

## Effect of Hot Spring Water Drinking on Glucose Metabolism

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### 温泉水の飲泉が糖代謝に与える影響

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#### 抄 録

〔目的〕 硫黄泉やナトリウム炭酸水素塩泉の飲泉適応症に糖尿病が上げられているが詳細な検討はされていない。今回、温泉水飲泉の糖代謝に与える影響を知る目的で、硫黄泉と単純泉において検討した。

〔対象・温泉水〕 検討した温泉水は川湯温泉水（酸性・含硫黄・鉄（II）-ナトリウム・アルミニウム-硫酸塩・塩化物泉（硫化水素型）、pH1.98）とあすかの湯（アルカリ性単純泉、pH8.9）である。前者は2型糖尿病患者8名と健常人3名、後者は2型糖尿病患者6名について検討した。

〔方法〕 一回の飲泉効果を知る目的で、一週間の間隔をあけて5倍に希釈した川湯温泉水200ml、あるいは水道水を飲用後に経

口糖負荷試験（OGTT）を行った。次に長期飲泉効果を見る目的で糖尿病患者を対象に毎日二回、川湯温泉水は4週間、あすかの湯は一週間飲泉を継続して血糖値のコントロール状態を検討した。

〔結果〕 川湯温泉水飲用後のOGTTでは水道水飲用後に比して血糖値の上昇が有意に抑えられた（ $p<0.05$ ）。また、飲泉の長期効果として川湯温泉水ではHbA<sub>1c</sub>値の低下（ $p<0.05$ ）、あすかの湯では1.5-アンヒドロ-D-グルシトール（1.5AG）値の改善が認められた（NS）。

〔考察〕 これらの温泉水の飲泉により糖尿病患者の血糖値改善効果が期待され、特に禁忌症のない患者では試みてよい治療法と考えられる。

Key words : drinking treatment, diabetes mellitus, hot spring water, GTT

## I INTRODUCTION

Balneotherapy (spa treatment) is characterized by a natural complex therapy comprising not only hot spring water bathing but also various kinds of in- and out-door exercises and proper diet therapy. One of the main indications of balneotherapy is type 2 diabetes mellitus without severe complications<sup>1)</sup>. In the areas of hot springs and health resorts, spring water drinking is traditionally practiced to control blood sugar levels and glucose lowering effect was reported<sup>2,3)</sup>. However, no investigation concerning influence on oral glucose tolerance test (OGTT) has been made. In the present study, effect of pre-drinking of spring water on the values of OGTT (short term study) is examined and also one- or four-week drinking treatment (long term study) is performed in diabetic patients.

## II METHODS

### 1 Short term effect

After informed consent was obtained from each subject, 11 volunteers (8 type 2 diabetic patients and 3 healthy subjects, 4 men, 7 women, 65.6±4.7 (mean±SEM) years old) participated in the OGTT. Two hundred *mℓ* of tap water or five times diluted spring water from Kawayu Onsen (K-O, acid alum vitriol hydrogen-sulfide springs, pH1.98, 55.0 °C) was used for OGTT, which was performed after drinking tap water or K-O spring water over 30 min at a week interval. Blood samples were collected to determine plasma glucose and serum insulin levels before drinking tap water or spring water, just before taking a test drink (Trelan-G75®), 30, 60, 90, 120 min thereafter.

### 2 Long term effect

Seven out of eight diabetic patients drank K-O spring water (200 *mℓ*, 5 times diluted) twice daily for 4 weeks. Then the levels of HbA<sub>1c</sub> (normal value ≤5.8) and HOMA-R (homeostasis model assessment: IRI (μU/*mℓ*) × FPG (mg/*dℓ*) / 405, normal value ≤2) were examined. In addition, another 6 diabetic patients (2 men, 4 women, 66.7±4.3 years old) drank spring water (200*mℓ*) from Asuka-no-yu (A-Y, alkaline simple thermals, pH8.9) twice daily for a week, then the levels of 1.5-Anhydro-D-glucitol (1.5AG, normal value ≥14) were measured. The patients' diets, exercise routines and treatment were stable during these study periods.

## III RESULTS

### 1 Short term effect

Increments in plasma glucose levels were significantly lower with pre-drinking of K-O spring water than those with tap water drinking (Fig.1, *p*<0.05). Serum IRI levels tended to be higher with spring water drinking at earlier phases (30 min, 60 min) of OGTT than those with pre-drinking of tap water (Fig.2, Table 1).

### 2 Long term effect

Hemoglobin A<sub>1c</sub> levels significantly decreased from 7.1±1.0% to 6.8±1.0% by daily drinking of K-O spring water (Table 2, *p*<0.05). HOMA-R levels were obtained from 6 patients and these values decreased in 4 patients and the other 2 showed increases which were

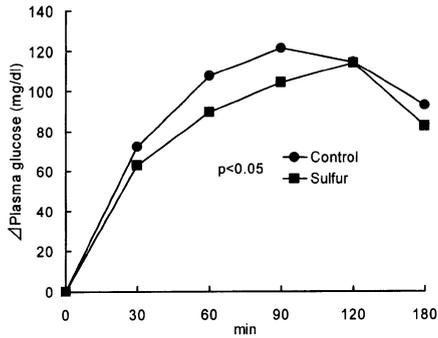


Fig.1 Changes in plasma glucose levels.

Oral glucose tolerance test was performed after drinking tap water (200 mL, Control) or spring water (200 mL, 5 times diluted, Sulfur) at a week interval. Mean values are shown. (n=11)

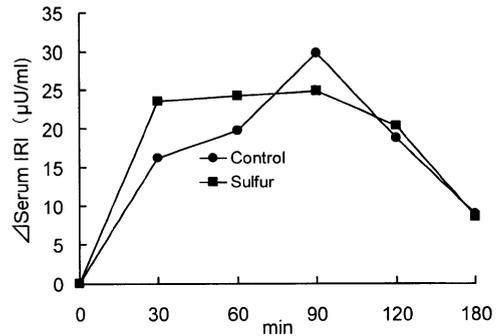


Fig.2 Changes in serum immunoreactive insulin (IRI) levels.

Oral glucose tolerance test was performed after drinking tap water (Control) or spring water (Sulfur) at a week interval. Mean values are shown. (n=11)

Table 1 Increments in IRI (immunoreactive insulin) levels at 30 and 60 min from Fig.2

	30 min	60 min
Tap water	16.3±5.0	19.8±4.4
Sulfur spring water	23.5±8.2	24.3±7.6

(mean±SEM, n=8, NS)

Table 2 HOMA-R (Homeostasis model assessment) and HbA<sub>1c</sub> (hemoglobin A<sub>1c</sub>) levels before and after 4-month drinking of sulfur spring water

No.	Before		After	
	HOMA-R	HbA <sub>1c</sub>	HOMA-R	HbA <sub>1c</sub>
1	0.4	11.8	0.9	11.5
2	2.2	10.2	2.1	9.5
3	2.5	5.6	1.9	5.5
4	1.0	5.2	0.7	5.1
5	1.4	6	1.5	5.9
6	1.4	5.2	0.7	4.9
7	-	5.4	-	5.4
mean±SEM	1.5±0.3	7.1±1.0	1.3±0.3	6.8±1.0*

\* p<0.05 vs. Before

within the normal ranges (Table 2, NS). By drinking A-Y spring water for a week, 1.5AG levels increased in 4 out of 6 patients (data not shown). The overall values rose from 6.1±1.0 to 7.0±1.8 μg/dL (NS).

#### IV DISCUSSION

In Japan, drinking treatment is traditionally performed at hot spring areas though it is not a medically approved therapy. Characteristics of hot spring water applicable to drinking treatment of diabetes mellitus are bicarbonate springs, sulfated springs and sulfur springs<sup>4</sup>. The mechanisms of glucose lowering effects of those springs have not been clarified, yet. In the present study, pre-drinking of sulfur spring water is supposed to have a potential of enhancing the insulin response to glucose loading at the earlier phase of OGTT (30, 60 min). In normal subjects, the peak of insulin secretion in OGTT is observed at 30 min. Therefore, increased early phase response by drinking sulfur spring water is profoundly helpful to glucose metabolism.

In the long term experiments, HbA<sub>1c</sub> levels decreased. Although diabetic control got

better, glucose and insulin responses in OGTT did not show any changes (data not shown); however, insulin responses in OGTT were blunted at 90 and 120 min (NS). Probably, the mechanisms of glucose lowering effects of drinking sulfur spring water are different between long and short term treatment. Taking the fact that tendencies of decreased insulin secretion and HOMA-R values into consideration, it is suggested that insulin resistance is reduced by long term drinking of sulfur spring water. On the other hand, even the drinking of alkaline simple thermals had a tendency of improving glucose metabolism. This is the first report that shows the effectiveness of simple thermals for glucose metabolism. Since the number of participants were very low, additional studies will be needed.

## V CONCLUSION

Drinking of sulfur spring water from Kawayu Onsen and alkaline simple thermals from Asuka-no-yu are thought to be beneficial for the diabetic patients.

### References

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## Summary

Drinking of hot spring water containing sulfur or sodium bicarbonate is reported to be beneficial for diabetic patients. In the present study, sulfur spring water and water from simple thermals were chosen to examine their effects on glucose metabolism. Eleven volunteers including eight type 2 diabetic patients and three healthy subjects drank hot spring water from Kawayu Onsen (K-O, acid alum vitriol hydrogen-sulfide springs, pH1.98), and another six patients from Asuka-no-yu (A-Y, alkaline simple thermals, pH8.9). Oral glucose tolerance test (OGTT) was performed after drinking tap water (200 mL) or K-O spring water (5 times diluted) at a week interval (short term effect). Increments in plasma glucose levels were significantly lower ( $p < 0.05$ ) with pre-drinking of spring water than those with pre-drinking of tap water. To know the long term effect of drinking, patients drank K-O water twice daily for 4 weeks or A-Y water twice daily for a week. Hemoglobin A<sub>1c</sub> levels decreased significantly ( $p < 0.05$ ) by drinking K-O water and the levels of 1.5-Anhydro-D-glucitol increased by A-Y water (NS). From these findings, it is suggested that drinking hot spring water from K-O and A-Y is beneficial for diabetic patients if they have no contraindications for drinking these kinds of spring water.