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Shinrin-yoku (forest-air bathing and walking) effectively decreases blood glucose levels in diabetic patients

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Abstract The influence of "shinrin-yoku" (forest-air bathing and walking) on blood glucose levels in diabetic patients was examined. Eighty-seven (29 male and 58 female) non-insulin-dependent diabetic patients [61 (SEM 1) years old] participated in the present study. Shinrin-yoku was performed nine times over a period of 6 years. The patients were divided into two parties. They then walked in the forest for 3 km or 6 km according to their physical ability and/or the existence of diabetic complications. The mean blood glucose level after forest walking changed from 179 (SEM 4) mg · 100 ml^{-1} to 108 (SEM 2) mg · 100 ml^{-1} (P<0.0001). The level of glycated haemoglobin A_{1c} also decreased from 6.9 (SEM 0.2)% (before the first shinrin-yoku) to 6.5 (SEM 0.1)% (after the last shinrin-yoku; P<0.05). Blood glucose values declined by 74 (SEM 9) mg · 100 ml^{-1} and 70 (SEM 4) mg · 100 ml^{-1} after short- and long-distance walking respectively. There was no significant difference between these values. Since the forest environment causes changes in hormonal secretion and autonomic nervous functions, it is presumed that, in addition to the increased calorie consumption and improved insulin sensitivity, walking in a forest environment has other beneficial effects in decreasing blood glucose levels.

Key words Forest environment · Shinrin-yoku · Diabetes mellitus · Exercise therapy

Introduction

In Japan, recreation and relaxation in a forest environment is called "shinrin-yoku" (forest-air bathing and walking). It is a kind of climatherapy and aromatherapy. Walking in a forest, breathing the volatile components emitted from the forest, is very pleasant and refreshing. Volatile compounds have been reported to have various biological effects and to cause changes in physiological function. For instance, blood pressure decreases, saliva secretion increases, salivary cortisol concentration tends to decrease and autonomic nervous activity becomes well-balanced after shinrin-yoku (Miyazaki and Motohashi 1996). Therefore, blood glucose levels would be expected to change as a result of performing shinrin-yoku.

Exercise therapy is essential and fundamental to the treatment of diabetes mellitus. Strenuous exercise such as running is very harmful to patients, especially when they have severe diabetic complications. However, walking is a relatively light exercise and effectively reduces the blood glucose level in patients (Klachko et al. 1972). It is difficult to continue exercise every day. We therefore recommend diabetic patients to walk about 10,000 steps a day if they are free from any complications since walking exercise can be continued with relatively little effort. In the present study, we investigated blood glucose levels before and after each shinrin-yoku to determine whether shinrin-yoku was beneficial for diabetic patients.

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Methods

Eighty-seven (29 male and 58 female) non-insulin-dependent diabetic patients, whose average age, height and body mass were respectively 61 (SEM 1) years, 155.4 (SEM 1.0) cm and 57.2 (SEM 1.0) kg, volunteered for the present study. The patients were divided into two parties, they then walked in the forest for about 3 km (a short distance) or 6 km (a long distance) according to their physical ability and/or the existence of diabetic complications. There were seven patients who changed their walking distance from the long to the short course during the present study. After breakfast, at 0830 hours, they came to the hospital. A sample of peripheral venous blood was taken for glucose determination and the patients then departed for the destination by bus. Prior to forest walking, preparatory exercise such as muscle stretching was performed for about 10 min. During shinrin-yoku, in order not to be exhausted, they were instructed to walk at their own pace and to check their pulse so that it did not exceed 110–120 beats · min^{-1}. A second blood sample was collected after completion of the

Table 1 Meteorological conditions during the performance of shinrin-yoku

	1	2	3	4	5	6	7	8	9
Month	May	Sept.	May	Oct.	May	Oct.	May	May	Oct.
Weather	Fine	Fine	Cloudy	Cloudy	Fine	Cloudy	Fine	Cloudy	Fine
Temperature (°C)	23	22	12	16	13	11	19	15	11
Altitude (m)	10	40	10	30	300	350	10	40	300

Table 2 Blood glucose levels (mg · 100 ml^{-1}, mean±SEM) before and after shinrin-yoku

	1	2	3	4	5	6	7	8	9	Mean
Before	179±12	182±13	185±10	201±13	173±10	170±8	170±13	200±13	159±13	179±4
After	112±8*	108±6*	114±7*	113±8*	126±8*	109±7*	94±6*	105±10*	89±5*	108±2*
Participants	24	27	29	20	27	31	26	25	28	Total 237

*P<0.0001

walk, before lunchtime. A total of 50 samples from healthy participants (medical staff) could also be obtained in the same manner. The level of glycated haemoglobin A_{1c} (HbA_{1c}) in the blood is representative of the mean blood glucose level in the previous 4–8 weeks. To assess the background level of diabetes mellitus, the levels of HbA_{1c} were obtained from 82 patients before the first trial of shinrin-yoku and after the last trial, with an interval of at least 1 month between measurements. Blood pressure was measured before the first and the second venous blood collection while the patient was seated. In total, shinrin-yoku was performed nine times over a period of 6 years and the total number of participants was 237. The number of occasions each subject participated ranged from one to nine. The detailed meteorological conditions for each session of shinrin-yoku are summarized in Table 1. The Ethics Committee of Hokkaido University School of Medicine approved this experiment and informed consent was obtained from all subjects.

Results

The short-distance walk consisted of about 5,000 steps and took about 30 min to complete; the long distance walk (about 10,000 steps) took about 60 min. During shinrin-yoku, no one complained of hypoglycaemic symptoms or a feeling of sickness. Blood glucose levels decreased significantly after shinrin-yoku on all nine occasions (Table 2). Blood glucose levels declined by 74 (SEM 9) mg · 100 ml^{-1} and 70 (SEM 4) mg · 100 ml^{-1} after short- and long-distance walking respectively. There was no significant difference between these values (Table 3). Levels of HbA_{1c} also decreased from 6.9 (SEM 0.2)% (before the first shinrin-yoku) to 6.5 (SEM 0.1)% (after the last shinrin-yoku; P<0.05). In normal subjects, the level of blood glucose decreased from 89 (SEM 3) mg · 100 ml^{-1} to 82 (SEM 2 mg · 100 ml^{-1}; P<0.05) after shinrin-yoku. The maximum blood pressure decreased from 147 (SEM 3) mmHg to 140 (SEM 3) mmHg after shinrin-yoku (P<0.05) and the pulse rate remained around 90 beats · min^{-1} in almost all subjects.

Table 3 Blood glucose levels (mg · 100 ml^{-1}, mean±SEM) before and after shinrin-yoku at different walking distance. There was no significant difference between the changes in glucose level resulting from the two walking distances

	Short distance (3 km)	Long distance (6 km)	
Before	190±8	175±4	
After	116±5	104±3	
Difference	74±9	70±4	
% Decrease	38.9	40.0	Mean 39.7
Participants	68	169	Total 237

Discussion

The decreased levels of blood glucose after shinrin-yoku suggest that walking in a forest is beneficial for diabetic patients. The subjects walked at a pace of 80–90 m · min^{-1} and kept their pulse rate lower than 110–120 beats · min^{-1}, which corresponded to a workload of 40–50% VO_{2max}. They were presumed to consume 150–200 kcal by short-distance walking and 300–350 kcal by long-distance walking. There are several reports concerning the effects of exercise on blood glucose levels in diabetic patients. The level of blood glucose has been reported to decline by 13 mg · 100 ml^{-1} in diabetic patients after 30 min exercise on a cycle ergometer at an intensity of 75% VO_{2max} (Schneider et al. 1987). Paternostro-Bayles et al. (1989) reported that after 40 min exercise on a cycle ergometer at 40–50% VO_{2max}, a fall in blood glucose level of 16.5 mg · 100 ml^{-1} was observed. A decrease of 40 mg · 100 ml^{-1} was obtained after 3 h exercise on a cycle ergometer at 40% VO_{2max} (Koivisto et al. 1984). After a half-mile walk at 4 m.p.h. on a 2.5° treadmill slope, the glucose level decreased by 24.5 mg · 100 ml^{-1} (Klachko et al. 1972). Furthermore, the effect of underwater exercise for 30 min in a pool filled with hot (38° C) spring water on blood glucose levels has been investigated in patients (Ide et al. 1984). In this case, they were presumed to consume 200–250 kcal and the blood glucose value de-

creased by 21.2% (48.6 mg · 100 ml^{-1}). In the present study, after shinrin-yoku the blood glucose level decreased by 39.7% (71 mg · 100 ml^{-1}) in the patients and no difference was observed between short- and long-distance walking. In addition, in normal subjects blood glucose levels were within the normal range and far less decrement (7.9%, 7 mg · 100 ml^{-1}) was observed after shinrin-yoku. These facts indicate that, in addition to the effects of walking, the forest environment has other beneficial effects in reducing blood glucose levels in diabetic patients. In the forest environment, volatile and non-volatile compounds called phytoncides are emitted by plants. These phytoncides influence other species. For instance, it has been reported that inhalation of Taiwan Hinoki wood oil decreased blood pressure and stabilized autonomic nervous activity and that after shinrin-yoku, salivary cortisol concentration tended to decrease (Miyazaki and Motohashi 1996). Although Taiwan Hinoki did not exist in the areas where we walked in this study, the same kinds of odoriferous substances were present. Indeed, the maximum blood pressure significantly decreased after shinrin-yoku. In addition to the energy consumption caused by walking itself, the so-called phytoncides are thought to be related to the decreased blood glucose levels.

Numerous negative ions are found in the air of mountains, forests and hot springs and these ions give us a feeling of refreshment (Hawkins and Baker 1978). Exposure to negative ions enhances parasympathetic nervous activity and decreases blood glucose levels (Tom et al. 1981). It is assumed that the large number of negative ions in a forest environment is another cause of the decrement in blood glucose levels.

In daily outpatient clinics, increases in the levels of HbA_{1c} and blood glucose, brought about mainly by poor dietary and/or exercise treatment, are often observed. Decreased HbA_{1c} values in patients imply that treatment for diabetes mellitus is achieving success. It is possible that shinrin-yoku could contribute to the continuation of a program of exercise.

In conclusion, shinrin-yoku (forest-air bathing and walking) is useful in the treatment of diabetes mellitus.

References

Hawkins LH, Baker T (1978) Air ions and human performance. Ergonomics 21:273–278

Ide H, Sakai H, Asanuma Y, Agishi Y (1984) Balneotherapy in diabetics (Japanese with English abstract). J Jpn Assoc Phys Med Balneol Climatol 47:84–91

Klachko DM, Lie TH, Cunningham EJ, Chase GR, Burns TW (1972) Blood glucose levels during walking in normal and diabetic subjects. Diabetes 21:89–100

Koivisto VA, DeFronzo RA (1984) Exercise in the treatment of type II diabetes. Acta Endocrinol [Suppl] 206:107–111

Miyazaki Y, Motohashi Y (1996) Forest environment and physiological response. In: Agishi Y, Ohtsuka Y (eds) New frontiers in health resort medicine. Kokoku, Sapporo, pp 67–77

Paternostro-Bayles M, Wing RR, Robertson RJ (1989) Effect of life-style activity of varying duration on glycemic control in type II diabetic women. Diabetes Care 12:34–37

Schneider SH, Khachadurian AK, Amorosa LF, Gravras H, Fineberg SE, Ruderman NB (1987) Abnormal glucoregulation during exercise in type II (non-insulin-dependent) diabetes. Metabolism 36:1161–1166

Tom G, Poole MF; Galla J, Berrier J (1981) The influence of negative air ions on human performance and mood. Hum Factors 23:633–636