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The Low-Carb Versus Low-Fat Debate: A Critical Path to Precision Nutrition

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Abstract:
Global obesity and its associated chronic diseases have made low-carbohydrate diets (LCD) and low-fat diets (LFD) mainstream weight-loss strategies, yet their effectiveness and safety remain controversial, with significant methodological limitations in existing research. This paper systematically examines the core controversies surrounding LCD and LFD, focusing on inconsistent definitions, trade-offs between short-term and long-term weight loss, population heterogeneity, disease-specific applicability, and methodological flaws. The study results show that ambiguous definitions—such as varying standards for LCD (e.g., ≤45% of total calories from carbohydrates versus ≤20g/day of carbohydrates)—undermine the comparability across studies. LCD exhibits advantages in short-term weight loss (≤12 months) but lacks such advantages in the long term (≥2 years), and is associated with potential cardiovascular and nutritional risks. Males derive more benefits from LCD, while females show no significant difference in response between the two diets. LCD better improves symptoms of polycystic ovary syndrome (PCOS) in the short term, whereas LFD provides superior long-term blood glucose stability for type 2 diabetes. Additionally, neglecting food quality—such as distinguishing between healthy and unhealthy fats—distorts conclusions about health outcomes. This paper clarifies controversies in the field, highlights methodological gaps, and guides the shift toward precision nutrition, supporting evidence-based dietary recommendations for weight management and chronic disease prevention.

Keywords: Low-carbohydrate diet LCD; low-fat diet LFD; gender-specific responses.

1. Introduction

In recent years, the number of obese and overweight people in the worldwide population has increased significantly. This phenomenon becomes a serious public health problem. According to statistics, by

2022, there will be over 1 billion people who are obese or overweight[1]. In various ways of losing weight, changing diet is widely known as the most effective and the most feasible way. It is especially useful for people to try to lose weight by decreasing the intake of two main sources of energy, which are carbohydrates and fats. These two ways are called the Low-Carbohydrate diet (LCDs) and the Low-Fat Diet (LFDs). And these two ways have always been a hot research direction. There is a lot of research comparing these two ways of diet‘s effectiveness in losing weight and improving metabolism. Some randomized controlled trials pointed out that in the short term, a low-carbohydrate diet has a more obvious weight effect. Especially in the early six months, the participants had lost on average 1.3 kilograms. But with the low-fat diet, the efficiency is relatively weak[2]. However, other studies have shown that, with the same total caloric intake, the long-term differences in weight loss between these two diets are no obvious difference. Furthermore, a low-fat diet offers more advantages with lower low-density lipoprotein cholesterol.

In the international research, a lot of systems that use meta-analyses have compared these two diets with long-term tracking and comparative analysis, but there is still a lack of a unified conclusion. It is especially controversial in individual adherence, which means if the person obeys the requirements of the doctor or the plan during the diet. And it is also controversial in metabolic adaptation and the factors of cardiovascular risk. The ongoing academic discourse surrounding the comparative efficacy of low-carbohydrate diets (LCDs) and low-fat diets (LFDs) transcends a simplistic binary question of which is superior. The impetus for this review is rooted in the critical limitations that afflict the extant body of research. These limitations include the absence of standardized definitions for what constitutes „low-carb“ or „low-fat,“ the dichotomy between short-term advantages and long-term health outcomes, and a general neglect of food quality and population heterogeneity. These methodological inconsistencies have generated conflicting findings and rendered direct comparisons across studies largely futile, thereby obscuring evidence-based dietary recommendations.

To navigate this intricate landscape, this paper employs a structured framework. First, it critically examines the central trade-off between short-term weight loss efficacy and long-term metabolic sustainability. Secondly, it explores the pivotal role of individual factors, such as gender and specific disease states (e.g., PCOS, diabetes), in modulating dietary response. This challenges the notion of a one-size-fits-all approach to dietary interventions. The analysis culminates in the identification of definitional ambiguity as the fundamental flaw, and its consequences. This review posits that the pursuit of a universally superior diet is a futile endeavor. Instead, it advocates for a paradigm shift away from the entrenched LCD-versus-LFD dichotomy and toward the promising field of precision nutrition, which prioritizes individualized strategies based on unique physiological markers, behavioral preferences, and long-term health goals.

2. The Difference in Definitions between Low Carbohydrate Diet (LCD) and Low-Fat Diet (LFD)Section Headings

LCD focuses on limiting carbohydrate intake and increasing the proportion of protein or fat energy supply, but there is no unified standard for carbohydrate intake in the field, mainly consisting of two definition systems. Under broad standards, most studies classify diets with a carbohydrate energy supply ratio of ≤ 45% as low-carbohydrate diets, which still retain some whole grains and low GI fruits. The protein and fat energy supply ratios are usually 20% -30% and 30% -40%, respectively, which are closer to improved balanced diets and have a higher audience acceptance. Under strict standards, some studies adopt a daily carbohydrate intake of ≤ 20g (accounting for less than 5% of total energy), or a carbohydrates to energy ratio of ≤ 20%. Such diets require complete exclusion of grains and most fruits, and rely on high-fat and high protein foods such as meat, eggs, and avocados[3]. Short term metabolic changes are more significant, but compliance is lower. Despite significant differences in definitions, all low carbohydrate dietary patterns have the core goal of limiting refined carbohydrates and reducing blood sugar fluctuations, achieving weight loss by reducing glycogen reserves and promoting fat breakdown, which is a key feature that distinguishes them from other dietary patterns.

Low fat diet focuses on reducing fat intake and compensating for energy gaps by increasing carbohydrate or protein intake, but its definition is also ambiguous. Under conventional standards, mainstream research considers a diet with a fat-to-energy ratio of ≤ 20% as a low-fat diet. This type of diet typically limits the intake of animal fats and vegetable oils, with whole grains, vegetables, and lean meat as the main food sources. The fat intake is about 30-50g/d (calculated at 1800kcal per day), aiming to achieve weight loss and cardiovascular protection by reducing total calorie and saturated fat intake. Under the extremely low-fat standard, some intervention studies targeting high-risk populations for cardiovascular disease use a fat-to-energy ratio of ≤ 10% as the standard. This type

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of diet requires strict restriction of all fat sources, even excluding healthy fats such as nuts and avocados. The carbohydrate-to-energy ratio can be as high as 60% -70%. Although it can significantly reduce LDL-C, it is prone to long-term essential fatty acid deficiency, poor taste, and low compliance. The key issue in the current field is that most studies do not clearly distinguish between „conventional low-fat diet" and „extremely low-fat diet", often mixing the data of the two, resulting in differences in the conclusion of „weight loss effect of low-fat diet". For example, a very low-fat diet with stricter calorie restrictions may have better short-term weight loss effects than a conventional low-fat diet, but long-term nutritional imbalances can easily lead to weight rebound[4]. This confusion in definition directly affects the comparability of research conclusions.

3. Controversy over the Weight Reduction Effect of LCD and LFD

The "short-term advantage theory" meta-analysis suggests that LCD is significantly more effective than LFD in short-term weight loss of ≤ 12 months. This meta-analysis included 38 randomized controlled trials involving 5600 participants. The results showed that the LCD group lost an average of 6.8kg of weight within 12 months, while the LFD group lost an average of 4.5kg. The difference between the two groups was statistically significant, with MD=2.3kg, 95% CI 1.1-3.5, $P<0.01$. Moreover, the LCD group performed better than the LFD group in terms of waist circumference reduction and triglyceride reduction, with a waist circumference reduction of MD=3.2cm and triglyceride reduction of MD=-0.3mmol/L[2]. The core of short-term advantage lies in the rapid consumption of water and glycogen by LCD, which requires 3-4g of water per gram of glycogen storage. LCD restricts carbohydrate intake, leading to rapid depletion of glycogen reserves, accompanied by a large amount of water loss, resulting in a „rapid weight loss" effect. At the same time, an increase in the proportion of fat supply can activate lipolytic enzymes, promote the release of free fatty acids from adipocytes, and further enhance the weight loss effect. In addition, the high protein content of LCD (usually 25% -30%) can enhance satiety, which is achieved by increasing the secretion of cholecystokinin, thereby reducing total calorie intake and indirectly assisting in weight loss.

In contrast to the „short-term advantage theory", the „long-term equivalence theory" points out that the short-term advantages of LCD are difficult to maintain and may be accompanied by health risks. Miller et al. conducted an integrated analysis of 12 studies followed up for ≥ 2 years and found that the average weight loss difference between the LCD group and the LFD group at 2 years decreased to 0.8kg, with a 95% CI of -0.5-2.1 and $P>0.05$, indicating no statistical significance. Moreover, there was no significant difference in weight rebound rate between the two groups, with 42% in the LCD group and 38% in the LFD group. Researchers believe that the reason for the long-term convergence of effects is the decrease in compliance. The strict carbon and water restrictions of LCD can easily lead to a monotonous diet and social inconvenience. The compliance rate at 2 years is only 35%, significantly lower than the 52% of LFD. Partial LCDs, especially those dominated by saturated fat, may elevate LDL-C levels and increase cardiovascular risk. For example, Brown et al. followed up 2000 LCD users and found that subjects with a daily intake of saturated fat ≥ 20g had LDL-C levels that increased by 0.4mmol/L compared to baseline, with $P<0.05$[5]. However, in the LCD group dominated by unsaturated fats such as olive oil and nuts, there was no significant change in LDL-C. This suggests that the cardiovascular risk of LCD is closely related to the source of fat, but most current studies do not distinguish between fat types, leading to ongoing controversy over whether LCD increases cardiovascular risk. Long-term LCD can also lead to insufficient intake of dietary fiber, vitamins, and essential fatty acids. Jones et al. found that the average daily dietary fiber intake of the LCD group was 12g, significantly lower than the recommended amount (25-30g/d), and the deficiency rates of vitamin C and vitamin B1 were 28% and 19%, respectively, significantly higher than the 12% and 8% in the LFD group. Meanwhile, long-term depletion of glycogen may lead to a decrease in exercise endurance, with subjects' weekly exercise duration reduced by 1.2 hours compared to baseline[6].

4. Population Heterogeneity

Gender is a key variable regulating the effects of LCD and LFD, and most studies support the conclusion that ‚men benefit more significantly from LCD, while women have no significant difference in response to the two diets'. The randomized controlled trial included 500 participants, with 250 males and 250 females. The results showed that at 12 months, the male LCD group lost an average of 7.5kg, which was significantly better than the male LFD group's 4.8kg, with $P<0.05$. The average weight loss of the female LCD group was 5.2kg, while the average weight loss of the female LFD group was 4.9kg, with no significant difference, $P>0.05$. At the same time, the insulin resistance index (HOMA-IR) of the male LCD group decreased by 28%, significantly better than the 15% of the male LFD group, P<0.05. The decrease in HOMA-IR between the two groups of females was 18% and 16%, respectively, with no significant difference. In addition, the decrease in triglycerides in the male LCD group (-0.35mmol/L) was significantly better than that in the female LCD group (-0.18mmol/L) [7]. Similar results were validated, which included 1200 participants, 600 males and 600 females. A 2-year follow-up showed that the male LCD group had a „weight loss maintenance rate" (the proportion of weight loss≥5%) of 42%, significantly higher than the male LFD group's 28%. The weight loss maintenance rates of the two groups of women were 31% and 29%, respectively, with no significant difference.

The current explanation for the mechanism of gender differences mainly focuses on two hypotheses: „compliance differences" and „metabolic physiological differences", both of which are supported by evidence, but a unified conclusion has not yet been formed. Jones et al. found that the 12-month compliance rate for male LCD was 58%, significantly higher than the 32% for females. The gender compliance rate difference of LFD is relatively small, with 55% for males and 51% for females. Researchers believe that women have a higher „social need" for diet, such as participating in meals, home cooking, etc. The strict carbon and water restrictions of LCD are prone to conflict with social scenes, leading to a decrease in compliance. Men have a stronger „goal orientation" towards diet and are more likely to adhere to strict dietary plans. However, this hypothesis cannot fully explain the differences in metabolic indicators. Even in the subgroup matched with compliance rates, where both male and female compliance rates were 40%, the reduction in HOMA-IR in the male LCD group was still significantly higher than that in the female group, at 25% and 17%, respectively, P<0.05. This indicates the existence of other mechanisms. From a physiological perspective, males have a higher proportion of muscle mass, about 40% -45%, while females have a higher proportion of fat mass, about 25% -30%. Muscle tissue is more sensitive to insulin, and LCD is more likely to produce metabolic benefits for males with a higher proportion of muscle mass by reducing blood sugar fluctuations and improving insulin sensitivity. In addition, men have higher levels of testosterone, which can promote the activity of lipolytic enzymes and enhance the lipolysis effect of LCD. However, this hypothesis lacks direct molecular evidence and further research is needed to explore the differences in metabolic pathways that are specific to sex. Regardless of the mechanism, the existence of gender differences clearly indicates the limitations of a „one size fits all" dietary recommendation, and personalized dietary guidance should prioritize gender factors.

5. Controversy over the Applicability of LCD and LFD in Specific Disease Populations

Polycystic ovary syndrome (PCOS) patients have a high rate of overweight/obesity, and dietary intervention is the basic treatment. Current research generally suggests that LCD is more suitable for PCOS women, but the long-term effects are controversial. A study of 150 women with PCOS showed that after 6 months of LCD (carbon water ≤30% total energy) intervention, HOMA-IR. The decrease in Kaohsiung hormone levels and the increase in ovulation rate were significantly better than those in the LFD group. Researchers believe that LCD alleviates symptoms by improving insulin resistance; However, during the 2-year follow-up, the ovulation rate of the LCD group decreased to no significant difference compared to the LFD group, and the rate of dietary fiber deficiency was higher, indicating that LCD intervention in PCOS women should pay attention to nutritional balance[8]. The core demand of the type 2 diabetes population is „weight loss+blood glucose stabilization". The short-term hypoglycemic and HbA1c effects of LCD are significantly better than LFD, but the long-term risk of hypoglycemia may increase. Although LFD (especially high fiber type) has weak short-term blood glucose reduction, it has better long-term blood glucose stability and a lower incidence of cardiovascular events [9]. The current controversy revolves around the trade-off between short-term glycemic control and long-term safety. Most guidelines recommend using LCD for those with poor blood sugar control in the short term, while LFD is preferred for those with cardiovascular risk[10].

6. Limitations of Domain Methodology

The ambiguous definition of LCD and LFD is a core methodological flaw in the field of controversy. Differences in the definition of the same dietary pattern can directly lead to contradictory conclusions, such as the opposite conclusions on LDL-C changes in different LCD studies[5]. The blurred boundaries of different dietary patterns also make „cross comparison" meaningless, as the macro nutrient structures in the comparison scenarios are different, making it difficult to unify conclusions[3]. At the same time, most current studies only focus on the proportion of macronutrients, ignoring differences in food quality and the significant impact of different fat types on health outcomes. Some LCD studies do not distinguish between fat types, leading to confusion in conclusions about cardiovascular effects[5]. Queue studies have shown that

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unhealthy LCD and LFD are associated with an increase in all-cause mortality, while healthy types are associated with a decrease in mortality, indicating that research conclusions that ignore food quality may have biases and cannot provide reliable evidence for clinical guidance[9,10].

7. Conclusion

This paper clarifies the controversies, limitations, and directions of low-carbohydrate diets (LCD) and low-fat diets (LFD) for weight loss. Key findings: Definition ambiguities undermine cross-study comparability. LCD has short-term weight loss advantages but no long-term superiority, with potential cardiovascular and nutritional risks. Males benefit more from LCD, while females show no diet response difference. LCD improves PCOS short-term, but LFD stabilizes type 2 diabetes blood glucose long-term. Ignoring food quality exacerbates conclusion contradictions. This paper sorts chaotic outcomes and addresses methodological bottlenecks. Limitations include reliance on existing literature and lack of rare subgroup data. Future research should unify definitions/standards, screen dietary response biomarkers, and combine digital technologies to develop personalized nutrition strategies for integrated weight management and health promotion.

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