Journal of Nutrition & Food Sciences
ISSN: 2155-9600

Takao T, et al., J Nutr Food Sci 2016, 6:1
DOI: 10.4172/2155-9600.1000460

Research Article Open Access

Different Glycemic Responses to Sucrose and Glucose in Old and Young Male Adults

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Rec Date: Dec 27, 2015; **Acc Date:** Jan 20, 2016; **Pub Date:** Jan 29, 2016

Abstract

Background: GI (glycemic index) is used to show the potency of foods to increase blood glucose. No research has been carried out about age differences of GI of foods of distinct structures such as glucose and sucrose. We wanted to know if there is a big difference in GI depending upon ages of people to take foods.

Methods: GI is measured by the area under the blood glucose curve two hours after consuming 50 g of test carbohydrates in relation to 50 g of glucose or white bread. Although GI is influenced by the source and the amounts of foods, it is not known whether GI is affected by age. We gave 50 gram of either glucose or sucrose in a cross over study to two groups of healthy men, older (n=44, mean age=62.4 ± 9.6) and younger (n=36, mean age=20.6 ± 1.6). Results: GI in response to sucrose was 82.8% compared to that of glucose in the younger men and 73.6% in the older men ($p<0.05$). Sucrose administration produced a rise in plasma insulin that was 76.2% of that observed with glucose in the younger men compared with 34.2% in the older men ($p<0.05$).

When the amounts of blood glucose and insulin after the administration of glucose or sucrose were measured, glucose increased more in spite of increase in insulin in old men. In young men, nearly same amounts of insulin caused smaller increase in blood glucose levels.

Conclusion: These results may indicate that GI is very much different between old and young men even if the same foods with distinct structures are given, and insulin release to increase in glucose in young men is more sensitive than old men.

Keywords: Glycemic index; Glucose; Sucrose; Insulin; Age

Abbreviation

GI: Glycemic Index; GL: Glycemic Load

Introduction

Blood levels of glucose after a meal are controlled by the rate of appearance of glucose into the blood and its clearance from the circulation. Dietary carbohydrate clearly influence plasma glucose levels, but dietary fat and protein can also influence plasma glucose levels [1,2]. The total carbohydrate intake from a meal is a good indicator of postprandial plasma glucose [3-7], but the impact of the type and source of carbohydrate on postprandial glucose levels has not been examined.

Term of glycemic index (GI) has been introduced by Jenkins and coworkers in 1981 [7,8] and is defined as the area under the blood glucose curve measured two hours after consuming 50 g of test carbohydrates in relation to 50 g of glucose or white bread [9,10]. In 1997 [8,9], the term glycemic load (GL) was introduced to quantify the overall glycemic effect of food as to its specific carbohydrate content. GL equals GI multiplied by the carbohydrate density of the food which is usually given as g carbohydrate per 100 g serving.

Research on GI indicates that even when foods contain the same amount of carbohydrate, there are up to fivefold differences in glycemic impact [8,9,10]. In addition, several studies have found that the overall GI and glycemic load (GI × g carbohydrate) of the diet, but not total carbohydrate content, are independently related to the risk of developing type 2 diabetes [8,9], cardiovascular disease [11], and some cancers [12,13].

A meta-analysis published in 2003 indicated that a diet rich in low GI foods is associated with lower levels of hemoglobin A1C in diabetic patients as compared to high GI foods [14]. Although sucrose has a lower GI than glucose (since it is composed by glucose and fructose) [8], it is unclear if there are differences in the plasma glucose (and insulin) response to sucrose and glucose as a function of age. If GI (or GL) varies with age, then foods cannot be assigned specific GL values, and age-related norms would have to be established. In this paper we report changes in blood levels of glucose and insulin when 50 g of either glucose or sucrose solutions were administered to old men and young men.

Ethics

This work has been approved by the Ethical committees of Showa Women's University and NPO "International projects on food and health" and has been carried out in accordance with The Code of

Ethics of the World Medical Association (Declaration of Helsinki) for experiments.

Methods

We asked acquaintances older than 50 and checked their health carefully and recruited them if there were no health problems such as diabetes, hypertension and not serious diseases experienced in the past. They did not smoke in the past. We obtained informed consent prior to conducting the protocol which had been approved by the Ethical Committee of Showa Women's University.

Participants were given self-administered diet history questionnaires and described answers on each item by recollection of diets they took. From these questionnaires, we calculated the intake of energy, carbohydrate, fat and protein.

Measurement of GI

Participants after overnight fast were randomized to 550 mL solutions containing 50 g of glucose or sucrose (or 500 mL water as a control). Bottles containing 500 ml of water was added with either 50 g of glucose or sucrose.

Participants were asked not to eat anything after 21:00 PM of the previous night and not to take breakfast. Blood was taken between 9:00 AM and 10:00 AM and given either glucose or sucrose solution or water as a control. We measured blood glucose from a finger stick (TERUMO kit) and other plasma factors were measured after the separation of plasma from the blood.

Plasma of these samples was obtained by centrifugation and levels of lipids, amino acids and insulin were measured for backgrounds of these participants.

Insulin was measured by CLEIA (chemiluminescent immunoassay) method, Amino acids were measured by high speed liquid chromatography and cholesterol was measured by homogenious methods. Triglycerides were measured by GK/GPO methods.

Various parameters of participants

Table 1 indicates various parameters of participants. We compared these parameters with those reported by the Japanese Ministry of Welfare [14]. It is shown that participants of the present experiments are in average range as to height and weight. Energy and protein uptakes are similar between young men and old men but young people take more lipids and carbohydrates, but old men take more sugar.

	Aged group	Young group	Remarks
Age (years)	62.4 ± 9.6	20.8 ± 1.6	**
Height (m)	1.68 ± 0.07	1.72 ± 0.06	*
Weight (kg)	68.8 ± 10.9	65.5 ± 10.2	
BMI (kg/m^2)	24.3 ± 3.2	22.2 ± 3.3	*
Estimated energy intake (kcal/day)	2115.1 ± 460.2	1988.8 ± 591.8	
Estimated protein intake (g/day)	66.6 ± 28.8	69.3 ± 25.1	
Estimated lipid intake (g/day)	49.1 ± 22.6	60.4 ± 24.8	*
Estimated carbohydrate intake (g/day)	198.6 ± 89.4	271.5 ± 91.3	**
Estimated sugar intake (g/day)	6.0 ± 4.3	4.4 ± 3.7	*
Blood glucose (mg/dl)	91.7 ± 16.3	78.9 ± 13.1	**
Blood insulin (μU/ml)	6.19 ± 3.79	6.87 ± 4.19	

Table 1: Heights of average Japanese men (m) 18-20; 1, 71, 50-69; 1.66, >70; 1.61, body weights of average Japanese men (kg): 18-20; 63, 50-69; 65, >70; 59.7 (*p<0.05, **:p<0.01).

Statistics

Standard ANOVA methodology was used and $p<0.05$ was considered significant difference. In the Figures, bars represent standard deviations.

Results

Table 2 shows plasma lipids levels and their changes after the administration of glucose or sucrose in young and old men. LDL-cholesterol, TG, and total-cholesterol are higher in old men than young men. Omega fatty acids such as EPA, DHA and arachidonic acids are higher in old men than young men. Lipids levels did not change much after the administration of glucose or sucrose.

Blood lipids	**Aged group**				**Young group**			
	0 min.	**120 min.**			**0 min.**	**120 min.**		
	(n=44)	**control(n=13)**	**glucose(15)**	**sucrose(n=16)**	**(n=36)**	**control(n=11)**	**glucose(n=12)**	**sucrose(n=13)**
HDL-Chol. (mg/dl)	60.9 ± 14.6	56.5 ± 11.3	60.5 ± 13.6	64.5 ± 15.9	61.0 ± 11.7	65.9 ± 11.6	63.9 ± 9.1	58.5 ± 12.0
LDL-Chol. (rng/dl)	123.7 ± 30.2**	133.7 ± 29.0	126.7 ± 28.4	107.9 ± 26.5	104.6 ± 24.4**	98.6 ± 27.2	104.3 ± 25.2	99.7 ± 17.0
TG (mg/dl)	126.4 ± 81.30*	124.1 ± 49.9	119.0 ± 75.3	107.9 ± 61.2	75.1 ± 31.90*	83.9 ± 39.0	60.4 ± 26.6	63.5 ± 22.9
T-Chol. (mg/dl)	209.9 ± 32.3#	213.7 ± 31.0	211.9 ± 29.2	195.5 ± 35.2	174.3 ± 25.50*	175.9 ± 29.0	176.5 ± 27.1	165.6 ± 19.8
dihomo- γ-linoleinic acid (μg/ml)	36.5 ± 10.3	37.2 ± 8.4	36.8 ± 14.9	34.9 ± 7.1	34.4 ± 8.3	36.2 ± 9.5	34.3 ± 8.6	32.1 ± 6.8

arachidonic acid (μg/ml)	210.1 ± 48.4**	213.6 ± 47.7	208.5 ± 54.9	193.0 ± 42.2	170.3 ± 38.4**	177.7 ± 33.4	175.0 ± 42.9	158.8 ± 38.0
EPA (μg/ml)	87.1 ± 46.7**	71.4 ± 29.2	84.0 ± 43.9	92.7 ± 56.1	27.5 ± 18.10*	27.0 ± 14.5	24.9 ± 15.2	27.5 ± 22.7
DHA (μg/ml)	158.6 ± 52.2**	147.9 ± 35.4	153.2 ± 54.3	166.0 ± 62.6	78.3 ± 20.6**	82.6 ± 21.6	77.2 ± 22.0	73.0 ± 20.5
EPA/AA	0.423 ± 0.214**	0.349 ± 0.163	0.421 ± 0.206	0.471 ± 0.241	0.161 ± 0.102**	0.157 ± 0.091	0.146 ± 0.091	0.165 ± 0.117

Table 2: The blood lipids level of aged and young group, aged group vs. young group (*p<0.05, **p<0.01).

Table 3 shows that base line levels of total, and non-essential amino acids and their changes after the administration of glucose or sucrose in young or old men. Baseline levels of total and non-essential amino acids but not essential amino acids were higher in old men than in young men. The levels of total, non-essential, and essential amino acids decreased after the administration of glucose or sucrose, but the extent of decreases were more in young men.

	Aged group				**Young Group**			
	0 min	**120 min**			**0 min.**	**120 min.**		
Amino Acids	**(n=44)**	**Control (n=13)**	**glucose(n=15)**	**sucrose(n=16)**	**(n=36)**	**Control (n=11)**	**glucose(n=12)**	**sucrose(n=13)**
Total AA(nmol/ml)	2865.2 ± 242.3+	2769.3 ± 188.6	2337.3 ± 214.3**##	2535.8 ± 222.9**#	2727.8 ± 209.8+	2508.0 ± 197.7**	2203.1 ± 145.6**##	2359.3 ± 196.2**
NEAA(nmol/ml)	1884.2 ± 196.5++	1799.7 ± 141.8	1595.0 ± 172.6**#	1752.3 ± 195.3	1763.7 ± 141.3++	1624.6 ± 142.8*	1471.2 ± 104.0**	1598.9 ± 149.9**
EAA(nmol/ml)	981.1 ± 93.6	969.6 ± 101.5	742.3 ± 66.7**##	783.5 ± 74.5**##	964.2 ± 95.0	883.3 ± 64.8#	731.9 ± 74.9	760.4 ± 70.5**##
EAA/NEAA	0.525 ± 0.062	0.542 ± 0.065	0.468 ± 0.046**##	0.451 ± 0.058**##	0.548 ± 0.048	0.546 ± 0.033	0.499 ± 0.054*	0.477 ± 0.044**##

Table 3: 0 min of Aged group vs. Young group -1-:p<0.05, ++, p<0.01 0 min vs. 120 min. *:p<0.05, **:p<0.01 120 min. of Aged group vs. Young group #:p<0.05, 44, 4<0.01.

Figure 1 shows changes in blood glucose levels after the administration of glucose or sucrose in old men. The rate of increase in blood glucose levels after the administration of glucose or sucrose were almost same up to 30 min. then blood glucose levels declined more rapidly after the administration of sucrose compared with that of glucose.

The levels were equal after 120 min. Figure 2 shows changes in blood glucose levels after the administration of glucose or sucrose to young men. It is shown that the rates of increase in blood glucose levels were identical between after the administration of glucose or sucrose. In contrast to the case of old men blood glucose levels declined at almost same rates after the administration of glucose or sucrose.

As known well, GI is the indicator of blood glucose levels when foods are taken. Since sucrose contains 50% of glucose. GI should be nearly 50% when glucose or sucrose is administered. However, it is shown here that GI of 50 g of sucrose is 73.6% compared to when 50 g of glucose is given to old men. Furthermore GI of sucrose is 82.8% compared to glucose administration in young men. These results mean that GI (measured from AUC) depends upon the age of people who uptake foods, and the kind of foods containing glucose.

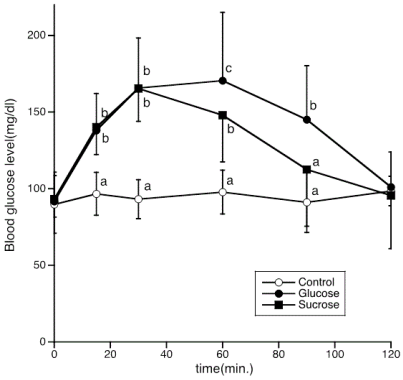

Figure 1: Changes in blood glucose levels after the administration of 50 g. of sucrose or glucose to old men. Control group took water. a vs. b; p<0.05, b vs. c; p<0.05.

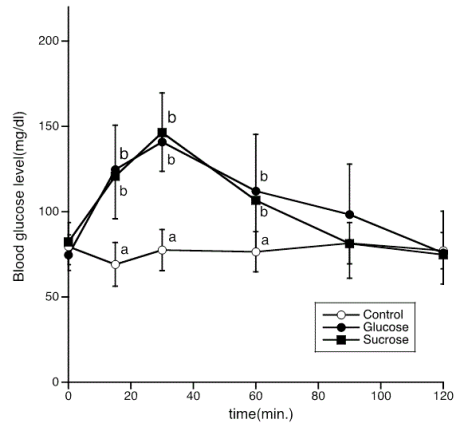

Figure 2: Changes in blood glucose levels after the administration of 50 g. of sucrose or glucose to young men. Control group took water. a vs. b; $p<0.05$.

Figure 3 shows changes in changes in insulin levels after the administration of 50 g of glucose or sucrose to old men. It is shown here that levels of insulin after the administration of glucose were more than twice as much when the levels of insulin were compared after administration of sucrose in old men. On the other hand, Figure 4 shows that plasma insulin levels were 76.2% when sucrose was administered compared to the administration of glucose in young men. This shows that easiness of insulin release by the kind of food have a great influence on GI.

The amounts of secreted plasma insulin levels were lower in old men (34.2%) compared to young men (76.2%) when sucrose was administered compared to the administration of glucose (Figures 3 and 4). Figures 5-9 show the amounts of blood glucose and insulin after the administration of glucose and sucrose, respectively. The amounts of glucose and insulin were higher after the administration of glucose than that of sucrose in old men, but there were no statistic differences in the amounts of glucose and insulin after the administration sucrose and glucose in young men.

Figures7-9 show that uptakes of sucrose and sweet beverage did not influence BMI (body mass index), fasting glucose levels or triglycerides levels in young and old men.

Discussion

Blood glucose levels increase after uptake of foods containing carbohydrates, but the same amounts of administered carbohydrates cause different responses depending upon the source of the foods, Wolever et al. [6] indicated that blood glucose levels were significantly different when the source of foods are potato, spaghetti, bread or barley [6]. They also showed that carbohydrate source and amount influenced glucose and insulin response.

It is also well documented that high protein low carbohydrate diet causes low blood glucose levels after the meal [15-18]. This may be not only due to the low carbohydrate content in the meal, but the protein content may have influenced on blood glucose levels.

In most of experiments which compared the source of carbohydrate containing foods the same amount of carbohydrate caused different responses in the levels of blood glucose and insulin.

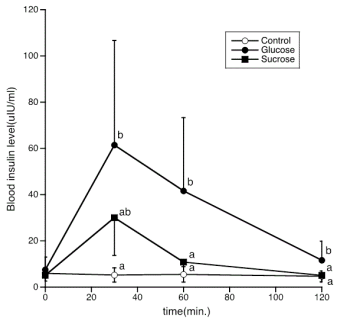

Figure 3: Changes in blood insulin levels after the administration of sucrose or glucose to old men a vs b; $p<0.05$, a vs ab; $p<0.05$.

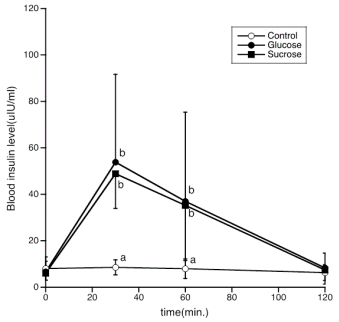

Figure 4: Changes in blood insulin levels after the administration of sucrose or glucose in young men a vs b; $p<0.05$.

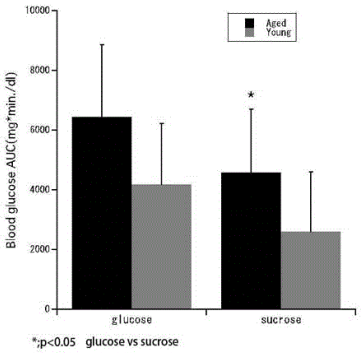

Figure 5: The amounts of blood glucose after the administration of sucrose or glucose to young men or old men. Bar represent standard deviation and * represents $p<0.05$.

As to the influence of age on responses to carbohydrate uptake, only data showing that high GI or GL are indicators of metabolic risks for adults and elderlies [19,20]. Venn et al. [21] indicated that there was no difference in GI between groups of mean age 28.8 (19-32) and mean age 48.8 (56-86). They compared GI when cornflakes or sustain was

given. AUC responses to the breakfast cereals in the older group were approximately double that of the young group. Compared with the younger group, GI of cornflakes was 25% higher in the older group.

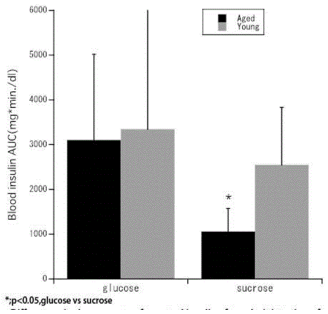

Figure 6: Blood Insulin level for Young and Aged people.

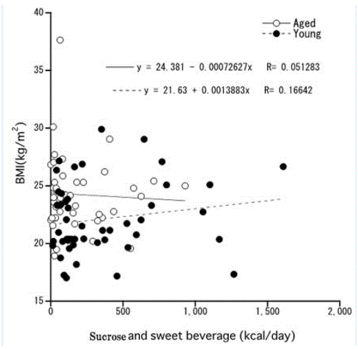

Figure 7: Body Mass Index for Young and Aged people.

Although these data show that there was a difference in GI depending upon age group, no comparison of GI was made using substance of distinct structure such as glucose and sucrose. Also nobody compared insulin levels after different foods were taken in old and young group.

In the present research, we compared differences in the responses to the administration of sucrose or glucose to healthy old men and young men. Both groups received the same amount of sucrose and glucose, thus the source of carbohydrate was identical.

As shown in Figure 1 blood glucose levels increased rapidly and at the same rate after the administration of 50 g of sucrose or glucose in old men, and the glucose levels declined faster after the administration of sucrose compared with glucose administration.

On the other hand, when the same amounts of glucose or sucrose were given to young men, the blood glucose levels rose at about the same rate and declined also at about the same rate. At 90 min, glucose levels after administration of glucose looked higher than sucrose administration at young men, but there was no statistical difference.

If GI calculated from the area under the glucose or sucrose curve, GI of sucrose is 73.6% of GI of glucose in elderlies and GI of sucrose was 82.8% of glucose. Since sucrose is composed of glucose and fructose and fructose is considered to have no influence on blood glucose levels, GI of sucrose should be theoretically 50% of glucose. But GI of sucrose was higher than 50% and more so in young men. Since it takes time for fructose to be metabolized and converted to glucose, high GI after the administration of sucrose compared to the glucose uptake should be due to either higher response of insulin secretion after the uptake of sucrose or influence of sweet taste on blood glucose levels.

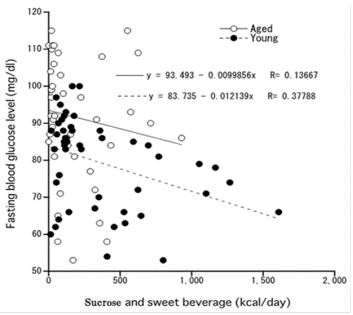

Figure 8: Fasting Blood Glucose for Young and Aged people.

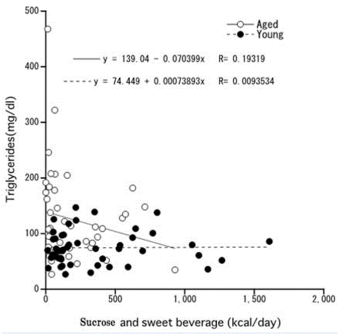

Figure 9: Triglycerides level for Young and Aged people.

Recently, Suez et al. [22] showed that the administration of artificial sweeteners induce higher blood glucose levels compared to the administration of glucose [22], which they attributed to roles of gut microbes. So, sweet taste may cause higher blood glucose levels when sucrose is given.

It has been documented that stimulation of taste buds by sucrose induces hedonic effects on Nucl. Accumbens [23]. The stimulation of cephalic phase of insulin release by the sweeteners sucrose and saccharin when applied to the oral cavity only was shown [24]. Thus sucrose may cause increased secretion of insulin. Higher increase in blood glucose after sucrose administration in young men may partly be due to glucose production by gut microbes in the presence of substances of sweet taste as shown in Figures 5-6.

Since BMI and plasma triglyceride levels are different between young and old men, BMI and triglyceride levels may have influenced the present results. Figures7-9 indicates that intakes of sucrose and sweet beverage did not influence BMI, fasting glucose levels or plasma triglyceride levels. So, BMI or triglyceride levels may not have affected the results of the present experiments.

Acknowledgements

We are grateful for Professor William Harris S, Department of Medicine, University of South Dakota, for reading the manuscript and providing valuable suggestions. Experiments were designed and performed by all of the authors. AT wrote a manuscript. Statistical analyses were done by TT. All authors read the manuscript and approve the final manuscript. All the authors had responsibities for a final content. Takao T: No conflicts of interest, Ogawa Y: No conflicts of interest, Ishii Y: No conflicts of interest, Shimizu F: no conflicts of interest, Takada T: No conflicts of interest.

Financial Support

This study was supported by grants by Ito Memorial Foundation and NPO International projects on food and health.

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