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High-carb or low-carb, that is a question

Hirobumi Igawa, Toshinari Takamura

Commentary

Department of Endocrinology and Metabolism, Kanazawa University Graduate School of Medical Sciences, 13-1 Takara-machi, Kanazawa, Ishikawa 920-8640, Japan

Corresponding author: Toshinari Takamura MD, PhD,

E-mail: ttakamura@m-kanazawa.jp

Tel: +81-76-265-2711; Fax: +81-76-234- 4214

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Introduction

The content of our diet and the mode of consumption remains a central topic of debate with respect to diabetes, obesity, and longevity. In particular, macronutrient balance may affect health because there is cross-talk among metabolic pathways for carbohydrate, fat, and protein[1]. In this commentary, we overview very recent advances in the understanding of the effects of macronutrient balance on body composition and energy metabolism.

1. Restriction of dietary carbohydrate does not contribute to body fat loss in humans

In 2016, Hall et al. showed that a ketogenic diet (KD; 2400 kcal/day, 6% carbohydrate, 77% fat, 17% protein) was not accompanied by decreased body fat in obese people[2].. In this study, 17 men classified as overweight or obese were admitted to metabolic wards, where they consumed a high-carbohydrate baseline diet (BD; 2400 kcal/day, 48% carbohydrate, 35% fat, 17% protein) for 4 weeks followed by 4 weeks of KD. Hall et al. measured energy expenditure by metabolic chambers during each diet period.

Energy expenditure transiently increased by 100 kcal/day in the first week of the KD period. However, this change was limited, and there was no significant difference between BD and KD at the study endpoint, which suggests that the proportion of carbohydrate to fat in the diet had little effect on energy expenditure.

The subjects lost 0.8 kg of body weight with a reduction in body fat of -0.5 kg during the BD period, while the subjects lost 2.2 kg of body weight with a reduction in body fat of -0.5 kg during the KD period. Body weight significantly decreased in the KD period compared to that in the BD period, but there was no significant difference in body fat loss between KD and BD. In the early phase of KD, body weight rapidly decreased by 1.6 kg, despite a body fat loss of only 0.2 kg and increased urinary nitrogen excretion, suggesting that body water loss or skeletal muscle loss might contribute to body weight loss during the KD period.

This study indicates that the restriction of dietary carbohydrate does contribute to body weight loss but not to body fat loss.

2. Altered adaptation to macronutrient oxidation underlies reduced fat diet-induced body fat loss

The same group (Hall et al.) investigated the mechanisms underlying altered body fat loss between a low-carbohydrate diet and a low-fat diet in humans by precisely estimating the energy balance and macronutrient oxidation[3]. In this study, 19 people classified as obese (mean BMI 36 kg/m^2) were admitted to metabolic wards. The subjects had an energy-balanced diet (2740 kcal/day, 50% carbohydrate, 35% fat, 15% protein) for 5 days followed by a random assignment for 6 days to a 30% calorie-restricted diet, with a restriction placed on the intake of carbohydrate (RC: 1918 kcal/day, 29% carbohydrate, 50% fat, 21% protein) or fat (RF: 1918 kcal/day, 71% carbohydrate, 8% fat, 21% protein). RC had a 60% restriction of dietary carbohydrate. RF had an 85% restriction of dietary fat. The investigators measured the energy balance and macronutrient oxidation by metabolic chambers before and after each diet.

Although there was no significant difference in the energy expenditure between RC and RF, RF resulted in greater cumulative body fat loss (Table 1). The differences in fat loss were due to transient differences in carbohydrate balance concurrent with persistent differences in fat balance. Initially, in RC, fat oxidation rapidly increased by 600 kcal/day and carbohydrate oxidation decreased by 600 kcal/day. However, the fat oxidation achieved a plateau due to adaptation to the carbohydrate restriction after several days, whereas the carbohydrate oxidation kept decreasing without adaptation (Table 1). In contrast, RF resulted in minimal adaptation to carbohydrate and fat restriction, thereby leading to greater fat loss than RC (Table 1).

It is perplexing that in spite of no difference in the energy balance between RC and RF, RC resulted in greater weight loss than RF. A few previous studies indicate that weight loss by restriction of carbohydrate intake is involved in skeletal muscle mass loss[4,5]. In RC, protein oxidation slightly increased, which might lead to skeletal muscle loss. It is possible that reduced insulin secretion contributed to the increased protein oxidation.

Unexpectedly in the study by Hall et al.[3], RF decreased the plasma levels of ghrelin, a hormone-stimulating appetite, whereas RC increased it. This suggests that RF decreases appetite compared to RC.

3. Low protein–high carbohydrate diet decreases body fat in mice

Recent studies in drosophila and mice revealed that low protein–high carbohydrate (LPHC) diets increased the lifespan, whereas a reduction in the total energy intake had no positive impact on longevity[6,7]. In mice, branched-chain amino acids contribute to the development of obesity-associated insulin resistance in a high-fat diet[8]. In the liver, obesity-induced insulin resistance is induced by chronic endoplasmic reticulum stress[9], which is caused by defective protein degradation[10,11] and possibly by excessive intake and synthesis of proteins[1].

Solon-Biet et al. showed in mice that the LPHC diet caused greater body fat loss than a high protein–low carbohydrate (HPLC) diet[12] (Table 2). The LPHC diet increased energy intake compared to the HPLC diet due to the phenomena of protein leverage, where the protein intake is prioritized over fat and carbohydrate intake[13]. In spite of the increase in the energy intake, the LPHC diet reduced body fat mass due to increased energy expenditure (Table 2), which is consistent with increased diet-induced thermogenesis serving to consume excess energy and slow development of adiposity[14]. This study suggests that a diet replacing carbohydrate with protein may be of little advantage in body fat reduction.

Conclusion

The studies reviewed in this commentary clearly reject the claim that carbohydrate restriction is required for body fat loss, at least with respect to energy oxidation and balance. However, it remains controversial to recommend a definite nutrient balance[15]. In particular, the effects of high or low carbohydrate diet on body fat are still a debatable issue. To confirm the content of a diet and the mode of consumption for the purpose of body fat loss, long-term and large-scale clinical evidence is required.

Human rights statement and informed consent

This article does not report any original studies with human or animal subjects that were performed by any of the authors.

Conflict of interest

H.Igawa decleares that he has no conflict of interest. T.Takamura received lecture fees from Mitsubishi Tanabe Pharma Corporation, AstraZeneca K.K., Astellas Pharma Inc., MSD K.K., Daichi Sankyo Co. Ltd.

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Table 1 The comparative effects of dietary carbohydrate and fat on energy expenditure and body fat

		Carbohydrate vs. Fat	
		Low carbohydrate (High fat) Less calorie	Low fat (High carbohydrate) Less calorie
Energy expenditure		↓↓	↓
Oxidation	Fat	↑, soon achieves plateau	→
	Carbohydrate	↓↓	→
Body fat		↓	↓↓

Table 2 The comparative effects of dietary carbohydrate and protein on energy expenditure and body fat

	Carbohydrate vs. Protein	
	Low carbohydrate (High protein) Ad libitum	Low protein (High carbohydrate) Ad libitum
Food intake	→	↑
Energy expenditure	→	↑
Body fat	→	↓