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Does Salt Obesity Exist?

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Abstract

Background: Glucose transport within the intestine is performed by the SGLT1 cotransporter if it is attached to two sodium ions. Salt provides one sodium ion per molecule consumed. In humans its ingestion is commonly ten times the amount needed and its consumption is generally accompanied by high carbohydrate diets. This project evaluates if a large salt intake in the diet leads to the development of obesity. This work was raised thinking that a simple strategy to reduce the weight would decrease the amount of salt in food.

Methods: The effect of salt on the dynamics of glucose absorption in the gut was evaluated making glucose tolerance curves with salt (1.55 molar of glucose 3.1 molar of salt) and without salt. Salty tastes simulating increased food intake and promoting weight gain in Wistar rats were also analysed.

Results: The experiments showed that excessive salt intake prevents the transport of glucose from the intestinal lumen into the bloodstream. Additionally, salty tastes favoured increased food intake and weight gain.

Conclusion: Sodium that naturally flows from the cytoplasm of enterocytes into the intestinal lumen, maintains the glucose cotransporter SGLT1 saturated and ensures at all times the transport of glucose that has been ingested in the diet. Excessive salt intake prevents the absorption of glucose from the intestinal lumen. Moreover, salty taste favours increased food intake and weight gain in Wistar rats.

Keywords: Intestine; Obesity; Cytoplasm; Wistar rats

Introduction

According to the World Health Organization (WHO) obesity is defined as abnormal or excessive fat accumulation, caused by factors such as genetic inheritance; the behavior of the nervous, endocrine system. Altogether, there are two main causes: Higher intake of calories than the body uses and/or less physical activity than the body needs. It has been established that men with more than 25% body fat and women with more than 35% body fat are obese [1]. According to the aforementioned criterion it has been reported that around the world there are 300 million obese people [2].

Fat tissue produces bioactive proteins known as adipocytokines [3] as epidermal growth factor that binds heparin (HB-EGF), leptin, Tumor Necrosis Factor Alpha (TNF-a), the inhibitor of Plasminogen Activator-1 (PAI-1), resistin and adiponectin. The expression of these adipocytokines (except adiponectin) increases with the accumulation of visceral fat and contribute to the development of chronic diseases such as heart disease, diabetes, hypertension, cerebrovascular events, kidney failure and some forms of cáncer [3-9].

Adenosine Triphosphate (ATP) is the main energy molecule to develop physiological functions of the human body and can be generated from three nutritional sources: Carbohydrates, fats and proteins.

If carbohydrates are abundant in a diet and exceed the physiological requirements and the ability to store them in the liver as glycogen, then the surplus will be precursor favoring lipid biosynthesis increasing the amount of body fat [10].

Glucose is the main source of energy for cellular metabolism and as carbohydrate, is generally ingested in the form of starch, which is a polymer that is degraded by the enzymes amylase (present in saliva and released by the pancreas) and maltase (released by the pancreas in duodenum). The glucose molecule ingested in the diet is transported from the light of the small intestine into the bloodstream by co-transporter SGLT 1 [11].

Glucose transport through the gut membrane is divided into two stages. First, the active transport of sodium ions from the interior of epithelial cells into the bloodstream, causing lowering of intracellular ion concentration. This reduction induces the passage of sodium, from the intestinal lumen into the cell through the epithelial brush border by facilitated diffusion. Two sodium ions are first combined with the transport protein SGLT1, which in order to carry out their function must be attached to the glucose molecule, so that both sodium and glucose are transported together into the cytoplasm of the enterocyte. Once there, transport proteins and enzymes facilitate the diffusion of glucose into the paracellular space across the basolateral membrane, and from here into the bloodstream [12].

The amount of carbohydrate that is ingested and absorbed by the intestine per day, varies with the eating habits and economic level of the population. If Indigenous peoples are not included, who practically do not eat carbohydrates, the rest of the world has a diet in which 50-80% of the calories are provided by carbohydrates [13].

Foods rich in protein, such as meat, milk and eggs have a higher cost than corn, wheat, rice and potatoes, which are rich in carbohydrates. Thus, the wealthier sectors of society eat proportionately more protein [14].

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This research is based on the following facts:

a. The transport of glucose and many amino acids in the intestine are dependent on sodium [11].

b. Salt intake (whose chemical composition is a chloride ion and sodium ion) by humans is usually 10 times greater than the amount required [14].

c. Consumption of food rich in carbohydrates is common in the population and can cause obesity [15].

As research objectives, it was proposed to study:

i. The effect of salt on the dynamics of glucose uptake in intestine by performing glucose tolerance curves (two moles of sodium per mole of glucose and as control, a glucose tolerance curve without sodium).

ii. The effect of the salty taste in food intake and weight gain in Wistar rats.

Methods

To evaluate the effect of salt on the concentrations of glucose absorbed from the intestinal lumen into the bloodstream of the rat. In two groups of 14 Wistar rats weighing 200-250 g, capillary glucose was measured (reading at 0 min). To do this, the tail of the rat was cut and a drop of blood was placed in a glucometer (Brand contour TS). Then each of the rats of both groups, were administered by oral gavage, 3 mL of glucose solution (técnica química S.A. Cat. No. 61040) at a concentration of 1 g/kg (1.55 molar), which corresponds to a tolerance curve adapted from human to rat. In the control group the glucose solution did not contain salt, whereas in the problem group the glucose solution contained salt (Sigma Aldrich Cat. No. 57653) at a concentration of 3.1 molar. We then proceeded to measure capillary glucose time: 30 min, 60 min and 120 min.

To analyse whether the saltiness stimulated increased food intake and weight gain in Wistar rats, a feed with the following composition was prepared: 465,692 g of corn flour, 155 g of cornstarch, 100 g of sugar cane, 1000 g of egg whites, 40 g of oil, 50 g of bran, two capsules of vitamins and minerals and sodium benzoate 0.05 %. Food for the problem group was added with 20 g of salt while food for the control did not have added salt. The food was pelleted and baked. Thereafter the food was fed to the rats for 5 weeks. We proceeded to measure the weight of each animal at the start of treatment and after the treatment and to measure food consumption per rat/day at baseline and during the last week of treatment. To perform the analysis of the influence of salty taste on food consumption and weight gain, one month old wistar rats were used. These rats were divided into two groups of seven wistar rats: A group of males and a group of females who received unsalted diet as well as other two groups of seven rats each; a female group and a male group that received a diet supplemented with salt. The rats were divided into groups of males and females since a difference in weight was observed between both groups of the same age. Basal glucose in these groups of rats was not measured.

To measure the weight of the animals and measure the food consumed Electronc balance scales FY-3000 brand AND were used.

The data of food intake were expressed as mean, glycemic level and body weight were expressed as mean ± SD. The groups were compared with ANOVA test and Bonferroni test for comparison between pair of groups. The significance level employed was 95%. The data analysis was carried out with Sigmaplot software for Windows.

Results

To corroborate the hypothesis that salt ingested in the diet increases the efficiency in the transport of glucose from the intestinal lumen into the bloodstream, glucose tolerance curves were performed in two groups of 14 rats. One group served as the control group and the other as a problem group. Glucose concentration was determined in the blood Figure 1 shows that the salt significantly impede the absorption of glucose in the intestine at 30 min, 60 min and 120 min post administration of glucose solution. Figure 1 shows the time course of the glycemic level post-administration of the glucose load, the data showed that the salt-treated group significantly decrease the absorption of glucose in the intestine when is compared to control group. Figure 2 shows that salt intake increased significantly food intake in the salt-treated group respect to control group. Moreover, the salt intake increased significantly the body weight in both females and males (Figure 3).

Discusion

During this research project analysis of the effect of salt intake on the development of obesity in Wistar rats was addressed assumption that a decrease in the amount of salt in food would be a simple measure to reduce weight in people. The proposal was made taking into consideration the following facts:

a. The transport of glucose from the intestinal lumen into the bloodstream is carried out by a protein called SGLT1 that cotransports two sodium ions and the glucose molecule into the enterocyte and then glucose and sodium are transported from cytoplasm linto the bloodstream.

b. That according to the World Health Organization (WHO) normal consumption of salt (formed by a sodium ion and a chloride ion) should be only 2 g/day and salt intake in humans is 10 times the amount needed [14].

Figure 1 shows the presence of salt or sodium ions is not necessary in the food consumed so glucose can pass from the intestinal lumen into the bloodstream. Reports show that in the intestine there is a quantity of sodium of about 20-30 g that naturally recirculates in enterocytes [16,17], and if this recirculation is inhibited uptake of glucose and amino acids in the intestine is prevented [18,19].

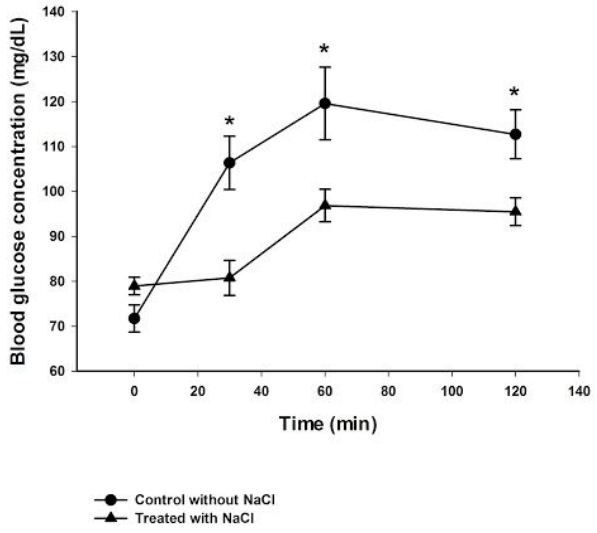

Figure 1: Glucose tolerance curves performed in Wistar rats (n=14).

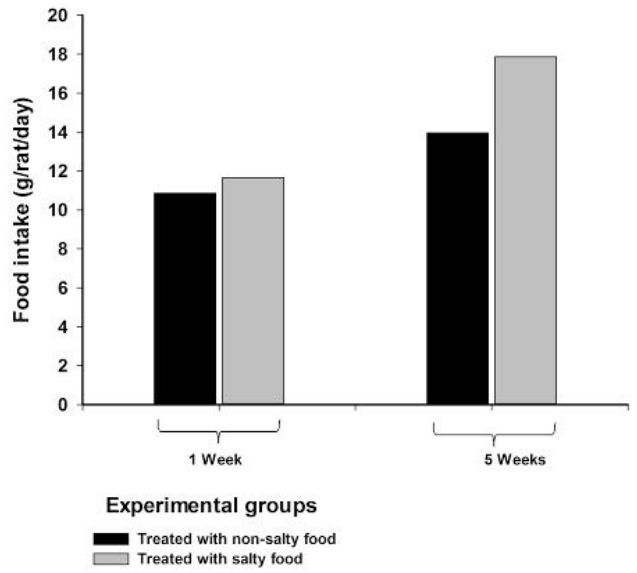

Figure 2: Food intake per rat per day at baseline and during the last week of treatment.

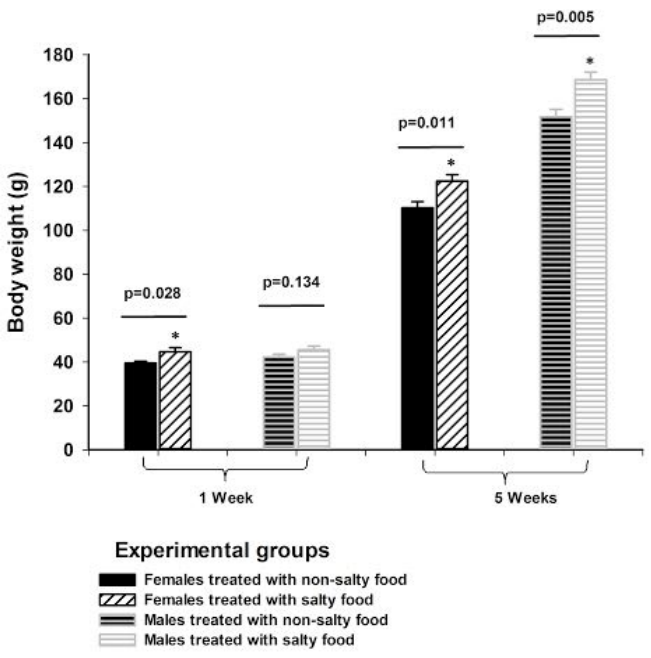

Figure 3: Salty taste favours increased weight gain in both males and females.

According to the results of this research, recirculation of sodium in the enterocyte is sufficient to maintain saturated the SGLT1 transporter and to ensure at any time the entry of glucose from the intestinal lumen into the bloodstream.

The salt that is ingested in food prevents the passage of glucose from the intestinal lumen into the bloodstream (Figure 1). According to literature if salt is consumed, the intestinal fluid becomes hypertonic and osmotic flow is from the blood to intestinal lumen. Established as a first step, the isotonicity of intestinal contents with plasma and extracellular fluid, comes transport mechanisms that lead to Na^+, water, glucose, amino acids, fatty acids and other substances from the intestinal lumen into the blood [17,18]. For this reason we conclude initially that unabsorbed glucose is lost in the stool due to diarrhea caused by salt intake. However the pilot experiments to analyze whether glucose tolerance curves with salt with respect to unsalted control curves produced diarrhea in rats could not corroborate this hypothesis. The treatment with salt did not produce diarrhea, so another possible explanation may be the inhibition by sodium ion of the binding site of the glucose to the SGLT1 transporter by salt excess.

Moreover we note that saltiness produces a greater appetite in animals, and greater weight gain. It would be an interesting experiment to assess whether this flavour produces increased expression of leptin as this hormone regulates appetite from the hypothalamus [20]. Previous study performed in healthy white and African American adolescents showed that high sodium intake is positively associated with adiposity, leptin, and tumor necrosis factor-alpha independent of total energy intake and sugar sweetened soft drink consumption [21]. Several reports agree with the results that are shown in this report since it had previously been confirmed that high salt intake is one of the major reasons of obesity [22]. The results of the present work performed in rats shows that weight gain is not due to the fact that salt intake in foods increases the efficiency of glucose transport from the intestinal lumen to the blood stream, but rather the salty taste increases the appetite which is reflected in the amount of food consumed and in the gain of weight of the rats. This evidence indicates that dietary salt may be linked to obesity and that this relationship is dependent of energy intake.

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