



Original Article

## Long-term changes of psychological factors regarding exercise in patients with type 2 diabetes after discharge and the effect of these changes on glycemic control

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**Abstract.** [Purpose] In the medical treatment guidelines for type 2 diabetes, the utility of the approach using self-efficacy and stage of change has been previously demonstrated. Although the effects of short-term approaches have been shown, a few studies have examined long-term changes over time. The purpose of the present study was to investigate longitudinally the factors that affect the stage of change, self-efficacy for exercise, and glycemic control for 12 months in patients with type 2 diabetes after the intervention of the disease by receiving diabetes and glycemic control education. [Participants and Methods] The study included 29 patients with type 2 diabetes as participants who were able to follow up for 12 months after the intervention. The changes over time were investigated using stage of change and self-efficacy as psychological indicators of exercise. Factors affecting HbA1c values after 12 months of intervention were examined with information on diabetes and social background. [Results] There was no significant difference in self-efficacy for exercising at 3, 6, and 12 months after discharge. In contrast, participants in the stage of change showed a significant improvement at 6 and 12 months after discharge in comparison to 3 months after discharge. HbA1c values decreased at 12 months while comparing patients after 3 months and 12 months after discharge. The only factor affecting HbA1c value 12 months after discharge was the duration of diabetes. [Conclusion] The results suggested that stage of change and self-efficacy for exercise might have a little long-term effect on glycemic control.

**Key words:** Self-efficacy, The stages of change, HbA1c

(This article was submitted Jul. 29, 2021, and was accepted Sep. 8, 2021)

### INTRODUCTION

Exercise therapy is an important treatment in the treatment of type 2 diabetes, but the implementation rate of exercise therapy is low<sup>1)</sup>. In recent years, the psychological intervention has been often used to encourage exercise therapy. The approach based on the transtheoretical model (TTM) proposed by Prochaska et al.<sup>2)</sup> is well-known as an effective method for exercise therapy and nutritional guidance<sup>3–6)</sup>. TTM is composed of a stage of change, processes of change, decisional balance, and self-efficacy (SE). In particular, the stage of change and SE are useful in various situations as predictors for the degree of execution and continuation of medical behavioral treatment. Previous studies concerning type 2 diabetic participants have indicated that the higher the SE for exercise, the higher the stage of change, and studies have reported that SE is important for the transition to the stage of change<sup>3, 7)</sup>. Dutton et al. also examined the relationship between SE and physical activity levels after educational intervention and reported that the increasing SE relates to physical activity levels<sup>8)</sup>. Gao

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et al. further reported that higher SE directly affects glycemic control<sup>9</sup>). However, few previous studies have examined the long-term changes over six months or longer. In fact, in our report on the effects of SE with respect to exercise and glycemic control at 12 weeks after guidance, there was no noted correlation between SE with respect to exercise and glycemic control at 12 weeks after the instruction, and the need for the long-term study was reported<sup>10</sup>). If a correlation between SE and stage of change can easily evaluate the psychological state of exercise and long-term glycemic control is recognized, it may be possible to predict the patient course based on a psychological evaluation. Furthermore, it may reduce the risk of interruption of exercising and encourage the performance as well as a continuation of exercise.

Therefore, we targeted type 2 diabetic patients who were admitted to our hospital for the purpose of diabetes education and glycemic control along with underwent exercise guidance intervention; The purpose of the present study was to investigate the time course of SE for exercising and stage of change at 12 months after the intervention of factors affecting glycemic control over a period of 12 months.

## PARTICIPANTS AND METHODS

The participants comprised 85 diabetic patients admitted to the Japanese Red Cross Kanazawa Hospital between March 2015 and February 2018. All subjects were hospitalized for two weeks for glycemic control improvement and educational program participation. Of the participants 56 patients were excluded (10 who did not give consent to participate in the study, 16 for whom follow up for 12 months could not be performed, 10 who were hospitalized for a non-diabetes-related illness, 13 who were switched to home doctor, 4 for whom treatment was discontinued, and 3 who died). A total of 29 patients who consented to participate and for whom follow-up could be performed for 12 months after discharge were selected as participants. The 29 participants consisted of Japanese persons living near Kanazawa City. The educational program was conducted by physicians, nurses, dietitians, laboratory technicians, pharmacists, and physiotherapists. Physiotherapists were in charge of guidance and education-related exercises, which included “group education for acquiring knowledge” and “individual instruction and counseling according to each patient’s individual lifestyle” so that exercise could be continued after discharge in addition to “practice of the content that was taught”. Next, we collected information on diabetes (vascular complications, history of insulin injection, and educational hospitalization history) and social backgrounds (presence of family members living in the same household and employment status). Diabetic polyneuropathy was defined as diminished defense sensation or abnormal nerve conduction velocity as determined by the 4.5 Semmes-Weinstein monofilament test. The presence of retinopathy was defined as simple retinopathy or as a more severe case. Diabetic nephropathy was defined as urine albumin/creatinine where the ratio exceeded 30 mg/g creatinine. The following two evaluations were performed to examine the changes over time in the psychological state of exercise after discharge. The endpoints were stage of change and SE. They both were measured at discharge and 3, 6, and 12 months after discharge.

In the evaluation of the stage of change, the following five stages were defined as items according to the definition of Oka et al.<sup>11</sup>): Pre-contemplation period (does not exercise now and does not intend to do it within the next 6 months), Contemplation period (does not currently exercise, but intends to do so within the next 6 months), Preparatory period (exercises now, but not regularly), Action period (currently exercises, but within 6 months of starting), and Maintenance period (currently exercises regularly, for 6 months or longer). The participants were requested to select the most applicable responses.

Self-efficacy for exercise was assessed using an exercise SE scale developed by Oka<sup>7</sup>). The scale was a self-administered questionnaire consisting of four items, physical fatigue, mental stress, busyness, bad weather was evaluated using a five-point scale (1=I have no confidence, 5=I am very confident). The total score was between 4 and 20 points. Measurements were performed at discharge as well as at the period of 3, 6, and 12 months after discharge.

As an index of glycemic control, HbA1c values were measured at admission and at the period of 3, 6, and 12 months after discharge. In order to identify factors affecting glycemic control at 12 months after discharge; gender, age, body weight, the status of vascular complications, duration of diabetes, presence/absence of insulin usage, presence/absence of family member living in the same household, and work employment history were collected and examined. All participants were given informed consent in writing prior to enrollment.

The study protocol was approved by the Kanazawa Red Cross Hospital Ethics Committee (No. 971).

For statistical analysis, the normality of each variable was confirmed by the Kolmogorov-Smirnov test. The behavioral modification stage included the following stages in analysis: “Precontemplation period”=1, “Contemplation period”=2, “Preparation period”=3, “Execution period”=4, and “Maintenance period”=5; The analysis was performed as ordinal scale data by assigning these numerical values. Behavioral modification stage and SE for exercise at discharge, along with 3 months, 6 months, and 12 months after discharge were analyzed using the Friedman test and compared using Bonferroni’s method as a post-doc test. HbA1c levels at each follow-up were analyzed using one-way analysis of variance and compared using Bonferroni’s method as a post hoc test. Furthermore, stepwise multiple regression analysis was performed to investigate the individual factors affecting HbA1c levels at the period of 12 months after discharge. The dependent variables consisted of HbA1c levels, and the independent variables consisted of gender, age, body weight, vascular complications, duration of diabetes, use of insulin, presence of family member living in the same household, and employment history.

The significance level was set at  $p=0.05$ . All data were analyzed using the SPSS software program (ver.11.0, IBM Corp., Armonk, NY, USA).

## RESULTS

Patient attributes are shown in Table 1. Regarding BMI, women showed a propensity to obesity ( $27.8 \pm 8.1 \text{ kg/m}^2$ ). The duration of diabetes was less than half a year in 8 patients, and the maximum was 25 years. Furthermore, approximately half of the participants underwent initial educational hospitalization, and the other half had experienced multiple educational hospitalizations. SE for exercise was as follows: at discharge,  $15.6 \pm 2.7$ ; at 3 months after discharge,  $14.5 \pm 3.7$ ; at 6 months,  $14.7 \pm 3.6$ ; and at 12 months,  $14.6 \pm 3.9$ . The values measured in each follow-up were compared, and no significant differences and changes were noted (Table 2). The behavior modification stage in each follow-up was significantly improved at 6 months and 12 months compared with 3 months after discharge (Table 3). HbA1c levels decreased significantly at 3 months, 6 months, and 12 months after discharge compared with at admission and shown improvement. However, a comparison of 3 months and 12 months after discharge revealed that the results at 12 months decreased (Table 4). The only factor affecting HbA1c levels in the period of 12 months after discharge was the duration of diabetes (Table 5).

**Table 1.** The participants' characteristics

Characteristic	n=29
Age (years)	61.2 $\pm$ 11.5
Gender (male/female)	15/14
Body weight at admission (kg)	66.1 $\pm$ 16.7
Male (kg)	67.5 $\pm$ 15.8
Female (kg)	64.6 $\pm$ 18.1
Body mass index ( $\text{kg/m}^2$ )	26.1 $\pm$ 6.9
Male ( $\text{kg/m}^2$ )	24.5 $\pm$ 5.6
Female ( $\text{kg/m}^2$ )	27.8 $\pm$ 8.1
Duration of diabetes (years)	8.4 $\pm$ 7.8
Diabetic polyneuropathy (%)	51.7
Diabetic retinopathy (%)	17.2
Diabetic nephropathy (%)	6.9
History of cerebrovascular disease (%)	10.5
History of coronary artery disease (%)	10.3
Living with family (%)	82.8
Working full-time or part-time (%)	41.4
Injecting insulin (%)	37.9
First educational hospitalization (%)	51.7

**Table 2.** Change of self-efficacy for exercise of participants

At discharge	At 3 months after discharge	At 6 months after discharge	At 12 months after discharge
15.6 $\pm$ 2.7	14.5 $\pm$ 3.7	14.7 $\pm$ 3.6	14.6 $\pm$ 3.9

**Table 3.** The participants' changes in exercise behaviors

At the time of discharge	At 3 months after discharge	At 6 months after discharge	At 12 months after discharge
4 (4, 5)	4 (4, 5)	5 (4, 5)*	5 (5, 5)**

Median (25 percentile, 75 percentile).

\*p<0.05: vs. at 3 months after discharge, \*\*p<0.01: vs. at 3 months after discharge.

**Table 4.** HbA1c value (%)

At admission (%)	At 3 months after discharge (%)	At 6 months after discharge (%)	At 12 months after discharge (%)
9.6 $\pm$ 2.1	7.1 $\pm$ 0.9*	7.3 $\pm$ 1.1*	7.4 $\pm$ 1.2*,**

HbA1c: glycated hemoglobin (hemoglobin A1c).

\*p<0.01 vs. at admission, \*\*p<0.05 vs. at 3 months after discharge.

**Table 5.** Factors affecting HbA1c levels at 12 months after discharge

Characteristic	$\beta$ -Regression
Age (years)	0.072
Gender	-0.055
Body weight	-0.046
Duration of diabetes	0.515*
Diabetic polyneuropathy	0.201
Diabetic retinopathy	0.3
Diabetic nephropathy	0.022
History of cerebrovascular disease	-0.015
History of coronary artery disease	-0.297
Living with family	0.071
Working full-time or part-time	0.183
Injecting insulin	-0.063

R=0.515. R<sup>2</sup>=0.265. Adjusted R<sup>2</sup>=0.238.

\*p<0.05.

## DISCUSSION

An important result of the present study was the fact that the stage of change progressed, and SE for exercise did not decrease over time for 12 months, and it was possible to maintain the exercise behaviors for 12 months after educational hospitalization.

Regarding the relationship between the behavioral modification stage and the SE, it is well known that SE increases as the behavioral modification stage progresses. However, the results showed that while the behavioral modification stage progressed with time, improvement of SE was not observed. In a previous study by Maeba et al.<sup>12)</sup>, it was reported that from the pre-contemplation stage to the Action period, SE for exercising increased as the stage progressed, but there was no difference in SE after the Action period. It appears that the change in SE for exercise was small because the proportion of subjects in the present study occupying the stage after the Action period was high.

Regarding the ability to maintain exercise behaviors, Sperl-Hillen et al. indicated that patients who received individualized instruction could maintain a higher SE for more than one year in comparison with patients who did not receive educational intervention and reported the efficacy of individualized instruction<sup>13)</sup>. In the present study also, most of the participants received not only group education but also individual exercise guidance according to the lifestyle of each patient during the educational hospitalization, and it appeared that exercise SE could be maintained due to the effects.

Furthermore, Sudo et al.<sup>14)</sup> reported that when designing an educational program, it is more effective to actually perform and lecture exercises rather than perform passive teaching. Therefore, when compared with previous studies, the intervention with group education, individual guidance, and exercise practice may have been effective for maintaining exercise behavior.

In addition, regarding changes over time of HbA1c value, Norris et al.<sup>15)</sup> reported that the effect of self-management education does not last beyond four months. Sperl-Hillen et al.<sup>13)</sup> noted that peak HbA1c levels after individual guidance occurred at 120 days. HbA1c value improved in comparison with value at admission but gradually decreased after HbA1c value reached the minimum value in 3 months after discharge. These results are similar to those of previous studies, and support the fact that improvement of glycemic control does not provide long-lasting effects.

Another result is that HbA1c value decreased after 12 months despite the fact that the SE for exercise and stage of change could be maintained at a high level without decreasing. Examination of individual factors revealed that factors affecting HbA1c value were by the duration of diabetes. It is well known that the duration of diabetes affects glycemic control and that the longer the illness, the worse the glycemic control<sup>16)</sup>. In the present study, the effects on HbA1c value after 12 months showed the same results as those of previous studies, and in the case of the participants of the present study, the longer the disease period, the worse the glycemic control. Diabetic patients with long illnesses tend to have poor glycemic control because of dysfunction of insulin secretion due to beta-cell dysfunction<sup>17)</sup>. Evaluation of insulin secretion ability in the participants in the present study could not be executed. Therefore, the correlation between insulin secretory ability and the duration of diabetes was not examined in the present study. However, since the duration of diabetes is likely to have some effect on glycemic control, a further study including insulin secretion ability is needed in the future.

On the basis of these two results, it is highly likely that SE for exercise and stage of change will have a little long-term effect on glycemic control. The effects of educational hospitalization and guidance for glycemic control did not continue long term, and the longer the illness, the shorter the effects. In addition, since the duration of diabetes affects glycemic control, it may be necessary to take into account individual illness duration and frequent follow-up after discharge, regardless of the continuation of exercise behavior.

Our study has limitations. First, it should be noted that the amount of exercise could not be evaluated in the present study. In the present study, we only evaluated the presence or absence of regular exercise and confidence regarding exercise using a questionnaire, but the amount of exercise was not inquired about. Therefore, even if SE for exercise is high and the stage of change can be maintained, the actual exact amount of exercise remains unknown. It is necessary to examine this point by adding an evaluation using a pedometer, activity meter, etc. In addition, to the 85 participants, the present study included 29 patients for whom follow-up could be performed without interruption for 12 months. A total of 16 patients for whom follow-up could not be performed and four in whom treatment was discontinued were excluded. Therefore, it is possible that the participants in the present study may have comprised a group in which SE with respect to exercise and the stage of change could be maintained at a high level. Furthermore, for glycemic control, not only exercise therapy but also the degree of implementation of diet and pharmacotherapy are considered important<sup>14</sup>). Therefore, the viewpoints of other therapies are also important, but the effects on dietary compliance and pharmacotherapy were not examined and explained. Examination of these items can be considered as an issue for future study.

### *Conflict of interest*

The authors declare no conflicts of interest associated with this manuscript.

## REFERENCES

- 1) Arakawa S, Watanabe T, Sone H, et al.: The factors that affect exercise therapy for patients with type 2 diabetes in Japan: a nationwide survey. *Diabetol Int*, 2015, 6: 19–25. [[CrossRef](#)]
- 2) Prochaska JO, Velicer WF: The transtheoretical model of health behavior change. *Am J Health Promot*, 1997, 12: 38–48. [[Medline](#)] [[CrossRef](#)]
- 3) Sekikawa K, Tabusadani M, Nojima H, et al.: Effect of teaching physical exercise on behavioral change in patients with type 2 diabetes. *Physical Therapy Science*, 2009, 24: 587–592.
- 4) Nakagawa Y, Moriya K, Itoh K, et al.: Beneficial effects of a transtheoretical model of health behavior change-based continued nutritional education program on the behavior of patients with type 2 diabetes. *Tenshi Coll*, 2013, 14: 19–39.
- 5) Jones H, Edwards L, Vallis TM, et al.: Diabetes Stages of Change (DiSC) Study: Changes in diabetes self-care behaviors make a difference in glycemic control: the Diabetes Stages of Change (DiSC) study. *Diabetes Care*, 2003, 26: 732–737. [[Medline](#)] [[CrossRef](#)]
- 6) Sudo N, Yoshiike N: A systematic review of the long-term effectiveness of education programs using a transtheoretical model to promote and maintain physical activity. *Eiyogaku Zasshi*, 2008, 66: 57–67. [[CrossRef](#)]
- 7) Oka K: [Stages of change for exercise behavior and self-efficacy for exercise among middle-aged adults]. *Nippon Koshu Eisei Zasshi*, 2003, 50: 208–215 (in Japanese). [[Medline](#)]
- 8) Dutton GR, Tan F, Provost BC, et al.: Relationship between self-efficacy and physical activity among patients with type 2 diabetes. *J Behav Med*, 2009, 32: 270–277. [[Medline](#)] [[CrossRef](#)]
- 9) Gao J, Wang J, Zheng P, et al.: Effects of self-care, self-efficacy, social support on glycemic control in adults with type 2 diabetes. *BMC Fam Pract*, 2013, 14: 66. [[Medline](#)] [[CrossRef](#)]
- 10) Matsui N, Washida K, Shoji M, et al.: Decrease in self-efficacy for exercise at 12 weeks after exercise education in diabetic. *Patients Health*, 2017, 9: 649–656.
- 11) Oka K, Takenaka K, Miyazaki Y: Assessing the stage of change for exercise behavior among young adults: the relationship with self-reported physical activity and exercise behavior. *J Health Psychol Res*, 2000, 8: 17–23.
- 12) Maeba K, Takenaka K: Associations between sources of exercise self-efficacy and stages of change for exercise among older adults. *Behavioral Medicine research*, 2012, 18: 12–18.
- 13) Sperl-Hillen J, Beaton S, Fernandes O, et al.: Are benefits from diabetes self-management education sustained? *Am J Manag Care*, 2013, 19: 104–112. [[Medline](#)]
- 14) Sudo N, Yoshiike N: Effects of health education on the glycemic control of type 2 diabetic patients: a meta-analysis. *Eiyogaku Zasshi*, 2006, 64: 309–324. [[CrossRef](#)]
- 15) Norris SL, Lau J, Smith SJ, et al.: Self-management education for adults with type 2 diabetes: a meta-analysis of the effect on glycemic control. *Diabetes Care*, 2002, 25: 1159–1171. [[Medline](#)] [[CrossRef](#)]
- 16) Khattab M, Khader YS, Al-Khawaldeh A, et al.: Factors associated with poor glycemic control among patients with type 2 diabetes. *J Diabetes Complications*, 2010, 24: 84–89. [[Medline](#)] [[CrossRef](#)]
- 17) UK Prospective Diabetes Study (UKPDS) Group: Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet*, 1998, 352: 837–853. [[Medline](#)] [[CrossRef](#)]