

Calorie Balance Model and Carbohydrate-Insulin Model

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For metabolic syndrome including obesity and diabetes, weight reduction is necessary [1]. For that purpose, there were various ways of thinking and various weight reduction methods so far. They include calorie restriction (CR), low carbohydrate diet (LCD), other types of weight reduction methods, the application of glycemic index (GI) and so on [2,3]. Among them, LCD has been recently in attention, and many clinical cases and research have been reported [4,5].

The author and colleagues have continued treating many patients with obesity and diabetes mellitus, and clinical research using CR and LCD meals [6]. According to the previous medical reports and our data, the degree of insulin secretion is remarkably suppressed when the amount of carbohydrate intake is decreased. Based on the above, we have repeatedly investigated the relationship among the decrease of carbohydrate intake, suppression of insulin secretion amount, and reduction of body weight [7,8].

Under such circumstances, various theories, therapy and weight loss methods have been reported [9]. Recently, a new theory or an impressive way of thinking have been proposed in relation to these field. In this article, the important points would be described in comparison with the conventional theory.

Firstly, there has been conventional and standard theory in the nutrition field. As the basis of nutrition, the idea of energy balance was fundamental theory and common sense for many years. Weight increases and decreases depending on whether the energy intake energy balance is plus or minus, which is applied to the conventional calorie restriction (CR) method [10].

Certainly, it is true that weight loss decreases rapidly when reducing caloric intake in short period. However, everyone is experiencing difficulty in weight loss, even if the intake calories are reduced little by little every day. Even if calorie intake is reduced by 100-200 kcal per day, it is rare that body reduction can be expected for 2-3 months, as calculated in theoretical method. Thus, it can be said that clinical problems could not be solved merely by theory and practice in calorie balance model [11].

Secondly, the application of energy balance theory alone would not be enough [12]. Indeed, there are two laws of thermodynamics for consideration in nutritional balance. One is a conservation of energy law, and another is a dissipation law. As to the application of these laws, however, controversy would be present for several reasons. They include that i) LCD shows greater weight reduction compared to isocaloric diets of different composition, ii) metabolic advantage may be present than energy laws, iii) glucose can be produced from protein in the necessary situation with the mechanism of gluconeogenesis [12].

Among these, there are various ways of thinking. One is from the mechanism of Glycemic Index (GI). GI can influence considerably the glucose variability, which may be predominantly considered and emphasized [13]. When we continue to consume low GI foods by restricting high GI foods, it is usual that the total intake energy amount also decreases naturally. Therefore, person does not have to worry about the amount of energy in total.

Another way of thinking can be found. Even if the total calories are the same, there are various situations with predominant content of carbohydrate, protein or lipid [14]. Thus, glucose variability would be different at all in various situations, according to the balance of macronutrients.

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Thirdly, a new idea has been proposed. The problem among obesity, weight reduction and diet content has been unsolved worldwide for a long time. The new idea transcends the conventional calorie balance theory, and it can clinically explain that excessive secretion of insulin causes obesity [15]. As a new theory on obesity and weight reduction, a carbohydrate-insulin model was proposed. The authors advocated this theory were Ludwig and Ebbeling, who have continued research at the Harvard University Obesity Prevention Center [16]. In their previous report, LCD and low GI diet were effective compared with CR [16]. Among them, long-term management of CR for obesity was unsuccessful because the energy balance theory is inadequate. As a new theory, the Carbohydrate - Insulin Model of Obesity: Beyond "Calories In, Calories Out" was reported [17].

A new model will be compared with the conventional model. In the conventional energy balance model, clinically common case would be shown in the following [18]. As a person overeats and decreases physical activity, energy balance become positive. Then, blood energy substrate of glucose and lipid increases, and body fat accumulates. When he has energy-limiting meal for weight reduction, he always feels hunger and wants to take more. As decreased calorie intake and body fat reduction, basal metabolism rate falls and energy consumption also decreases. Because of this compensation mechanism, it will be difficult for him to keep energy balance negative for long.

On the other hand, newly proposed "carbohydrate-insulin model" is a way of thinking in reverse flow from the previous thinking [17]. The starting point is the excessive secretion of insulin in response to increased carbohydrate ingestion. Then, body fat accumulates and the substrate (sugar, lipid) of blood energy decreases. From this process, a person feels hunger and tends to have more energy intake. As the important point of this new theory, the cause of obesity would be the excessive insulin secretion, and the compensation of the energy substrate in blood. As a result, he would have increased appetite and excessive energy intake.

As a supporting evidence for glucose-insulin model, there is a report using bidirectional Mendelian randomization analysis of genome-wide association studies [19,20]. Higher genetically determined IRI was strongly associated with higher BMI, which was consistent with a causal role in obesity. On contrast, higher genetically determined BMI was not associated with IRI.

Based on the Carbohydrate-Insulin Model, Ludwig et al. have issued 6 items of dietary recommendations [17]. The essences of those are summarized in the following: i) Reduce high-glycemic load (GL) carbohydrates, ii) Emphasize low-GL carbohydrates such as nonstarchy vegetables and nontropical whole fruits, iii) When consuming grain products, choose whole kernel or traditionally processed alternatives, iv) Increase nuts, seeds, avocado, olive oil, and other healthful high-fat foods, v) Maintain an adequate, but not high, intake of protein, vi) Replace with dietary fat for carbohydrate may provide greatest benefit, for metabolic syndrome or type 2 diabetes.

In summary, new theory of the carbohydrate-insulin model of obesity was introduced and discussed. There have been several

influencing factors to glucose variability such as CR, LCD, GI, and genetic predisposition. Further discussion concerning effective diet for obesity and metabolic syndrome would be expected in the future study.

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