ECRONICON OPEN ACCESS

EC NUTRITION
Research Article

Two Pyramids - Two Products Phase Nutrition - New Model Nutrition of Humans

EK Mukhamejanov*, AK Kulnasarov and SS Erdjanova

JSC National Medical University Named After S. Asfendiarov, Almaty, Kazakhstan

***Corresponding Author**: EK Mukhamejanov, JSC National Medical University Named After S. Asfendiarov, Almaty, Kazakhstan.

Received: October 29, 2018; **Published:** December 31, 2018

Abstract

A conceptual model of the interdependence between the metabolism of proteins, fats and carbohydrates taking into account the transport of the carbon skeleton and the stages of the relationship between the processes of formation and utilization of ATP energy, which demonstrates the key role of protein metabolism and the maintenance of glucose homeostasis with different organism availability in energy was proposed. In supporting the processes of vital activity of the body, two periods should be analyzed. The first one is absorptive period, which is for providing rehabilitation processes, the expression of which is the "food pyramid" and the second one is post-absorptive period, which is for the energetic provision of physical and mental work, the expression of which is the "energy pyramid". These pyramids differ in the ratio of macronutrients, and in their composition, which must be taken into account when developing the principles of human nutrition. Although obesity is seen as a simple discrepancy between the amount of intake of food calories and their utilization for physical activity, however, do not take into account the large energy expenditure on volatile processes, in particular, the process of protein synthesis. The process of protein synthesis depends on the availability in the substrate (amino acids), the intensity of mRNA expression (transcription) and the speed of reproduction (translation), so the violation at each of these stages will affect the energy balance and promote the development of obesity. Half of the protein mass is muscle, so it largely determines the homeostasis of glucose and the development of energy balance, which is presented in the form of an interdisciplinary model for the development of diabetes, obesity and cardiovascular diseases. In conclusion, technologies were proposed to support the process of protein synthesis and ways of preventing and treating obesity. The model of phase nutrition is analyzed when it is necessary to use food compounds separately for the absorbent and post-absorbent periods. Proceeding from this situation, a specialized product was developed to feed patients with obesity.

Keywords: *Obesity; Protein Metabolism; Food Model; Energy Homeostasis; Non-Communicable Disease*

Introduction

First food, people faces is a mother's milk. By its composition, the mother's milk can be attributed to the high fat (HF) principle of nutrition. When a child starts natural feeding, he already gets high carbohydrate (HC) food, but the principle of HF is maintained in the intervals between HC nutrition. Thereafter, two food streams are present in human nutrition: one HC exogenous or absorptive and the other is HF endogenous or post-absorptive. All theories of balanced nutrition concern the human needs for food compounds and energy in the absorptive period, while the post-absorptive period remained on the sidelines. Sidedness to any problem always leads to a deadlock, in particular violation in nutrition is currently the main cause of high morbidity and mortality of man. It is necessary to fundamentally change the way we think about balanced diet and separately consider the need for food compounds in the of exogenous and endogenous periods and start approach with a problem of faze in human nutrition.

Materials and Methods

During the development of the phase feeding model, the literature data and the results of our own research were used.

Results and Discussion

Carbohydrates are the main source of energy, because glucose is the only source of energy for such vital tissues as the brain and blood cells, so all types of metabolism, all regulatory systems are aimed at maintaining glucose homeostasis.

Carbohydrates enter the body at varying rates, thus one could conventionally identify two opposite states: feeding and fasting. From the energy supply standpoint these states can be defined as the state of "Surplus energy", or glucose (after meals), and the state of "Energy deficiency" (prior to next intake of meals) when the glucose supply is made on the account of glycogenolysis and gluconeogenesis.

Glucose homeostasis may be maintained on the account of auto-regulation of enzymes involved in its utilization and synthesis [1]. However, such a regulation has limited potential, and one can observe considerable fluctuations of glucose levels at excessive or deficient intake of carbohydrates with food, as well as at various physiological and pathological conditions that determine the existence of more powerful systems for maintaining glucose homeostasis of the body.

Even though carbohydrates usually constitute over half of energy value of daily ration, however, the body is forced to balance on the edge of their deficit and to save glucose molecule from complete oxidation, for instance, by recycling it via lactate (Cori cycle). Later Felig [2] proposed a model of recycling of glucose via amino acid alanine (glucose-alanine cycle). This model considers the involvement of protein metabolism in maintaining glucose homeostasis.

These models do not take into account the fluctuating character of food intake (they are stationary models), and they disregard the interrelationship between the metabolisms of every nutrient (proteins, lipids and carbohydrates). Moreover, generation of lactate and alanine occurs during the period of "Surplus energy", but gluconeogenesis is blocked at this stage while there is no depot of neither lactate, nor alanine in body. Glucose synthesis from lactate and alanine is activated during the "Energy deficiency", but there is no nutrient inflow which would energize the generation of lactate and alanine, thus these stages occur actually in different time.

Taking into consideration the routes of transportation of carbon skeleton and stages of interrelation between the processes of generation and utilization of ATP energy dependent on supply of the body with food energy, we have developed a model of glucose homeostasis of the body which takes into account the metabolism of all nutrients (Figure 1).

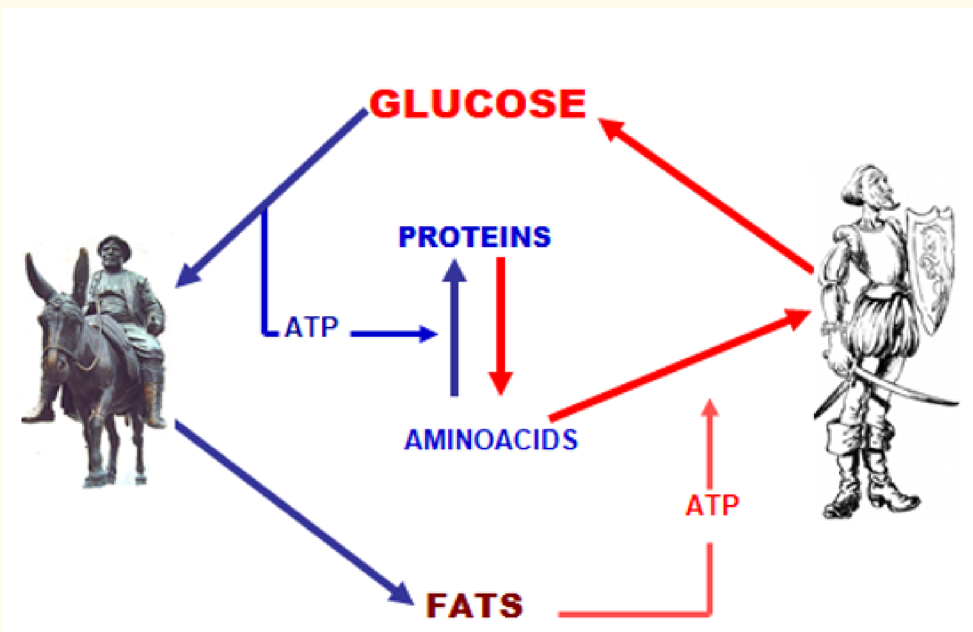

Figure 1: A conceptual model of interrelation between metabolism of protein, fat and carbohydrates for utilization exogenous (➞) and endogenous (➞) nutrition flows.

During the "Surplus energy" (for utilization exogenous nutrition flow or Sancho Panches) glucose utilization (dissimilation) is accomplished via storing it as glycogen and oxidation. If glucose inflow exceeds its dissimilation rate, then the excess carbon skeleton is utilized for the synthesis of lipids, that is, a combined anabolic lipogenesis is switched on.

Glucose oxidation results in the generation of ATP energy, therefore, there should exist routes to utilize this energy, since the excess ATP automatically block glycolysis. One may consider three principal ways of utilization of ATP energy: expenditures for physical activity, expenditures for heat production, and utilization for protein synthesis. In fact, physical activity, increased heat production and increased protein intake result in acceleration of glucose utilization. From the dietetic standpoint the process of protein synthesis is of interest. In other words, the rate of amino acids intake with food is an important regulator of glucose utilization.

Thus, during the "Surplus energy" the process of glucose dissimilation is associated with the two assimilation processes: with lipogenesis in regard of carbon skeleton, and with protein synthesis in regard of generation and utilization of ATP energy.

Even though glycolysis and protein synthesis are interconnected via generation and utilization of ATP energy, however, these metabolic flows are closely interrelated since no protein synthesis occurs without energy supply while reduced utilization of ATP energy blocks ATP generation or glycolysis. In such case an excess carbon skeleton will be redirected to lipid synthesis resulting in obesity.

During the "Energy deficiency" (for utilization endogenous nutrition flow or Don Quixote) glucose homeostasis is maintained on the account of its endogenic synthesis from amino acids, those results in protein catabolism to supply the required substrates while lipolysis and lipid oxidation get activated to supply the energy for gluconeogenesis. This stage is characterized with combination of two dissimilation processes (protein catabolism and lipid oxidation) and one assimilation process (gluconeogenesis). Glucose synthesis is associated with lipid oxidation through the generation and utilization of ATP energy, while with protein catabolism - via routes of transportation of carbon skeleton.

Though gluconeogenesis and lipid oxidation are associated with each other through the generation and utilization of ATP energy, these metabolic flows are inter-dependent. For example, blockade of lipolysis [3] or lipid oxidation [4] automatically causes the decline of gluconeogenesis resulting in hypoglycemia, and on the contrary, the reduction of concentration of the substrate for gluconeogenesis blocks ATP synthesis from acetyl-CoA and results in condensing of excess acetyl groups in acetoacetate and oxybutyrate, leading to ketosis, for instance, in diabetes or fasting [5].

Thus, glucose homeostasis in the body depends to considerable extent on interrelations between the metabolism of proteins, lipids and carbohydrates. This dependence is determined by the capacity of any component of the food to affect individual steps of conversion of other nutrients with involvement of regulatory function of hormones. This model may serve as a theoretical basis to develop a dynamic model of balanced nutrition.

Models of glucose recycling via lactate or alanine are circular, that is, carbon skeleton of glucose is used to synthesize lactate or alanine while glucose synthesis requires the return of carbon skeleton. In our model during the "Surplus energy" the carbon skeleton of glucose is used for lipid synthesis while at the "Energy deficiency" there occurs a loss of that carbon skeleton (elimination in the form of carbon dioxide at lipid oxidation). On the contrary, ATP energy generated at glucose oxidation is spent for protein synthesis, and we again get back the carbon skeleton.

Hence, our model can be defined as a cross-like one, since there is no direct route of transportation of carbon skeleton or energy because of opposite direction of assimilation and dissimilation of proteins, lipids and carbohydrates during the "Surplus energy" and the "Energy deficiency". If during the "Surplus energy" one observes activation of protein and lipid assimilation and carbohydrate dissimilation, then during the "Energy deficiency" protein and lipid dissimilation and carbohydrate assimilation occur, thus glucose homeostasis in the body is maintained on account of utilization its excess flow to include the carbon skeleton in lipid synthesis, while ATP energy is directed to protein synthesis, and during the endogenic glucose synthesis lipids provide ATP energy while proteins supply the carbon skeleton.

Metabolism intensity is controlled by neuro-endocrine system. The "Surplus energy" is signaled by acetylcholine and insulin levels while the "Energy deficiency" is mediated through noradrenaline and glucagon levels. Therefore, on the one hand, the neuro-hormonal status reflects energy balance of the body, and on the other hand, it depends on the intensity and ratio of nutrient flows.

Extensive studies on the specifics of metabolism in fasting or intake of individual nutrients are available; therefore these states are a convenient model to assess the intensity of metabolic flows from the position of the proposed model.

Hepatic glycogen stores almost completely disappear after a 24 - 48 hour fasting [6], therefore the body is supplied with glucose due to protein catabolism [7] and lipid oxidation. Introduction of the key gluconeogenic amino acid (alanine) causes an increased glucose production in the liver [8] while oleic acid (energy substrate for gluconeogenesis) increases hepatic glucose production almost two fold [9], and on the contrary, the inhibition of lipolysis [3] or fatty acid oxidation [4] result in hypoglycemia.

Muscular alanine synthesis in fasting is completely dependent on the levels of branched amino acids produced in protein catabolism, and their levels are elevated during the first week of starvation. A two-week feeding of rats with low-protein chow did not affect blood glucose level [10], but the starvation caused more expressed hypoglycemia. A low level of alanine in blood plasma of adults [11] and children [12] is mentioned at protein-energy deficiency, and fasting caused more pronounced hypoglycemia.

Obesity is the most prevalent metabolic disorder. Among the causes of obesity the most often is over-eating, especially carbohydrates [13]. This correlates well with the considerations on the character of metabolic flows during the "Surplus energy" when the surplus flow of under-oxidized glucose (lactate) is directed to lipid synthesis. There are available data evidencing to the development of lactate-acidosis in obesity [14] and high correlation between blood lactate concentration and size of adipocyte [15].

Obesity causes activation of metabolic flows during the "Surplus energy", therefore obese patients have an increased blood concentration of insulin [16] while on the contrary glucagon levels are lower [17].

Diabetes can be classified as a metabolic disorder where the activation of metabolic flows characteristic for the "Energy deficiency" takes place. Therefore, the effect of glucagon is more prevalent.

Thus, metabolic changes arising at various physiological states of the body and metabolic disorders are determined to a considerable extent by inadequacies between nutrient flows that stipulate the possibility of correcting them with nutritional factors.

A certain balance between individual nutrient flows should be maintained. During the "Surplus energy" such balance should be met between the flows of glucose and amino acids. Excess glucose flow induces hyperglycemia and lipidemia, while inadequate glucose intake with food leads to a lower inclusion of amino acids in proteins resulting in hyperaminoacidemia. Therefore, adequacy between these nutrient flows is the most important principle of balanced nutrition.

During the "Energy deficiency" depot flows are utilized. The balance between the flows of amino acids (pool of free amino acids) and lipids is of key importance at this stage. It is well known, that lipid reserves (in the form of triglycerides) are much higher than protein reserves (in the form of muscular protein), and therefore the prevalence of lipid flow is the most often seen phenomenon. This inadequacy becomes more evident in low-protein rations when there are no enough amino acids or energy for protein synthesis. In such cases there occurs the reduction of the pool of free amino acids and more pronounced hypoglycemia and ketosis in fasting. Hence, there take place dynamic changes of metabolic indices which depend on the ratio of individual nutrients in food; therefore, the proposed model is a theoretical basis for the dynamic model of balanced nutrition.

This dynamic model of balanced nutrition allows understanding the necessity of maintaining certain ratios of proteins, lipids and carbohydrates in food. Increasing of individual nutrients causes an increased concentration of its metabolites and differently-directed change of concentration of metabolites of nutrient flows associated with it, that is, an increased concentration of metabolite flows associated with carbon skeleton transportation routes, and, on the contrary, a decreased concentration of metabolite flows associated with the generation and utilization of ATP energy. All these aspects should be considered at designing a balanced nutrition rations at various physiological states and metabolic disorders.

With food, people get about 100 food compounds, so the wide range of people can understand their needs, the United States Department of Agriculture has developed a model of human nutrition in the form of a pyramid. But it touches upon the needs of a person only during the absorptive period, whereas nutrition should be presented in the form of two pyramids - food and energy (Figure 2).

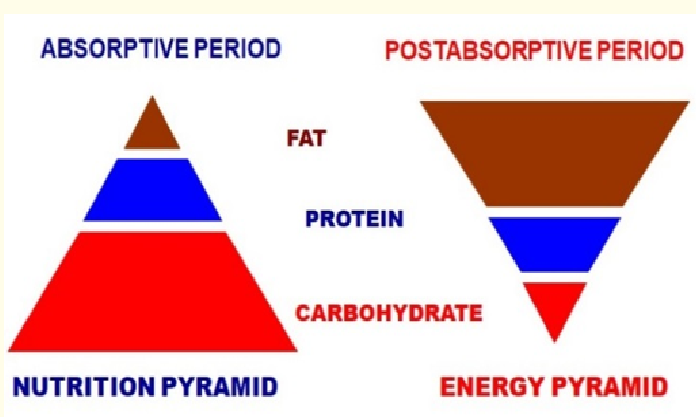

Figure 2: *Two pyramids in human nutrition*

If in the food pyramid the main nutrient is carbohydrates, then in the energy pyramid - fats. In addition to the ratio of macronutrients, these pyramids differ in the composition of food compounds necessary to ensure the activity of their metabolic processes. Thus, for the food pyramid, saturated fats are required as basic, polyunsaturated plant and fish fats for constructing cell membranes and synthesizing biologically active compounds; Anabolic amino acids (leucine, valine, isoleucine), irreplaceable (lysine, methionine, threonine) and mediator (tyrosine, phenylalanine) are required as proteins; as carbohydrates - starch polysaccharide, maltose disaccharide and glucose monosaccharide. In the energy pyramid, saturated short-chain (4 - 10 carbon atoms) triglycerides, such as palm oil, are suitable as fats; as proteins - gluconeogenic amino acids (alanine, serine, glycine); as carbohydrates - polysaccharide inulin, monosaccharides fructose and galactose. In other words, all food compounds should be divided into two groups: some are required for the food pyramid, but have a negative impact on the functioning of the energy pyramid. For example, glucose promotes the secretion of the hormone insulin and the activation of metabolic pathways that promote protein synthesis and repair and renew cellular structures (rehabilitation) and store excess energy, but at the same time inhibit energy generation processes. In other words, at the same time the working capacity decreases - "well-fed animal is not a hunter".

When we work, we use the energy deposited in the body. This is the so-called endogenous nutrition. Nowadays the life style of a person has changed significantly. This is due to decline in physical labor and a predominance of intellectual and operator activities, which led to a reduction in fat consumption and increased need for glucose. This led to the development of a deficit of the one energy source (glucose), against an excess of the other - fats. An energy imbalance has been developed that contributes to the increase of metabolic pathologies - diabetes, obesity and cardiovascular diseases. It is necessary to adjust the energy imbalance by developing a specialized product for the work phase or the post-absorptive period. Based on such principles, we have developed a specialized product for feeding obese patients, to which English patent GB 2496119 of January 22, 2014 was received. This product does not induce the secretion of insulin, so working capacity doesn't decrease; it contributes to the maintenance of glucose homeostasis, reducing fat deposit and prevents the development of functional disorders using technologies to reduce body weight.

On the other hand, food energy pyramid connections have a negative influence on the processes of rehabilitation. In the literature, a large amount of information about the negative effect of fructose monosaccharide [18] and palm oil [19] has accumulated. Many of these aspects have been repeatedly discussed in the scientific literature regarding sugar and its component of fructose as toxic compounds promoting the development of chronic non-infectious diseases. Fructose is not used as an energy source in humans, but in the liver it is converted into glucose and in this form is used as an energy source. During HC diet, insulin secretion occurs, which is an information signal about the excess intake of glucose from food. Therefore, during insulinemia, gluconeogenesis is blocked in the liver and fructose from the food passes through the liver unchanged, which increases fructose level in blood (fructosemia) and lead to the development of its toxic effects. However when fructose enters the post-absorptive period, it totally turns into glucose and has not its toxic effects. Moreover, in the absorptive period fructose promotes activation of lipogenesis and obesity, but in the post-adsorption period it promotes fat oxidation and activation of energy use processes (6 ATP molecules are consumed to synthesize glucose from fructose) and lipid oxidation and a decrease in body mass index are noted. The same dependence is noted for palm oil. Palm oil is not required for rehabilitation processes and entering the absorption period it contributes to the development of lipidemia, but when it enters the post-absorptive period it enhances gluconeogenesis, improves glucose homeostasis and activates utilization and promotes weight loss. Therefore, the phasic nature of the intake of food compounds is an important aspect of maintaining health and developing preventive and curative measures against weight gain.

Conclusion

In human nutrition, there are two food streams, which can be represented in the form of pyramids: in the absorptive period - Food pyramid, and in the post-absorptive - Energy pyramid. The task of the food pyramid is to ensure the processes of renewal of protein and cellular structures and the storage of excess energy flow, and the energy - to provide energy to physical and mental work. Pyramids differ in both the ratio of macronutrients and the supply of food compounds, the violation of which contributes to the deterioration of the physiological and metabolic systems of the body and the development of non-communicable diseases. Thus, when developing rations or products of therapeutic and prophylactic action, it is necessary to take into account not only food compounds, but also the phasic nature of their intake.

Bibliography

1. Nordlie RC. "Fine-tuning of glucose concentrations". *Trends in Biochemical Sciences* 10.2 (1985): 70-75.

2. Felig P. "The glucose-alanine cycle". *Metabolism* 22.2 (1973): 179-207.

3. Toews CJ., *et al*. "The regulation of gluconeogenesis. The effect of pent-4-enoic acid on gluconeogenesis and on gluconeogenic metabolite concentrations of isolated perfused rat liver". *Journal of Biological Chemistry* 245.4 (1970): 818-824.
4. Williamson JR., *et al*. "Interrelation between fatty acid oxidation and the control of gluconeogenesis in perfused rat liver". *Advances in Enzyme Regulation* 6 (1968): 67-100.
5. Brady LJ., *et al*. "Influence of prolonged fasting in the dog on glucose turnover and blood metabolites". *Journal of Nutrition* 107.6 (1977): 1053-1060.
6. Goodman MN., *et al*. "Glucose metabolism in rat skeletal muscle at rest". *Diabetes* 23.11 (1974): 881-888.
7. Cahill GP. "Metabolic role of muscle". *Muscle Metabolism During Exercise* (1971): 103-109.
8. Felig P., *et al*. "Alanine: key role in gluconeogenesis". *Science* 167.3920 (1970): 1003-1004.
9. Felig P., *et al*. "Amino acids metabolism during prolonged starvation". *Journal of Clinical Investigation* 48.3 (1969): 584-594.
10. Wapnir RA and Lifshitz P. "Fasting-induced hypoglycemia in experimentally malnourished rats". *Journal of Nutrition* 107.3 (1977): 383-390.
11. Smith SR. "Gluconeogenesis from alanine". *Metabolism* 23 (1974): 603.
12. Snydermann SE. "Metabolic changes in children". *Pediatric Research* 2 (1968): 131.
13. Felig P., *et al*. "Amino acid metabolism in the regulation of gluconeogenesis in man". *American Journal of Clinical Nutrition* 23.7 (1970): 986-992.
14. De Meutter RC and Shreeve WW. "Conversion of DL-lactate-2-C14 or -3C14 or pyruvate -2-C14 to blood glucose in humans: effects of diabetes, insulin, tolbutamide and glucose". *Journal of Clinical Investigation* 42.4 (1963): 525-533.
15. Vendsborg PB and Bach-Mortensen N. "Fat cell size and blood lactate in humans". *Scandinavian Journal of Clinical and Laboratory Investigation* 37.4 (1977): 317-320.
16. Rabinowits D and Zierler KL. "Forearm metabolism in obesity and its response to intraarterial insulin". *Journal of Clinical Investigation* 41 (1962): 2173-2181.
17. Wise JK., *et al*. "Evaluation of alfa-cell function by infusion of alanine in normal, diabetic and obese subjects". *New England Journal of Medicine* 288.10 (1973): 487-490.
18. Lee WC., *et al*. "Translational insights on developmental origins of metabolic syndrome: Focus on fructose consumption". *Biomedical Journal* 41.2 (2018): 96-101.
19. Mancini A., *et al*. "Biological and Nutritional Properties of Palm Oil and Palmitic Acid: Effects on Health". *Molecules* 20.9 (2015): 17339-17361.

Volume 14 Issue 1 January 2019