Original

The Effect of Problem-Solving-Based Blood Glucose Management through Real-Time Self-Monitoring: A Case Study

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ABSTRACT *Background and Purpose* This study aimed to develop a nutrition education *program* for high school students and evaluate whether its implementation in regular classes improves health literacy (hereafter referred to as HL), health/eating knowledge, attitudes, and behaviors.*Methods* A non-randomized controlled trial was conducted with 98 high school students, divided into an intervention group (57 students) and a control group (41 students) at the class level. The primary endpoints were changes in HL and eating behaviors, while the secondary endpoints were changes in health awareness, attitudes, and knowledge. The intervention group participated in a total of four lessons using the nutrition education *program* composed of a card game, videos, three-color food cards, and cooking practice, while the control group received only a single lesson on health promotion. A pre- and post-intervention questionnaire surveys were conducted, along with a process evaluation based on feedback from both students and teachers. *Results* We conducted a per-protocol analysis on 47 students (83.9%) in the intervention group and 26 students (63.4%) in the control group who completed the follow-up. No significant changes in HL were observed during the intervention period in either group, and no significant differences were found between the groups. The significant improvements in the intervention group compared to the control group were observed only in the items related to health knowledge: the term BMI and its appropriate range, and lean body mass. In the process evaluation, high school students showed interest in the nutrition education program, and teachers expressed a desire to continue incorporating it into their classes. *Conclusion* No significant intervention effects were observed in HL, eating behaviors, or health awareness and attitudes. However, the process evaluation revealed positive feedback from students or teachers, indicating that the nutrition education *program* could be accepted and feasible in the school setting.

Keywords: high school students, health literacy, nutrition education *program*

INTRODUCTION

In recent years, health literacy (hereafter referred to as HL) has gained attention as a concept that enables individuals to obtain, understand, evaluate, and utilize health information (1), allowing them to maintain and promote their health throughout their lives (2). Developing HL through health education is not merely about understanding knowledge but is emphasized as a practical ability to recognize issues, make decisions, and take action using communication and social skills to maintain and improve health (3). On the other hand, during childhood and adolescence in which health risks have not still become apparent, it is presumed that active efforts to enhance HL are necessary from the perspective of acquiring healthy lifestyle habits. Research on HL has indicated a correlation between adolescent nutrition, physical activity, and HL, and intervention programs have been recommended to enhance HL (4). However, studies on HL (5,6) and observational research on HL among high school students (7,8) remain limited in Japan.

The high school curriculum guidelines (9) emphasize "thinking and decision-making skills" and state that students should "gather necessary information, acquire knowledge, and make judgments and decisions." Furthermore, they highlight the need for appropriate decision-making, behavioral choices, and the creation of environments that support health. High school represents the final stage in which school-based interventions can be implemented, while also being a period of increasing lifestyle diversity and prominent

nutritional challenges. Therefore, the development of a nutrition education *program* (hereafter referred to as *the program*) and intervention research are necessary.

Accordingly, this study reports on the development process and evaluation of *the program* aimed at improving HL, which can be incorporated into formal high school classes in Japan.

MATERIALS AND METHODS

2-1. Setting, Participants, and Ethical Considerations

A non-randomized controlled trial was conducted at two high schools, with 57 students assigned to the intervention group and 41 students to the control group at the class level.

We requested cooperation to the target schools, and after discussions and coordination with the school principals and teachers in charge, written explanations were provided to the students and their guardians to obtain informed consent. Participation was voluntary, and it was explained that responses would not affect grades or result in any disadvantages. Since the study was conducted during regular classes, to ensure anonymity during the consent process, documents were distributed and collected in sealed envelopes individually.

The study was reviewed and approved by the Research Ethics Committee of Aomori University of Health and Welfare (Approval No. 22059).

2-2. Study Procedure (Fig. 1)

The intervention and data collection period lasted four months, from November 2022 to March 2023. Pre- and post-intervention surveys were conducted to assess changes in HL, eating behaviors, health awareness and attitudes, and health knowledge.

The baseline survey was conducted for both groups before the first lesson, and the post-intervention survey was conducted at the end of the four-month *program* for the intervention group and at the same time for the control group. The primary endpoints were changes in HL and eating behaviors, while the secondary endpoints were changes in health awareness, attitudes, and knowledge. The intervention group participated in four lessons using *the program*, while the control group received a single lesson on health promotion. Additionally, a process evaluation was conducted based on feedback from students and teachers.

Date	Frequency	Time	Intervention †	Control ‡
2022 /11	1	50min	★Pre-survey Health promotion for adolescents(1) Card games(1) Videos	★Pre-survey Health promotion for adolescents
	2	50min	Health promotion for adolescents(2) Card games(2) Three-color food cards	
2023 /3	3	50min	Cooking practice	
	4	50min	Tasting and reflection ★Post-survey	★Post-survey

† The intervention group incorporated puberty health promotion, card games, videos, three-color food cards, and cooking practical sessions.
The lessons were structured as four 50-minute sessions, all conducted in person.
‡ The control group participated in one session of health promotion education for adolescence and completed a self-administered questionnaire survey with identification.

Fig 1. Research flow

2-3. Structure and Materials of the Nutrition Education Program (Fig. 2)

The program incorporated games, videos, three-color food cards, and cooking practice with the aim of fostering the ability to obtain, understand, evaluate, and utilize health information. To design the intervention content, we conducted a needs assessment and survey among high school students (10). The

survey (10) indicated that more than 50% of students were unaware of the "appropriate BMI range," yet many reported being "dissatisfied with their current weight." Furthermore, students identified "weighing themselves" and "cooking" as burdensome activities. In response, the lectures provided detailed explanations on appropriate BMI ranges and lean body mass, and students were guided through BMI calculations.

Based on the results, we developed *the program*. To maintain engagement, *the program* was not limited to lectures but also incorporated interactive elements such as games, videos, three-color food cards, and cooking practice to create a dynamic learning experience.

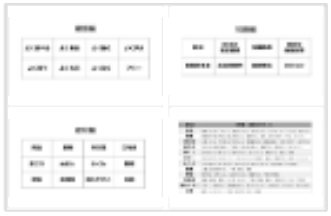
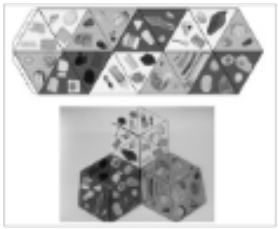
	Card games	Videos	Three-color food cards
Contents ・ Composition	Learn through games (health edition, knowledge edition, symptoms edition), become aware of your own and others' thoughts, physical discomfort, and bodily changes, and promote interactive communication.	University students created materials on the theme of "women's thinness," allowing high school students to deepen their understanding of the current state of thinness among Japanese women, the reasons for the increasing desire to be thin, DOHaD, and more, leading to greater awareness.	Understand food balance, learn its connection to cooking practice, and decide on ingredients for the cooking session. Create and use folded cards.
			

Fig 2. Content and structure of the nutrition education program

1) Card Game

Since positive feedback was received regarding the use of games in class, we determined that including the game in *the program* would not pose significant issues. The game's concept was to "imagine the feelings of others experiencing physical discomfort and communicate with them to foster mutual understanding."

High school students rarely have opportunities to discuss topics related to health or disease prevention. As a result, they struggle to verbalize symptoms of physical discomfort and remain dissatisfied with their weight despite lacking knowledge of appropriate BMI range. The game was designed to help students learn about "health" "knowledge " and "symptoms " . Through this interactive experience, students could recognize their own and others' perspectives, symptoms of discomfort, and bodily changes, while also improving their ability to communicate their symptoms to others (10).

2) Video

A lack of adequate health education has been identified as a factor contributing to underweight issues and insufficient energy intake among females (11). To address this, we requested university students to collaborate for creating a video on the theme of "female thinness." The video aimed to enhance understanding of the current state of underweight women in Japan and the reasons behind the growing desire to be thin, making the content easier to comprehend.

Many of the university students involved had previously experienced weight-related concerns and dieting during their high school years, recognizing the importance of effective initiatives to improve high school students' HL. Therefore, we incorporated a peer education approach, allowing university students to share important health-related information and promote a healthy body image among high school students. The goal was to create an engaging and informative learning experience.

The video consisted of two sections: a lecture and a cooking demonstration. Narration was provided by university students. The featured dish was "*Komatsuna* Fried Rice," which could be easily prepared using a single frying pan. The ingredients consisting of rice, *komatsuna* (Japanese mustard spinach), eggs, dried

whitebait, green onions, and sesame seeds, were selected to address deficiencies in energy, iron, and calcium intake.

3) Three-Color Food Cards

The three-color food card system which divides food into red, yellow, and green groups based on their functions is commonly used in school meal programs in primary and secondary schools. Therefore, we adopted it as a reference material because high school students are thought to be familiar with it.

In addition to learning about food balance, students were encouraged to apply this knowledge to cooking practice. *The program* was designed to help students understand food selection and meal planning, addressing difficulties they had previously identified, such as "cooking," "considering nutritional balance," and "planning meal combinations" (10).

The author proposed multiple (three to five) menu options, and students engaged in discussions to select a menu. They then determined the ingredients and portion sizes for their chosen meal.

4) Cooking Practice

The "Food and Nutrition" component of the home economics curriculum (12) emphasizes efficient cooking methods and their application to meal planning and menu creation. During discussions on the nutrition education *program*, teachers highlighted that students' dietary intake was often inadequate and that they had limited opportunities to cook. Based on this finding, we incorporated a cooking practice session where students selected their own menu.

The selected dish was "*Onigirazu*"—a sandwich-like rice ball that does not require shaping by hand. Using the knowledge gained from the three-color food card activity, students planned the ingredients and portions based on the following categories:

1. Yellow: Energy-providing foods
    - Rice, oil, mayonnaise
2. Red: Body-building foods (supporting blood, muscles, bones, and teeth)
    - Eggs, tuna, ham, seaweed, edamame
3. Green: Body-regulating foods (supporting skin, mucous membranes, and various body functions)
    - Spinach, tomatoes, cucumbers, carrots

For the cooking session, students were divided into groups of three per cooking station, with ingredients and utensils pre-prepared. The cooking process involved spreading half of the rice onto a sheet of seaweed, layering the chosen ingredients, adding the remaining rice, and folding the seaweed from all four corners. After explaining safety precautions, a demonstration was conducted, followed by hands-on cooking. Each student prepared their dish creatively and took photos of their completed meal.

2-4 Evaluation Methods

1) Questionnaire Composition

Basic information being collected only in the pre-intervention survey included grade level, age, gender, height, weight, and club activity participation. The pre- and post-intervention surveys assessed HL, eating behaviors, health awareness and attitudes, health knowledge, daily routines, exercise frequency, and menstrual records. HL was measured using the Communicative and Critical Health Literacy (CCHL) scale (13).

2) Data Collection and Analysis

The questionnaire was administered twice before and after the intervention in a self-reported format. Survey forms were distributed and collected in sealed envelopes to ensure confidentiality. Participants who were absent, left questions blank, or failed to provide their names were excluded from the analysis. A per-protocol analysis was conducted for the remaining participants.

Intra-group comparisons and inter-group comparisons were analyzed for HL, eating behaviors, health awareness and attitudes, health knowledge, daily routines, exercise frequency, and menstrual records.

Statistical power was set at 80%, with a 5% alpha error. A medium effect size ($d = 0.50$) was used to calculate a required sample size of 26 participants per group using G*Power 3.1.9.7.

For group comparisons of HL scores and baseline characteristics, t-tests were conducted. Pre- and post-intervention comparisons within groups were analyzed using the Wilcoxon signed-rank test for ordinal variables and McNemar's test for nominal variables. Mann-Whitney U tests were used for inter-group comparisons of changes. Missing data were treated as missing values. Statistical analyses were performed using IBM SPSS Statistics Ver. 29® (IBM Japan), with a significance level of <5% (two-tailed).

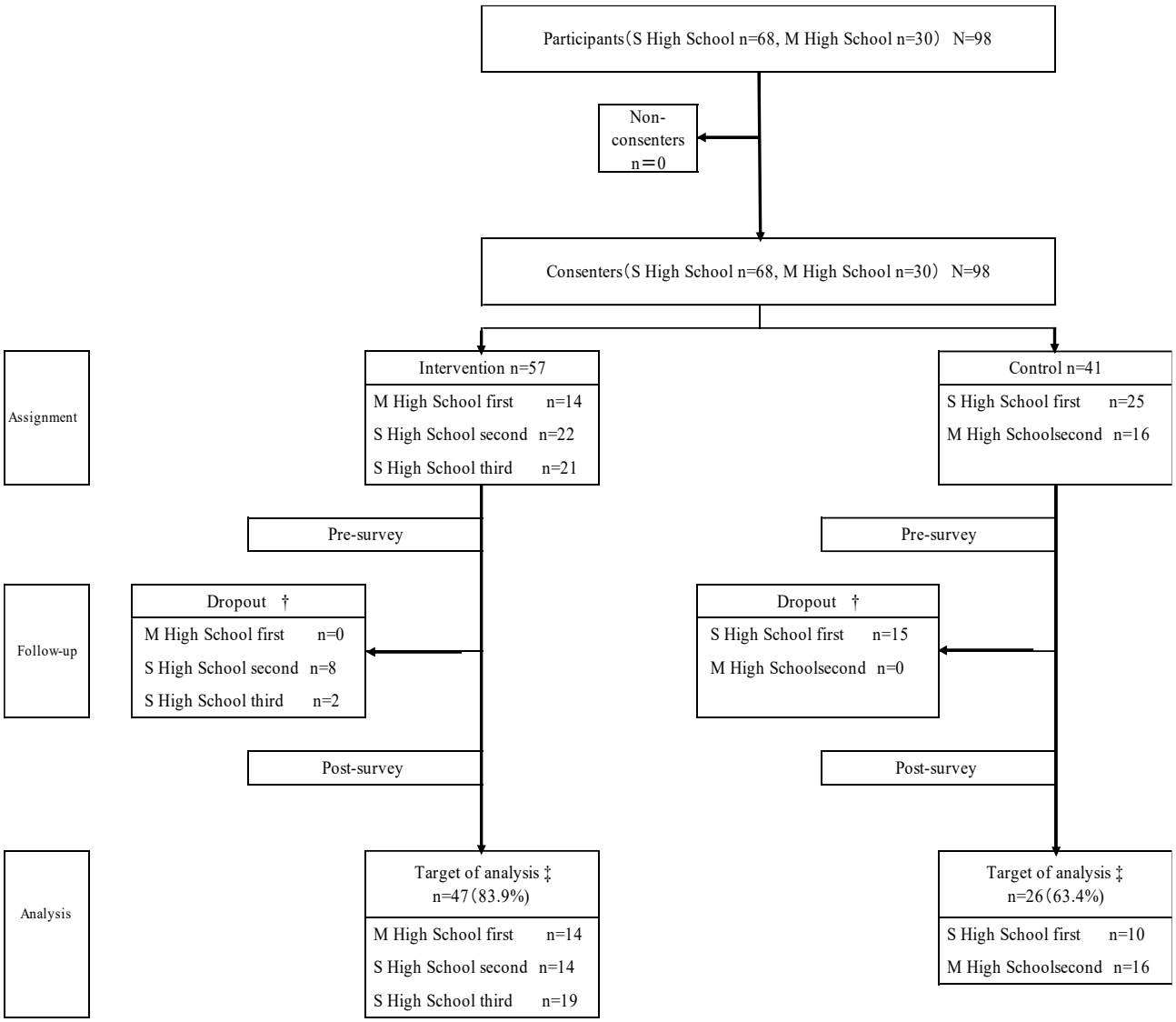
3) Process Evaluation

Process evaluation was conducted based on *program* implementation status, student feedback, and teacher comments. Free-response feedback from students was categorized into themes related to games, lessons, and cooking practice. Teacher feedback was classified into observations of student engagement and opinions on

the program.

RESULTS

The number of participants included in the analysis was 47 (83.9%) in the intervention group and 26 (63.4%) in the control group (Fig. 3).



It was targeted at first, second, and third-year students from five classes at S High School and M High School.
Consent was obtained from all participants, and the allocation was done by high school and grade (by class)
The dropout rate was 28% in the intervention group and 60% in the control group at S High School, while at M High School, the dropout rate was 0% in both the intervention and control groups.
† Dropout refers to those who were absent from the classes, attended but did not fill out the questionnaire items, or filled out the questionnaire but did not provide their name, making it impossible to conduct pre- and post-comparisons.
‡ Analysis subjects refer to those who are identified by name and have no missing responses.

Fig 3. Comparison test flow chart

3-1 Basic Information of Participants

No significant differences were observed between the intervention and control groups (Table 1).

Table 1. Basic attributes

	Intervention		Control	
	n=47	SD	n=26	SD
Age	16.6	0.79	16.4	0.80
Height (cm)	163.5	9.16	160.0	8.07
Weight (kg)	57.0	12.66	54.3	13.99
Body Mass Index (kg/m²)	21.3	4.12	21.0	3.76
Gende Boys	20人(43%)		5人(24%)	
Girls	27人(57%)		21人(76%)	
Sports Club	21人(45%)		11人(42%)	
Non-Sports Club	26人(55%)		15人(58%)	

N=73

Age, height, weight, and BMI are presented as the mean and standard deviation.

Gender and club activity are presented as the number of participants (%).

3-2 Primary Endpoint

1) HL Score (Table 2, 3)

The mean HL score before the intervention was 3.85 (SD 0.86) in the intervention group and 4.01 (SD 0.47) in the control group, with no significant differences between the groups at baseline.

After the intervention, the mean HL score was 3.94 (SD 0.62) in the intervention group and 3.90 (SD 0.58) in the control groups.

There were no significant changes in the mean HL scores before and after the intervention within each group, nor were there significant differences between the intervention and control groups.

A comparison of pre-intervention HL score averages by grade level showed that first-year students had a mean of 3.91 (SD 0.62) and second-year students had a mean of 3.79 (SD 0.68), with no significant differences between them.

Table 2. Comparison of overall distribution of health literacy scores

		Total HL score														
		5-9		10-14		15-19		20-24		25		Median	Interquartile range		$P^{\dagger}$	$P^{\ddagger}$	$P^{\S}$
		n	(%)	n	(%)	n	(%)	n	(%)	n	(%)						
Whole (n=73)	Pre	2	(2.7)	2	(2.7)	29	(39.7)	34	(46.6)	6	(8.2)	20	(17 | - 22)	0.728	-	-
	Post	1	(1.4)	4	(5.5)	26	(35.6)	35	(47.9)	7	(9.6)	20	(18 | - 21)			
Intervention (n=47)	Pre	2	(4.3)	2	(4.3)	18	(38.3)	20	(42.6)	5	(10.6)	20	(17 | - 22)	0.862	0.862	0.839
	Post	1	(2.1)	2	(4.3)	17	(36.2)	21	(44.7)	6	(12.8)	20	(18 | - 21)			
Control (n=26)	Pre	0	(0.0)	0	(0.0)	12	(46.2)	14	(53.8)	0	(0.0)	20	(18 | - 22)	0.404	-	-
	Post	0	(0.0)	2	(7.7)	8	(30.8)	15	(57.7)	1	(3.8)	20	(18 | - 22)			

†: For the comparison between pre-intervention and post-intervention, the Wilcoxon signed-rank test was conducted.

‡: For the comparison between the intervention group and the control group before the intervention, the Mann-Whitney U test was conducted.

§: For the comparison between the intervention group and the control group after the intervention, the Mann-Whitney U test was conducted.

Table 3. Comparison of mean health literacy scores

		n	HL Mean	SD	*P*
H L Before and after	Intervention	47	0.094	0.62	0.11 †
(Post - pre)	Control	26	-0.108	0.43	
Intervention	Post	47	3.94	0.74	0.31 ‡
	Pre	47	3.85	0.86	
Control	Post	26	3.90	0.58	0.22 ‡
	Pre	26	4.01	0.47	
Pre Boys		25	3.95	0.83	0.47 †
Pre Girls		48	3.90	0.74	
Pre first-year students		24	3.91	0.62	0.68 †
Pre second-year students		30	3.79	0.68	
Pre third-year students		19	3.93	0.85	

N=73

† For the between-group comparison, the Mann-Whitney U test was conducted.

‡ For the within-group comparison, the Wilcoxon signed-rank test was conducted.

2) Eating Behavior, Daily Routine, Exercise Frequency, and Menstrual Records(Table.4)

There were no significant changes before and after the intervention within either the intervention or control groups, and no significant differences were observed between the groups.

Table 4. Food behavior, lifestyle, exercise frequency, and menstrual records

		Intervention (n=43)			Control (n=26)			Intervention vs Control	
		Pre	Post		Pre	Post		Pre	Post
		n %	n %	$P^{\dagger}$	n %	n %	$P^{\dagger}$	$P^{\ddagger}$	$P^{\ddagger}$
Breakfast	Eat almost every day	34 (72.4)	33 (70.3)	0.317	23 (88.5)	21 (80.8)	0.48	0.118	0.293
	Eat 2-3 times a week	9 (19.1)	9 (19.1)		2 (7.7)	4 (15.4)			
	Hardly eat	4 (8.5)	5 (10.6)		1 (3.8)	1 (3.8)			
Lunch	Eat almost every day	42 (89.3)	42 (89.3)	0.317	25 (96.2)	26 (100.0)	0.317	0.298	0.087
	Eat 2-3 times a week	2 (4.3)	3 (6.4)		1 (3.8)	0 (0.0)			
	Hardly eat	3 (6.4)	2 (4.3)		0 (0.0)	0 (0.0)			
Dinner	Eat almost every day	45 (95.7)	46 (97.9)	0.564	25 (96.2)	23 (88.5)	0.157	0.933	0.093
	Eat 2-3 times a week	2 (4.3)	1 (2.1)		1 (3.8)	3 (11.5)			
	Hardly eat	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)			
Cooking	Almost every day	5 (10.6)	7 (14.9)	1	4 (15.4)	2 (7.7)	0.014	0.723	0.361
	Make it 2-3 times a week	23 (48.9)	19 (40.4)		12 (46.2)	10 (38.5)			
	Hardly cook	19 (40.5)	21 (44.7)		10 (38.5)	14 (53.8)			
Bedtime (weekdays)	Before 10p.m	4 (8.5)	3 (6.4)	0.74	5 (19.2)	2 (7.7)	0.059	0.245	0.518
	10 to 11p.m	6 (12.8)	8 (17.0)		4 (15.4)	6 (23.1)			
	11p.m to midnight	21 (44.7)	19 (40.4)		10 (38.5)	10 (38.4)			
	After midnight	16 (34.0)	17 (36.2)		7 (26.9)	8 (30.8)			
Bedtime (holidays)	Before 10p.m	3 (6.4)	3 (6.4)	1	3 (11.5)	3 (11.5)	0.705	0.604	0.697
	10 to 11p.m	4 (8.5)	4 (8.5)		3 (11.5)	2 (7.7)			
	11pm - midnight	17 (36.2)	17 (36.2)		8 (30.8)	9 (34.6)			
	After midnight	23 (48.9)	23 (48.9)		12 (46.2)	12 (46.2)			
Wake-up time (weekdays	Before 6 o'clock	19 (40.4)	15 (31.9)	0.034	8 (30.8)	10 (38.5)	0.705	0.849	0.519
	From 6 to 7	20 (42.6)	24 (51.0)		16 (61.5)	13 (50.0)			
	From 7 to 8	8 (17.0)	6 (12.8)		2 (7.7)	1 (3.8)			
	After 8 o'clock	0 (0.0)	2 (4.3)		0 (0.0)	2 (7.7)			
Wake-up time (holidays)	Before 6 o'clock	2 (4.3)	1 (2.1)	0.331	3 (11.5)	3 (11.5)	0.763	0.922	0.877
	From 6 to 7	10 (21.3)	8 (17.0)		2 (7.7)	3 (11.5)			
	From 7 to 8	15 (31.9)	18 (38.3)		10 (38.5)	7 (26.9)			
	After 8 o'clock	20 (42.5)	20 (42.6)		11 (42.3)	13 (50.1)			
Sleep time (weekdays)	Less than 6 hours	19 (40.4)	21 (44.7)	0.763	9 (34.7)	7 (26.9)	0.763	0.115	0.043
	6 to 7 hours	21 (44.7)	18 (38.3)		7 (26.9)	10 (38.5)			
	7 to 8 hours	6 (12.8)	7 (14.9)		5 (19.2)	4 (15.4)			
	Over 8 hours	1 (2.1)	1 (2.1)		5 (19.2)	5 (19.2)			
Sleep time (holidays)	Less than 6 hours	3 (6.4)	4 (8.5)	0.334	1 (3.8)	2 (7.7)	0.386	0.232	0.323
	6 to 7 hours	13 (27.7)	16 (34.1)		5 (19.2)	5 (19.2)			
	7 to 8 hours	17 (36.1)	12 (25.5)		9 (34.6)	9 (34.6)			
	Over 8 hours	14 (29.8)	15 (31.9)		11 (42.4)	10 (38.5)			
Exercises other than physical education	Hardly ever	16 (34.0)	17 (36.2)	0.763	4 (15.4)	4 (15.4)	0.655	0.065	0.035
	2-3 days a week	16 (34.0)	15 (31.9)		9 (34.6)	8 (30.8)			
	Every day	15 (32.0)	15 (31.9)		13 (50.0)	14 (53.8)			
Menstruation	Recording, aware of the cycle	12 (44.4)	9 (33.3)	0.681	8 (38.1)	9 (42.9)	0.705	0.894	0.467
	Recording, but not aware of the cycle	2 (7.4)	4 (14.8)		4 (19.0)	4 (19.0)			
	Not recording, aware of the cycle	10 (37.0)	12 (44.5)		8 (38.1)	6 (28.6)			
	Not recording, and not aware of the cycle	3 (11.1)	2 (7.4)		1 (4.8)	2 (9.5)			

N=73

Menstrual record =48

†: A comparison of pre- and post-intervention within the group was conducted using the Wilcoxon signed-rank test.

‡: A comparison of pre- and post-intervention between groups was conducted using the Mann-Whitney U test.

3-3 Secondary Endpoint

1) Health Awareness and Attitudes (Table 5)

No significant changes were observed before and after the intervention within either the intervention or control groups, nor were there any significant differences between the groups.

Table 5. Health awareness

		Intervention (n=47)			Control (n=26)			Intervention vs Control	
		Pre	Post		Pre	Post		Pre	Post
		n %	n %	$P^{\dagger}$	n %	n %	$P^{\dagger}$	$P^{\ddagger}$	$P^{\ddagger}$
My weight	Not satisfied	34 (72.3)	30 (63.8)	0.102	19 (73.1)	16 (61.5)	0.083	0.947	0.847
	satisfied	13 (27.7)	17 (36.2)		7 (26.9)	10 (38.5)			
My condition	Not satisfied	26 (55.3)	16 (34.0)	0.008	10 (38.5)	7 (26.9)	0.102	0.29	0.533
	satisfied	21 (44.7)	31 (66.0)		16 (61.5)	19 (73.1)			

N=73

†: A comparison within the group was conducted using the McNemar test.

‡: A comparison between groups was conducted using the chi-square test.

In the intervention group, approximately 90% of participants rated five out of seven items—"adequate sleep," "balanced physique," "moderate exercise," "eating three meals a day," and "paying attention to dietary balance", as important (either "very important" or "important") both before and after the intervention.

2) Health Knowledge (Table 6)

In the intervention group, significant changes were observed before and after the intervention regarding knowledge of "the term BMI," "the appropriate BMI range," "lean body mass," and "one's own physical condition."

When comparing between groups, significant differences were found in "The term BMI", "The appropriate BMI range", and "Lean body mass".

Table 6. Health knowledge

		Intervention (n=47)			Control (n=26)			Intervention vs Control	
		Pre	Post		Pre	Post		Pre	Post
		n %	n %	$P^{\dagger}$	n %	n %	$P^{\dagger}$	$P^{\ddagger}$	$P^{\ddagger}$
The term BMI	Don't know	14 (29.8)	3 (6.4)	<0.001	8 (30.8)	8 (30.8)	1	0.931	0.006
	Iknow	33 (70.2)	44 (93.6)		18 (69.2)	18 (69.2)			
Normal BMI range	Don't know	34 (72.3)	13 (27.7)	<.001	20 (76.9)	17 (65.4)	0.083	0.671	0.002
	know	13 (27.7)	34 (72.3)		6 (23.1)	9 (34.6)			
Lean body mass	Don't know	40 (85.1)	23 (48.9)	<.001	24 (92.3)	19 (73.1)	0.025	0.373	0.047
	know	7 (14.9)	24 (51.1)		2 (7.7)	7 (26.9)			

N=73

†: A comparison within the group was conducted using the McNemar test.

‡: A comparison between groups was conducted using the chi-square test.

3-4 Process Evaluation

1) Students' Free Responses

The following comments were extracted as free responses.

(1) Card Game

- There were many words I didn't know.
- Using the symptom cards in the game helped me realize what symptoms I might have.
- If I know, I can approach things confidently and positively.
- I learned not to be swayed by incorrect information and to gather reliable information.

(2) Lessons

- I didn’t know the BMI criteria before.
- If you focus too much on weight, it can lead to amenorrhea or osteoporosis.
- There is a lot of information, and I need to decide whether it's true or false.

(3) Cooking Class

- I feel like I could make this at home.
- I used to skip breakfast, but I realized that eating breakfast makes my day more enjoyable.
- I found cooking fun.
- Since I love eating, I felt very happy during the cooking class.
- I will try to eat more and increase my portion sizes.
- I plan to cook at home, even if it's just a little.
- I will start by being more conscious of eating breakfast and small things.
- I think I will try cooking at home.

2) Teacher Feedback

The following comments were extracted as free responses.

(1) Student Behavior

- In cooking classes, students showed creativity and initiative, and they became more interested in food.
- After the cooking class, some students brought their own lunch or snacks, saying, “I can make this with what I have at home.”
- Students felt a sense of familiarity with the video created by college students and showed interest in the simple recipes.

(2) Nutrition Education Program

- *The program* catered to students who had difficulty engaging or had varying interests, and continued participation led to knowledge retention. I want to incorporate it into future lessons.
- Before participating in *the program*, students only used the height and weight scales in the hallway of the health room. After the program, they were seen calculating their BMI after measuring their height and weight.

DISCUSSION

4-1 Health Literacy (HL)

1) Comparison with Previous Research Using the Measurement Scale

In this study, the pre-intervention mean HL score for the intervention group was 3.85 (SD 0.86), and for the control group, it was 4.01 (SD 0.47). This is comparable to the study by Kasahara et al. (8), which reported average HL scores of 3.66 (SD 0.81) for males and 3.71 (SD 0.68) for females. There was no significant difference when comparing the results of this study with those of Kasahara et al.

2) Within-group and Between-group Comparisons

For each item, there were no changes observed within the intervention group or the control group when comparing pre- and post-intervention surveys. Additionally, no significant differences were found when comparing the pre- and post-intervention surveys between the intervention and control groups. Regarding the interactive HL measurement scale, 34.0% of respondents agreed somewhat, and 55.3% strongly agreed with the information gathering items. However, there was significant variability in responses for information extraction, communication, critical HL, reliability judgment, and decision-making.

It has been reported that previous school health education primarily focused on the transmission of basic health knowledge, without providing skills to engage in community activities (14). *The program* developed in this study aimed to go beyond knowledge transmission, incorporating activities designed to foster active engagement and dialogue, allowing students to participate interactively.

Despite the positive intent and structured design of *the program*, the absence of significant changes in HL, eating behavior, and attitudes towards health suggests the need for further exploration and refinement of such *programs*. The lack of significant effects may be related to factors such as the duration of the intervention, the specific content delivered, or the engagement level of students with the materials and activities provided.

4-2 Eating Behavior and Eating Habits

1)Teacher Feedback

Teachers reported positive outcomes, such as students becoming more interested in cooking and bringing breakfast or lunch from home. In particular, students showed creativity during cooking classes, taking an active interest in food preparation. Feedback highlighted that *the program* helped students gain interest in meal planning and cooking, making it an important foundation for maintaining healthy eating habits.

3) Cooking Frequency and Future Implications

Around half of the students responded that they cooked "2-3 times a week," which may be influenced by the busy schedules of high school students with academics and extracurricular activities. However, it is expected that after graduation, when students often live independently, the frequency of cooking will increase. The hands-on cooking experiences and food-related activities in *the program* help reduce the burden and anxiety around cooking, encouraging students to enjoy the process. Feedback included comments like "cooking is fun" and "it's delicious when you eat together," which suggests that *the program* fostered a positive attitude toward cooking and shared meals.

4-3 Health Awareness and Attitudes

1)Pre- and Post-Intervention Health Awareness

Around 90% of students in both the intervention and control groups indicated that aspects such as "sleep" and "balanced body composition" were important both before and after the intervention. This suggests that a baseline awareness already existed among students. The program's interactive nature, which encouraged listening to others' opinions and engaging in two-way communication, was thought to reinforce these attitudes and maintained health awareness.

2)Body Weight and Satisfaction

Following the intervention, more students expressed satisfaction with their body weight, and learning how to calculate BMI and understand the criteria helped correct misconceptions about body image and weight. Additionally, increased satisfaction with their physical condition was observed, as students were able to reflect on and understand their symptoms and health status through discussions with peers.

4-4 Health Knowledge

1)Knowledge Acquisition and Behavior Change

A positive change in health knowledge was observed in the intervention group, especially concerning decision-making processes related to health. This suggests a direct effect of the program on students' knowledge. Acquiring knowledge about health is crucial for the prevention of lifestyle diseases. The process of actively engaging in discussions and learning from each other is expected to strengthen problem-solving abilities, and repeated learning is essential for effective retention.

2) Comparison with Other Studies

The LifeLab program based at Southampton University Hospital has reported lasting changes in HL and critical judgment related to personal behaviors (16). This program, combined with other studies, has led to an increase in awareness and positive changes in attitudes regarding adolescent health. Although HL improved, knowledge alone did not result in behavioral changes, suggesting that sustainable behavior change requires further research. Teachers also need training in supporting students to make healthier choices.

3)Further Considerations

While knowledge about health improved through the program, there were no substantial behavioral changes or lasting transformation in health habits. This underscores the challenge of achieving long-term behavior change. For sustainable change, students need to develop the ability to identify challenges in their own lifestyles and to select and apply accurate health information. It is also important to consider integrating family support and feedback into the program. Health education that focuses on information collection, discussion, critical thinking, and decision-making can play a significant role in fostering long-term health literacy.

4-5 Process Evaluation

In this study, no negative feedback was received about *the program*. On the contrary, the majority of the participants found *the program* to be enjoyable and engaging, providing a fun and interactive learning experience. Instead of passively acquiring knowledge, the students were able to engage in active and dialogic learning, creating a relaxed atmosphere where they could freely discuss health issues and physical conditions. This type of two-way communication was useful in drawing out the students' interest and attention.

1) Students' Free Descriptions

(1) Card Game

Students reported that the card game helped them recognize their own symptoms and approach health issues with a positive attitude. The game made them aware that symptoms can vary from person to person, which led to an appreciation for different perspectives. The card game allowed students to gain a deeper understanding of their symptoms, and they recognized the importance of gathering accurate information for health improvement.

(2) Class

During the lessons, students were able to select actions and plans to improve their health based on the information provided, which helped them critically evaluate and choose reliable information. The use of active learning in high school classes is expected to led students to think more comprehensively, expand their ideas, and deepen their understanding. Dialogic learning seemed particularly effective, and students were able to acquire information, evaluate it, make decisions, and apply critical thinking.

(3) Cooking Classes

In cooking classes, even students who usually participated less in regular lessons became more active and engaged. The cooking activities allowed students to set realistic and achievable health goals. Moreover, they learned the joy of cooking and the importance of eating meals. Recent trends, such as the rising popularity of "*Onigirazu"* (rice ball wraps), which is easy to prepare and eat, fit well into the curriculum and helped reduce skipping meals and provide a convenient snack option. These cooking lessons seemed as valuable in promoting health.

2) Teacher Feedback

Teachers noted that students' interest and engagement in the program increased as they learned about their own bodies. Given that high school graduation marks a time when students' lifestyle habits change significantly, introducing such programs is expected to enhance students' motivation for health improvement. Teachers expressed positive feedback, and some mentioned they desire to keep using *the program* in the future. They also felt that *the program* could be easily implemented in high school classes.

4-6 Limitations of the Study

To assess the true effects of the intervention, a randomized controlled trial would be ideal. However, conducting such an experimental design in real-world school settings is often challenging. Therefore, this study adopted a quasi-experimental design with a non-randomized control group, conducting the intervention in two high schools with practical field constraints. The participants in this study may have had a high level of interest or concern about food and nutrition, which could have influenced the outcomes. While the program was designed to encourage active participation and knowledge transfer, there was insufficient consideration of activities to foster critical thinking during the application of this knowledge. Further research could improve these aspects to strengthen t*he program's* effectiveness.

CONCLUSION

This study developed a nutrition education *program* aimed at improving health literacy (HL) among high school students and implemented it through an intervention trial in classrooms. However, it was not possible to demonstrate whether *the program* led to healthier eating habits. On the other hand, students were able to actively and dialogically engage in learning, gain a better understanding of their own health, and develop an interest in the nutrition education *program*. Teachers expressed interest in continuously incorporating *the program* into their lessons, and the feasibility of implementation in schools was favorable.

For high school students, it was crucial to cultivate the ability to obtain, understand, evaluate, and apply health information, as well as to develop the process of critical thinking to address health issues related to their lifestyles. Introducing health education in the classroom and allowing students to acquire knowledge was effective and highly satisfactory. It is believed that this would lead to improved HL and support long-term, healthy behaviors and appropriate decision-making in the future.

In light of this, to enhance the feasibility of introducing the developed nutrition education *program* in classrooms, standardization of t*he program's* procedures and content is necessary. *The program* will be refined to improve HL from the perspective of developing problem-solving skills for health issues. A more sophisticated research design will be used to conduct a follow-up intervention study.

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