Changes in Problematic Mealtime behaviors among 3- to 6-Year-Old Children Following Sapere-Based Sensory Education: A Pre-Post Intervention Study

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Abstract: *Introduction:* Feeding difficulties are commonly observed in children, especially those with developmental concerns. This study aimed to evaluate the effects of Sapere-based sensory education on mealtime behavior and food acceptance in preschool-aged children using a pre-post intervention design.

Methods: A quasi-experimental, multi-site prospective study was conducted with 148 children aged 3 to 6 years. Participants were divided into two groups: 74 children with problematic mealtime behavior (PMB), assessed using the ASD-Mealtime Behavior Questionnaire, and74 age- and sex-matched non-PMB in contrast. Food pickiness and neophobia were evaluated using a validated food rejection scale. The intervention consisted of sensory-based dietary education using the Sapere method, with assessments conducted before and six months after the intervention.

Results: Significant improvements were observed in the PMB group following the intervention. Specifically, reductions were observed in clumsiness/manners (–4.2 ± 0.8, $p < 0.001$), interest/concentration during eating (–1.7 ± 0.7, $p = 0.014$), and oral motor function difficulties (–1.0 ± 0.5, $p = 0.039$). Food pickiness also showed a significant decrease (–1.4 ± 0.4, $p = 0.002$). Although selective eating and food neophobia showed downward trends, the changes were not statistically significant. In contrast, no significant changes were noted in the non-PMB group for any behavioral or food rejection measures.

Conclusion: Sapere-based sensory education may effectively reduce problematic mealtime behaviors and food pickiness among preschool-aged children. These findings support the potential utility of sensory-based interventions for promoting healthy eating behaviors in early childhood.

Keywords: Preschool children, mealtime behavior, Sapere method, sensory education.

INTRODUCTION

Early life exposure to a variety of tastes and flavors plays a vital role in shaping long-term dietary habits and promoting healthy eating. Feeding difficulties are frequently observed in young children, particularly those with developmental challenges [1-5]. Dietary patterns established during early childhood can significantly influence health outcomes across one's lifespan. Food neophobia and pickiness are common barriers to achieving a healthy diet in children [6,7]. Food neophobia, defined as the reluctance to try unfamiliar foods, typically emerges around the age of two and remains most prominent between the ages of two and six. Although it is considered a regular part of development, persistent neophobia can reduce dietary variety and contribute to suboptimal nutrient intake.

Sensory education is a promising approach for improving food acceptance. It aims to stimulate children's curiosity, enhance their interest in food, and encourage them to explore new tastes, thereby increasing their intake of vegetables and other nutritious foods. One such approach is the Sapere method, derived from the Latin word "sapere," meaning "to know," "to feel," and "to taste." Developed from Jacques Puisais' philosophy in Le Goût et l'enfant, the Sapere method has been widely adopted in kindergartens and schools in countries such as Finland, Sweden and Norway [8].

However, to date, the Sapere method has not been extensively studied in early childhood settings in Japan, except for a pilot study conducted by our research group.

This study aimed to assess the impact of Sapere-based sensory education on mealtime behaviors and food acceptance among preschool-aged children in Japan using a prospective pre–post intervention design.

METHODS

Study Design and Participant Information

This study adhered to the principles outlined in the Declaration of Helsinki and was approved by the Ethics

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Committee of the National Hospital Organization Kyoto Medical Center (approval number: 24-071).

The study was registered in the UMIN Clinical Trials Registry (registration number: UMIN000050570). All participants provided written informed consent after receiving a thorough explanation of the study protocol.

The inclusion criteria included children aged 3–6 years. The exclusion criteria were as follows: 1) individuals younger than 3 years or older than 7 years, and 2) individuals whose parents or caregivers could not read Japanese.

Intervention

A six-session nutrition education program was designed and implemented based on the Sapere method with an emphasis on multisensory food experiences. The program followed a model in which an external instructor, a registered dietitian, visited the kindergarten, bringing all the necessary educational materials and food items. The children were organized into small groups of four to six, each supported by a nursery teacher who encouraged active participation and provided emotional support during the sessions. Each session lasted approximately 30 minutes and followed a structured four-part format. Introduction (5 min): Children's attention and curiosity were stimulated using picture-story shows and role-model demonstrations. Observation (10 min): Children were encouraged to explore the food items using sight, touch, and smell, and to verbalize their sensory impressions. Tasting (10 min): Sampling or sipping of food was conducted in a supportive environment, allowing the children to express their impressions freely. Reflection (5 min): Children indicated their preferences and experiences using a simple worksheet with visual aids. A small-step approach was adopted throughout the observation and taste phases. The instructor provided gentle, sequential demonstrations (e.g., look → touch → smell → taste → listen) to reduce anxiety and encourage gradual sensory engagement. The sessions were conducted monthly for six months. In Sessions 1–3, familiar fruits and vegetables were used to introduce and enhance the children's awareness of the five senses. In Sessions 4–6, the program introduced traditional Japanese ingredients such as konbu (kelp), katsuobushi (dried bonito flakes), and a variety of potatoes and citrus fruits to deepen children’s understanding of flavor (particularly umami), texture, and color. Table **1** outlines the components, sensory activities, and learning objectives of each session.

Figure **1** presents examples of the worksheets used across the six structured sessions of the taste education program. Each session focused on a specific theme, designed to stimulate sensory exploration through guided group activities. In Session 1, children explored oranges and onions by touching and smelling them through a bag and then closely observed the cut surfaces. They attempted to peel onions with their hands by focusing on the tactile sensations. Tasting was intentionally postponed to reduce initial sensory overload. In Session 2, the children compared the three bananas at varying ripeness levels (ripe, less ripe, and spotted). They observed differences in color, softness,

Table 1: Overview of Nutrition Education Sessions

Session	Ingredients	Activities	Learning Objectives
1st	Orange and Onion	Touch and smell the orange and onion inside a bag, and carefully observe the cut surfaces; try peeling the onion while feeling its texture	Focus attention using visual cues and smell (onion tasting postponed for future session)
2nd	Three Types of Bananas	Observe the differences in softness and smell at varying ripeness levels; taste and compare texture and stickiness	Explore all five senses (visual, tactile, olfactory, taste, auditory) through a familiar fruit
3rd	Five basic flavors (Broths)	Taste simple broths made with salt, sugar, lemon, konbu, and coffee ingredients	Recognize the five basic tastes and understand how taste perception varies with ingredients
4th	Umami (Bonito & Salmon Broth)	Compare the smell and taste of two types of dried fish used in umami-rich broths	Deepen understanding of Japanese umami-rich traditional ingredients and their flavor profiles
5th	Three Types of Potatoes	Comparing white, red, and purple potatoes, tasting them steamed	Understand how appearance and color influence perceptions of flavor and texture
6th	Unshu mandarin orange	Observing the surface and inside of an Unshu mandarin orange, peel it and taste it while noting texture changes	Learn about the structure of Unshu mandarins; observe sensory changes during peeling and tasting

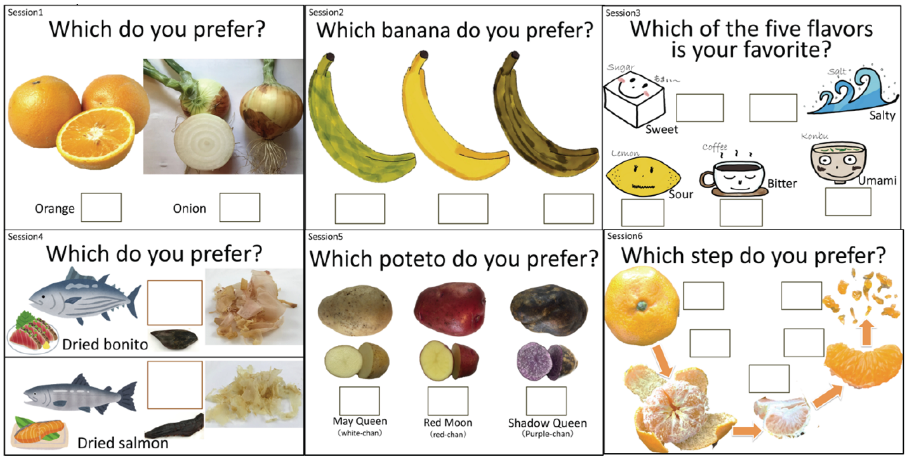

Figure 1: Examples of Worksheets Used in Sessions 1 to 6.

aroma, and taste for each type, noting differences in texture and flavor. This session encouraged the use of all five senses for familiar fruits. Session 3 introduced five basic tastes—saltiness, sweetness, sourness, bitterness, and umami—through a broth tasting. Broths were prepared using simple ingredients, including salt, sugar, lemon, kombu, and coffee. The children were encouraged to identify the dominant flavor in each sample and articulate their taste preferences. In Session 4, the focus was on umami using traditional Japanese broths made from bonito and salmon. Children compared the smell and taste of both types of dashi, enhancing their recognition and appreciation of umami-rich foods common in Japanese cuisine. In Session 5, the children were asked to taste steamed white, red, and purple potatoes. They observed differences in appearance and texture and discussed how color and shape might influence the perception of taste. Finally, in Session 6, Unshu mandarin oranges were used to explore sensory changes that occur during handling and eating. Children observed the peel and inside of the fruit, peeled it themselves, and tasted it while paying attention to changing aromas and mouthfeel.

A six-session sensory education program, based on the Sapere method, was implemented to promote children's awareness and enjoyment of food through multisensory experiences. Each session was designed to focus on the different sensory attributes of familiar foods and gradually build confidence and interest in tasting.

Measurement

Demographic information, including age, sex, age of onset, and anthropometric indices such as body mass index (BMI). We measured and recorded height and weight, respectively. BMI was calculated as the individual's weight in kilograms (kg) divided by the square of the height in meters (m^2).

Height, body weight, and BMI standard deviation scores (SDS) were calculated based on growth charts stratified by age and sex developed by the Japanese Society for Pediatric Endocrinology [8]. These charts were constructed using data from the 2000 National Survey of Physical Development in Japan, comprising 18,550 anthropometric measurements of infants and toddlers collected by the Ministry of Health, Labor, and Welfare and 695,600 measurements of school-aged children obtained by the Ministry of Education, Culture, Sports, Science, and Technology. Information on household structure (e.g., the presence of siblings, grandparents, or other cohabitants) and food allergies (assessed using 10 specific items) was collected.

Dietary Assessment

Children's dietary patterns in relation to the eight food groups (grains, fish, meat, eggs, soybeans/soy products, vegetables, fruit, and milk) were evaluated as objective variables,as well as their intake of processed foods, including four items (sweetened beverages, confectionery, instant noodles, and fast food). The survey inquired how often the children consumed foods in each group (≥2 times/d, once a day, 4–6 d/week, 1–3 d/week, less than once a week or rarely) [9].

Food Diversity Score

The food diversity score (FDS) represents the total number of food groups consumed at least once daily. The FDS assigns one point for consumption occurring once or more per day and zero points for consumption occurring less than that. There were eight types of food: Rice, bread, and noodles are the grainfood group. Therefore, the maximum score was eight points [9].

Parental Care Behavior

Thirteen items were used to assess parental care behaviors related to their child's diet based on the question, "Are you (the parent) careful about your child's diet?" These items were grouped into three categories: (1) food-related concerns (seven items), including nutritional balance, flavoring and seasoning, food size or softness, arrangement and color (e.g., the appearance and placement of foods on the plate), portion size, and the content and quantity of snacks; (2) mealtime practices (three items), including regular mealtimes, encouraging thorough chewing, and teaching table manners; and (3) parent–child communication (three items), including enjoying meals, eating together, and cooking together. Each item was rated with a "yes" or "no" response [9].

Problematic Mealtime Behavior

A total of 42 items of the Autism Spectrum Disorder Mealtime Behavior Questionnaire (ASD-MBQ) for children were organized into a five-factor structure: 1) selective eating (11 items), 2) clumsiness/manners, 3) interest in and concentration on eating, 4) oral motor function, and 5) overeating [10-12]. The overall Cronbach's α coefficient was 0.930, with subscale coefficients ranging from 0.781 to 0.923. In this study sample, the overall Cronbach's α coefficient was 0.888, with subscale coefficients ranging from 0.680 to 0.908. The mixed-effects analysis revealed a significant group effect on scores ($\beta = 0.33$, 95% CI: 0.22-0.44, $p < 0.001$), indicating that group membership was associated with higher scores. In contrast, neither the effect of time ($p = 1.000$) nor the group × time interaction ($p = 1.000$) reached statistical significance. A modest variance component (0.11) was observed at the individual level, reflecting between-subject variability. Based on a previous study, the cutoff score for selective eating was set at 1.59. The cutoff values for clumsiness/manners, interest in/concentration on eating, oral motor function, and overeating were 1.86, 2.06, 1.63, and 1.90, respectively. Their parents rated the survey. The ASD-MBQ is applied in this study because it not only evaluates the degree of eating behaviors in children aged three years and older with autistic traits, but is also commonly used as a cutoff to identify potential autism-related concerns among typically developing preschool children.

The Child Food Rejection Scale

Food rejection was assessed using the Child Food Rejection Scale (CFRS). The CFRS is a validated and widely used instrument developed by Rioux *et al*. [13]. These contain two subscales that correspond to two aspects of food rejection, food pickiness (5 items) and food neophobia (6 items). In this study sample, the overall Cronbach's α coefficient was 0.915, with subscale coefficients ranging from 0.817 to 0.917. Parents were asked how much they agreed with the statements regarding their child's pickiness (e.g., "My child refuses certain foods due to their texture", "My child sorts his/her food on the plate", "My child rejects certain foods after tasting them", "My child can accept one food one day and refuse it the next day", "My child can eat some foods in large amounts and completely reject others") and neophobia (e.g., "My child is constantly looking for familiar foods", " My child is suspicious of new foods", "My child only likes the familiar foods", " My child rejects a novel food before even tasting it", "My child gets upset at the sight of a novel food", " My child won't try a novel food if it is touching another food he/she does not like"). Each item was scored by one of the parents on a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree). The total score could range from 11 to 55, with higher scores indicating greater food pickiness and neophobia.

Statistical Analysis

Participants were divided in to a non-problematic mealtime behavior (PMB) group and a PMB group. With respect to sample size, an a priori power analysis was conducted. Assuming a medium effect size (Cohen's $d = 0.5$), a two-sided significance level of 0.05, and 80% power, indicated that approximately 64 participants per group (128 in total) would be required for an independent two-group comparison. Data were analyzed using the t-test, Fisher's exact test, McNemar, and Spearman's correlation coefficient. Patients with missing data were excluded from analysis. Analyses were performed using R software. Statistical significance was defined as a two-tailed $p < 0.05$.

RESULTS

Participants

Of the 449 children assessed for eligibility, 249 were enrolled in the study after excluding 75 children who did not meet the inclusion criteria or were excluded for other unspecified reasons. The children participated in the program, which was conducted across 24 classes in nine nursery schools and kindergartens. Each session involved 15 to 20 children, and to ensure consistency of delivery, the program was facilitated by two fixed registered dietitians who were also researchers in nutrition education. All enrolled participants received the Sapere-based sensory education intervention. Post-intervention assessments were completed for 249 children, while 41 participants were lost to follow-up owing to missing data. Among the 249 assessed participants, 208 were classified into two outcome-based groups: 115 in the non-PMB group and 93in the PMB group. At baseline, the two groups differed significantly in age (4.8 ± 0.9 vs 4.3 ± 0.9, p=0.001), which was also reflected in differences across the ASD-MBQ items. Therefore, to allow for a valid comparison of the intervention effects, we performed baseline matching of the groups by age and sex. A total of 60 children were excluded from the analysis due to either unmatched pairs. After 1:1 age and sex matching, 148 children (74per group) were included in the final analysis.

The clinical characteristics of the study participants are presented in Table **2**. A total of 148 children were included in the study: 74 in the non-PMB group and 74 in the PMB group. The mean age in both groups was 4.5 ± 0.9 years, with no statistically significant difference observed between groups. The proportion of male participants was identical in both groups (56.8%). No statistically significant differences were found between the two groups in terms of height, body weight, BMI, or SDS. Although the PMB group tended to have slightly lower height SDS and body weight SDS compared to the non-PMB group, these differences were not statistically significant. Participation in developmental support programs was reported by 4.1% of the non-PMB group and 1.4% of the PMB group, with no statistically significant difference. The attendance rate in the program was reported to be 92.6% in the non-PMB group and 96.4% in the PMB group, with no statistical difference. There were no significant differences in the prevalence of allergies to

Table 2: Clinical Characteristics of the Participants at Baseline

Variables	Non-PMB group(n=74)	PMB group(n=74)	P value
Age (years)	4.5 ± 0.9	4.5 ± 0.9	0.909
Male sex, n (%)	42 (56.8)	42 (56.8)	0.999
Height (cm)	102.9 ± 7.8	101.2 ± 7.3	0.203
Height SDS	0.29 ± 2.6	-0.39 ± 1.0	0.051
Body weight (kg)	16.4 ± 2.5	15.8 ± 2.3	0.170
Body weight SDS	0.3 ± 2.4	-0.3 ± 0.9	0.095
BMI (kg/m^2)	15.5 ± 1.2	15.4 ± 1.2	0.753
BMI SDS	0.1 ± 1.0	0.0 ± 0.9	0.159
Developmental support programs, n (%)	3 (4.1)	1 (1.4)	0.620
Food allergy, n (%)	7 (9.5)	7 (9.5)	0.999
Eggs	5 (6.8)	5 (6.8)	0.999
Milk	2 (2.7)	1 (1.4)	0.999
Wheat	2 (2.7)	2 (2.7)	0.999
Soy	0	0	NA
Grains	0	0	NA
Tree nuts	2 (2.7)	3 (4.1)	0.999
Crustaceans (e.g., shrimp, crab)	0	0	NA
Fruits	1 (1.4)	0	0.999
Fish/Meat	2 (2.7)	1 (1.4)	0.999
Other	0	2 (2.7)	0.497

Mean ± standard deviation or n (percent). *P<0.05 (vs. control group).
SDS, standard deviation score. NA, Not Applicable.

eggs, milk, wheat, soy, grains, tree nuts, crustaceans, fruits, fish, meat, or other foods between the groups. The most commonly reported allergies were eggs and milk, affecting 9.5% of the participants in both groups.

FFQ

Table **3** shows the changes in food frequency and diversity scores before and six months after the intervention in both the non-PMB and PMB groups.

In the non-PMB group, no significant changes were observed in the frequency of consumption for most food items. However, a statistically significant reduction was found in the intake of sweetened beverages. Other items such as rice, bread, vegetables, and fruits showed minimal variation, with no significant differences from baseline. A similar pattern was observed in the PMB group. Most food items did not exhibit significant changes. The Food Diversity Score was calculated based on eight dietary items, with higher scores indicating a greater diversity of food intake. The distribution of scores was skewed toward the upper range. The mean score was 7.20 (SD = 1.16), with a median of 8 and an interquartile range of 7–8. Scores ranged from 2 to 8, with the majority of children (56.8%) achieving the maximum score of 8. The distribution was as follows: 0.7% scored 2, 0.7% scored 3, 2.0% scored 4, 5.4% scored 5, 14.2% scored 6, 20.3% scored 7, and 56.8% scored 8 (n = 148). There were no statistically significant differences detected between the non-PMB and PMB groups. The non-PMB group showed a negligible mean change of -0.1 ± 0.5, while the PMB group exhibited a significant increase of 0.3 ± 0.9. These results indicate that while overall food intake frequency remained stable, targeted improvements were seen in the reduction of sweetened beverage intake in the non-PMB group and an increase in food diversity in the PMB group following the intervention.

Parental Care of Children's Diet

Table **4** summarizes the changes in parental concerns and practices regarding their child's diet before and six months after the intervention in both the non-PMB and PMB groups. In the non-PMB group, six months after the intervention, a significant increase was observed in parental concern for nutritional balance. Other concerns, such as flavoring and seasoning, food size or softness, and color arrangement, did not show statistically significant changes. Snack-related concerns (quantity) showed minimal changes and were not statistically significant. Likewise, mealtime practices, including regular meal times, chewing properly, and good table manners,

Table 3: Food Frequency and Food Diversity Score

Variables	Non-PMB group	Non-PMB group	Change	PMB group	PMB group	Change
	baseline	6Ms later		baseline	6Ms later	
Rice	12.3 ± 3.2	12.1 ± 3.2	-0.1 ± 2.9	11.8 ± 3.6	11.6 ± 3.7	-0.2 ± 3.6
Bread	4.9 ± 2.3	5.0 ± 2.1	0.1 ± 1.7	5.3 ± 3.0	5.2 ± 2.3	-0.2 ± 2.8
Noodle	1.8 ± 1.4	1.7 ± 1.1	-0.1 ± 1.4	1.7 ± 1.2	1.7 ± 1.2	0.0 ± 1.1
Fish	2.6 ± 1.5	2.3 ± 1.2	-0.3 ± 1.5	2.4 ± 1.8	2.3 ± 1.9	-0.1 ± 1.8
Meat	5.4 ± 3.4	5.1 ± 3.1	-0.2 ± 2.4	4.7 ± 2.4	4.8 ± 2.3	0.1 ± 2.5
Eggs	3.7 ± 2.2	3.5 ± 2.6	-0.1 ± 2.0	3.0 ± 2.3	3.1 ± 2.3	0.1 ± 1.7
Beans/tofu	3.3 ± 2.1	3.5 ± 2.3	0.2 ± 2.5	3.6 ± 2.9	3.7 ± 3.1	0.1 ± 2.2
Vegetable	10.4 ± 4.2	10.5 ± 4.4	0.2 ± 3.5	9.4 ± 5.1	9.9 ± 5.1	0.5 ± 3.8
Fruit	5.1 ± 3.9	5.3 ± 4.0	0.2 ± 3.0	4.0 ± 3.0	4.2 ± 3.4	0.1 ± 2.8
Dairy products	7.5 ± 4.0	7.4 ± 4.5	-0.0 ± 3.0	8.5 ± 4.5	7.9 ± 4.1	-0.6 ± 3.8
Tea	13.0 ± 2.9	12.8 ± 3.1	-0.3 ± 3.4	12.6 ± 3.2	12.7 ± 3.5	0.0 ± 3.7
Sweetened beverage	3.2 ± 3.5	2.5 ± 3.1	-0.7 ± 2.5*	3.2 ± 3.3	3.7 ± 3.9	0.4 ± 2.7
Snack	5.1 ± 3.0	5.1 ± 3.3	0.0 ± 3.2	5.3 ± 3.6	5.0 ± 3.3	-0.3 ± 3.5
Instant foods	0.5 ± 0.5	0.4 ± 0.4	-0.0 ± 0.6	0.4 ± 0.5	0.5 ± 0.9	0.1 ± 0.9
Fast foods	0.6 ± 0.4	0.6 ± 0.5	0.0 ± 0.4	0.5 ± 0.5	0.7 ± 0.7	0.1 ± 0.5
Food diversity score, points (out of 8 points)	7.4 ± 1.1	7.3 ± 1.1	-0.1 ± 0.5	7.0 ± 1.2	7.3 ± 0.9	0.3 ± 0.9*

The units, times per week. (e.g., The figures for "every day" responses were converted to seven times per week.) Mean ± standard deviation. *P<0.05 (vs. baseline).Food diversity score: the total number of 8 food groups (grain, fish, meat, eggs, soybeans and soy products, vegetables, fruit, and milk) eaten at least once a day.

Table 4: Parental Care of Children's Diet

Variables	Non-PMB group			PMB group		
	baseline	6Ms later	P value	baseline	6Ms later	P value
Food-related concerns (5 items)						
Nutritional balance	53 (71.6)	62 (83.8)	0.035*	53 (71.6)	57 (77.0)	0.344
Flavoring and seasoning	35 (47.3)	42 (56.8)	0.230	29 (39.2)	35 (47.3)	0.263
Size or softness	23 (31.1)	22 (29.7)	0.999	18 (24.3)	18 (24.3)	0.999
Assorted arrangement and colors	21 (28.4)	26 (35.1)	0.302	14 (18.9)	15 (20.3)	0.999
Amount	44 (59.5)	45 (60.8)	0.999	42 (56.8)	48 (64.9)	0.377
Snack (2 items)						
Contents	15 (20.3)	11 (14.9)	0.388	11 (14.9)	12 (16.2)	>0.999
Amount	18 (24.3)	21 (28.4)	0.508	18 (24.3)	23 (31.1)	0.302
Mealtime practices (3 items)						
Regular mealtimes	34 (45.9)	39 (52.7)	0.359	32 (43.2)	24 (32.4)	0.057
Chewing well	20 (27.0)	28 (37.8)	0.115	16 (21.6)	16 (21.6)	0.999
Table manners	48 (64.9)	54 (73.0)	0.263	42 (56.8)	41 (55.4)	0.999
Parent–child communication (3 items)						
Enjoying meals	37 (50.0)	41 (55.4)	0.523	28 (37.8)	32 (43.2)	0.523
Eating together	56 (75.7)	55 (74.3)	0.999	48 (64.9)	50 (67.6)	0.815
Cooking together	19 (25.7)	12 (16.2)	0.039*	17 (23.0)	12 (16.2)	0.267

Number (percent).*P<0.05 (vs. baseline) for McNemar test.

remained essentially unchanged.

In the PMB group, none of the food-related concern items showed statistically significant changes, although there were modest improvements in nutritional balance and the amount of food consumed. Similarly, snack-related amount tended to increase but without statistical significance. However, a decline was noted in the practice of "regular mealtimes", whereas chewing well and table manners remained stable.

Problematic Mealtime behavior, Pickiness, and Neophobia

Table **5** summarizes the changes in mealtime behavior and food rejection scores following the intervention in both the non-PMB and PMB groups. In the non-PMB group, no statistically significant changes were observed across the subscales. Scores for selective eating, clumsiness/manners, interest/ concentration on eating, oral motor function, and overeating remained stable. Similarly, changes in food pickiness and food neophobia were not significant, indicating limited improvement in food acceptance. In contrast, the PMB group demonstrated statistically significant improvement across several domains. Clumsiness/manners markedly decreased, while interest/concentration on eating and oral motor function also improved significantly. Although selective eating decreased, this change was not statistically significant. Regarding food rejection, food pickiness significantly declined, and food neophobia showed a non-significant trend toward reduction.

DISCUSSION

This study demonstrated that Sapere-based sensory education was associated with notable improvements in several domains of mealtime behavior among preschool-aged children with PMB. In contrast, no statistically significant changes were observed in the non-PMB group, suggesting that the program may have been particularly relevant for those with initial behavioral challenges.

In the PMB group, the most pronounced improvements were observed for clumsiness/manners, interest in and concentration during meals, and oral motor function. These changes are consistent with the goals of sensory education, which seek to enhance children's engagement with food through multisensory experiences. Improvements in oral motor function, although modest, are particularly relevant as they may facilitate better chewing and increased acceptance of a broader range of food textures.

Although the reduction in selective eating did not reach statistical significance, the overall trend suggested a positive direction, indicating that a more extended follow-up period is needed to detect more substantial behavioral shifts. Notably, food pickiness significantly decreased, and food neophobia also

Table 5: Mealtime behavior and Food Rejection Scale

	Group	Baseline	6Ms later	Change	P value	Effect size (95%CI)
1. Selective eating (11 items)	Non-PMB	18.5 ± 0.7	18.9 ± 0.8	0.4 ± 0.5	0.436	0.31
	PMB	26.8 ± 1.1	25.6 ± 1.2	-1.2 ± 0.7	0.088	(-0.02, 0.63)
2. Clumsiness/Manners (12 items)	Non-PMB	21.9 ± 0.6	21.2 ± 0.7	-0.6 ± 0.6	0.298	0.59
	PMB	31.5 ± 0.8	27.3 ± 0.8	-4.2 ± 0.8	<0.001*	(0.26, 0.92)
3. Interest in/Concentration on Eating (9 items)	Non-PMB	17.3 ± 0.4	18.0 ± 0.6	0.7 ± 0.5	0.191	0.46
	PMB	25.4 ± 0.7	23.7 ± 0.8	-1.7 ± 0.7	0.014*	(0.13, 0.79)
4. Oral motor Function (5 items)	Non-PMB	7.4 ± 0.2	7.0 ± 0.2	-0.3 ± 0.2	0.164	0.21
	PMB	10.3 ± 0.5	9.4 ±0.4	-1.0 ± 0.5	0.039*	(-0.11, 0.54)
5. Overeating (5 items)	Non-PMB	7.3 ± 0.3	7.1 ± 0.3	-0.2 ± 0.3	0.403	0.07
	PMB	9.0 ± 0.4	8.6 ± 0.3	-0.4 ± 0.4	0.317	(-0.26, 0.39)
6. Food pickiness (5 items)	Non-PMB	15.1 ± 0.5	14.4 ± 0.5	-0.7 ± 0.5	0.117	0.18
	PMB	18.9 ± 0.5	17.5 ± 0.7	-1.4 ± 0.4	0.002*	(-0.14, 0.50)
7. food neophobia (6 items)	Non-PMB	15.4 ± 0.7	15.6 ± 0.7	0.1 ± 0.5	0.815	0.14
	PMB	19.6 ± 0.7	19.1 ± 0.8	-0.5 ± 0.5	0.291	(-0.18, 0.46)

Mean ± standard deviation. *P<0.05 (vs. baseline).

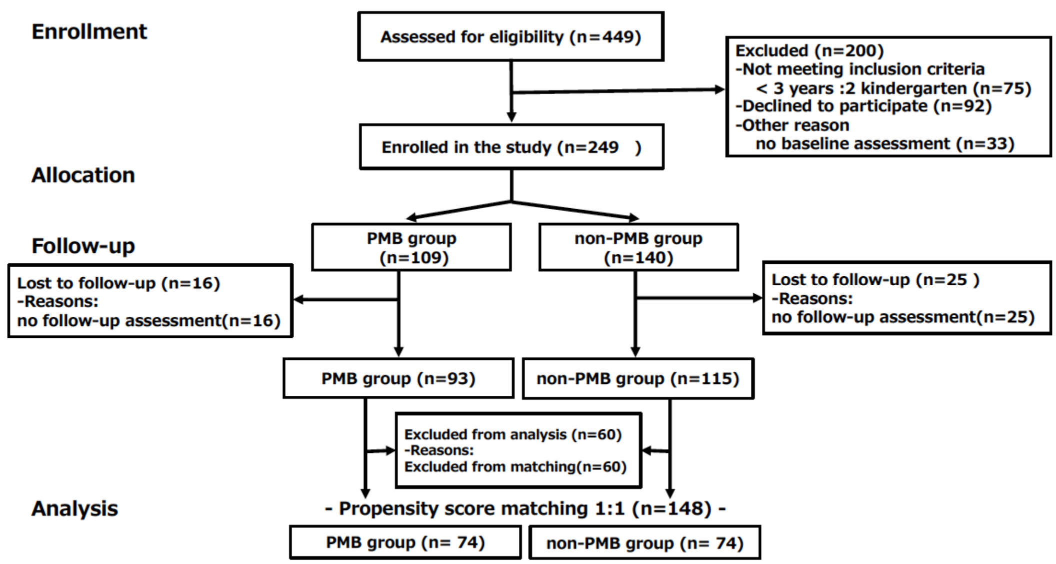

Figure 2: Flow diagram of the Mealtime behavior study.

declined, albeit not significantly. These findings support previous research indicating that early exposure to diverse sensory experiences may help reduce children's reluctance to try unfamiliar foods; however, they should be interpreted with caution, as all children participated in the program, and causal inferences cannot be firmly established. Nonetheless, the most evident improvements were observed in children with lower initial PMB levels, highlighting the potential responsiveness to sensory-based education. The lack of a significant change in the non-PMB group across all measured behaviors reinforces the importance of structured interventions. Children in the non-PMB group exhibited stable behavioral patterns, emphasizing that problematic mealtime behaviors and food refusal tendencies may persist without targeted approaches.

Taken together, these results suggest that sensory-based food education, such as the Sapere method, may provide a practical and engaging strategy to support children with PMB. Such interventions also play a role in broadening dietary variety and improving nutritional intake by gradually addressing both behavioral challenges and sensory-related barriers to food acceptance. However, the results should be regarded as preliminary, and further research with larger sample sizes, control groups, and more extended follow-up periods is needed to clarify the sustainability of these effects and to determine whether early improvements in food acceptance lead to long-term dietary benefits.

Further research with more extended follow-up periods and larger sample sizes may help clarify the sustainability of these effects and determine whether early improvements in food acceptance lead to long-term dietary benefits.

Parental Care of Children's Diet

In the PMB group, food- and snack-related concerns showed slight but non-significant improvements. Notably, the proportion of families practicing "regular mealtimes" declined significantly, while other mealtime practices and aspects of parent–child communication remained essentially unchanged. Maintaining regular mealtimes is associated with better dietary quality and more favorable lifestyle habits [14]. Therefore, irregular mealtimes may contribute to problematic mealtime behavior. Additionally, the proportion of families cooking meals with children decreased in both groups. Although the reason for this is unclear, this trend may reflect a decrease in parental engagement with their child's dietary habits, including picky eating and distracted behavior during meals. Moving forward, it is essential to develop interventions that actively engage parents—potentially through incorporating elements of the Sapere method—to support improvements in children's mealtime behaviors better.

Limitations

This study has several limitations, including a lack of long-term follow-up and missing data on underlying health conditions, such as type 1 diabetes [15]. In the BRA study conducted among Norwegian preschool children aged 3–5 years, no significant effects were observed on parent-reported frequency of vegetable intake. Future studies should incorporate dietary records with photographs to validate intake more accurately.

In addition, our study has several further limitations. First, no non-intervention comparison group was included. Second, the outcomes relied on parent-reported measures, which may be subject to reporting bias. Third, some participants dropped out after the intervention due to non-submission of questionnaires, and it is possible that attrition was more frequent among families less interested in improving the child's food environment. Fourth, the analyses did not account for the clustering structure within classes. Finally, the generalizability of the results to children outside Japan is uncertain, particularly in settings where common Japanese food ingredients such as kombu and bonito are less familiar.

Implications for Future Research

Future studies should address these limitations by incorporating a non-intervention control group, using validated dietary assessment methods beyond parent reports, and applying analytic approaches that account for class-level clustering. Strategies to minimize attrition, particularly among families with lower baseline interest in their child's food, are also needed. Furthermore, cross-cultural studies are warranted to examine the applicability of the program in settings where Japanese food staples are less familiar, while considering the use of globally common umami sources such as fish bones, cheese, mushrooms, and vegetable-based bouquet garni.

CONCLUSION

In conclusion, Sapere-based sensory education may effectively reduce problematic mealtime behavior and food selectivity in preschool-aged children. These findings highlight the potential of sensory-based interventions to promote healthy eating habits from an early age. Early childhood nutritional interventions can be cost-effective and offer lasting, intergenerational health benefits [16]. While the Nutrition Now e-learning tool is recognized as a valuable resource for guidance on early-life nutrition, its successful implementation requires greater staff involvement, improved parental access, and structured planning. Further research is warranted to optimize and scale such interventions.

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ETHICS APPROVAL

This study was approved by the Ethics Committee of the National Hospital Organization (NHO) Kyoto Medical Center (No. 24-071)

CONSENT TO PARTICIPATE

Written informed consent was obtained from all participants, and for those under 18 years of age, permission was also obtained from their legal guardians.

HUMAN AND ANIMAL RIGHTS

This study involved only human participants. No animals were used in this research. The study was conducted in accordance with the principles of the Declaration of Helsinki.

CONFLICT OF INTEREST

None to be declared

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