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The Effectiveness of Low-Carb Diet vs Low-Fat Diet on Body Composition in People with Obesity: A Literature Review

Efektivitas Low-Carb Diet vs Low-Fat Diet *terhadap* Body Composition *pada Orang dengan Obesitas:* Literature Review

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ABSTRACT

Background: Obesity is still become a serious problem today. Obesity is caused by excessive adipose tissue. One of many factors that contribute to a person's obesity is food intake. Excess carbohydrate and fat intake will be stored in the form of triglycerides in adipose tissue. In the meantime, Low-Carb Diet (LCD) and Low-Fat Diet (LFD) are one of the most popular treatments on obesity. However there are many pros and cons related to each diet based on several studies.
Objectives: The indicated study aims to determine the effectiveness of LCD and LFD on body composition in people with obesity.
Methods: The study was conducted through journal and literature review, based on five journal publications, filtered by related keywords. In accordance to inclusion and exclusion criteria within the last ten years in Pubmed/Medline database, Science Direct, and Wiley Online Library with the keywords "Low-Carb Diet", "Low-Fat Diet", "Body Mass Index", "Lipid Levels", "Adipose Tissue", "Obese", and "Body Water".
Discussion: Total body mass and fat mass decreased significantly after being given LCD intervention compared to LFD. The group that was given two dietary interventions also losing weight, but there was no changes in body water. In addition, negative effects were found from the LCD and LFD interventions such as constipation, fatigue, polyuria, nausea, vomiting, changes in appetite, and headaches. Kidney failure, ketosis, and premature coronary artery also occurred in the group that was given with LCD intervention.
Conclusions: LCD and LFD interventions can affect body composition of people with obesity.

INTRODUCTION

Obesity is a condition where body has excessive body fat or adipose tissue, so that total body weight greater than normal[1]. Obesity is still a problem in various parts of the world, both in developed and developing countries with an increasing prevalence every year. In accordance with the World Obesity Atlas (2022), in 2030, it is predicted that one out of five women, and one out of seven men are obese (BMI ≥30 kg/m^2), or equal to 1 billion people in the world are predicted to be obese[2]. According to the latest Riskesdas in 2018, the obesity prevalence in adults aged >18 years is 35.4% among total population with an increase of 1.9% of obesity prevalence from 2016. The increasing prevalence of obesity is one of the issue that should be taken seriously since its impact on the body could be fatal, both to the momentary and deep-rooted terms.

Obesity can increase the risk of certain diseases. Obesity is known as the risk factor of many diseases, specifically coronary heart disease, heart failure, and even premature death[3]. Obesity is associated with risk factors in cardiovascular health which resulted in inflation of cholesterol and blood pressure that are significantly higher than usual. Some studies consider that the relationship between obesity and cardiovascular diseases basically are happened due to the consequences of the hormones desperation and moving factors including adipokine, chemokine, and growth factor components of inflammation and the effect of prothrombotic[3]. Obesity can lead to perivascular fat deposit increment around the heart and blood vessel. The Increasing number of fat around blood vessel can lead to proinflammatory and profibrotic cytokine overload. This trigger inflammation and atherosclerosis which resulted in the increase of intima media thickness and decreased arterial elasticity.

Several factors directly contribute to a person's obesity are diet, lifestyle, lack of activity, genetic, and

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several other factors that directly affect energy allocation in the body such as psychological, biological, individual, and even environmental[4]. Carbohydrate, protein, and fat influence the incidence of obesity through effects of food intake, digestion, absorption of nutrient intake, and metabolism in the body. Basically, obesity is caused by the excessive adipocyte tissue. In obesity, high carbohydrate intake leads to excessive glucose which will then converted into glycerol for further storage in the form of triglycerides in adipocyte tissue, and excessive protein intake also causes adipocyte mass to increase. In addition, high-fat consumption over a long period of time can also increase the risk of obesity where fat absorbed in the structure of free fatty acids and stored in the form of triglycerides in adipocyte tissue[5].

Losing about 5 to 10% of body weight during the first six months is the main goal of obesity management. Obesity management emphasizes lifestyle interventions which include changes in diet, increased physical activity, and behavior modification. The main cause of obesity is poor eating behavior so that patient management focuses on dietary interventions in the form of limiting calorie intake. Selection of the right diet affects the success of weight loss. Therefore, knowing the long-term effectiveness and side effects of various diet therapies is very important. Significantly, there are several types of diets that can lose weight in a short time such as low-carb diets (LCD) and low-fat diets (LFD). A low-carbohydrate diet (LCD) is a diet that restricts carbohydrate intake determined by the proportion of total daily energy[6]. The possible effects of a low-carbohydrate diet are decreased insulin concentration, increased lipolysis, decreased resting respiratory, and increased gluconeogenesis[7].

Low-fat diets (LFD) are related to cholesterol concentration, in which the high-density lipoprotein (HDL) is significantly lower than usual, and decreased cholesterol total concentration. Low-fat diets also have an effect on weight loss. Approximately 1.57 kg, the relative weight loss on the low-fat diet was due to a smaller increase in body weight over time in the control group in some trials, decreasing body weight in the low-fat group but increasing in the control group[7]. The serum lipids level is the one that got an intervening effect with the intervention of a low-fat diet, but there is no effect that is clear on TAG levels[7].

According to research by Wachsmuth et. al (2022), LCD can significantly reduce total body mass in a short time. The existence of a decrease in body mass weight is evidenced by the body fat weight proportion and visceral fat that decreased significantly[15]. However, there was no changes from the LCD intervention to the composition of water in the body. Meanwhile, research by Kahleova et. al (2020) stated that LFD reduced the average body weight in total of 6.4 kg in intervention group, different in comparison to control group by 0.5 kg. This shows that LFD plays a major role in reducing body fat level, as evidenced in the volume of fat mass and visceral fat that decreased in participating group[8]. However, both studies are flawed as they failed to look at the long-term effects of LCD and LFD to body composition. Therefore, other literature have not yet included the negative effect of LCD and LFD on body composition. Thus, this literature review purpose is to compare the effect, both the positive and the negative impact of LCD and LFD on body composition.

METHODS

The study was conducted through literature review. The review was compiled based on research publications within the last ten years using clinical trial study design (2012-2022). Data were collected using electronic databases including PubMed/Medline, Science Direct, and Wiley Online Library. Low-Carb Diet; Low-Fat Diet; Body Mass Index; Lipid Level; Adipose Tissue; Obese; Body Water were the keywords used for this literature review, which were found in English language, international journal, and can be read in full text, using the "AND" search approach. The inclusion criteria for this study were studies using obese patient subjects undergoing low-carb diet and low-fat diet. The exclusion criteria for this study were studies with research subjects other than human, research design using review, or studies with other dietary intervention.

This literature review was conducted following the PRISMA guidelines which consisted of four-stage flow chart (Figure 1). In the first stage, 295 journals were obtained, some journals were eliminated due to identical results and others were eliminated because being out of the year ranges, which then resulting in 104 journals. Some journals also eliminated in regard to its non-compliance with research questions. Fifty one journals were eliminated and the remaining 53 journals followed the third stage.

Some research articles were excluded because they were not fully accessible, leaving 20 journals in the fourth stage. After reviewing the 20 journals, the fourth stage excluded several research articles for several reasons such as using different dietary interventions, subjects used in the studies were non-obese, and the research study did not describe low-carb diet and low-fat diet. As a result of thorough filtering and reviews, 5 relevant journals were used in our study.

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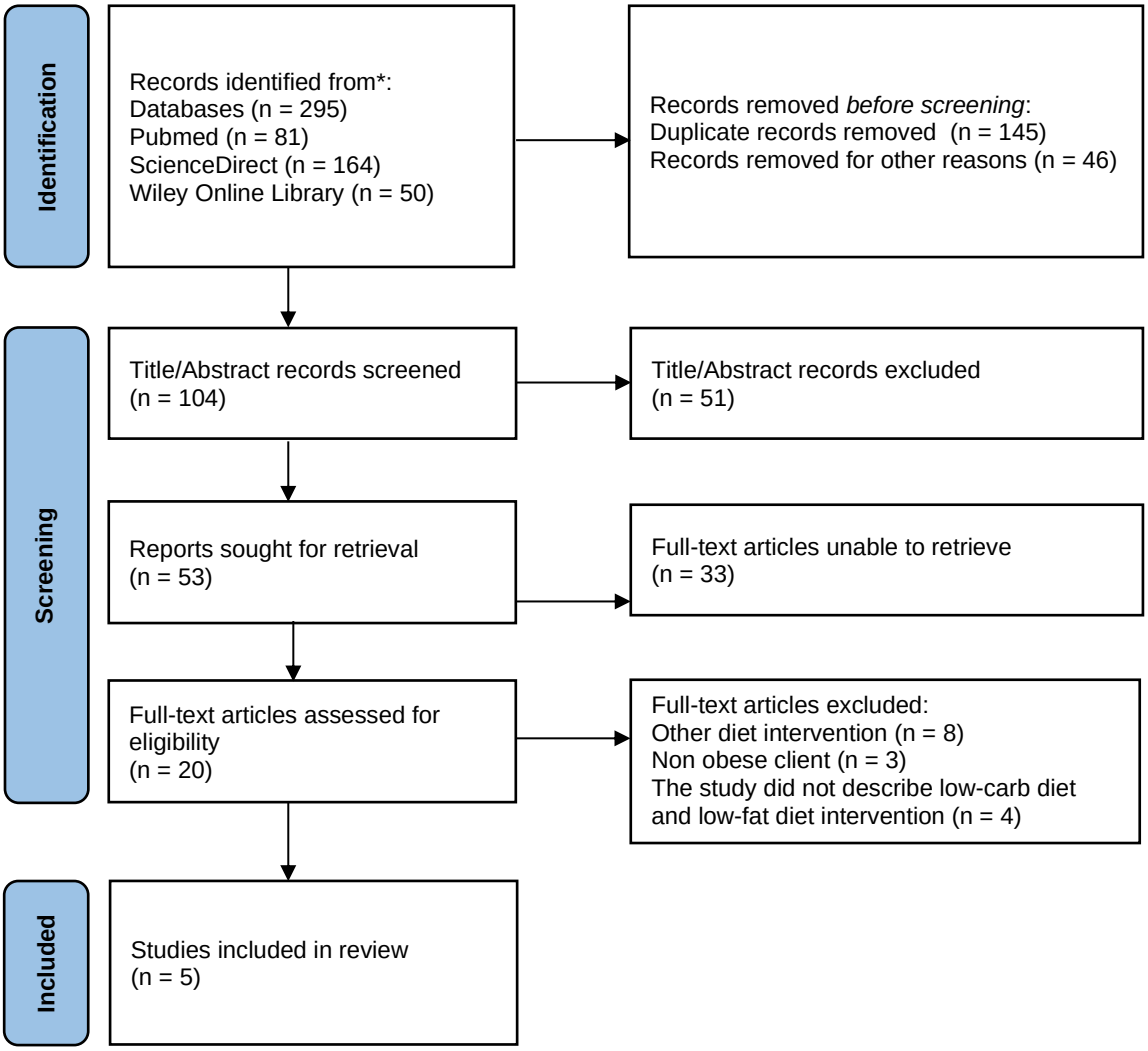

Figure 1. PRISMA Flow chart of the Literature Review reporting the comparison between the impact of LCD and LFD on body composition

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DISCUSSION

Table 1. Results of studies reporting on the comparison between the impact of LCD and LFD on body composition

Research Title	Author	Year	Method	Instrument	Sample	Outcome	Intervention Type	Control	Intervention Period	Result	Reference
The Impact of a High-Carbohydrate/Low Fat vs. Low-Carbohydrate Diet on Performance and Body Composition in Physically Active Adults: A Cross-Over Controlled Trial	Wachsmuth et al.	2022	Non-randomized, Cross-Over Controlled Trial	Venous blood sample, Bioelectrical impedance analysis	24 adults that are physically active, which consisted of 14 females, age 25.8 ± 3.7 years, and with BMI 22.1 ± 2.2 kg/m^2. Six of them enrolled in the research as a control group.	Body mass, body fat, lipid level, and body water	Participants were assigned to do HC diet for 3 weeks, and followed with wash-out period for 3 weeks, and continued with LC diet for 3 weeks.	6 people with regular nutritional intake or without intervention	3 weeks	There were no changes in cholesterol total (LDL-C, HDL-C) during the intervention of LCD in the control group, with $p > 0.05$. On the other hand, there were significant reduction of total cholesterol following the intervention of the High-Carbohydrate / Low-Fat diet, with $p = 0.02$. In the LC arm, body mass decreased significantly compared to the baseline, with $p < 0.001$. There were not any significant	15

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Research Title	Author	Year	Method	Instrument	Sample	Outcome	Intervention Type	Control	Intervention Period	Result	Reference
										changes when LCD was compared with HC, with p = 0.99, as much as the control group, compared with both intervention arms, with p > 0.05. Moreover, no changes were found in substantial body water amid to the intervention of LCD.	
Weight Loss on Low-Fat vs. Low Carbohydrate Diets by Insulin Resistance Status Among Overweight Adults and Adults With Obesity: A Randomized Pilot Trial	Gardner et al.	2016	Randomized Pilot Trial	Calibrated clinical scale, standard wall-mounted stadiometer, waist circumference scale, digital pedometer, and established clinical chemistry laboratory needs	61 premenopausal women and men aged 18-50 years with BMI 28-40 kg/m^2, treatment stable for ≥ 3 months and stable weight for the previous 2 months. Participants are not suffering from hypertension (except for those who are stable on antihypertensive	Weight-loss	Class based education program led by a single health education to follow either an LF or LC diet.	-	6 months	There was no significant interaction between IR-IS status and diet determination, with all p > 0.05, and weight loss detected by IR-IS status or diet group, there was no significant differences in	26

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Research Title	Author	Year	Method	Instrument	Sample	Outcome	Intervention Type	Control	Intervention Period	Result	Reference
					drugs), heart disease, type 1 or 2 diabetes mellitus, liver disease, kidney disease, active cancer or neoplasm, hyperthyroidism (unless treated and controlled), taking medication which may affect energy expenditure/weight or blood lipid, consuming alcohol ≥ 3 drinks/day, smoking, pregnant, lactating, during the previous 12 months experienced no menstruation, or planning to become pregnant in the next year.					the main effect.	
Effect of Low-Fat vs Low-Carbohydrate Diet on 12-Month Weight Loss in Overweight Adults and the Association With Genotype Pattern or Insulin	Gardner et al.	2018	Randomized clinical trial	An intervention with DIETEFITS	609 adults with age range from 18 to 50, without diabetes, and BMI between 28-40 kg/m^2.	Weight-loss	DIETEFITS, whereas participants were assigned to do healthy LCD or LFD depend on randomization that determined	-	12 months	No significant changes were found in both diet-genotype patterns (p = 0.20) and diet-insulin secretion (INS-30) interaction (p = 0.47).	13

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Research Title	Author	Year	Method	Instrument	Sample	Outcome	Intervention Type	Control	Intervention Period	Result	Reference
Secretion The DIETFITS Randomized Clinical Trial							by computerized random-number generation.				
Adherence to low-carbohydrate and low-fat diets in relation to weight loss and cardiovascular risk factors	Hu et al.	2016	Clinical trial	Weight measurement with standardized weight methods.	148 adults with obesity within the age range of 22-75 in the region Greater New Orleans.	Weight-loss	Intervention given to follow LCD with restricted consumption of carbohydrate without fiber to < 40 g d-1 or LFD that restricted total fat consumption < 30% of daily energy and < 7% fat of daily energy.	-	12 months	Compliance with LCD was more likely to be associated with greater weight loss (= -2.2 kg or 2.3%, p = 0.01). The markers of compliance to a LCD were not related alongside to the adjustment in body weight, fat mass or lean body mass.	12
Effects of Low-Carbohydrate and Low-Fat Diets: A Randomized Trial	Bazzano et al.	2014	A randomized, parallel-group trial	Low-carb diet (<40 gram/day) or Low-fat diet (<30% fat; <7% saturated fat). Each group was counseled regularly	148 men without cardiovascular disease and diabetes	Body composition, body weight, waist circumference, and serum lipid.	Participants either assigned to LCD group (40 g/day without total fiber) or LFD group (less than 30% of daily intake from total fat, 7% from	-	12 months	There was a larger reduction of body weight in participants on a low-carbohydrate diet with a mean difference in changes of	11

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Research Title	Author	Year	Method	Instrument	Sample	Outcome	Intervention Type	Control	Intervention Period	Result	Reference
				during the trial.			saturated fat) depend on the randomzation			−3.5 kg with p = 0.0002, change in fat mass with a mean difference in changes of −1.5% with p = 0.011, change in the proportion of total cholesterol to high-density lipoprotein (HDL) cholesterol with a mean difference of changes -0.44 with p = 0.002, and at triglyceride level there was an average difference in changes of −0.16 mmol/L with p = 0.038.	

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Overall, there were five research articles included in this literature review after determining the inclusion and exclusion criteria (Figure 1). The five research articles were analyzed regarding the impact of LCD versus LFD on body composition in people with obesity. There is a relationship between Low-Carb Diet versus Low-Fat Diet on body composition in obesity. LCD versus LFD able to reduce body water, Body Mass Index (BMI), lipid level, and weight.

Body composition in human is a branch of science that studies the regulation of body composition. Body composition measurements not only reveal the systemic nutritional state of the body, it also provides information for diagnosis and treatment of several illnesses. Thus later on, it distributed in close relation to the health status at all age level[9]. Body composition consisted of fat mass and non-fat mass (free fat mass), such as water content in the body (body water)[10]. Body composition is usually measured using Bio Impedance Analyser (BIA) which consisted of body weight and height, which can then be determined to the nutritional status based on the calculation of Body Mass Index. Body Mass Index is correlated with the fat contained in the body[4].

Weight Loss

Body weight is one of the important parameters to determine whether body has absorbed enough nutrients or not. Body weight can be used to evaluate the balance between food intake that enter the body and energy spent on physical activities. Obesity is a term that often used to express excess body weight, due to the buildup of nutrients, mainly carbohydrate, protein and fat[11]. LCD and LFD diets are two of the most popular methods used on people with obesity. Research by Bazzano et al. (2015) showed that obese patients who underwent LCD intervention for 12 months had greater weight loss in comparison to obese patients who underwent LFD intervention[12]. Fat mass loss accounts for most weight loss on low-carb diet. Similar results were also stated in Hu et al. (2016), which showed that adherence to LCD resulted in a weight loss of 2.2 kg or 2.3% greater than the same adherence to LFD[13].

Meanwhile, based on research by Gardner et al. (2018) showed that there was no significant changes between LCD and LFD with weight loss for 12 months[14]. In addition, the study by Gardner et al (2016) also showed that there was no significant interaction in weight loss between LCD or LFD group and IR (Insulin Resistance) - IS (Insulin Sensitive) status. However, all participants lost considerable weight with the average of 6 months weight loss for 49 participants who completed the protocol about 9.0 ± 6.5 kg, which represents 8.9 ± 5.7% of initial weight[15].

Body Mass Index

Body Mass Index (BMI) is a calculation used to find out the characteristics of the anthropometric parameters of weight or height in adults and then the results will be classified into groups[16]. According to Wachsmuth et al. (2022), there were changes in subjects' anthropometry in response to a specific diet. The total body mass significantly decreased after given both dietary interventions. During LFD intervention, a significant weight loss went from 65.2±11.2 kg at the beginning to 63.8±11.1 kg after three weeks. During the LCD intervention, body mass also decreased significantly from 64.8 ± 11.6 to 63.5±11.3 kg. There were no significant differences were found when LCD compared to High Carbohydrate Diet or LFD, and when one of these intervention groups was compared with the corresponding control group[17].

The same results were also presented by Bazzano et al. (2014), which states that there was a weight changes in the group given the LCD and LFD interventions. Nonetheless, it is stated that more significant weight loss occurred in the group that was given the LCD intervention compared to the LFD with a difference in weight loss of 3.5 kg[12]. Weight loss in patients after undergoing both diet interventions for 12 months will also causing a decrease in body mass, because body weight is used to measure BMI along with height[12].

The journal also mention changes in the circumference of the waist, where the circumference changes were more pronounced in the group that were given the LCD intervention for 3 and 6 months, but the differences were not too significant compared to LFD intervention[12]. Waist circumference has a close relationship with BMI. BMI is tightly related to the degree of adipose tissue. To identify the degree of fatty tissue in the body, it can be done by measuring waist circumference, this is due to fat accumulation around the hip and waist[18].

Lipid Level

Adipose tissue is a tissue that stores body fat as triacylglycerol which represents the main energy reserve in humans. The type of adipose tissue is determined by adipocyte cells because adipocytes are the most numerous of the many cell types in adipose tissue. Adipose tissue is closely related to the amount of fat in individual with obesity.

Someone with obesity has a relationship with high levels of total cholesterol, LDL cholesterol, and triglycerides. Obesity can cause various chronic diseases, dyslipidemia that accompanies obesity is related to metabolic syndrome and cardiovascular disease, diabetes, heart disease, stroke, and several types of cancer[19]. From these problems, a diet is needed to reduce lipid level in the body, including LFD and LCD. Based on the study of Bazzano et al. (2015), LCD reduces more risk factors for cardiovascular disease than LFD among obese black and white adults. LCD results in a much greater decrement in the ratio of total cholesterol to HDL cholesterol compared to LFD. Total cholesterol has been identified as a strong and independent predictor of coronary heart disease (CHD). In addition, serum triglyceride level also decreased significantly in the LFD and LCD groups, with a greater reduction in LCD group. In addition, among participants in LFD and LCD groups there were a reduction in LDL cholesterol level, with no significant difference between groups[12].

In study by Wachsmuth et al. (2022), total cholesterol and LDL cholesterol levels decreased significantly inHigh-Carbohydrate/Low-Fat diet group. There was also no changes in total cholesterol (LDL-C,

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HDL-C) during three weeks of LCD intervention or in control group. Meanwhile, triglyceride levels increased significantly in LFD group and tended to decrease without being significant in LCD group[17].

Body Water

Total body water (TBW) is a component of fat-free mass. Changes in TBW are affected by fluid displacement[20]. Total water content assessment is one of the crucial thing in clinical treatment. This is due to total body water content in the body has significant implication for patient care including determining drug dosage, assessment and treatment for dehydration, as well as energy and fluid nutrition, requirement needed for parenteral and prescription for dialysis. From research by Mahoot (2020), there is a correlation between TBW and body weight[21].

Men who have normal weight have an average 9% more TBW than women with ideal body weight. Combined with both obese and overweight individuals, men have an average TBW greater than women by 7.7%. Individuals who are overweight and obese have lower TBW and tend to be hypo hydrated than individuals who have normal weight. Higher percentage of body fat in obese individuals are also associated alongside lower TBW, relatively[21]. Based on research conducted by Wachsmuth et al. in 2022 showed that there was no substantial change during LCD diet to TBW[17].

LCD and LFD Negative Impact

LCD is a diet which give limitation of carbohydrate intake less than 45% of the total energy requirement. Carbohydrate restriction can have different effects on each individual depend on metabolism, hormone, and physical activity. Carbohydrate restriction that is too extreme adopted can cause decrement in blood glucose and induction of ketone bodies (ketosis)[22]. Ketosis may cause unwanted effects, such as nausea, headache, fatigue, bad breath, and increased acid which able to cause bone loss. In LCD intervention, the consumption of carbohydrate is replaced by the consumption of high-protein foods which are often high in fat. High consumption of saturated fat can increase plasma LDL so that it able to increase the risk of premature coronary artery disease[23].

LFD is associated with the reduction of HDL, LDL, and TC concentrations. The possible effect on someone with LFD is not much different compared to someone with LCD. Side effects that may occurred such as constipation, fatigue, polyuria, nausea, vomiting, changes in appetite, and frequent headaches[7]. According to research from Gardner et al (2018) both LCD and LFD can cause serious side effects. Serious side effects associated with the study were renal failure and diverticulitis. Kidney failure usually occurred in patients who undergo LCD. From the analysis conducted by Acharya et al. (2021) the incidence of kidney failure in people who practicing LCD with a high-fat diet is 5.6%[24]. Uric acid is the most common kidney stone found in people who apply LCD, it may closely related to the occurrence of hypocitraturia and acidosis. Acidosis is related to the citrate reabsorption in proximal tubule, which in turn can have an impact on hypocitraturia[24]. Meanwhile, there is still no research on the side effects of these two diets with diverticulitis, so further research is needed.

The effect of LCD and hypoglycemia has been widely demonstrated in previous studies. According to case reports, the pathophysiological basis for hypoglycemia in LCD intervention is the body's failure to adapt to fat metabolism. In addition, in a rat study that gave the LCD intervention and a high-fat diet showed a decrement in glucagon release, thus proving that LCD increases the risk factor for hypoglycemia[25].

Although LDL-C level reduced among obese individuals following a low-fat diet, there were increment in triglyceride level and decrement in high-density lipoprotein cholesterol level. Fat and saturated fatty acid can have unfavorable effects on gut microbiota and associated with an unhealthy metabolic state[26]. The consumption of large amount of energy-dense foods with a high content of saturated fatty acids able to cause dysbiosis in the gut and is associated with obesity and chronic low-grade inflammation[27].

CONCLUSIONS

LCD and LFD interventions can both affect the changes in body composition in people with obesity. From these five journals, it is stated that LCD intervention is more effective for weight loss in people with obesity compared to LFD intervention. This happened because the provision of LCD intervention able to reduce fat mass in the body, so that weight loss and body mass index are more significant. In addition, there is a relationship between LCD and saturated fat intake, where saturated fat has an effect on LDL cholesterol level. However, to determine which of the LCD or LFD diets is more effective for weight loss, further research is still needed. Meanwhile, there was no effect on water content in the body on people who underwent either the LCD or LFD diets.

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