the Management of Obesity

Asad Ullah, Muhammad Jamil and Johar Jamil

Abstract

The epidemic of obesity is taking over many parts of the world. The etiology of obesity is multifactorial; however, disordered energy balance regulation is a central feature. Obesity is managed by lifestyle changes alone or in combination with pharmacotherapy or bariatric surgery. Diet is an essential part of the primary and secondary prevention of obesity. Various dietary patterns have successfully induced acute weight loss, but no diet stands apart from others. Most agree that an ideal weight loss diet should be nutritionally adequate, safe, effective, affordable, and culturally admissible. Creating a negative energy balance is the underpinning theme across weight loss diets. Despite early weight loss, most individuals struggle to maintain weight long-term. Weight gain occurs due to a complex interaction of physiological, environmental, and psychological factors. Long-term weight management is influenced by lifelong conformity to low energy diet, lifestyle changes and ongoing support from family, friends, and healthcare professionals. Strategies should be implemented at the population level to prevent obesity. Policymakers, schools, businesses, healthcare providers, community leaders and individuals must unite at local, national, and international levels to fight the epidemic of obesity.

Keywords: low fat diet, low carbohydrate diet, Mediterranean diet, weight loss, fasting

1. Introduction

Obesity is a complex chronic disease with abnormal or excessive body fat that impairs health, increases the risk of long-term medical complications, and reduces life span. Obesity is associated with diabetes mellitus, hypertension, cardiovascular disorders, neurological conditions, e.g., Alzheimer's dementia, fatty liver disease, and certain cancers.

The prevalence of obesity has almost tripled globally between 1975 and 2016 [1]. It has reached to epidemic level and is expected to grow in the foreseeable future.

Patients with body mass index (BMI) >25 kg/m^2 or high abdominal girth (men >102 cm and women >88 cm) should consider weight loss. Other factors, such as a family history of obesity, fat distribution, obesity-associated comorbidities, and cardiovascular risk factors, influence obesity management.

Setting a weight loss goal is the first step. It should be realistic, achievable, and reasonable. Weight loss could be divided into two phases, i.e., initial rapid weight loss (up to 6 months) and slow maintenance phase (lifelong). Diet plays a substantial

Health outcome	Improvement after 10 kg weight loss
Blood pressure (BP)	10 mm Hg drop in systolic BP
	20 mm Hg drop in diastolic BP
Diabetes mellitus	50% drop in fasting glucose level
Lipid profile	10% drop in total cholesterol
	15% drop in LDL cholesterol
	30% drop in triglycerides
Mortality	20% fall in overall mortality

Table 1.
Advantages of 10 kg weight loss.

role in the early phase of weight loss. Research shows that a modest 5–10% weight loss improves lipid profile, glycemic control, and blood pressure [2] (**Table 1**). It is clinically safe and achievable; hence most weight loss programs aim for 5–10% weight loss in the acute phase.

Weight maintenance is more challenging. Adherence to a low-fat diet and regular physical activity determine success.

Lifestyle modification (including diet, stress management, sleep, and physical exercise) is the first line of treatment for class I (BMI 30–34.9 kg/m^2) & class II (BMI 35–39.5 kg/m^2) obesity. Most agree that diet plays a fundamental role in the etiology of obesity. The modern diet is rich in refined carbohydrates, animal fats, salt, additives, preservatives, and ultra-processed foods. All these attributes drive weight gain and obesity. Therefore, modifying diet alone or combined with other interventions could prevent or treat obesity.

Public health and social marketing shape the dietary patterns of the public. The current focus is on selecting healthy food and eating less. Unfortunately, this has created a misconception that calorie restriction is the only or main factor responsible for weight loss. Indeed, weight loss needs calorie restriction, but the mechanics of weight loss are far more complex than just calorie restriction.

2. Nutritional strategies for weight loss

Clinical and commercial weight loss programs have successfully used various dietary patterns. A common theme among weight loss diets is setting up a negative energy balance. Most weight loss programs target 0.5 to 1 kilogram weight loss per week. A calorie deficit of 500 per day or 3500 per week is sufficient to achieve this target. The recommended calorie intake for a patient is calculated by first calculating the resting metabolic rate and multiplying it by an appropriate physical activity factor to get the calories for weight maintenance. Then subtract calories to induce weight loss. A fixed-calorie diet is a relatively easy alternate approach. It recommends a predetermined daily calorie intake based on the calorie level, which caused weight loss in clinical trials.

After deciding the daily calorie intake limits the next step is to choose the appropriate diet. Patients and families should be actively involved in selecting the weight loss diet to ensure success.

Generic name	Popular examples	Dietary composition
Diets with variable macronutrient composition		
Low fat, high carbohydrate diet	Ornish, Pritkin, T factor and Fit or Fat diets	Carb- 45-65%
		Fat- ≤10–19%
		Protein- 10-20%
Low carbohydrate, high fat, high protein diet	Atkins, Stillman, Scarsdale & Carb addict's diet	Carb ≤20% (<100–125 g/day)
		Fat- 55-65%
		Protein- 25-40%
High protein, low carbohydrate diet	Sugar busters, Zone, South beach diets	Carb- 40-50%
		Fat- 30-40%
		Protein- 25-40%
Balanced low-calorie dietary patterns		
	Mediterranean diet	Carb- 35-40%
		Fat- 40-50%
		Protein- 12-20%
	DASH diet	Carb- 55-60%
		Fat- 20-30%
		Protein- 15-30%
	Portfolio	
	Nordic	
	Vegetarian	
	Low glycemic index	
	Paleolithic	
Calorie restricted diets	Low energy diet	900–1200 kcal/day
	Very low-energy diet - Optifast, Medifast diets & Health management resources program	<800 kcal/day
Food based approaches		
Intermittent fasting	Alternate day fasting 5:2 Time-restricted feeding	
Non-dieting approaches	Heath at every size	

Table 2.
Common dietary approaches for weight loss.

Table 2 summarizes some of the commonly used weight loss diets.

2.1 Macronutrient-based approaches for weight loss

The human diet comprises macronutrients, micronutrients, dietary fiber, and water. The macronutrients, i.e., carbohydrates, fat, and protein, are energy sources. Fat is the most energy-dense macronutrient and contains 9 kcal/gram. Carbohydrates and protein provide ~4 kcal/gram.

Macronutrient	Recommended proportion of energy from macronutrients/day for the healthy population
Carbohydrate	45–65%
Fat	20–35%
Protein	10–35%

Table 3.
Macronutrient reference values for the healthy population.

Dietary reference intake (DRI) provides reference values of nutrients in healthy populations. **Table 3** demonstrates the daily requirements of macronutrients for healthy individuals [3].

Macronutrient-based calorie-restricted diets have variable macronutrient composition. Keeping energy constant, increasing one macronutrient will result in a compensatory reduction of another macronutrient. For instance, a low carbohydrate diet will have relatively high fat and protein content.

2.1.1 Low-fat diet

A low-fat diet provides 20–25% of energy from fat, and a very low-fat diet yields 10–20% of energy from fat. The proponents of a low-fat diet hypothesize that reducing the most calorie-dense macronutrient, i.e., fat, could result in weight loss. However, this relationship is not as straightforward as it sounds. Epidemiologic data show increased body weight despite a reduction in overall fat intake.

A meta-analysis comparing low-fat and regular-fat diets reported greater weight loss (3–5 kg) in individuals with a 10% or more reduction in dietary fat intake [4]. Another review showed a dose-dependent decrease in weight with a low-fat diet. Every 1% reduction in fat was associated with 0.28 kg weight loss [5]. However, another meta-analysis failed to show a difference in weight loss with reduced and normal-fat diets [6].

Indeed high-fat intake is associated with weight gain; however, the weight loss effect is unclear within the low-fat range (<30% of total energy). A systematic review reported higher weight loss in higher fat quartiles within the low-fat range [7]. Weight loss achieved with a low-fat diet is comparable to other weight loss diets.

A low-fat diet is associated with reduced triglyceride levels. However, triglycerides could increase if high glycemic index (GI) carbohydrates replace fat. Interestingly, low GI carbohydrates or mono/polyunsaturated fat do not increase triglycerides [8].

It is a challenge to maintain a very low-fat diet long term.

2.1.2 Low-carbohydrate diet

This diet yield <45% of daily calorie intake from a carbohydrate source. But there is a lack of consensus on the exact amount of carbohydrates, making it difficult to compare outcomes of studies.

The low-carbohydrate intake suppresses insulin secretion, which decreases fat storage (carbohydrate-insulin model). The higher protein content enhances satiating and higher metabolic burn (200–300 kcal) due to the thermogenic effect. Although unproven, some also argue that the calories from proteins are less prone to be stored as fat than the equivalent caloric intake from a carbohydrate source.

A meta-analysis of 38 studies shows greater weight loss with a low carbohydrate diet than a high carbohydrate diet (16.9 vs. 1.9 kg respectively). However, randomized cross-over and randomized controlled trials did not report a significant difference in weight loss between low and high carbohydrate diet [9].

Carbohydrate-restricted diet enhances satiety and is easy to follow. Studies show increased insulin sensitivity and improvement in glycemic control with a high-fat diet [10]. Evidence confirms the benefits of a low-carbohydrate diet in type II diabetes mellitus [11]. They are famous for rapid weight loss, especially the ketogenic version.

Adverse effects include fatigue, nausea, halitosis, muscle cramps, dizziness, and headache. Most low-carbohydrate diets limit fruit and vegetables, which increases the risk of micronutrient deficiency, e.g., vitamin A, B1, B6, E, folic acid, calcium, potassium, and dietary fiber. Moreover, adherence to a very low-carbohydrate diet is a challenge.

Studies have raised concerns about increased cardiovascular risks with a low-carbohydrate diet, especially if the saturated fat intake is high. A meta-analysis confirmed an increase in low-density lipoprotein with a low carbohydrate diet, although high-density lipoprotein and triglycerides improved [12]. The high protein content of this diet could increase urinary calcium excretion, leading to osteoporosis. Renal impairment could ensue due to high acid load [13]. Gout could occur due to high purine content.

2.1.3 Ketogenic diet

Also called the keto diet is a very low carbohydrate diet that allows 20–50 grams of carbohydrates per day and induces ketosis. The ketogenic diet suppresses insulin secretion, thus switching the energy source from glucose to fat. The body attempts to keep glucose levels at an appropriate level through gluconeogenesis. However, as the body's ability to synthesize glucose declines, fat is mobilized and utilized to produce ketones through ketogenesis, which meet the body's energy demands. Ketosis suppresses appetite, food cravings and hunger [14], thus encouraging rapid weight loss. Notably, nutritional ketosis does not cause metabolic acidosis [15] as opposed to diabetic ketoacidosis.

Keto diets are popular in the weight loss industry but do not have full support from the medical community due to their side effects. **Table 4** shows the two commonly used ketogenic diets and their macronutrient contents.

A meta-analysis of 14 randomized trials with 12 months or more follow-up reported greater weight loss with a very low carbohydrate ketogenic diet [WMD: 0.91 kg (95% CI: −1.65 to −0.17) p = 0.47] compared to a low-fat diet [16].

Besides weight loss, the ketogenic diet has a therapeutic role in diseases such as epilepsy, non-alcoholic steatohepatitis, Alzheimer's disease, polycystic ovary syndrome, acne and certain cancers [17]. The exact mechanisms of therapeutic actions of the ketogenic diet are not fully understood; however, **Table 5** [17] illustrates the suggested mechanisms.

Types of Ketogenic diet	Carbohydrate	Fat	Protein
Low carbohydrate or keto diet	5–10%	65–80%	15–25%
Very low-energy diet	30–50%	5–35%	35–45%

Table 4.
Composition of ketogenic diets.

Disease condition	Proposed mechanisms
Epilepsy	• Affecting Mammalian target of rapamycin pathway • Reduced excitability of neurons • Direct anticonvulsant effect of ketones
Non-alcoholic steatohepatitis	• Enhancing hepatic insulin sensitivity • Reduced gluconeogenesis • Decrease intrahepatic triglycerides
Alzheimer's disease	• Improved neuronal excitability • Mitochondrial function • Protection against β-amyloid
Polycystic ovary syndrome	• Lowering of blood insulin level • Reduced insulin-like growth factor 1 (IGF-1)
Acne	• Reduced IGF-1
Cancers	• Reduced blood glucose and insulin levels

Table 5.
Proposed therapeutic mechanisms of keto diets in various medical conditions.

The long-term safety of the keto diet is yet to be confirmed. Epidemiological data correlate a low carbohydrate diet with high mortality [18]. The high-fat content of the keto diet is a concern. It adversely affects the gut microbiome, brain function, cardiovascular health, and metabolic profile. Furthermore, compliance with the ketogenic diet is a challenge.

The Keto diet should be used cautiously with sodium-glucose transporter 2 (SGLT2) inhibitors in diabetic patients [19] due to the risk of metabolic acidosis.

Most of the macronutrient-based dietary approaches result in significant weight loss in the short term. No macronutrient distribution has shown a meaningful advantage over others regarding weight loss or cardiometabolic benefits. POUND LOST study [20] compared four diets with macronutrient permutations in obese adults (BMI 25–40 (kg/m^2) in a free-living setting. Body weight and body fat (total, visceral, hepatic, and subcutaneous fat) were measured at 6 and 24 months. Regardless of the macronutrient composition, most participants lost body fat (12.4%), lean mass (3.5%), visceral fat (16.1%), subcutaneous fat (13.6%) and abdominal fat (13.8%) at 6 months. The critical determinants for weight loss were low-calorie density and high fiber intake. The structured eating patterns might have also contributed to weight loss. At 24 months, most participants regained 40% of the lost weight with no difference between the diets.

Quality of the macronutrients is equally crucial for health benefits. Eco-Atkin study [21] randomly assigned 47 overweight adults with hyperlipidemia to either a low carbohydrate (26%) vegan diet with high protein (31%) and fat (43%) from gluten, soya, vegetable oils and nuts or high carbohydrate lacto-ovo vegetarian diet (58% carbohydrate, 25% fat & 16% protein). Weight loss at 4 weeks was similar in both groups; however, total cholesterol, high-density lipoprotein ratio (−8.1%), low-density lipoprotein (−8.7%) and apolipoproteins B: A1 ratio (−9.6%) were significantly lower in the low carbohydrate group. Blood pressure was also lower in the low-carbohydrate vegan group. Twenty-three patients completed 6 months of follow-up in a free-living setting. Study participants lost further weight in both groups (−6.9 vs. −5.8 kg respectively). Lipid markers declined in both groups but more in the low carbohydrate

vegan group than in the comparator group. This study highlighted the weight loss and cardiovascular benefits of a vegan diet over a vegetarian diet. Similarly, the Prospective Urban Rural Epidemiology (PURE) study reported low non-cardiovascular and all-cause mortality in individuals with high fruit, vegetable, and legume intake [22].

In clinical studies, restrictive dietary approaches show weight loss in the short term; however, increased hunger and dissatisfaction reduce their effectiveness and long-term sustainability.

2.2 Balanced low-calorie diets patterns

This approach focuses on the whole diet rather than targeting a specific macronutrient. Besides acute weight loss, it has beneficial cardiometabolic effects independent of weight loss. They are more satisfying and have a better consumer acceptance profile. Therefore, long-term compliance is better. A few common balanced macronutrient dietary patterns are discussed below.

2.2.1 Mediterranean diet pattern

The Mediterranean diet is popular in the Mediterranean basin but is adopted worldwide due to its favorable effects on cardiovascular risks and weight loss. Some of the longest-living people in the world have consumed the Mediterranean diet. Its ingredients are not homogeneous and vary from region to region. However, it is primarily a plant-based diet, which promotes a high intake of local fruit, vegetables, unrefined grains, nuts, legumes, and olive oil. Fermented dairy products, fish, and red wine are allowed in moderation, while a low intake of meat and meat products is recommended. Mediterranean diet is rich in dietary fiber, micronutrients, antioxidants, monounsaturated and omega-3 polyunsaturated fats. It is low in saturated fat. It offers more food diversity than restrictive diets.

Studies show contradictory results about the weight loss outcomes of Mediterranean diet. A systematic review of 21 epidemiologic studies provided mixed results regarding the effects of the Mediterranean diet on weight loss [23]. The mixed results could be due to heterogeneity, varied comparators, and inconsistent follow-up periods. A recent systematic review [24] of 5 randomized trials reported moderate weight loss (−3.8 to −10.1 Kg) beyond 12 months using the Mediterranean diet. The weight loss was superior to the low-fat diet but equal to the low-carbohydrate and American Diabetes Association diet. Further studies are needed to clarify the role of the Mediterranean diet in weight loss.

Regardless of weight loss, the antioxidant and anti-inflammatory properties of the Mediterranean diet have beneficial effects on the cardiometabolic profile. Some experts believe that the anti-atherogenic effect is related to bioactive constituents in Olive oil (esp. extra virgin oil) [25] rather the mono-unsaturated fat. PREvención con DIeta MEDiterránea (PREDIMED) study is the largest randomized controlled trial designed to assess the cardiovascular benefits of the Mediterranean diet [26]. The study randomly assigned 7447 participants with cardiovascular disease risk factors but no diagnosis of cardiovascular disease into three groups. Group 1 was assigned to a Mediterranean diet enriched with extra virgin olive oil (MD + EVOO), group 2 had a Mediterranean diet with nuts (MD + nuts) and group 3 was prescribed a low-fat diet. No restrictions were placed on energy intake. The unadjusted hazard ratio for the cardiovascular event was 0.70 (95% CI: 0.53–0.91) in MD + EVOO and 0.7 (95% CI:0.53–0.94) in MD + nuts compared to the control group. The risk of developing

diabetes mellitus was lower in the MD groups. In June 2018, the PREDIMED study was retracted and republished due to errors in the randomization. However, study results and overall conclusion remained unchanged after re-analysis.

2.2.2 Dietary approach to stop hypertension (DASH) diet

DASH dietary pattern was introduced in the 1990s to prevent and treat hypertension. It advocates the intake of fresh fruit, vegetables, low or fat-free dairy and nuts. DASH diet recommends lower sodium intake (<1.5 g/day) and discourages using saturated fat and sweetened beverages.

A meta-analysis of the DASH diet reported a reduction in systolic and diastolic blood pressure by −7.4 and −4.4 mm Hg, respectively, compared to the comparator [27].

Besides its blood pressure-lowering effect, several studies have highlighted the favorable effects of the DASH diet on lipid profile, blood glucose and insulin resistance. It correlates with lower colorectal cancer risk and improved celiac and diverticular disease [28]. A meta-analysis of 13 studies revealed the weight loss effects of the DASH diet [29]. The weighted mean difference was −1.42 kg (95% CI: −2.03 to −0.82) in 8–24 weeks. The weight loss effect was more pronounced with a low-calorie DASH diet in obese individuals.

2.2.3 Portfolio pattern

It is a modified plant-based diet with cholesterol-lowering foods such as olive oil, nuts, legumes, pulses, barley, oats, psyllium, etc. Its role in weight loss is not clear.

2.2.4 Nordic pattern

It was launched in 2004 and comprised the traditional diet consumed in Nordic countries. It encourages the use of fruit, vegetables, spices, seafood, and unsaturated oils (Canola oil), while processed foods and red meat are discouraged.

A randomized study reported a mean weight loss of −4.7 kg with an ad libitum Nordic diet compared to −1.5 kg with an average Danish diet [30].

2.2.5 Vegetarian pattern

It is a heterogeneous diet emphasizing the consumption of plant-based food (e.g., fruit, vegetables, seeds, legumes etc.). A vegetarian diet is classified depending on the restrictions applied, but avoiding meat is a constant feature. Vegans avoid any food of animal origin, lacto-vegetarians can take dairy products, and lacto-ovo-vegetarians can take dairy and eggs.

The vegetarian diet is rich in polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), minerals, fiber, antioxidants, and plant sterols. All these ingredients favorably influence lipid profile and cardiovascular risks. The low-calorie density of vegetarian food encourages weight loss.

Multiple studies have shown weight loss with vegetarian diet [31].

2.2.6 Low glycemic index dietary pattern

The glycemic index is the blood glucose response to a defined amount of carbohydrate (50 grams) in a test food relative to a reference food (usually white bread). The

GI was primarily developed for managing diabetes mellitus; however, it has earned popularity in weight management.

Low GI foods positively modify blood glucose levels, insulin levels, blood pressure and lipid profile. Studies show an association between low GI food with higher weight loss (−1 to 3 kg) compared to other energy-restricted diets in the short term [32].

2.2.7 Paleolithic pattern

It is also called the 'old stone age' or 'caveman diet'. This pattern is based on the diet practiced by our ancestors 2 million years ago. Its ingredients vary from region to region but generally allow vegetable, fruit, pasture-raised or grass-fed meat, fish, poultry, and nuts. At the same time, processed foods, grains, legumes, and dairy are restricted.

The Paleolithic diet is nutritious; however, compliance is challenging due to the elimination of commonly consumed beverages and foods. Limited available research showed improved insulin sensitivity, lipid profile, weight loss and an association with lower frequency of certain cancers [33, 34].

2.3 Low-calorie dietary pattern

A low-calorie diet (LCD) allows 900–1200 kcal/day. LCD is popular for achieving rapid weight loss in a short time; however, weight regain is a concern. A systematic review reported a mean weight loss of 7–13 kg at 14 weeks [35]. The weight loss declined to 6–7 kg at 12 months and 3.5 kg at 2 yr. Most individuals were close to the pre-intervention weight at 5 yr., highlighting the difficulty in maintaining weight long-term. Interestingly, men attain higher weight loss with LCD than women (11.8 vs. 10.3% respectively) [36].

Furthermore, sustaining LCD is challenging due to its restrictive nature and low energy content. These diets pose the risk of micronutrient deficiency. Therefore, it should be supplemented with either multivitamins or fortified food.

The very low-calorie diet (VLCD) provides <900 kcal/day. It is best preserved for those with acute threatening health risks from obesity and where rapid weight loss could improve the outcomes. VLCD is used briefly before bariatric surgery to reduce the risk of complications.

Weight loss with VLCD is more impressive than with LCD. Ninety per cent of the patients accomplish more than 10% weight loss with VLCD vs. 60% of the patients with LCD. Weight loss slows substantially after 12 weeks due to a low resting metabolic rate and declining voluntary energy expenditure. Like LCD, the weight loss is more in men than in women (2–2.5 kg vs. 1.5–2 kg/week). Adding behavioral therapy and exercise to VLCD increases weight loss [37]. Studies show that VLCD could help in maintaining weight [37].

The Diabetes remission clinical trial (DiRECT) trial reported a high likelihood of diabetes mellitus remission with VLCD at 1 & 2 yr. follow-ups [38].

Some experts fear that the rapid weight loss with VLCD will follow rapid weight gain. But studies do not support this hypothesis [39].

VLCD is administered in a liquid formula based on milk or egg protein. It is supplemented with vitamins, fatty acids, and electrolytes to compensate for micronutrient deficiency. The protein content of VLCD is high (0.8–1.5 g/kg) to counter the lean mass loss.

Common side effects	Less frequent side effects
Dry skin	Electrolyte imbalance Cardiac arrhythmia
Fatigue, weakness, and lethargy	Seizures
Cold intolerance	Cholelithiasis
Dizziness	Osteoporosis
Nutritional ketosis	Anemia
Gastrointestinal effects - nausea, vomiting, constipation	Hair loss
Menstrual abnormalities	Skin thinning
	Muscle cramps
	Edema
	Nutrient deficiency

Table 6.
Side effects and complications of VLCD.

Table 6 summarizes the side effects of VLCD. Patients on VLCD therapy require close metabolic monitoring and should be administered only under the supervision of physicians with experience in this area.

VLCD is contraindicated in patients with a history of cardiovascular diseases, cardiac conduction abnormalities, recent myocardial infarction, type I diabetes mellitus, renal disease, hepatic disorders, burns, and pregnant or lactating women. Behavioral contraindications include acute psychiatric illness, substance abuse, major depression, bulimia nervosa, and bipolar disorder. Caution should be exercised if used in the elderly and pediatric population.

2.4 Food-based approaches

These dietary approaches recommend using specific foods such as fruit, vegetables, pulses (lentils, chickpeas, peas & beans etc.), nuts, whole grains, and dairy products. Evidence shows that these foods have a role in weight loss, maintaining body weight, and reducing cardiovascular risks.

2.5 FAD diets

The FAD diet is marketed as a quick fix for rapid weight loss in a short period. It is administered as a very restrictive diet or eating a few foods in an unusual pattern, such as eating only tomatoes. Such programs often make unreasonable claims that are not based on scientific evidence. A FAD diet could be harmful and should be discouraged.

2.6 Intermittent energy restriction

Fasting has been used for health benefits since the 5th Century BC [40]. In modern medicine, fasting in obesity management goes back to 1960s. Unfortunately, it went out of fashion due to serious adverse events. However, it has re-emerged as a therapeutic option recently. Besides weight loss, calorie restriction enhances insulin sensitivity, improves blood pressure, and reduces cardiovascular risks in animals. Furthermore, fasting correlates with cancer prevention and increased life expectancy in pre-clinical studies. The exact mechanisms for these changes are not fully understood. One hypothesis is the upregulation of the Sirtuins (SIRTs) signaling pathway. Sirtuin 1 (SIRT1) is an intra-nuclear molecule which deacetylates transcription factors

involved in longevity and stress management. Calorie restriction upregulates SIRT1, which, in turn, reduces inflammation and increases insulin sensitivity [41]. SIRT1 reduces fat storage and resets the hormones linked with age pacing via the proliferator-activated receptor gamma pathway [42].

Fasting could be total prolonged fasting (TPF) or intermittent fasting (IF). TPF involves going without food for days. It is counterproductive for weight loss due to a compensatory decline in metabolic rate and physical activity. Moreover, it is associated with severe lean mass and micronutrient deficiency.

Intermittent fasting (IF) offers a sustainable and healthy alternative. It consists of fast and feast windows. Few or no calories are ingested during the fast, followed by ad libitum eating. IF is not a diet as such instead; it is about the timing of eating. In other words, any diet could be intercalated with IF.

Three common forms of IF are a 5:2 diet, alternate day fasting and time-restricted feeding (TRF). The 5:2 diet entails two fasts and five ad libitum feeding days per week. Alternate day fasting involves a day of fasting followed by an ad libitum eating day. TRF is the most popular form of IF. It implies an 8–10 hr. daytime feeding window followed by a 14–16 hr. fast (including overnight fast). The supporters of TRF hypothesize that eating food late at night may disrupt circadian rhythm, hormonal balance, glucose tolerance, reduce resting energy expenditure, and alter body temperature rhythms. Therefore, changing the eating time may improve the metabolism.

Fasting can reduce body weight by multiple mechanisms, i.e., calorie restriction, ketogenesis, interfering with the gut microbiome and establishing a feeding routine. A study compared a 5:2 diet with continuous energy restriction (1200–1500 kcal/day). The weight loss was comparable in the two groups (−6.8 ± 6.4 kg vs. −5.0 ± 7.1 kg, respectively) [43]. Another review of 40 studies reported that the IF caused 7–11 pounds of weight loss over 10 weeks; however, it was not superior to continuous energy restriction [44]. Furthermore, the adaptative responses to weight loss with IF were not different from continuous energy restriction.

Fasting remains an option in managing obesity, but further research is required.

2.7 Non-dieting approach

The traditional weight loss dietary approaches are predominately restrictive and fail to support weight maintenance. Non-dieting lifestyle approach is a popular alternative to the conventional weight-focused approach. The proponents of this weight-neutral approach believe that health is the outcome of behaviors independent of body weight. It focuses on a meaningful and fulfilling lifestyle. In a non-dieting program, food intake is guided by internal body cues, e.g., hunger and satiety [45], rather than external signals, such as meal time or events. Patients are encouraged to accept and respect their body size/shape at any weight. Health at Every Size (H@ES) is a program based on this philosophy. Besides intuitive eating, cognitive behavioral therapy and reasonable levels of physical activity administered in a non-restrictive way are other essential elements of H@ES.

Although the non-dieting approach is weight neutral, some studies have reported weight loss with this pattern. A randomized study compared a non-dieting eating pattern (1800 kcal/day) to a restrictive diet (1200 kcal/day). Weight loss was less in the non-dieting group than in the comparator group initially. However, at 12 months, greater weight loss was observed in the non-dieting group (10 vs. 4.5 Kg) than in the comparator [46]. Other studies revealed contradictory results; therefore, further research is needed.

The non-dieting approach has limitations and is not suitable for everyone. It is contraindicated in obese individuals fond of high-fat or high-sugar foods, those with extreme hunger signals, who consider eating large portions normal, and who lack the comprehension of healthy nutrition.

The non-dieting approach improves eating-related psychological disorders such as binge eating, depression, anxiety, and poor self-image [47].

3. Practical dietary interventions for weight loss

Regardless of the weight loss dietary approach, the following interventions could assist in achieving sustainable weight loss. It is essential to incorporate these strategies into daily routines to achieve the desired results.

3.1 Replacing high for low energy density foods

Studies show that people eat a consistent amount of food regularly. Therefore, diminishing the calorie density will lower the energy intake while eating satisfying meals.

The food energy density could be reduced by adding water-rich foods such as vegetables and non-starchy fruit. Another approach is reducing fat by using low-fat versions, e.g., grilled meat instead of fried meat or low-fat milk instead of full-fat dairy, without restricting the portion size. Besides quantity, the quality of fat also matters. Most dietary guidelines recommend substituting trans and saturated fat with monounsaturated and polyunsaturated fat.

Utilizing low-calorie dense foods at different meal courses could also help achieve sustainable weight loss. Studies indicate that selecting a large portion of low-energy-density food in the first course (starters) promotes satiety and helps lower the total calorie intake, e.g., low-calorie-dense salads and broth-based soups. Most of the energy intake occurs during the main course. Substituting high-calorie dense foods with low-calorie dense foods in entrée could support weight loss.

Food portion is another variable which influences energy intake. The larger the portion size, the higher the energy intake.

In a nutshell, reducing calorie density and controlling portion size promote weight loss.

3.2 Increasing satiety and adequate nutrients intake

3.2.1 Protein and fiber for fullness and satiety

An effective weight loss diet should satisfy hunger and induce satiety. Protein is the most satiating macronutrient. Protein intake reduces food intake and decreases the likelihood of snacking. Furthermore, protein preserves lean mass while on a low-calorie diet. It, in turn, keeps up basal metabolic rate supporting weight loss.

Dietary fiber comes from plant-based foods, but humans cannot fully digest dietary fiber. The undigested fiber confers a sense of fullness. Studies show that dietary fiber has a role in weight loss. Besides weight loss, it also has a role in preventing cardiovascular diseases, diabetes mellitus, stroke, and cancer (esp., bowel cancers) [48].

Dietary fiber exists in two forms, i.e., insoluble and soluble viscous forms. Insoluble fiber adds bulk to stool but does not impact the cardiometabolic profile. Soluble viscous fiber (found in oats, psyllium, barley, fruit, and vegetables) improves the cardiometabolic profile and glycemic control. DRI recommends an intake of 25–38 g of mixed fiber per day.

3.2.2 Reducing or eliminating the use of ultra-proceed foods

Ultra-processed food goes through multiple industrial processes (milling, molding) and has added ingredients which compromise its nutritional value. They are high in salt, sugar, and fat but deficient in fiber and micronutrients. For example, ice cream, chocolate, soft drinks, fries, sweetened breakfast cereals etc.

Several studies correlate the consumption of ultra-processed food with weight gain, risk of type II diabetes mellitus, cardiovascular diseases, cancers, depression, and overall mortality [49]. High glycemic load, poor nutritional value, displacement of healthful foods and poor gut-neuronal satiety signaling are some reasons for poor health outcomes.

A cohort study with almost 9 years of follow-up reported a 26% greater risk of weight gain in the higher quartile (6.1 servings/day) of ultra-processed food consumers compared to the lower quartile (1.5 servings/day) [50]. Eliminating or reducing ultra-processed food will support healthy weight and reduce the risk of diseases associated with such foods.

3.2.3 Using low calories beverages and water

Sugar-sweetened beverages (SSBs) add empty calories. It encourages weight gain by stimulating insulin secretion and probably activating the dopaminergic reward system in the brain. SSBs increase the risk of insulin resistance and cardiovascular risks independent of weight gain. The incidence of type II diabetes mellitus is higher among SSB consumers. Fruit drinks, sodas, sweetened carbonated drinks, cordials, sports drinks, and flavored drinks are examples of SSBs. Fruit juices are considered healthy and have nutrients; however, they are calorie dense and could cause weight gain if consumed in higher quantities.

Studies report a direct dose-response correlation between SSBs and long-term weight gain [51].

Substituting water or low-calorie sweetened beverages (tea, coffee, sparkling water etc.) for SSBs may promote healthy weight by reducing total calorie intake.

3.2.4 Substituting non-nutritive sweeteners for nutritive sweeteners

Nutritive sweeteners (NS) contain calories and promote weight gain; non-nutritive sweeteners (NNS) were introduced to replace NS.

NNS has zero or few calories. Logically, NNS use will reduce energy intake and weight. However, studies show mixed results. Prospective cohort studies report weight gain and increased risk of type II DM with NNS, while randomized controlled trials show beneficial effects of NNS on weight and type II DM [52]. This divide in studies conclusions is likely due to study design and differences in the controls. Controls in prospective studies are free living, and additional variables are not controlled for, while randomized trials control for additional variables. Further research is needed to provide insights into the benefits or harms of NNS.

4. Healthy dietary patterns tools

Selecting the right portion size is a challenge for most people. There is a need for tools that could guide the public in choosing the appropriate portion size.

Meal replacement (MR) or pre-packaged food is one such tool. It contains fixed calories (typically 200–300 kcal/serving). MR is available in various forms, such as snack bars, frozen meals, or shakes. It could be employed as a partial (as part of a low-calorie diet) or total meal replacement (as part of a very low-calorie diet).

In the first three to 4 months, partial meal replacement achieves 10–12% weight loss [53]. Systematic reviews and meta-analyses have demonstrated the efficacy of MR in achieving greater weight loss with partial meal replacement compared to conventional weight loss diets. MR has favorable effects on type II diabetes mellitus. The DiRECT study confirmed a 20-fold higher remission of diabetes mellitus at 12 months with total liquid meal replacement [38].

Portion control tools such as plates, bowels, serving spoons, cups, scales etc., could help limit food quantity; however, studies show these measures are insufficient. Poor compliance is a significant problem. Educating patients about proportion size is more effective. My Plate campaign is an example of a portion control education tool. It was launched by the United States Department of Agriculture (USDA) to promote healthy eating. It is an online tool which guides individuals about what and how much to eat.

Smartphone applications (apps) can support weight loss. Quite a few apps are already available in the market. Apps make weight loss activities measurable (by collecting data such as food intake, physical activity, distance traveled, sleep quality, heart rate, stress levels etc.), giving the consumer more control. The efficacy of apps in weight loss is controversial. Further studies are needed to validate their use in weight management. Apps could be used as an adjunct to other weight loss measures.

5. Maintaining weight loss

Many people succeed in losing weight, but only a few manage to keep it off. Some individuals regain a substantial amount of weight within 2 years, and most will retrieve all the weight lost in 5 yr. [54].

Why is weight maintenance so difficult? The initial rapid weight loss is followed by protective homeostatic changes, which resist further weight loss. Orixigenic hormone (ghrelin) increases while anorexigenic hormones (cholecystokinin, leptin, amylin, peptide YY and glucagon-like peptide 1) decrease [55]. Furthermore, the resting metabolic rate declines with weight loss. The muscles become more efficient in conserving energy. The net result of these changes is increased appetite and reduced energy expenditure resulting in weight gain [56]. Motivation drops as weight loss hits a plateau. The problem is further complicated by the easy availability of calorie-dense food and disinhibited eating habits.

Weight maintenance cannot be achieved only with diet; It requires a more holistic approach, including diet, physical activity, behavioral changes, and psychological support. Adherence to a low-calorie density diet and lifestyle modification are the keys to long-term success.

Research shows that individuals with ongoing support from friends, family, and healthcare professionals do better than those without help. The technology could be utilized to support sustainable weight loss. Genomics could help in selecting the appropriate diet for the right patient.

The National Weight Control Registry (NWCR) findings are an invaluable resource for weight maintenance. NWCR was established in 1994 to determine the characteristics of successful weight loss maintainers [57]. The database prospectively tracks over 10,000 individuals who have lost 30 pounds or more [mean 66 pounds (30–300 pounds)] and maintained it for at least 1 yr. [mean 5.5 yr. (1–66 yr)] [58].

The database has certain limitations. Firstly, it is not a prevalence study, and the sample is not random. Therefore, the results could not be extrapolated to the general population. Secondly, the participants self-identify themselves as eligible for the registry. Most of the information is self-reported, which is liable to bias. Thirdly, 80% of the participants are predominantly white females. Their mean age ranges between 45 and 49 yr. Despite its limitations, many studies support the NWCR findings.

The critical lessons learnt from the NWCR database are as follows: NWCR participants lost weight utilizing various interventions in the acute phase; however, there is limited variability in the strategies used for weight maintenance. Most consumed low fat (<30%), high carbohydrate and low energy diet to keep the weight off.

More than 90% of the participants used physical activity and diet to maintain weight. Most individuals do regular exercise (average 1 hour per day). Studies have revealed that physical activity preserves lean body mass regardless of weight loss which helps maintain a higher metabolic rate. Regular physical activity could also be a biomarker for compliance with other positive lifestyle modifications.

Seventy-eight per cent of the participants reported eating breakfast regularly. How breakfast contributes to sustainable weight loss is not clear. Perhaps eating breakfast may be more satiating than eating late in the day. Eating breakfast is correlated with lower BMI [59].

Almost all participants of NWCR weigh themselves at least weekly, and some even more frequently. Identifying increasing weight can act as an early warning sign that feeds back to institute corrective and preventative measures.

The dietary pattern of weight maintainers is consistent over the weekdays, weekends, and vacations all over the year.

Almost two-thirds of the individuals in NWCR spent less time in front of the television screen than the average American adult (≤ 10 hours vs. 28 hours per week). Watching TV is a passive activity, and most people also eat while watching TV. It is unclear what part of the energy balance contributes to weight gain, but watching TV is an independent marker of weight status regardless of the reason.

There are some exceptions to the behaviors mentioned above. Four per cent of the NWCR participants do not take breakfast; some individuals (<10%) take a low carbohydrate diet, and 9% do little or no exercise to maintain weight.

6. Conclusions

Obesity is a chronic disease which is associated with increased morbidity and mortality. The prevalence of obesity has increased globally.

It is managed by lifestyle modification alone or in combination with medications or surgery. Diet is an integral part of the primary and secondary prevention of obesity. There is no consensus on the best dietary approach for weight loss. However, most agree that an ideal weight loss diet should be culturally acceptable, palatable, satiating, low-energy-dense, nutritious, affordable, and sustainable. Most dietary guidelines recommend a high intake of whole grains, legumes, fresh fruit, vegetables,

and nuts. Moderate consumption of unprocessed meat, eggs, and milk is encouraged, while refined sugars, high sodium, trans fat, and processed foods are discouraged. Patient and family involvement is essential in selecting the right diet plan for better compliance.

Most patients can achieve 5–10% weight loss with diet, but few can maintain it over an extended period. Management goals for weight maintenance are different; here, the emphasis is on long-term compliance with low calorie-dense, low-fat diet, physical activity, behavioral change, and psychosocial support.

Besides managing obesity at an individual level, tackling it at a population level is necessary. The existing measures for controlling obesity are inadequate. The public and private sectors need to step in and play their role. Weight management programs should be built into job plans, especially for high-risk jobs. Schools should embed healthy eating and physical activity in the curriculum. Food laws should promote healthy eating and exercise. There is room for improvement in the marketing regulations of unhealthy foods and drinks.

Acknowledgements

I would like to express my special thanks to my parents, wife, and children, who supported me in completing this work.

Conflict of interest

"The authors declare no conflict of interest." This work is not funded.

Notes/thanks/other declarations

None.

The Role of Dietary Interventions in the Management of Obesity
DOI: http://dx.doi.org/10.5772/intechopen.111529

Author details

Asad Ullah[1*], Muhammad Jamil[2] and Johar Jamil[3]

1 University of Liverpool, Liverpool, UK

2 Retired General Practitioner, Peshawar, Pakistan

3 University of Swabi, Swabi, Pakistan

*Address all correspondence to: drasadullah99@hotmail.com

References

[1] WHO. Obesity and overweight. [updated 2023; cited 2023 01-03-2023]; 2021. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

[2] Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. The New England Journal of Medicine. 2002;**346**(6):393-403

[3] Trumbo P, Schlicker S, Yates AA, Poos M. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. Journal of the American Dietetic Association. 2002;**102**(11):1621-1630

[4] Astrup A. The role of dietary fat in obesity. Seminars in Vascular Medicine. 2005;**5**(1):40-47

[5] Astrup A. The American paradox: The role of energy-dense fat-reduced food in the increasing prevalence of obesity. Current Opinion in Clinical Nutrition and Metabolic Care. 1998;**1**(6):573-577

[6] Pirozzo S, Summerbell C, Cameron C, Glasziou P. Should we recommend low-fat diets for obesity? Obesity Reviews. 2003;**4**(2):83-90

[7] Tobias DK, Chen M, Manson JE, Ludwig DS, Willett W, Hu FB. Effect of low-fat diet interventions versus other diet interventions on long-term weight change in adults: A systematic review and meta-analysis. The Lancet Diabetes and Endocrinology. 2015;**3**(12):968-979

[8] Hung T, Sievenpiper JL, Marchie A, Kendall CW, Jenkins DJ. Fat versus carbohydrate in insulin resistance, obesity, diabetes and cardiovascular disease. Current Opinion in Clinical Nutrition and Metabolic Care. 2003;**6**(2):165-176

[9] Bravata DM, Sanders L, Huang J, Krumholz HM, Olkin I, Gardner CD, et al. Efficacy and safety of low-carbohydrate diets: A systematic review. Journal of the American Medical Association. 2003;**289**(14):1837-1850

[10] Tay J, Thompson CH, Luscombe-Marsh ND, Wycherley TP, Noakes M, Buckley JD, et al. Effects of an energy-restricted low-carbohydrate, high unsaturated fat/low saturated fat diet versus a high-carbohydrate, low-fat diet in type 2 diabetes: A 2-year randomized clinical trial. Diabetes, Obesity & Metabolism. 2018;**20**(4):858-871

[11] Goldenberg JZ, Day A, Brinkworth GD, Sato J, Yamada S, Jönsson T, et al. Efficacy and safety of low and very low carbohydrate diets for type 2 diabetes remission: Systematic review and meta-analysis of published and unpublished randomized trial data. BMJ. 2021;**372**:m4743

[12] Mansoor N, Vinknes KJ, Veierød MB, Retterstøl K. Effects of low-carbohydrate diets v. low-fat diets on body weight and cardiovascular risk factors: A meta-analysis of randomised controlled trials. The British Journal of Nutrition. 2016;**115**(3):466-479

[13] Martin WF, Armstrong LE, Rodriguez NR. Dietary protein intake and renal function. Nutrition & Metabolism (London). 2005;**2**:25

[14] Abbasi J. Interest in the ketogenic diet grows for weight loss and type 2 diabetes. Journal of the American Medical Association. 2018;**319**(3):215-217

[15] Noakes TD, Windt J. Evidence that supports the prescription of low-carbohydrate high-fat diets: A narrative review. British Journal of Sports Medicine. 2017;**51**(2):133-139

[16] Bueno NB, de Melo IS, de Oliveira SL, da Rocha AT. Very-low-carbohydrate ketogenic diet v. low-fat diet for long-term weight loss: A meta-analysis of randomised controlled trials. The British Journal of Nutrition. 2013;**110**(7):1178-1187

[17] Paoli A, Rubini A, Volek JS, Grimaldi KA. Beyond weight loss: A review of the therapeutic uses of very-low-carbohydrate (ketogenic) diets. European Journal of Clinical Nutrition. 2013;**67**(8):789-796

[18] Seidelmann SB, Claggett B, Cheng S, Henglin M, Shah A, Steffen LM, et al. Dietary carbohydrate intake and mortality: A prospective cohort study and meta-analysis. The Lancet Public Health. 2018;**3**(9):e419-ee28

[19] Rosenstock J, Ferrannini E. Euglycemic diabetic ketoacidosis: A predictable, detectable, and preventable safety concern with SGLT2 inhibitors. Diabetes Care. 2015;**38**(9):1638-1642

[20] Sacks FM, Bray GA, Carey VJ, Smith SR, Ryan DH, Anton SD, et al. Comparison of weight-loss diets with different compositions of fat, protein, and carbohydrates. The New England Journal of Medicine. 2009;**360**(9):859-873

[21] Jenkins DJ, Wong JM, Kendall CW, Esfahani A, Ng VW, Leong TC, et al. Effect of a 6-month vegan low-carbohydrate ('Eco-Atkins') diet on cardiovascular risk factors and body weight in hyperlipidaemic adults: a randomised controlled trial. BMJ Open. 2014;**4**(2):e003505

[22] Miller V, Mente A, Dehghan M, Rangarajan S, Zhang X, Swaminathan S, et al. Fruit, vegetable, and legume intake, and cardiovascular disease and deaths in 18 countries (PURE): A prospective cohort study. Lancet. 2017;**390**(10107):2037-2049

[23] Buckland G, Bach A, Serra-Majem L. Obesity and the Mediterranean diet: A systematic review of observational and intervention studies. Obesity Reviews. 2008;**9**(6):582-593

[24] Mancini JG, Filion KB, Atallah R, Eisenberg MJ. Systematic review of the mediterranean diet for long-term weight loss. The American Journal of Medicine. 2016;**129**(4):407-15.e4

[25] Guo X, Tresserra-Rimbau A, Estruch R, Martínez-González MA, Medina-Remón A, Castañer O, et al. Effects of polyphenol, measured by a biomarker of total polyphenols in urine, on cardiovascular risk factors after a long-term follow-up in the PREDIMED study. Oxidative Medicine and Cellular Longevity. 2016;**2016**:2572606

[26] Estruch R, Ros E, Salas-Salvadó J, Covas M-I, Corella D, Arós F, et al. Primary prevention of cardiovascular disease with a mediterranean diet supplemented with extra-virgin olive oil or nuts. New England Journal of Medicine. 2018;**378**(25):e34

[27] Filippou CD, Tsioufis CP, Thomopoulos CG, Mihas CC, Dimitriadis KS, Sotiropoulou LI, et al. Dietary approaches to stop hypertension (dash) diet and blood pressure reduction in adults with and without hypertension: A systematic review and meta-analysis of randomized controlled trials. Advances in Nutrition. 2020;**11**(5):1150-1160

[28] Tyson CC, Nwankwo C, Lin PH, Svetkey LP. The dietary approaches to stop hypertension (DASH) eating pattern in

special populations. Current Hypertension Reports. 2012;**14**(5):388-396

[29] Soltani S, Shirani F, Chitsazi MJ, Salehi-Abargouei A. The effect of dietary approaches to stop hypertension (DASH) diet on weight and body composition in adults: A systematic review and meta-analysis of randomized controlled clinical trials. Obesity Reviews. 2016;**17**(5):442-454

[30] Poulsen SK, Due A, Jordy AB, Kiens B, Stark KD, Stender S, et al. Health effect of the New Nordic Diet in adults with increased waist circumference: A 6-mo randomized controlled trial. The American Journal of Clinical Nutrition. 2014;**99**(1):35-45

[31] Ivanova S, Delattre C, Karcheva-Bahchevanska D, Benbasat N, Nalbantova V, Ivanov K. Plant-based diet as a strategy for weight control. Foods. 2021;**10**(12):3052. DOI: 10.3390/foods10123052

[32] Thomas DE, Elliott EJ, Baur L. Low glycaemic index or low glycaemic load diets for overweight and obesity. Cochrane Database of Systematic Reviews. 2007;**2007**(3):Cd005105

[33] Frączek B, Pięta A, Burda A, Mazur-Kurach P, Tyrała F. Paleolithic diet-effect on the health status and performance of athletes? Nutrients. 2021;**13**(3):1019. DOI: 10.3390/nu13031019. Published 2021 Mar 21

[34] Whalen KA, McCullough M, Flanders WD, Hartman TJ, Judd S, Bostick RM. Paleolithic and mediterranean diet pattern scores and risk of incident, sporadic colorectal adenomas. American Journal of Epidemiology. 2014;**180**(11):1088-1097

[35] Glenny AM, O'Meara S, Melville A, Sheldon TA, Wilson C. The treatment and prevention of obesity: A systematic review of the literature. International Journal of Obesity and Related Metabolic Disorders. 1997;**21**(9):715-737

[36] Christensen P, Meinert Larsen T, Westerterp-Plantenga M, Macdonald I, Martinez JA, Handjiev S, et al. Men and women respond differently to rapid weight loss: Metabolic outcomes of a multi-centre intervention study after a low-energy diet in 2500 overweight, individuals with pre-diabetes (PREVIEW). Diabetes, Obesity & Metabolism. 2018;**20**(12):2840-2851

[37] Parretti HM, Jebb SA, Johns DJ, Lewis AL, Christian-Brown AM, Aveyard P. Clinical effectiveness of very-low-energy diets in the management of weight loss: A systematic review and meta-analysis of randomized controlled trials. Obesity Reviews. 2016;**17**(3):225-234

[38] Lean ME, Leslie WS, Barnes AC, Brosnahan N, Thom G, McCombie L, et al. Primary care-led weight management for remission of type 2 diabetes (DiRECT): An open-label, cluster-randomised trial. Lancet. 2018;**391**(10120):541-551

[39] Purcell K, Sumithran P, Prendergast LA, Bouniu CJ, Delbridge E, Proietto J. The effect of rate of weight loss on long-term weight management: A randomised controlled trial. The Lancet Diabetes and Endocrinology. 2014;**2**(12):954-962

[40] Britannica, The Editors of Encyclopaedia. "ṣawm". Encyclopedia Britannica, 1 Mar 2023. Available from: https://www.britannica.com/topic/sawm [Accesse: 5 March 2023]

[41] Madeo F, Carmona-Gutierrez D, Hofer SJ, Kroemer G. Caloric restriction mimetics against age-associated disease: Targets, mechanisms, and

therapeutic potential. Cell Metabolism. 2019;**29**(3):592-610

[42] Martin B, Mattson MP, Maudsley S. Caloric restriction and intermittent fasting: Two potential diets for successful brain aging. Ageing Research Reviews. 2006;**5**(3):332-353

[43] Carter S, Clifton PM, Keogh JB. Effect of intermittent compared with continuous energy restricted diet on glycemic control in patients with Type 2 diabetes: A randomized noninferiority trial. JAMA Network Open. 2018;**1**(3):e180756

[44] Seimon RV, Roekenes JA, Zibellini J, Zhu B, Gibson AA, Hills AP, et al. Do intermittent diets provide physiological benefits over continuous diets for weight loss? A systematic review of clinical trials. Molecular and Cellular Endocrinology. 2015;**418**(Pt 2):153-172

[45] Cummings S, Parham ES, Strain GW. Position of the American dietetic association: Weight management. Journal of the American Dietetic Association. 2002;**102**(8):1145-1155

[46] Sbrocco T, Nedegaard RC, Stone JM, Lewis EL. Behavioral choice treatment promotes continuing weight loss: Preliminary results of a cognitive-behavioral decision-based treatment for obesity. Journal of Consulting and Clinical Psychology. 1999;**67**(2):260-266

[47] Koller KA, Thompson KA, Miller AJ, Walsh EC, Bardone-Cone AM. Body appreciation and intuitive eating in eating disorder recovery. The International Journal of Eating Disorders. 2020;**53**(8):1261-1269

[48] Reynolds A, Mann J, Cummings J, Winter N, Mete E, Te Morenga L. Carbohydrate quality and human health: A series of systematic reviews and meta-analyses. Lancet. 2019;**393**(10170):434-445

[49] Elizabeth L, Machado P, Zinöcker M, Baker P, Lawrence M. Ultra-processed foods and health outcomes: A narrative review. Nutrients. 2020;**12**(7):1955. DOI: 10.3390/nu12071955

[50] Mendonça RD, Pimenta AM, Gea A, de la Fuente-Arrillaga C, Martinez-Gonzalez MA, Lopes AC, et al. Ultraprocessed food consumption and risk of overweight and obesity: The University of Navarra Follow-Up (SUN) cohort study. The American Journal of Clinical Nutrition. 2016;**104**(5):1433-1440

[51] Imamura F, O'Connor L, Ye Z, Mursu J, Hayashino Y, Bhupathiraju SN, et al. Consumption of sugar sweetened beverages, artificially sweetened beverages, and fruit juice and incidence of type 2 diabetes: Systematic review, meta-analysis, and estimation of population attributable fraction. BMJ. 2015;**351**:h3576

[52] Walbolt J, Koh Y. Non-nutritive sweeteners and their associations with obesity and type 2 diabetes. Journal of Obesity & Metabolic Syndrome. 2020;**29**(2):114-123

[53] Tsai AG, Wadden TA. The evolution of very-low-calorie diets: An update and meta-analysis. Obesity (Silver Spring). 2006;**14**(8):1283-1293

[54] Clinical Practice Guidelines For The Management Of Overweight And Obesity In Adults, Adolescents And Children In Australia 2013. Available from: https://www.nhmrc.gov.au/about-us/publications/clinical-practice-guidelines-management-overweight-and-obesity#block-views-block-file-attachments-content-block-1

[55] Lean ME, Malkova D. Altered gut and adipose tissue hormones in overweight and obese individuals: Cause or consequence? International Journal of Obesity. 2016;**40**(4):622-632

[56] Greenway FL. Physiological adaptations to weight loss and factors favouring weight regain. International Journal of Obesity. 2015;**39**(8):1188-1196

[57] Registry TNwc. Reserach findings. Available from: http://www.nwcr.ws/Research/default.htm

[58] Thomas JG, Bond DS, Phelan S, Hill JO, Wing RR. Weight-loss maintenance for 10 years in the National Weight Control Registry. American Journal of Preventive Medicine. 2014;**46**(1):17-23

[59] Sievert K, Hussain SM, Page MJ, Wang Y, Hughes HJ, Malek M, et al. Effect of breakfast on weight and energy intake: Systematic review and meta-analysis of randomised controlled trials. BMJ. 2019;**364**:l42