



Comparison between Threshold of Sweetness Perception and Blood Glucose Level at Resident Health Examination in Yakumo Town

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Abstract

Japan, a super-aging society, has 3.3 million diabetics. Diabetes is a common complication and requires early detection and early treatment. Dietary guidance is essential and it is necessary to prevent postprandial hyperglycemia. At the time of a health check-up, blood glucose and HbA1c levels can be measured by a blood test and the results can be shown, but diabetes can be prevented sooner if a simple sweetness threshold test can warn the patient on a daily basis. The purpose of this study was to conduct a simple sweetness test at the time of a health check-up in Yakumo-Town, Hokkaido, Japan and to screen early diabetes patients for the early detection and treatment of diabetes. By clarifying the relationship between the results of the sweetness threshold test and the blood sugar level and HbA1c level, we aimed to introduce a simple sweetness test for future health diagnosis. In 2019 at Yakumo-Town Resident Examination, which has been ongoing since 2007, 297 participants (168 females and 129 males) were selected. As a result, 6 males out of 129 male participants (4.7 %) and 3 females of 168 female participants (1.8 %) had abnormal values in sweet taste test (Tastedisc) results. The results of a simple sweetness threshold test were compared statistically between normal and higher blood glucose level and HbA1c values, but there was no statistically significant difference in the present results. Similarly, the BMI, abdominal girth, and body fat percentage were compared statistically with the results of the simple sweetness threshold test at normal values and above. As a result, there was no statistically significant difference between BMI and waist circumference, but there was a statistically significant difference in body fat percentage. Participants with a high percentage of body fat were found to have high simple sweetness threshold test values. Type 2 diabetes initially gains weight and later increases fasting blood glucose and HbA1c. When the simple sweetness threshold test value is increased in a person with a high body fat percentage, giving a cautionary recommendation may be effective in preventing diabetes.

Keywords: Gender; Healthy Elderly People; Sweetness; Taste Function; Yakumo Study

Introduction

The number of diabetics in the world continues to grow to more than 400 million. About 3.3 million people (male 1.85 million, female 1.45 million) have diabetes in Japan (2017). It has been reported that Alzheimer's disease may occur if blood sugar levels remain high after meals. It is said that people with diabetes often have different degrees of taste disorder. The reason is thought to be that neuropathy affects taste nerves, and diabetic nephropathy causes zinc, which is essential for metabolism of taste buds, to be excreted without being absorbed. Diabetes is also likely to cause changes in the salivary glands and impaired taste due to reduced salivary secretion. This creates a vicious cycle in which the flavors are depended and diabetes worsens. Therefore, teaching dietary improvement in the early stages of diabetes is very effective and can help prevent diabetic complications (diabetic nephropathy, diabetic neuropathy, diabetic retinopathy). Even for healthy people, taking too much sugar can lead to obesity, which is a situation that we want to avoid from the perspective of preventing metabolic syndrome. At present, extreme restricted diet recipes such as sugar-limited diet or sugar-off diet are circulating in Japan. For young workers before the age of 50, extreme carbohydrate restriction can cause hypoglycemia and should be under the guidance of a physician or a dietitian. For people aged 50 and older to older, mitochondrial energy production is possible in the body, so limiting carbohydrates helps prevent obesity and diabetes. However, extreme carbohydrate restriction also carries a higher risk of hypoglycemia than carbohydrate restriction performed by young people. Basically, carbohydrates are nutrients necessary for maintaining the body, and are necessary for maintaining and improving health. Therefore, if we can control taste, especially sweetness, it will be possible to prevent various diseases as a method to prevent excessive sugar intake. By finding and improving on factors related to the sweetness threshold, lowering the wetness threshold may help control carbohydrate intake.

The purpose of this study was to conduct a simple sweetness test at the time of a health check-up and to screen early diabetes patients for the early detection and treatment of diabetes. By clarifying the relationship between the results of the sweetness threshold test and the blood sugar level and HbA1c level, we aimed to introduce a simple sweetness test for future health diagnosis.

Materials and Methods

Participants

Participants were community dwellers who voluntarily participated in the Yakumo Study and had managed their everyday life themselves. The Yakumo Study was conducted since 1981 as a joint project between the town of Yakumo in Hokkaido and the Nagoya University Graduate School of Medicine. Professionals in the fields of epidemiology, internal medicine, orthopedics, neuropsychology, ophthalmology, otolaryngology, and urology joined the Yakumo Study. The analysed data were based on the database from 2019 from the neuropsychology and otolaryngology teams. The participants had been engaged in a variety of jobs, not only white collar but also in agriculture, fishery, and forestry. Therefore, this town can be regarded as representative of today's Japanese society. From the database, 297 participants (168 females and 129 males) were selected from data in August, 2019 (**Table 1**).

Participants	40's	50's	60's	70's	80's
Male (129)	10	24	49	39	6
Female (168)	23	40	65	38	3
Total (297)	33	64	114	77	9

Table 1: Age composition of participants in Yakumo inhabitants examination (n=297).

Assessment of Sweetness Taste Identification

The saltiness test was performed using test paper with liquid TASTEDISC (Sanwa Chemical Laboratory Co., Ltd) which include 5 different densities of Sugar on a liquid with test paper namely: 1(0.3%), 2(2.5%), 3(10%), 4(20%), 5(80%). The inspection method is as follows. 1) Show participants the taste choice paper: Sweet, Salty, Sour, Bitter. Taste something but I don't know, No taste. 2) Hold the filter paper disc with tweezers. The sweetening solution is dropped on the disc and moistened. 3) The moistened disc is gently placed on the chorda tympani innervation area of the participant's tongue. The chorda tympani innervation area is located 2 cm left and right from the tip of the tongue. 4) Instruct the user to answer one of the taste choice paper in 2~3 seconds with the mouth open. 5) The examiner then removes the disc from the participant's tongue with tweezers. 6) If a correct answer is not obtained, the test is continued using a solution having a higher concentration in order. 7) After gargle with water to prevent residual taste, perform the next taste test at intervals of 1 minute or more.

Ethical Review Board

This study was conducted with the approval of the Ethical Review Board (Nagoya women's university 'hitowo mochiita kennkyuuni kansuru iinnkai'). The approval number is 30-14.

Statistical Processing

The test results were confirmed to be normal distribution by F-test. Data that was normally distributed was compared with Student-t without correlation of parametric test. The data that was not normally distributed was compared without correlated Mann-Whitney test of the non-parametric test. In comparing the taste test and the olfactory test result performed on the same participant, with correlated Wilcoxon test of the non-parametric test.

Results

Participant's Body Composition and Blood Glucose Level and HbA1c Level

The results for males are shown in (Table 2), and the results for females are shown in (Table 3). In both male and female tables, the average was shown for every 40's to 80's. The average fasting blood glucose was within normal (<100 mg/dl) for all ages. For both males and females, the average HbA1c level increased with age. However, the body fat percentage was higher in females than in males at all age.

	Age	HbA1c	Blood glucose level mg/dl	Waist circumference cm	BMI kg/m/m	Body fat %
Male 40's (n=10)	45.5±3.2	5.6±0.2	87.6±9.1	84.8±10.0	25.7±3.8	23.7±6.0
Male 50's (n=24)	54.8±3.1	5.7±0.3	85.8±6.8	86.7±8.4	25.4±3.4	24.4±4.1
Male 60's (n=49)	64.8±3.3	6.0±0.8	98.3±23.6	86.5±7.5	24.6±3.1	24.7±4.2
Male 70's (n=40)	73.0±3.2	6.0±0.6	97.0±14.9	84.6±8.3	24.4±3.2	23.7±4.7
Male 80's (n=6)	84.8±3.8	6.3±0.6	89.3±10.7	87.4±7.0	25.1±2.5	24.3±5.5

Table 2: Average values of blood glucose level, HbA1c and body composition by age (Male n=129).

	Age	HbA1c	Blood glucose level mg/dl	Waist circumference cm	BMI kg/m/m	Body fat %
Female 40's (n=23)	45.2±2.6	5.5±0.3	80.7±9.3	76.7±8.1	22.8±4.1	33.2±6.7
Female 50's (n=40)	54.3±3.0	5.7±0.2	85.0±6.4	76.8±8.7	23.3±3.3	33.4±6.8
Female 70's (n=65)	64.5±2.8	5.8±0.4	88.4±8.9	77.7±8.1	23.5±3.5	33.9±5.7
Female 70's (n=37)	72.8±2.6	6.0±0.5	90.5±13.6	76.2±9.9	23.3±4.1	33.1±6.8
Female 80's (n=3)	82.0±2.0	6.0±0.1	86.3±11.7	78.1±12.3	22.9±5.8	31.1±12.9

Table 3: Average values of blood glucose level, HbA1c and body composition by age (Female n=168).

Simple Sweetness Threshold Test Result

(Table 4) shows the results of the simple sweetness threshold test. Male and female results are shown by age. Females require less consultation than males. The number of participants in the normal range was also found to be higher for females (66.1%) than males (54.55%).

	Normal	Observation	Consultation
Male 40's (n=10)	5	4	1
Male 50's (n=24)	13	9	2
Male 60's (n=49)	27	18	4
Male 70's (n=40)	24	13	3
Male 80's (n=6)	0	6	0
Female 40's (n=23)	15	6	2
Female 50's (n=40)	27	12	1
Female 70's (n=65)	43	21	1
Female 70's (n=37)	24	12	1
Female 80's (n=3)	2	1	0

Table 4: Sweetness test (Tastedisc) result (n=297).

Statistical Processing Results

Male blood glucose levels (Table 5), female blood glucose levels (Table 6), and male HbA1c level (Table 7), and female HbA1c level (Table 8) were statistically compared the participants sweetness threshold test results between normal range and others.

	40's		50's		60's	
	Normal	Observation or consultation	Normal	Observation or consultation	Normal	Observation or consultation
Blood glucose±Standard deviaton (mg/dl)	85.800±4.868	89.400±7.162	86.308±7.576	85.182±6.030	94.889±18.781	102.591±28.413
F test	P=0.208		P=0.227		P=0.026	
Unpaired student - t test	P=0.380		P=0.695		P=0.260	
Mann-Whitny test						
Normal= 0.3% and 2.5%, Observatio= 10% and 20%, Consultation = 80% and more than 80%						

Table 5: Statistical comparison of normal range in test results of weet taste (tastedisk) and bolld glucose level in need of observation or consultation by age of Male.

	40's		50's		60's		70's		80's		Total	
	Normal	Observat ion or consultat ion	Normal	Observa tion or consulta tion	Normal	Observa tion or consulta tion	Normal	Observat ion or consultat ion	Nor mal	Observa tion or consulta tion	Normal	Observat ion or consultat ion
Blood glucose±Stan dard deviaton (mg/dl)	79.400±7.998	83.250±1.560	85.556±6.034	83.923±7.088	87.721±8.393	89.783±9.742	90.583±1.4133	90.308±1.3237	-	-	86.622±9.951	87.983±1.0613
F test	P=0.147		P=0.276		P=0.224		P=0.415		-		P=0.296	
Unpaired student - t test	P=0.357		P=0.454		P=0.372		P=0.954		-		P=0.408	
Mann-Whitny test									-			
Normal= 0.3% and 2.5%, Observatio= 10% and 20%, Consultation = 80% and more than 80%												

Table 6: Statistical comparison of normal range in test results of weet taste (tastedisk) and bolld glucose level in need of observation or consultation by age of Female.

	40's		50's		60's		70's		80's		Total	
	Normal	Observat ion or consultat ion	Normal	Observat ion or consultat ion	Normal	Observat ion or consultat ion	Normal	Observat ion or consultat ion	Nor mal	Observat ion or consultat ion	Normal	Observat ion or consultat ion
Blood glucose±Stan dard deviaton (mg/dl)	5.560±0.182	5.640±0.230	5.623±0.228	5.773±0.380	5.863±0.527	6.086±0.956	5.813±0.406	6.244±0.799	-	-	5.778±0.429	6.050±0.771
F test	P=0.308		P=0.049*		P=0.003**		P=0.415		-		P=0.0001**	

Unpaired student - t test	P=0.559					
Mann-Whitny test		P=0.332	P=0.628	P=0.063	-	P=0.046*
Normal= 0.3% and 2.5%, Observatio= 10% and 20%, Consultation = 80% and more than 80%						

Table 7: Statistical comparison of normal range in test results of weet taste (tastedisk) and HbA1c in need of observation or consultation by age of Male.

	40's		50's		60's		70's		80's		Total	
	Normal	Observat ion or consultat ion	Normal	Observat ion or consultat ion	Normal	Observat ion or consultat ion	Normal	Observat ion or consultat ion	Normal	Observat ion or consultat ion	Normal	Observat ion or consultat ion
Blood glucose±Standard deviaton (mg/dl)	5.533±0.255	5.475±0.260	5.648±0.170	5.662±0.189	5.728±0.433	5.857±0.307	6.013±0.531	6.000±0.523	-	-	5.748±0.413	5.797±0.376
F test	P=0.501		P=0.346		P=0.040**		P=0.494				P=0.0001**	
Unpaired student - t test	P=0.610		P=0.823				P=0.946					
Mann-Whitny test					0.165						P=0.485	
Normal= 0.3% and 2.5%, Observatio= 10% and 20%, Consultation = 80% and more than 80%												

Table 8: Statistical comparison of normal range in test results of weet taste (tastedisk) and HbA1c in need of observation or consultation by age of Female.

The simple sweetness threshold test results in the normal range of the fasting blood glucose level (less than 100 mg/dl) and above were statistically compared (Table 9). The results were not statistically significant. The simple sweetness threshold test results in the normal range of the HbA1c level (less than 5.6 mg/dl) and above were statistically compared (Table 10). The results were not statistically significant. The simple sweetness threshold test results in the normal range of the body mass index (BMI) (less than 25 kg/m/m) and above were statistically compared (Table 11). The results were not statistically significant.

The simple sweetness threshold test results in the normal range of the body fat percentage (less than 25 %) and above were statistically compared (Table 12). The results were statistically significant. It became clear that the higher the body fat percentage, the higher the result of the simple sweetness threshold test (P<0.046*).

The simple sweetness threshold test results in the normal range of the waist circumference in male (less than 85 cm) and above were statistically compared (Table 13). The results were not statistically significant. The simple sweetness threshold test results in the normal range of the waist circumference in female (less than 90 cm) and above were statistically compared (Table 14). The results were not statistically significant.

	Blood glucose level (mg/dl)		Sweetness test result (Normal=1, Observation = 2, Consultation =3)	
	Less than 100 (n=82)	100 or more (n=215)	Blood glucose level Less than 100	Blood glucose level Less 100 or more
Blood glucose±Standard deviaton (mg/dl)	85.642±6.677	111.261±30.305	1.427±0.584	1.545±10.627
F test	P=0.0001**		P=0.290	
Unpaired student - t test			P=0.220	
Mann-Whitny test	P=0.0001**			

Table 9: Results of statistical comparison of sweetness test results between fasting blood glucose level less than 100 (Normal value) and 100 or more.

	HbA1c (%)		Sweetness test result (Normal=1, Observation = 2, Consultation =3)	
	Less than 5.6 (n=253)	5.6 or more (n=44)	HbA1c Less than 5.6	HbA1c 5.6 or more
Blood glucose±Standard deviation (mg/dl)	5.394±0.191	5.936±0.761	1.488±0.653	1.428±0.566
F test	P=0.0001**		P=0.055	
Unpaired student - t test			P=0.436	
Mann-Whitny test	P=0.0001**			

Table 10: Results of statistical comparison of sweetness test results between fasting HbA1c level less than 5.6 (Normal value) and 5.6 or more.

	BMI (kg/m/m/)		Sweetness test result (Normal=1, Observation = 2, Consultation =3)	
	Less than 25.0 (n=182)	25.0 or more (n=115)	BMI Less than 25.0	BMI 25.0 or more
Blood glucose±Standard deviation (mg/dl)	21.689±2.038	27..548±2.143	1.412±0.586	1.496±0.598
F test	P=0.279		P=0.409	
Unpaired student - t test	P=0.0001**		P=0.236	
Mann-Whitny test				

Table 11: Results of statistical comparison of sweetness test results between fasting BMI level less than 25.0 (Normal value) and 25.0 or more.

	Body fat (%)		Sweetness test result (Normal=1, Observation = 2, Consultation =3)	
	Less than 25.0 (n=214)	25.0 or more (n=83)	Body fat Less than 25.0	Body fat 25.00 or more
Blood glucose±Standard deviation (mg/dl)	20.889±3.036	32.497±6.312	1.402±0.563	1.554±0.649
F test	P=0.0001**		P=0.068	
Unpaired student - t test			P=0.046*	
Mann-Whitny test	P=0.0001**			

Table 12: Results of statistical comparison of sweetness test results between fasting body fat level less than 25.0 (Normal value) and 25.0 or more.

	Waist circumference (%)		Sweetness test result (Normal=1, Observation = 2, Consultation =3)	
	Less than 85.0 (n=56)	85.0 or more (n=73)	Waist circumference Less than 85.0	Waist circumference 85.0 or more
Blood glucose±Standard deviation (mg/dl)	78.327±4.478	91.003±4.721	1.571±0.657	1.521±0.626
F test	P=0.334		P=0.348	
Unpaired student - t test			P=0.682	
Mann-Whitny test	P=0.0001**			

Table 13: Results of statistical comparison of sweetness test results between fasting Waist Circumference level less than 85.0 (Normal value) and 85.0 or more in Male.

	Waist circumference (%)		Sweetness test result (Normal=1, Observation = 2, Consultation =3)	
	Less than 90.0 (n=156)	90.0 or more (n=12)	Waist circumference Less than 90.0	Waist circumference 90.0 or more
Blood glucose±Standard deviation (mg/dl)	75.729±7.477	93.733±4.338	1.365±0.546	1.417±0.515
F test	P=0.019*		P=0.442	
Unpaired student - t test			P=0.753	
Mann-Whitny test	P=0.0001**			

Table 14: Results of statistical comparison of sweetness test results between fasting Waist Circumference level less than 90.0 (Normal value) and 90.0 or more in Female.

Discussion

In the present results, there was no statistically significant difference between the blood glucose level or HbA1c level and the simple wetness threshold test result. The simple sweetness threshold test kit used this time uses purified sucrose. The ingredients are 97.80% sucrose (a carbohydrate with one molecule of glucose and fructose combined), 1.30% reducing sugar, 0.02% ash, and 0.80% moisture. In diabetes, the change I sweet taste sensitivity varies depending on the disease state, medical history, age, and the like. It has been reported that the taste threshold and intensity were not significantly different from those of healthy subjects, but there are many reports that they decreased. Further, there is a report that the threshold value of fructose dose not change in a sweet solution which is frequently changed, and only the threshold value for glucose increases [1, 2]. Initial experiences with tastes have an important impact on the later acceptance and enjoyment of food [3]. Children are most at risk for over-consuming sugar [4-6] Declination in sugar preference during adolescence could be associated with the cessation of growth [7]. Hormonal changes, especially in the secretion of insulin and leptin- both of which decrease sweet taste preference [8, 9]. The knowledge of taste preference changes during life is used by tobacco or cigarettes [10]. The sweet preference of pregnant women was significantly lower than that of non-pregnant women [11, 12]. Similar phenomenon occurs in postmenopausal women [13]. Changes in sweet sensitivity due to stressful lifestyles such as modern society [14] and changes in sweet sensitivity due to aging change [15] need to be further studied in the future.

If the test solution is made of glucose alone, the results may differ. Participants with a high percentage of body fat in the present results had a statistically significantly higher result of the simple sweetness threshold test. In order to prevent the transition to diabetes in the future, it is thought that introducing the simple sweetness threshold test kit used in this study to a health examination and alerting the subject will help prevent metabolic syndrome.

Conclusions

This time, we obtained the sweetness threshold test result by using the simple sweetness threshold test kit at the Yakumom –town resident’s check-up in Hokkaido. Based on the results, blood glucose, HbA1c, BMI, abdominal circumference, and body fat percentage were compared. As a result, there was no significant difference in the statistical comparison between the results of the simple sweetness threshold test in the normal range of blood glucose, HbA1c, BMI, and abdominal circumference and those outside the normal range. However, in the body fat percentage, there was a statistically significant difference in the results of the simple sweetness threshold test between the normal range and the other. We think that the introduction of the simple sweetness threshold test kit used at the time of health check-up will help prevent metabolic syndrome in the future. If a participant with a high body fat percentage and a simple sweetness threshold test value is high, a cautionary recommendation for improving dietary habits will be made, and it may be possible to prevent transition or diabetes or dyslipidemia. It is difficult to give a blood test every time a nutritional instruction is given before giving nutritional guidance. Based on the results obtained using the simple sweetness threshold test kit used in this study, it was suggested that early detection and early treatment of diabetes and dyslipidemia could be possible. In the future, we would like to continue studying with more participants.

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