Significance of "Shinrin-yoku (forest-air bathing and walking)" as an Exercise Therapy for Elderly Patients with Diabetes Mellitus

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高齢糖尿病患者における運動療法としての森林浴の意義

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抄　録

60歳～83歳のインスリン非依存性糖尿病患者48名（男性16名，女性32名，平均年齢66.8歳）を対象に，糖尿病教室の一環として6年間に9回の森林浴を行い，血糖値に与える影響を検討した。参加者は合併症の程度や体力に応じて，3－4kmと7－8kmの2コースに分かれて歩行し，のべ参加人数は116例に達した。歩行中低血糖症状や身体の不調を訴えた者はいなかった。森林浴後血圧は低下傾向を示し，歩行中の最大心拍数はほぼ全例で1分間90拍前後であった。血糖値は各々の森林浴前後で有意に低下し，9回の平均では186±6 mg/dlから109±4 mg/dlへと41.4%の低下を示した（mean±SEM, $p<0.00001$）。また短距離歩行群では79±10mg/dl，長距離歩行群では76±7 mg/dlの血糖値低下が歩行後認められたが，両者の低下率に差はなかった。運動療法は糖尿病治療の基本であるが，特に高齢者には心肺系に負担のかかりにくい運動が望ましく，森林内を歩行する森林浴は精神的なリフレッシュ作用もあり，高齢者糖尿病の運動療法に適しているものと思われる。

Key words : Forest, Shinrin-yoku, Diabetes Mellitus, Exercise, Elderly patient

INTRODUCTION

Exercise therapy is essential and fundamental to the treatment of diabetes mellitus. Since cardiopulmonary dysfunction is often observed in the aged people, especially when they suffer from diabetic complications, exercise therapy should be applied carefully. Walking is a relatively light exercise and effectively reduces the blood glucose levels in the patients[1]. It is difficult to continue exercise every day, therefore, we 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 a relatively little effort.

Walking in a forest environment and breathing the forest-air is called "shinrin-yoku", which is very pleasant and refreshing. Volatile components emitted from the forest were reported to have various biological activities and cause changes in physiological functions. It is reported that blood pressure decreases, saliva secretion increases, salivary cortisol concentration tends to decrease and autonomic nervous activity becomes well balanced after shinrin-yoku[2]. Therefore, shinrin-yoku is expected to have some effects on the blood glucose levels.

In the present study, we performed shinrin-yoku for the elderly diabetic patients and investigated the changes of blood glucose levels to know if shinrin-yoku was useful for those patients.

SUBJECTS AND METHODS

Forty-eight (16 male and 32 female) non-insulin dependent diabetic patients whose mean age was 66.8 years (range, 60-83), height and body mass index were 154.0±1.3 (mean±SEM) cm and 23.6±0.4 kg/m^2, volunteered for the present study. Among them, eleven patients experienced only dietary and exercise therapy, twenty-seven were medicated orally and ten by insulin administration. After taking breakfast, they came to the hospital at 0830h in the morning. They were taken peripheral venous blood for glucose determination and then departed for the destination that was about 45 min away by bus. Prior to the forest walking, preparatory exercise such as stretching themselves was performed for about 10 min. The patients were divided into two parties, then walked in the forest about 3-4 (short distance) or 6-7 (long distance) km according to their physical ability and / or the existence of diabetic complications. In both cases, about 10 min rest was given in the middle of the walking course. The second blood samples were collected after completion of the walking before lunchtime. During walking, no one complained of hypoglycemic symptoms nor feeling of sickness. Shinrin-yoku had been performed for 9 times over 6 years and overall number of the participants came up to 116. The number of participation of each subject ranged from 1 to 8 (mean, 2.4). The Ethics Committee of the Hokkaido University School of Medicine approved this experiment and informed consent was obtained from all subjects. Student's t-test was used for statistical analysis. A probability level of 0.05 or smaller was used to indicate statistical significance. Results are expressed as means±SEM.

RESULTS

It took about 5,000 and 10,000 steps, 30 and 60 min, in a short and a long distance walking, respectively (data not shown). Blood glucose levels significantly decreased after shinrin-yoku from 186±6 to 109±4 mg/dl ($p<0.00001$, Table 1). Blood glucose levels declined from 193±9 to 114±7 and from 181±8 to 106±5 mg/dl after short and long distance walking, respectively, and there was no significant difference between them (Table 2). No difference in HbAIC values between short and long distance walking was found either (Table 2).

DISCUSSION

Improvement of blood glucose levels was obtained in diabetic patients by balneotherapy, which was consisted of exercise in the pool, walking indoors and outdoors with a conventional therapy[3]. Among them, walking for at least 10,000 steps a day is strongly recommended to the patients without severe diabetic complications. We performed shinrin-yoku twice a year as a part of educational programs for diabetic patients. In the forests, they were instructed to keep their own walking paces not to be tired out. Blood pressure obtained from 31 patients tended to decrease from 147±6 / 82±3 to 138±6 / 81±3 (systolic / diastolic blood pressure, mmHg) after walking. Pulse rates in almost

Table 1 Blood glucose levels (mg/dl, mean±SEM) before and after shinrin-yoku

	1	2	3	4	5	6	7	8	9	mean
Before	173±15	187±20	202±17	205±21	176±13	175±11	183±20	222±24	168±18	186±6
After	113±10	107±8	110±9	112±13	118±12	120±11	98±10	124±22	86±8	109±4
P value	<0.0001	<0.005	<0.0001	<0.001	<0.005	<0.005	<0.005	<0.005	<0.0001	<0.00001

Before, blood glucose levels before walking; After, blood glucose levels after walking; P value, Before vs. After

Table 2 Blood glucose levels (mg/dl, mean±SEM) before and after shinrin-yoku at different walking distance

	Short distance (3-4 km)	Long distance (6-7 km)	Significance Short vs. Long
Before	193±9	181±8	n.s.
After	114±7*	106±5*	n.s.
Difference	79±10	76±7	n.s.
Initial HbAIC (%)	7.5±0.3	6.5±0.4	n.s.

Before, blood glucose levels before walking; After, blood glucose levels after walking; Difference, difference between Before and After; n.s., not significant; * $p<0.00001$ Before vs. After

all subjects were around 90 beats / min at most, which were correspondent to 40 % maximum oxygen uptake ($\dot{V}O_{2max}$). Therefore, shinrin-yoku is not thought to give a great load on cardiopulmonary system.

Decreased levels of blood glucose after shinrin-yoku suggest that walking in a forest is beneficial for diabetic patients. Since the subjects walked at a pace of 80-90 m/min for about 30-60 min, they were supposed to consume 150-200 kcal by a short distance walking and 300-350 Kcal by a long distance walking, respectively. It is very interesting that there was no significant difference in the amount of blood glucose decrement between short and long distance walking. Considering that no significant difference in control status between short and long distance walking was observed, 3-4 km shinrin-yoku is thought to be enough for diabetic patients as an exercise therapy.

The level of blood glucose was reported to decline by 13 mg/dl in diabetic patients afte 30 min exercise with a cycle ergometer at the intensity of 75 % $\dot{V}O_{2max}$[4]. Paternostro-Bayles et al.[5] reported that after 40 min exercise with a cycle ergometer at 40-50 % $\dot{V}O_{2max}$, 16.5 mg/dl fall in blood glucose level was observed. About 40 mg/dl decrease was obtaind by 3h exercise with a cycle ergometer at 40 % $\dot{V}O_{2max}$[6]. Furthermore, the effect of thirty-minute underwater exercise in a pool filled with hot spring water (38℃) on the blood glucose levels was investigated in the patients[7]. In this case, they were presumed to consume 200-250 kcal and the blood glucose value decreased by 21.2 % (48.6mg/dl), while no changes were observed in the same patients when they did not perform underwater exercise. In the present study, after shinrin-yoku, the blood glucose levels decreased by 39.7 % (71mg/dl), and this decrement was far greater than the values mentioned above. These facts indicate that not only walking itself but forest environment has some beneficial effects on falls in the blood glucose levels in diabetic patients. In forest environment, there are volatile and non-volatile compounds called phytoncide, which are emitted by plants and have much influence on the other lives. For instance, it was reported that inhalation of Taiwan Hinoki wood oil was able to decrease blood pressure and stabilize autonomic nervous activity, and that after shinrin-yoku, salivary cortisol concentration tended to decrease[2]. Though Taiwan Hinoki did not exist in the areas we walked, same kinds of odoriferous substances were presumably present there. In addition to energy consumption by walking itself, so-called phytoncide is thought to be related to the decreased blood glucose levels.

Numerous negative air ions are found in mountains, forests and hot spring areas and these ions give us feeling of refreshment[8]. By exposure to negative air ions, parasympathetic nervous activity is enhanced and blood glucose levels decreased[9]. It is assumed that large amount of negative air ions in a forest environment is another causative factor for decrement of blood glucose levels.

In conclusion, shinrin-yoku (forest-air bathing and walking) is a useful exercise therapy for the elderly diabetic patients.

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