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RESEARCH ARTICLE

Dietary Adherence, Self-Efficacy, and Health Behavior Change of WASHOKU-Modified DASH Diet: A Sub-analysis of the DASH-JUMP Study

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Abstract: ***Background*:** We previously reported the nutritional characteristics and effects of the DASH-JUMP diet, which is a WASHOKU-modified DASH diet, in Japanese participants with untreated high-normal blood pressure or stage 1 hypertension. The dietary adherence of the DASH diet in Japanese participants has never been evaluated before.

***Objective*:** We aimed to assess the relationships between dietary adherence, self-efficacy, and health behavior change among study participants who received the DASH-JUMP diet by home delivery.

***Methods*:** Participants were treated with the DASH-JUMP diet for 2 months and consumed their usual diets for the next 4 months. We conducted surveys using the stage of behavior change model questionnaire and the modified perceived health competence scale Japanese version questionnaire at baseline and 1, 2, 3, and 6 months to assess dietary adherence.

***Results*:** Forty-three participants (25 men, 18 women; mean age 53.6 ± 8.2 years) returned completed questionnaires, which we analyzed. Health behavior change was motivated by previous behavioral changes and improved biomarkers. The improvement and maintenance of self-efficacy were deeply related to health behavior change and previous self-efficacy. The experience of the DASH-JUMP study for participants included three processes to improve lifestyle habits: Phase 1, reflecting on previous lifestyle habits; Phase 2, learning through new experiences and the acquisition of knowledge; and Phase 3, desiring to maintain their own health.

***Conclusion*:** It indicated that the DASH-JUMP diet significantly increased self-efficacy and promoted health behavior change.

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1. INTRODUCTION

Cardiovascular Disease (CVD) is the deadliest disease worldwide, resulting in 17.7 million deaths each year [1]. The national medical expenses resulting from CVD have been increasing globally and exert a significant social burden. It is important to prevent hypertension, which causes CVD, to reduce national medical expenses [2]. Japan represents the world's first super-aged society and 27.7% of the population is now aged 65 years or older. The current mission statement of the Japanese Ministry of Health, Labor and Welfare is “extending the healthy life span”. As the proportion of the elderly population continues to increase and that of the working population decreases in the future, citizens will be faced with the challenge of preventing lifestyle-related diseases such as CVD by maintaining their own health. A previous study indicated that a central concept in health self-management is self-efficacy, *i.e.* having the confidence to carry out a behavior necessary to reach the desired

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goal [3]. Behavioral models have suggested that the most effective therapy prescribed by the most careful clinician will control hypertension only if the patient is motivated to take the medication as directed and to establish and maintain a health-promoting lifestyle [4]. Adherence to a suitable diet is an important outcome of self-efficacy and health behavior change. Past studies have reported that adherence to the DASH diet was associated with a lower risk of hypertension, coronary heart disease, and insulin resistance [5-7]. There have been few studies on self-efficacy and health behavior change among Japanese participants treated with a DASH-based diet or a diet provided by home delivery. Therefore, we aimed to assess self-efficacy and health behavior change among participants who were treated with the DASH-JUMP diet, which is a WASHOKU-modified DASH diet, to evaluate their ability to actively maintain their own health before and after the intervention.

2. MATERIALS AND METHODS

2.1. Study Design as a Sub-analysis of the DASH-JUMP Study

The DASH-JUMP study was an open-label single-arm trial. The present sub-analysis examined the temporal trends of self-efficacy and health behavior change during the DASH-JUMP study. Furthermore, we analyzed the relationships between these items, the adherence data, and the health outcomes of Blood Pressure (BP) reduction, weight loss, and dietary intake rate. The protocol of the DASH-JUMP study was described in detail in our previous reports [8, 9]. Sixty participants with high-normal blood pressure and stage I hypertension were enrolled in this study. The intervention period of the DASH-JUMP study was 2 months and participants consumed their normal diets for the next 4 months after the intervention. We examined participants' self-efficacy and health behavior change at baseline and after 1, 2, 3, and 6 months. Our study protocol was approved by the Ethics Committee of Yamaguchi University Faculty of Medicine and Health Sciences. We performed this examination in accordance with the principles of the Declaration of Helsinki.

2.2. Assessment of Self-efficacy

Self-efficacy was proved to be a better predictor of behavioral improvements gained from the partial mastery of threats at different phases of treatment [10]. In addition, perceived self-efficacy plays a significant role in diverse health behaviors including the control of eating and weight as well as adherence to preventive health programs [11]. A previous study suggested that self-efficacy is strongly related to health behavior change and maintenance [12]. In this study, we adopted the modified Perceived Health Competence Scale (PHCS) Japanese version [13, 14], which Togari *et al.* produced by modifying the original PHCS developed by Smith *et al.* [15]. The PHCS contains eight items, as follows: 1) I handle myself well with respect to my health; 2) No matter how hard I try, my health just doesn't turn out the way I would like; 3) It is difficult for me to find effective solutions to the health problems that come my way; 4) I succeed in the projects I undertake to improve my health; 5) I'm generally able to accomplish my goals with respect to my health; 6) I find my efforts to change things I don't like about my health, are ineffective; 7) Typically, my plans for my health don't work out well; and 8) I am able to do things for my health as well as most other people. Each item of the PHCS is rated using a 5-point Likert scale, with the total questionnaire score ranging from 8 to 40 points. The reliability and validity of the PHCS Japanese version have already been verified by Togari *et al.* [16]. The PHCS data were investigated at baseline, after 1 and 2 months of the intervention, and at 1 and 4 months after ceasing the intervention.

2.3. Assessment of Health Behavior Change

We assessed health behavior change derived from the experience of the DASH-JUMP diet among the study participants using the Transtheoretical Model (TTM) of health behavior change as developed by Prochaska [17, 18]. TTM concentrates on five stages of change, ten processes of change, the pros and cons of change, self-efficacy, and temptation. The five stages are precontemplation, contemplation, preparation, action, and maintenance. The model includes a measure of the target behavior that was based on critical assumptions about the nature of behavior change and interventions that can best facilitate such change [17]. Previous studies have reported on food intake and the stages of behavior change among Japanese subjects [19]. Additionally, we investigated the participants' opinions and impressions during each examination. We calculated the mean scores of TTM during the DASH-JUMP study at baseline, after 1 and 2 months of the intervention, and at 1 and 4 months after ceasing the intervention.

2.4. Statistical Analyses

Statistical analyses were performed using SPSS version 21.0 for Windows software (IBM, Armonk, NY, USA). *P*-values < 0.05 were considered statistically significant. The parameter "Δweight" represents the difference in weight loss from baseline to each examination point. The parameter "ΔBP" represents the differences in Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) reduction from baseline to each examination point. We used repeated measures analysis of variance or Friedman's test for the analysis of Δweight, ΔBP, PHCS, and TTM data obtained during the DASH-JUMP study at each examination point. When appropriate, we subsequently performed *post hoc* analysis by Bonferroni or Friedman's test for multiple comparisons. We divided the participants into two groups (High Self- Efficacy Group [HSEG] and Low Self-Efficacy Group [LSEG]) using the median PHCS score at baseline. The HSEG had a PHCS score above the median (*i.e.* ≥ 23) and the LSEG had a PHCS score below the median (*i.e.* < 23). We compared their clinical characteristics. Differences were assessed using the Mann-Whitney U test for data with a non-parametric distribution and unpaired Student's *t*-test for data with a parametric distribution. Furthermore, we evaluated the participants' awareness of the experience of the DASH-JUMP study and performed a content analysis. A multiple linear regression analysis was performed to predict health behavior change using the TTM score at each examination point as the dependent variable, while the independent variables were the average SBP and DBP at home, weight, fasting serum glu-

cose, urinary sodium and potassium, total cholesterol, the PHCS score at each examination point, sex, age, intake of confectionary, salt intake, physical activity level, sleeping time, current smoking, ingestion of alcohol and family history of CVD at baseline. Then, we performed another similar analysis using the PHCS score at each examination point as the dependent variable and all the other variables listed above as the independent variables. The average SBP and DBP values measured in the morning and evening at home were analyzed.

The internal consistencies (*i.e*., reliabilities) of the PHCS Japanese version and the TTM of health behavior change were assessed using Cronbach's α coefficient. The closer the value of α coefficient was to 1, the higher the reliability was considered to be.

3. RESULTS

3.1. Participants' Characteristics

The questionnaires of PHCS and TTM were distributed to 58 participants. Fully completed answer sheets at all examination points were returned from forty-three participants. The participants were divided into two groups, HSEG and LSEG, using the median score of PHCS. The characteristics of the research participants are shown in Table **1**. The mean age was 53.6 ± 8.2 years and 53.4% were male. There were no significant differences between the HSEG and LSEG at baseline in items other than the PHCS score. The HSEG showed a lower DBP, weight, smoking rate, family history of CVD, and consumption of alcohol, salt, and confectionery than the LSEG. In addition, the behavior change stage, physical activity level, and DASH-JUMP diet intake rate of the HSEG were higher than those of the LSEG. The HSEG showed a mean score of the preparatory period of behavior change stage, while the LSEG showed a mean score of the contemplatory period. However, the average SBP at baseline of the HSEG was higher than that of the LSEG. The sleeping time was similar in both groups.

3.2. The Internal Consistency of the PHCS and Health Behavior Change Questionnaires

The internal consistencies (*i.e*., reliabilities) of the PHCS and health behavior change questionnaires were assessed using Cronbach's α coefficient and values greater than 0.7 were considered satisfactory. The Japanese version of the PHCS had a Cronbach's α coefficient of 0.96, which was considered to be reliable. The Japanese version of the health behavior change questionnaire had a Cronbach's α coefficient of 0.64, which was considered to be almost reliable.

3.3. Dietary Adherence and BP in the Groups with Low and High Self-efficacy

The data for dietary adherence and BP in the HSEG and LSEG are shown in Fig. **1**. There were significant differences in PHCS between the two groups at each examination point. Significant differences were also found in DBP at each examination point except baseline, in health behavior change after 1 month, and in confectionary intake after 2 months. The HSEG had higher PHCS scores than the LSEG throughout the study period. The trends of the graphs for the PHCS

Table 1. Baseline characteristics of the participants grouped by their self-efficacy scores.

Characteristics of the Participants		High Self-efficacy Score Group	Low Self-efficacy Score Group	*P*-value
n		**22**	**21**	
Sex (male/female)		12 / 10	11 / 10	0.460
Age	(years)	55.1 ± 8.7	51.9 ± 7.6	0.203
Self-efficacy Score [a] from PHCS		28.9 ± 4.6	17.4 ± 3.7	0.000
Healthy behavior change score [a] from TTM		5.1 ± 2.1	4.1 ± 1.3	0.096
SBP at home [a]	(mmHg)	149 ± 12	145 ± 8	0.165
DBP at home [a]	(mmHg)	87 ± 8	89 ± 6	0.219
Weight [a]	(kg)	63.8 ± 10.6	68.9 ± 13.0	0.181
Physical activity level *	(Af)	2.5 ± 0.7	2.1 ± 0.9	0.115
Salt intake *	(g)	9.1 ± 3.5	9.3 ± 3.3	0.792
Intake of confectionery *	(kcal)	235 ± 137	243 ± 238	0.610
Ingestion of alcohol [a]	(%)	54.5	57.1	0.865
Current smoking [a]	(%)	9.0	19.0	0.352
Family history [a]	(%)	40.9	61.9	0.174
DASH-JUMP diet intake rate	(%)	90.7	86.2	0.159
Sleeping time [a]	(h)	6.6 ± 1.0	6.7 ± 0.8	0.832

Note: Data are presented as mean ± standard deviation or *n* (%). Data [a] measured at baseline. Data * from FFQg questionare at baseline. HSEG: High self-efficacy score group, LSEG: Low self-efficacy score group, The HSEG had a higher PHCS score (≥ 23 median) than the LSEG (< 23). Significance was determined using the unpaired Student's *t*-test or the Mann–Whitney test. SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure. The BP data represent average BP values measured in the morning and evening at home.

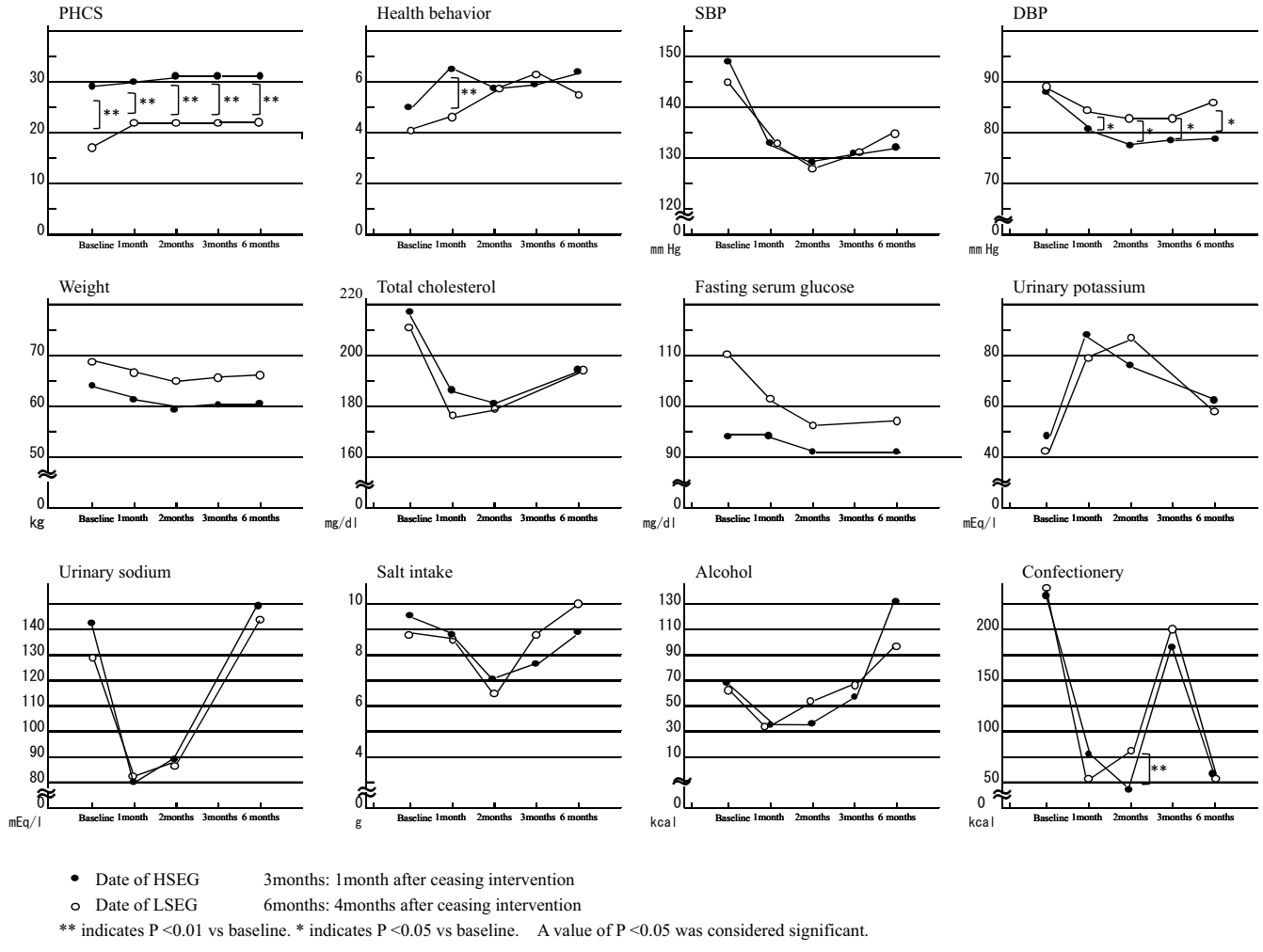


Fig. (1). The effect of dietary adherence due to difference in self-efficacy.

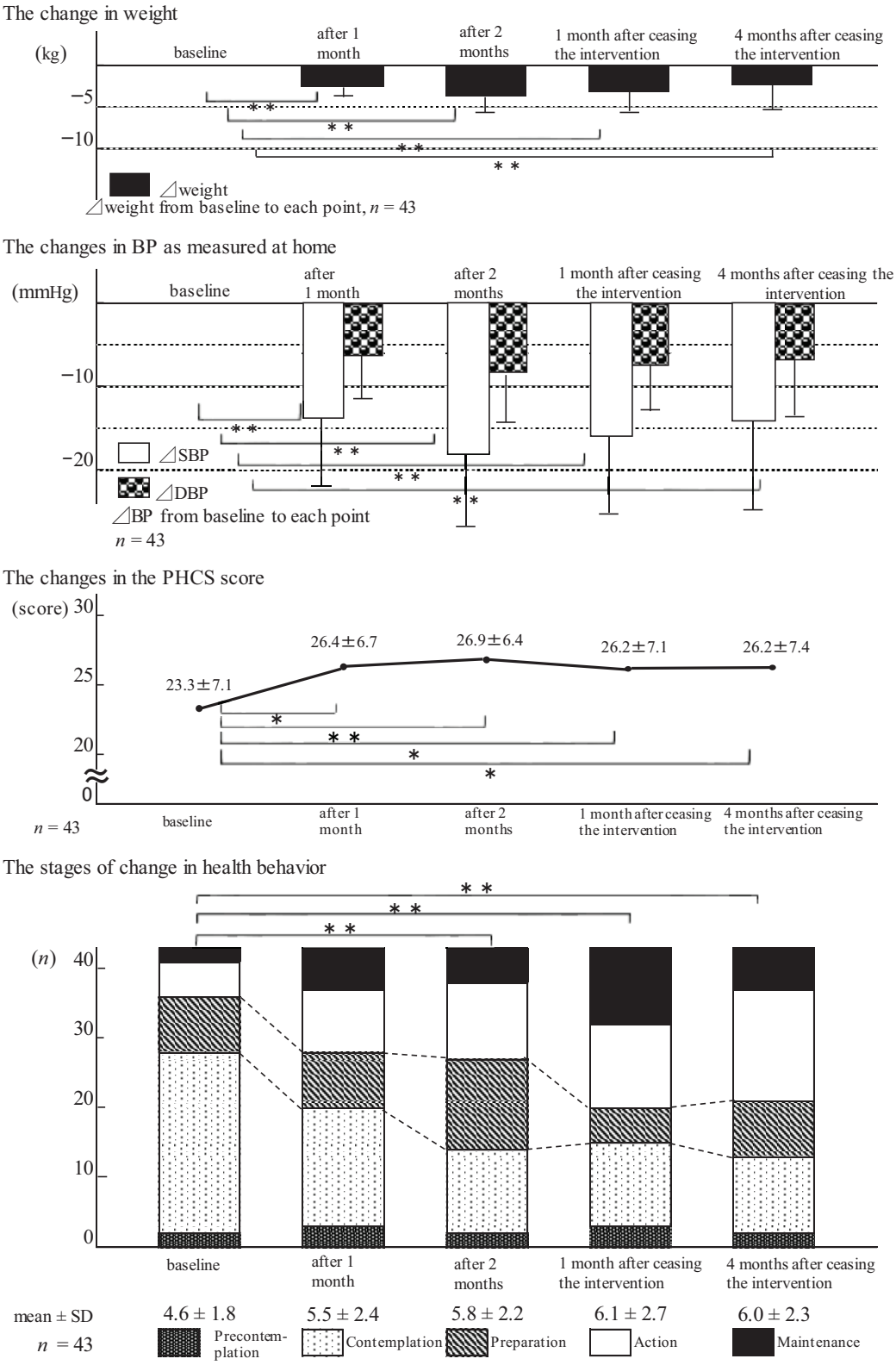
and health behavior change data differed between the groups. The DASH-JUMP intervention resulted in a rapid increase in self-efficacy in the LSEG after 1 month that was maintained thereafter, while the HSEG showed a slower increase in self-efficacy up to 2 months that was also maintained thereafter. The scores for health behavior change rose slightly in the LSEG from baseline to 1 month and then rapidly increased from 1 month of the intervention to 1 month after ceasing the intervention. At 4 months after ceasing the intervention, the scores for health behavior change decreased more in the LSEG than in the HSEG. The scores in the HSEG increased sharply from baseline to 1 month, decreased to the same value as the LSEG at 2 months, then gradually increased until 4 months after ceasing the intervention.

3.4. Dietary Adherence and Changes in PHCS and Health Behavior in all Participants

Fig. **2** shows the changes in weight loss, BP, PHCS and health behavior in all participants at each evaluation point during the study period. There were significant differences in weight loss ($p = 0.012$) and blood pressure reduction (SBP: $p = 0.000$, DBP: $p = 0.006$), with PHCS similarly showing a significant difference after 1 and 2 months ($p = 0.016$ and $p = 0.000$, respectively) and at 1 and 4 months after ceasing the intervention ($p = 0.017$ and $p = 0.030$, respectively). The health behavior change data showed a significant difference after 2 months ($p = 0.004$), and at 1 and 4 months after ceasing the intervention ($p = 0.000$, $p = 0.003$). After 2 months, body weight and blood pressure showed the largest proportional decreases and the PHCS score was higher than at the earlier examination points. Moreover, the behavior change data indicated increases in the proportion of participants in the preparation, action, and maintenance periods. At 4 months after ceasing the intervention, the health behavior change data showed the largest proportion of participants in the active period among all the examination points during the study period.

3.5. The Experience of the DASH-JUMP Study for Participants

Table **2** shows the experience of the DASH-JUMP study for participants. We performed a content analysis to evaluate the participants' awareness of their experience of the DASH-JUMP study. The experiences of the DASH-JUMP study that the participants reported could be categorized into three processes: Phase 1, reflecting on previous lifestyle habits;



After analysis with repeated measures ANOVA or Friedman's test, *P*-values derived from post-hoc analysis with Bonferroni or Friedman's test for multiple comparisons.
** indicates P <0.01 vs baseline. * indicates P <0.05 vs baseline. A value of P <0.05 was considered significant.

Fig. (2). Changes in weight loss, blood pressure, PHCS, and health behaviour during the study in all participants.

Table 2. The experience of the DASH-JUMP study for participants.

Process	Participant's Awareness
Reflecting on previous lifestyle habits	• I understood how my life so far was not optimal for maintaining my health. • I reflected on how much salt I consumed with my past eating habits and I learned a lot. • I have never succeeded so well in losing weight although I have tried many times before.
Learning through new experiences and the acquisition of knowledge	• I realized again that food is critical for maintaining health. • I understand how daily meals are important. • I did not think that blood pressure could be improved so much by changing the content of my meals. • When I underwent the DASH-JUMP diet therapy, I was surprised that there were such big changes in my blood pressure and weight. • This survey gave me an opportunity to study blood pressure and various diseases associated with blood pressure in detail. • After I had been suffering for a few months with a poor physical condition (headaches due to a rise in blood pressure), I received this therapy and I am truly amazed and grateful that my blood pressure improved within a few days and then became stable.
Desiring to maintain their own health	• Because these improvements in health are possible because of my own efforts, I am working for myself and I will strive to maintain my health in the future. • I learned a lot about the optimal contents of salt, oil, and so on in the three daily meals, and I would like to continue applying this knowledge to my future diet. • We will continue to consume a lot of seaweed and vegetables. • This will help us to stay at our current weight in the future.

Table 3. Factors affecting health behavioral change.

	Dependent Variable	Independent Variable	Standardized Partial Regression Coefficient	*P*	Partial Correlation Coefficient	VIF
1	Health behavior change at baseline	Age	0.471	0.001	0.471	1.000
		$P\Delta_F$: 0.001 R-squared : 0.222	-	-	-	-
		Adjusted R-squared : 0.203	-	-	-	-
2	Health behavior change after 1 month	Health behavior change at baseline	0.525	0.000	0.522	1.045
		Average DBP after 1 month	−0.287	0.041	−0.317	1.045
		$P\Delta_F$: 0.041 R-squared : 0.295	-	-	-	-
		Adjusted R-squared : 0.260	-	-	-	-
3	Health behavior change after 2 months	Weight after 1 month	0.592	0.000	0.620	1.097
		Health behavior change after 1 month	0.458	0.000	0.522	1.093
		Urinary potassium at baseline	−0.300	0.014	−0.379	1.045
		$P\Delta_F$: 0.014 R-squared : 0.488	-	-	-	-
		Adjusted R-squared : 0.449	-	-	-	-
4	Health behavior change at 1 month after ceasing the intervention	Health behavior change after 2 months	0.520	0.000	0.539	1.155
		Family history	−0.465	0.002	−0.482	1.251
		Health behavior change at baseline	−0.376	0.010	−0.405	1.260
		Urinary potassium at baseline	−0.280	0.040	−0.327	1.147
		$P\Delta_F$: 0.040 R-squared : 0.430	-	-	-	-
		Adjusted R-squared : 0.370	-	-	-	-
5	Health behavior change at 4 months after ceasing the intervention	Health behavior change at 1 month after ceasing the intervention	0.439	0.002	0.467	1.036
		Salt intake at baseline	−0.302	0.029	−0.342	1.036
		$P\Delta_F$: 0.029 R-squared: 0.333	-	-	-	-
		Adjusted R-squared : 0.299	-	-	-	-

Note: $n = 43$, Variable selection method : forward selection method. ANOVA $P < 0.01$. At 1 month after ceasing the intervention = after 3 months of the study period.

Table 4. Factors affecting PHCS.

	Dependent Variable	Independent Variable	Standardized Partial Regression Coefficient	*P*	Partial Correlation Coefficient	VIF
1	PHCS at baseline	Sex (male/female)	−0.709	0.000	−0.616	1.455
		Weight at baseline	−0.529	0.000	−0.528	1.285
		Age	0.322	0.017	0.375	1.119
		Fasting serum glucose at baseline	−0.301	0.022	−0.361	1.076
		$P\Delta_F$: 0.022 R-squared : 0.436	-	-	-	-
		Adjusted R-squared : 0.377	-	-	-	-
2	PHCS after 1 month	PHCS at baseline	0.797	0.000	0.739	1.188
		Urinary potassium at baseline	−0.394	0.001	−0.48	1.162
		Weight at baseline	0.313	0.009	0.403	1.136
		$P\Delta_F$: 0.009 R-squared : 0.555	-	-	-	-
		Adjusted R-squared : 0.521	-	-	-	-
3	PHCS after 2 months	PHCS after 1 month	0.616	0.000	0.757	1.682
		PHCS at baseline	0.377	0.000	0.580	1.672
		Health behavior change after 2 months	−0.197	0.006	−0.425	1.050
		$P\Delta_F$: 0.006 R-squared : 0.832	-	-	-	-
		Adjusted R-squared : 0.819	-	-	-	-
4	PHCS at 1 month after ceasing the intervention	PHCS after 1 month	0.618	0.000	0.755	1.716
		PHCS at baseline	0.241	0.012	0.402	1.788
		Health behavior change at baseline	0.266	0.001	0.527	1.094
		Urinary sodium at baseline	0.271	0.001	0.525	1.154
		Intake of confectionery	0.213	0.004	0.451	1.061
		Health behavior change at 1 month after ceasing the intervention	0.187	0.013	0.401	1.083
		$P\Delta_F$: 0.013 R-squared : 0.832	-	-	-	-
		Adjusted R-squared : 0.804	-	-	-	-
5	PHCS at 4 months after ceasing the intervention	PHCS at 1 month after ceasing the intervention	0.907	0	0.895	1.027
		Sleeping time	−0.178	0.018	−0.367	1.027
		$P\Delta_F$: 0.018 R-squared : 0.802	-	-	-	-
		Adjusted R-squared : 0.792	-	-	-	-

Note: $n = 43$, Variable selection method: forward selection method. ANOVA $P < 0.01$. At 1 month after ceasing the intervention = after 3 months of the study period.

Phase 2, learning through new experiences and the acquisition of knowledge; and Phase 3, desiring to maintain their own health.

3.6. Multiple Linear Regression Analysis

As shown in Fig. **1**, the self-efficacy was maintained at a high level following the initial increase, but the graph of the health behavior change data showed a different trend. To clarify what affects human health behavior change, multiple linear regression analyses were performed for the health behavior change and PHCS data at all examination points.

Table **3** shows the results of the multiple linear regression analysis for health behavioral change. Health behavior change at baseline as a dependent variable was significantly associated with age as an independent predictor. Health behavior change after 1 and 2 months of the intervention period and at 1 and 4 months after ceasing the intervention as a dependent variable was significantly associated with the participants' health behavior change in the past and their physiological data. Meanwhile, PHCS after 1 and 2 months of the intervention period and at 1 and 4 months after ceasing the intervention as a dependent variable was significantly associated with the participants' PHCS in the past. Especially, PHCS after 2 months of the intervention period and at 1 month after ceasing the intervention was significantly associated with health behavior change concurrently or in the past (Table **4**).

4. DISCUSSION

In this analysis of data from the small-scale, prospective, and observational DASH-JUMP study, we investigated the relationships between dietary adherence, self-efficacy and health behavior change. In the previous study, reported self-efficacy was an important correlate of hypertension self-care and was associated with weight management and diet adherence [20, 21]. Therefore, we assessed the effects of the DASH-JUMP diet provided by home delivery on self-efficacy, health behavior change and dietary adherence. A positive outcome of the DASH-JUMP intervention is that it raised the self-efficacy of the LSEG sharply after 1 month of intervention and the score of self-efficacy was maintained at a high level from after 1 month of the intervention period until 4 months after ceasing the intervention. The score of the HSEG rose more gently to reach a maximum after 2 months of the intervention period and the same high score was maintained until 4 months after ceasing the intervention. It is conceivable that the use of a home delivery method to provide the diet to participants contributed to the rapid increase in the self-efficacy of the LSEG.

In the previous study of Gleason *et al*., 35 subjects with established coronary heart disease received a home-delivered diet and participated in a lifestyle modification program. The authors reported that "The 8-week dietary modification program providing 2 meals/day of home-delivered, prepared meals can potentially alleviate confusion and simplify the diet for the patient. The subjects indicated they were satisfied with the ease, convenience and planning with these meals over the entire 2 months" [22]. We also thought that delivering meals to the participants' home would eliminate the time and effort required to make a difficult menu, purchase a large amount of food and cook the meals. Having prepared meals with an appropriate nutrition composition delivered directly to their homes is, therefore, an effective way to improve dietary adherence.

As a result of the dietary intervention, significant weight loss and blood pressure reduction occurred from 1 month after the intervention as shown in Fig. **2**. In agreement with past studies that reported that dietary adherence was associated with self-efficacy [23, 24], the participants' self-efficacy increased significantly from 1 month after the intervention and remained elevated during the rest of the study period. Meanwhile, the health behavior change data showed a significant difference after 2 months of the intervention period as compared to baseline. Although PHCS increased consistently during the intervention period and was maintained at a high level after ceasing the intervention, the behavioral change did not consistently increase after the first month of the intervention period.

The multiple linear regression analysis showed that health behavior change was significantly associated with previous health behavior change and improved physiological data. However, health behavior change was not significantly associated with PHCS. PHCS was significantly associated with previous PHCS. Both PHCS and health behavior change had significantly increased after 2 months of the intervention period, with higher proportions of the participants in the health behavior change stages of preparation, action and maintenance. The findings are consistent with those reported in previous studies [25, 26]. Bandura defined perceived self-efficacy as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events in their lives. Furthermore, he stated that "People's beliefs about their efficacy can be developed by four main sources of influence. The most effective way of creating a strong sense of efficacy is through mastery experiences. The second way of creating and strengthening self-beliefs of efficacy is through the vicarious experiences provided by social models. Social persuasion is a third way of strengthening people's beliefs that they have what it takes to succeed. The fourth way of modifying self-beliefs of efficacy is to reduce people's stress reactions and alter their negative emotional proclivities and misinterpretations of their physical states". In the DASH-JUMP study, the participants had the mastery experience of ingesting three DASH-JUMP meals every day for 2 months. Every day, the participants had the experiential learning opportunities of watching the DASH-JUMP food being delivered, touching the food, checking the contents of the food they will eat, using salt-restricted seasoning, cooking the food using a microwave, and eating the prepared meal. The participants had the perceptual experiences of recognizing the taste of the salt-restricted meals on the whole menu, the chewy texture of the food and the sense of satiety after meals. Participants considered that ingesting the delivered meals on a daily basis improved their health including the objectively confirmed lowering of their blood pressure, which may have influenced their increase in self-efficacy. After the end of the intervention period, when the participants ingested whatever they wanted to eat, their average blood pressure had already risen by 1 month after ceasing the intervention. However, the participants understood that their blood pressure would decrease if their dietary habits changed, so based on the recipes sent along with the DASH-JUMP meals, they had apparently shown positive changes in their diet by 4 months after ceasing the intervention. Although a reduced intake of alcohol and salt could not be observed, the participants' blood pressure did not rise any further and had not returned to their original values at 4 months after ceasing the intervention. The vicarious experiences of the DASH-JUMP study were that participants gathered and exchanged information with each other at the medical examinations. They talked about each other's physical changes, weight loss, decreased blood pressure and motivation to continue the DASH-JUMP diet in the waiting room. In addition, they taught each other about where to find supermarkets selling products that were included in the DASH-JUMP diet such as low-fat milk, low-fat yogurt and reduced-salt seasonings. To reduce the participants' stress reactions and alter their negative emotional proclivities and misinterpretations of their physical states, all the research staff maintained a familiar manner and treated the participants like family members. In addition, when the participants raised questions or complaints about the DASH-JUMP diet, the researchers had the opportunity to talk about the design rationale and intended effects of the diet and the study with the participants directly. Additionally, we took care to promote group dynamics among participants. We informed participants who found adhering to the DASH-JUMP diet stressful that they were

free to stop midway and we respected the free will of the participants. Because this study only addressed participants' eating habits and no other lifestyle habits, the participants were surprised to observe that their blood pressure showed a large decrease after they only ate different daily meals. Their experiences of the DASH-JUMP study motivated them to reflect on their previous lifestyle habits in the context of maintaining their future health (Phase 1 in Table **2**). In addition, the experience of DASH-JUMP diet for 2 months was not an experience of simply eating the delivered DASH-JUMP meal. Participants gained the same effect as active learning which understood the meal content, felt chewy texture and tasted salt restriction for 2 months. From that experience, they gained the knowledge of meal ingredients, seasonings, and chewing responses that they need to lower their blood pressure (Phase 2 in Table **2**). The experiences of successfully undergoing weight loss and blood pressure reduction by following the DASH-JUMP diet motivated the participants to express their desire to maintain their own health in the future (Phase 3 in Table **2**).

CONCLUSION

In conclusion, the findings indicated that the DASH-JUMP diet significantly increased the participants' self-efficacy and promoted positive health behavior change. Health behavior change was motivated by previous behavioral changes and improved biomarkers. The improvement and maintenance of self-efficacy were deeply associated with health behavior change and previous self-efficacy. The experiences of the DASH-JUMP study for the participants included the three processes of reflecting on their past eating habits, increasing their awareness of the importance of diet for maintaining their health and further improvement of their awareness of self-health management approaches. Providing the DASH-JUMP diet by home delivery may increase self-efficacy not only for people with a high initial self-efficacy but also for those with a low initial self-efficacy.

STUDY LIMITATIONS

The present study has several limitations. First, because the DASH-JUMP study was a small-scale and single-arm trial, the statistical power was low. Second, the participants in this study might have had a higher than average health consciousness because they sought to participate as subjects in the dietary intervention. Finally, this study was a short-term trial. Before we can generalize the findings, we need to conduct a long-term intervention study with the DASH-JUMP diet and evaluate its effects.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Our study protocol was approved by the Ethics Committee of Yamaguchi University Faculty of Medicine and Health Sciences, China.

HUMAN AND ANIMAL RIGHTS

No animals were used in this study. All human procedures were followed in accordance with the principles of the Declaration of Helsinki.

CONSENT FOR PUBLICATION

Patient consent were obtained..

FUNDING

None.

CONFLICT OF INTEREST

The authors received research funding from Maruha Nichiro Co., Ltd. (Tokyo, Japan). The DASH-JUMP study was a collaborative investigation between Maruha Nichiro Co., Ltd. and Yamaguchi University. Dr. Hiroshi Oda, Mr. Makoto Mitarai are employees of Central Research Institute, Maruha Nichiro Corporation. All authors declared no conflicts of interest.

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