A Study of Dietary and BMI Changes Over Time in Mothers of Children with Food Allergies

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Summary
Few follow-up surveys have been conducted with regard to the changes in diet of mothers of children with food allergy. We examined changes in food and BMI over time in the mothers of children with food allergies. A total of 146 mothers completed a diet survey twice, with the first conducted in 2013–2016 and the second in 2018, and the dietary changes were examined. Furthermore, among the 120 mothers who eliminated eggs from their diet in the first survey, 98 continued to eliminate eggs and 22 re-introduced eggs during the second survey, and the change over time was examined. Additionally, factors related to BMI were analyzed. We observed a change in the amount of egg intake over time within each group. As the number of children who consumed eggs as the causative food declined, the amount of eggs consumed by the concerned mothers significantly increased (median: 7.8 g/1,000 kcal → 12.7 g/1,000 kcal) (p < 0.01), even in children who continued to not consume eggs. We found a negative correlation between BMI in mothers of children with FA and vegetable protein. The mothers indicated that their awareness on food allergy improved, which we believe led to increased consumption of foods that had been restricted thus far. BMI was believed to be related to synchronization with the elimination–substitution diet.

Key Words: diet, eggs, survey, sweets, vegetable protein

The standard treatment of food allergies (FA) is by “eliminating the causative food to the necessary minimum based on accurate judgment” and consuming an alternative diet to substitute the eliminated food (1). Furthermore, the occurrence of FA can cause serious life-threatening symptoms; thus, rigorous countermeasures to prevent accidental ingestion of and contamination by foods containing allergenic substances are considered indispensable (1). Therefore, family members of children with FA (FA children), particularly the mothers (FA mother), must prepare elimination–substitution meals, and they tend to consume the same dishes as their child to ensure safety (2). Moreover, many FA children have other concurrent allergies, which must be addressed by a clean indoor and improved environment. Accordingly, having an FA child is a major burden physically as well as mentally, and we believe that it increases the characteristic diet and lifestyle of the entire family (3–8). We have been continuing to provide medical treatment guidance such as FA classroom for mothers of children with allergic diseases for some time. During these efforts, mothers with FA had a particular tendency to be thin and FA children had substantial stress for childcare. One example related to FA is a low body mass index (BMI) of FA mothers. Compared to mothers without an FA child, FA mothers show no difference in the amount of consumed calories; however, they tend to exhibit low BMI when the FA child was allergic to all top three causative foods combined, and the maternal quality of life (QOL) has been reported to decrease the mothers’ strict adherence to the elimination–substitution diet therapy (2, 9).

However, many FA cases that occurred during infancy disappear with age upon entering early childhood. FA children’s digestion and absorption functions develop as the child grows older. The child might gain tolerance to the causative foods as they develop; thus, they can consume foods that they had not been able to eat, consuming a broader range of foods (1). Consequently, the dietary content of the family with an FA child and of the FA mother changes as the FA child grows older. However, no follow-up surveys have been conducted with regard to how the diet changes, how it progresses, and the state of dietary changes.

As of 2013, a cross-sectional dietary survey was conducted on FA mothers. In the present study, a follow-up survey on dietary habits was conducted after 2–5 y in the same subjects who completed the previous survey.
to elucidate how the diet changes over time and assess changes in BMI.

SUBJECTS AND METHODS

Survey period and subjects. Among the mothers of FA children treated at the Osaka Habikino Medical Center (referred to as “medical center” hereafter) between July 2013 and August 2016 and who consented to participate in the survey, 312 who continued to attend the medical center from June to October 2018 (2013 subjects, 50 mothers; 2014 subjects, 50 mothers; 2015 subjects, 93 mothers; and 2016 subjects, 128 mothers). Among them, written consent was obtained for the purpose of follow-up survey on 146 mothers (46.8%). These 146 mothers consisted of 13 mothers (31.7%) who completed the 2013 survey, 20 (40.0%) in 2014, 49 (52.8%) in 2015, and 64 in 2016 (50.0%). The 166 mothers who did not provide written consent (53.2%) did not attend consultations or come to the hospital because of disease treatment, change of residence, or hospital transfer to a local medical institution. All FA children were subjected to an oral food challenge test (hereinafter food challenge test). Based on the results of the food challenge test, we found the quantity that can be safely taken as per the specialist physician and registered dietitian. In addition, among the 146 FA children, 69 had allergies to one of the three major causative foods (eggs, milk, and wheat) and 10 had allergies to all three foods. A total of 13 children did not have allergies to the three major causative foods but for foods other than the three major causative foods (e.g., buckwheat noodles and shrimp).

The exclusion criteria were defined as mothers found unsuitable as study subjects by the attending physician, such as when the mother has physical/psychological disorder, taking oral medication, and the child had chronic illness other than allergy. Furthermore, there were no overlapping subjects (Fig. 1).

Survey items. Subject profiles and dietary habits of the FA children were investigated. The same questionnaire was used in 2013-2016.

Profile survey. A self-recorded questionnaire was used, including questions on maternal age, maternal height/weight, number of family members, age of the FA child, details of allergenic foods containing the top three causative foods (egg, milk, and wheat), and presence or absence of substitute foods. All information was self-assessed, and BMI was calculated from the height and weight reported by the mothers themselves, without performing physical measurements. The use of food substitutes was defined as use of tofu and milk instead of egg, soy milk and small fish instead of milk, and rice flour and white sorghum instead of wheat.

Dietary habit survey. The brief-type self-administered diet history questionnaire (BDHQ) is used to estimate the amount of energy intake, nutrient intake, and intake according to food group based on the food frequency consumed per weekly unit over the past 1–2 mo, which ensured the reproducibility and validity without placing a burden to the subject (10, 11). The amount of energy intake was calculated per 1 kg of body weight, and the amount of nutrients apart from energy and energy intake according to food group was calculated per 1,000 kcal.

Statistical analysis. The results of the first survey
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Table 1. Patient characteristics.

|                          | Overall n=146 | 1st survey | 2nd survey | p value |
|--------------------------|--------------|------------|------------|---------|
| Age of mothers (y)       |              | 39 (36–42) | 42 (39–45) | <0.001*** |
| Body mass index (BMI) (kg/m²) | 20.2 (18.6–22.4) | 20.6 (18.9–22.9) | 0.148 |
| BMI<18.5/18.5 or >18.5/18.5 |              | 35/111     | 25/121     | 0.565   |
| Number of families (n)   |              | 4 (4–4)    | 4 (4–5)    | <0.001*** |
| Age of children (y)      |              | 7.0 (5.0–9.0) | 10.7 (8.7–12.6) | 0.039* |
| Total number of food causes: egg, milk, flour (piece) | 1.4 (±0.7) | 1.3 (±0.7) | 0.050 |
| Egg (with/without) (120/26) | 106/40     | 0.039*   |
| Milk (with/without) (72/74) | 63/83      | 0.039*   |
| Flour (with/without) (34/112) | 20/126     | 0.039*   |
| Total number of causes of food: other than eggs, milk, flour (with/without) (65/81) | 46/100 | 0.039*   |
| Substitute food use (use/not use) (85/61) | 64/82 | 0.039*   |

Data are expressed median (quartile), mean (±standard deviation) Wilcoxon signed-rank test, Paired t-test, Pearson’s Chi-square test. *p<0.05, ***p<0.001. # Overall the time period was 2.9 (±1.1) y.

were obtained using the survey results conducted in 2013–2016 (first survey, hereafter), and the results of the second survey were obtained in 2018 (second survey, hereafter).

Overall, the profiles and dietary status of 146 subjects during the first and second surveys were compared. Furthermore, the 120 mothers of egg-allergic children in the first survey were grouped into 98 with children who continued to eliminate egg (continued egg-elimination group) and 22 who reintroduced egg (egg reintroduction group hereafter) during the second survey, and the intra-group profiles and dietary status during the first and second surveys were compared. In addition, we evaluated the dietary status of eight mothers (hereinafter Add to egg-elimination group) who did not prohibit eggs the first time but prohibited eggs the second time (control group) and 18 mothers (Non-egg-elimination group) who did not prohibit eggs during both the first and second time.

Furthermore, three groups were created according to changes between the first and second surveys: the decreased group consisting of 34 mothers of children allergic to less than the top three causative foods; the unchanged group consisting of 91 mothers of children who showed no changes; and the increased group consisting of 21 mothers of children allergic to more than three foods. In each of these groups, the profiles and dietary status obtained by the first and second surveys were compared.

Moreover, the first and second maternal BMIs were compared to identify factors associated with BMI, a linear regression analysis (model 1–2) was performed, and differences between the first and second surveys were compared.

Model 1 consisted of BMI as the response variable and 13 items as explanatory variables for all subjects, including ages of the FA child and FA mother, the number of top three causative foods, the presence or absence of substitute foods used, vegetable proteins, cereals, pulses, green and yellow vegetables, other vegetables, fruits, meat, seafood, egg, milk, and sweets. Model 2 consisted of BMI as the response variable with two items as explanatory variables within each group, i.e., the decreased, unchanged, and increased groups, including ages of the FA child and FA mother and vegetable protein.

Analyses were performed using Statistical Analysis System (SAS) version 9.4 (SAS Institute Inc., Cary, NC, USA). For descriptive statistical analysis, the median (25% and 75% values) or mean (±standard deviation) were presented. Between-group comparison was performed using a paired t-test or Wilcoxon signed-rank test after verifying normality. The tendency of continuous variables was tested using a Jonckheere–Terpstra test, categorical variables between the two groups were compared using Pearson’s chi-squared test, and numerical prediction by linear model was performed using multiple regression analysis (stepwise method). For two-tailed testing was considered statistically significant.

Ethical considerations. This study was conducted with approval by the Ethical Review Board of Osaka Habikino Medical Center (approval no.: No. 904-1, approval date:
| Overall | n=146 | Mothers of infants for whom eggs were prohibited in both the first and second surveys | n=98 | Mothers of infants for whom eggs were prohibited during the first survey but not during the second survey | n=22 | Mothers of infants for whom eggs were not prohibited during the first survey but prohibited during the second survey | n=8 | Mothers of infants for whom eggs were not prohibited in both the first and second surveys | n=18 |
|---|---|---|---|---|---|---|---|---|---|
| Energy intake (kcal/kg) | 31 | 29 | 0.490 | 31 | 28 | 0.165 | 27 | 32 | 0.013* | 30 | 28 | 0.383 |
| Protein intake (g/1,000 kcal) | 36.3 | 37 | 0.277 | 36.3 | 36.1 | 0.545 | 37.1 | 34.9 | 0.235 | 35.5 | 41.1 | 0.196 |
| Fat intake (g/1,000 kcal) | 30.1 | 31 | 0.048 | 29.8 | 30.9 | 0.845 | 31.7 | 29.6 | 0.633 | 32.3 | 36.9 | 0.246 |
| Carbohydrate intake (g/1,000 kcal) | 117.5 | 133.9 | 0.153 | 140.6 | 134 | 0.307 | 131.8 | 138.9 | 0.235 | 130.8 | 126.6 | 0.099 |
| Cereals (g/1,000 kcal) | 223.6 | 210.9 | 0.016 | 223.7 | 211.9 | 0.078 | 211.3 | 247.1 | 0.016 | 210.7 | 208.0 | 0.178 |
| Potatoes (g/1,000 kcal) | 26.1 | 26.7 | 0.085 | 27.8 | 29.3 | 0.918 | 27.7 | 17.9 | 0.795 | 19.8 | 13.4 | 0.183 |
| Sugars (g/1,000 kcal) | 2.8 | 2.5 | 0.005** | 2.9 | 2.6 | 0.017 | 2.6 | 2.5 | 0.156 | 2.0 | 3.1 | 0.913 |
| Pulses (g/1,000 kcal) | 26.8 | 22.4 | 0.016 | 24.1 | 23.0 | 0.001*** | 20.0 | 19.9 | 0.167 | 20.1 | 20.2 | 0.329 |
| Green and yellow vegetables (g/1,000 kcal) | 59.7 | 76.9 | 0.016 | 75.3 | 59.5 | 0.061 | 59.7 | 59.5 | 0.061 | 59.7 | 59.5 | 0.061 |
| Other vegetables (g/1,000 kcal) | 96.5 | 87.3 | 0.119 | 97.8 | 89.2 | 0.378 | 91.8 | 74.3 | 0.019* | 110.5 | 100.6 | 0.001*** |
| Fruits (g/1,000 kcal) | 5.4 | 4.7 | 0.017 | 5.2 | 4.8 | 0.021 | 5.3 | 4.9 | 0.025 | 5.5 | 4.8 | 0.030 |
| Meat (g/1,000 kcal) | 41.8 | 43.8 | 0.246 | 42.1 | 43.5 | 0.522 | 42.4 | 43.9 | 0.522 | 41.4 | 43.8 | 0.522 |
| Eggs (g/1,000 kcal) | 7.8 | 12.7 | <0.001*** | 7.7 | 11.1 | <0.001*** | 7.5 | 14.7 | <0.001*** | 7.5 | 14.7 | <0.001*** |
| Milk (g/1,000 kcal) | 74.2 | 78.3 | 0.238 | 73.6 | 78.5 | 0.115 | 82 | 79.5 | 0.824 | 39.4 | 109.1 | 0.461 |
| Oils (g/1,000 kcal) | 8.1 | 6.7 | 0.019 | 6.2 | 6.5 | 0.801 | 6.4 | 6.4 | 0.801 | 4.8 | 7.8 | 0.003** |
| Sweets (g/1,000 kcal) | 19.1 | 23.6 | 0.006** | 19.1 | 22.0 | <0.001** | 21.7 | 27.6 | 0.799 | 21.9 | 27.3 | 0.547 |
| Beverages (g/1,000 kcal) | 104.4 | 123.8 | 0.546 | 101.6 | 141.3 | 0.948 | 101.5 | 129.3 | 0.948 | 274.1 | 285.3 | 0.742 |
| Seasoning spices (g/1,000 kcal) | 112.5 | 108.5 | 0.502 | 112.5 | 108.5 | 0.502 | 112.5 | 108.5 | 0.502 | 112.5 | 108.5 | 0.502 |
| Elapsed period (y) | 2.9 | 0.001 | 2.9 | 0.001 | 2.9 | 0.001 | 2.9 | 0.001 | 2.9 | 0.001 |

Data are expressed median (quartile). Wilcoxon signed-rank test. ** p < 0.01, *** p < 0.001.
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| Table 3. Comparison of changes in the number of foods containing the top three causative foods in FA children over time. |
|---------------------------------------------------------------|
| **Decreased group** | **Unchanged group** | **Increased group** |
| **n=34** | **n=91** | **n=21** |
| **Age of mothers** (y) | 40 | 39 | 40 | 40 | 38 | 40 |
| **(48–31)** | **(35–42)** | **(38–45)** | **(38–43)** | **(40–45)** | **<0.001***** |
| **BMI (kg/m²)** | 20.7 | 20.2 | 20.7 | 19.8 | 19.9 | **<0.001***** |
| **(18.7–22.1)** | **(18.4–22.6)** | **(18.9–23.1)** | **(19.0–21.9)** | **(19.1–22.6)** | **<0.001***** |
| **Age of children** (y) | 7.2 | 7.0 | 1.00 | 3.1 | 1.00 | 1.00 |
| **(5.0–8.0)** | **(5.0–8.0)** | **<0.001***** | **(5.0–8.0)** | **<0.001***** | **<0.001***** |
| **Children’s Status** | | | | | | |
| **Total number of food causes: egg, milk, flour** (piece) | 2.0 | 1.4 | 0.8 | 0.8 | 1.8 | **<0.001***** |
| **(0.6–2.0)** | **(0.7–2.0)** | **(0.6–0.6)** | **(0.6–0.6)** | **(0.6–0.6)** | **(0.6–0.6)** |
| **Total number of causes of food: other than eggs, milk, flour** (with/without) | 12.2 | 11.8 | 0.467 | 11.8 | 8.2 | 0.513 |
| **(1.2–2.2)** | **(8.0–8.0)** | **<0.001***** | **(8.0–8.0)** | **<0.001***** | **<0.001***** |
| **Cereals** (g/1,000 kcal) | 211.3 | 229.0 | 1.000 | 206.9 | 185.9 | **0.009** |
| **(166.7–261.4)** | **(173.5–265.8)** | **<0.001***** | **(168.9–249.4)** | **(182.0–236.7)** |
| **Potatoes** (g/1,000 kcal) | 21.2 | 25.8 | 0.473 | 28.0 | 28.4 | 0.422 |
| **(13.2–33.2)** | **(13.2–33.2)** | **(12.0–51.3)** | **(24.1–120.0)** | **(11.9–33.3)** | **0.009** |
| **Sugars** (g/1,000 kcal) | 2.7 | 1.0 | **0.005** | 2.1 | 2.1 | 0.355 |
| **(1.6–3.1)** | **(1.9–3.2)** | **(1.5–4.1)** | **(1.5–4.0)** | **(2.4–4.0)** | **0.022** |
| **Pulses** (g/1,000 kcal) | 28.0 | 26.4 | **<0.001***** | 29.2 | 48.7 | 0.022 |
| **(28.0–46.9)** | **(26.4–50.0)** | **<0.001***** | **(69.1–97.4)** | **(49.0–99.1)** | **0.38** |
| **Green and yellow vegetables** (g/1,000 kcal) | 61.5 | 7.2 | **<0.001***** | **(67.2–143.1)** | **(73.7–146.1)** | **0.08** |
| **(4.3–8.5)** | **(14.6–42.2)** | **<0.001***** | **(69.1–97.4)** | **(0.83)** | **<0.001***** |
| **Other vegetables** (g/1,000 kcal) | 91.9 | 95.0 | 0.842 | 91.7 | 90.7 | 0.919 |
| **(68.3–110.7)** | **(68.3–110.7)** | **<0.001***** | **(68.3–110.7)** | **<0.001***** | **0.019** |
| **Fruits** (g/1,000 kcal) | 27.1 | 35.4 | 0.094 | 31.3 | 28.4 | 0.452 |
| **(16.6–41.6)** | **(16.1–58.3)** | **0.055** | **(14.3–60.8)** | **(12.3–52.5)** | **0.452** |
| **Fishes** (g/1,000 kcal) | 35.1 | 26.4 | 0.091 | 35.1 | 28.4 | 0.094 |
| **(28.8–47.8)** | **(21.9–41.7)** | **0.091** | **(23.9–45.4)** | **(21.9–45.4)** | **0.523** |
| **Meat** (g/1,000 kcal) | 41.4 | 41.5 | 0.747 | 43.4 | 47.7 | 0.288 |
| **(35.0–56.9)** | **(35.6–51.0)** | **0.045** | **(39.2–49.0)** | **(41.4–56.0)** | **0.09** |
| **Eggs** (g/1,000 kcal) | 9.3 | 8.4 | **0.005** | 9.3 | 8.4 | 0.095 |
| **(7.3–14.5)** | **(1.9–14.9)** | **<0.001***** | **(4.4–14.7)** | **(72.2–81.2)** | **0.009** |
| **Milk** (g/1,000 kcal) | 56.7 | 76.6 | **0.046** | 74.5 | 10.20 | 0.257 |
| **(10.3–123.3)** | **(32.8–128.6)** | **0.046** | **(23.6–136.9)** | **(51.3–134.6)** | **0.055** |
| **Oils** (g/1,000 kcal) | 6.4 | 6.0 | 0.437 | 6.5 | 2.5 | 0.168 |
| **(5.0–8.5)** | **(5.1–8.4)** | **0.437** | **(5.4–7.3)** | **(7.8–8.6)** | **0.437** |
| **Sweets** (g/1,000 kcal) | 23.1 | 18.4 | **0.003** | 20.9 | 25.7 | 0.168 |
| **(12.4–33.1)** | **(9.1–28.0)** | **0.003** | **(12.7–27.4)** | **(11.5–36.0)** | **0.708** |
| **Beverages** (g/1,000 kcal) | 311.1 | 300.5 | **0.351** | 292.9 | 326.3 | **0.708** |
| **(162.2–530.1)** | **(158.9–487.7)** | **0.351** | **(257.5–488.5)** | **(276.1–499.5)** | **0.708** |
| **Seasoning spices** (g/1,000 kcal) | 111.4 | 118.7 | **0.372** | 80.8 | 91.9 | 0.272 |
| **(81.5–153.4)** | **(91.2–160.6)** | **0.372** | **(70.6–113.2)** | **(70.3–129.4)** | **0.272** |
| **Number of years passed** | 3.1 | 2.9 | 0.002 | 3.1 | 2.9 | 0.002 |

Data are expressed median (quartile), mean (±standard deviation). Wilcoxon signed-rank Test, Paired t-test, Pearson's Chi-square test Jonckheere–Terpstra test. *p<0.05, **p<0.01, ***p<0.001.
June 14, 2018), the ethical review board for research in Mukogawa Women’s University, Junior College Division (approval no.: No. 18-22, approval date: July 24, 2018), and in accordance with the Declaration of Helsinki. The study was conducted after explaining the study details to the subjects in advance and obtaining written consent from them. Information used was carefully obtained after the subjects provided their consent, which were anonymized so that individuals could not be identified in our analyses.

RESULTS

Profile survey

As shown in Table 1, the period of time elapsed between the first and second surveys was 2.9 (±1.1) y.

FA children were allergic to significantly fewer foods containing the top three causative contents and less likely used dietary substitutes significantly (p<0.05 for both). According to the top three causative foods, the number of children with wheat as the causative food decreased significantly (p<0.035); however, children with milk as the causative food remained unchanged. The number of children with egg as the causative food tended to decrease (p=0.050); however, eight children started eliminating eggs between the surveys. Furthermore, we found that children had a significantly reduced number of allergenic foods other than the top three causative foods (p=0.022).

The BMI of FA mothers increased; however, the number of subjects determined to be underweight with a BMI of ≤18.5 kg/m² did not change significantly (12).

Dietary habit survey

Comparison between the first and second surveys of all subjects

In Table 2, no significant changes were observed in the amount of energy intake and the amount of the top three nutrients. The intake amount according to the food group significantly increased for pulses, egg, and sweets, whereas the amounts of sugar and yellow/green vegetables were significantly decreased (p<0.01 for both).

Comparison between the first and second surveys for the group who continuously eliminated eggs and the group who reintroduced eggs

In Table 2, the amount of egg intake in both groups was significantly increased (p<0.05 for both). In addition, no significant differences were observed in the two control groups (Add to egg-elimination and Non-egg-elimination groups).

Comparison between the first and second surveys in the decreased, unchanged, and increased groups

In Table 3, the decreased group had significantly increased egg intake (p=0.003), but decreased intake of sugar, yellow and green vegetables, and other vegetables (p<0.05 for all). Furthermore, in the unchanged group, the intake amounts of pulses and sweets significantly increased (p<0.01 for both), whereas the intake amounts of sugar and yellow and green vegetables sig-

Table 4. Multiple regression models of body mass index.

| Model 1 | Overall: 1st survey (n=146) | Vegetable protein | -0.371 | 0.092 | -4.051 | <0.001*** |
|         | Cereals | 0.011 | 0.003 | 3.279 | 0.001** |
|         | Other vegetables | 0.010 | 0.005 | 2.242 | 0.027* |
|         | Eggs | 0.045 | 0.019 | 2.442 | 0.016* |
|         | Overall: 2nd survey (n=146) | Vegetable protein | -0.247 | 0.098 | -2.530 | 0.013* |
| Model 2 | Decrease group: 1st survey (n=34) | Vegetable protein | -0.283 | 0.137 | -2.068 | 0.047* |
|         | Increased group: 1st survey (n=21) | Vegetable protein | -0.265 | 0.107 | -2.473 | 0.023* |
|         | Increased group: 2nd survey (n=21) | Vegetable protein | -0.473 | 0.188 | -2.511 | 0.021* |

* p<0.05, ** p<0.01, *** p<0.001. Stepwise multiple regression analysis.

1Explanatory variables: 13 items including maternal age, the number of top three causative foods, presence or absence of substitute foods used, vegetable proteins, cereals, green and yellow vegetables, other vegetables, fruits, meat, seafood, egg, milk, and sweets.

2Explanatory variables: 2 items, i.e., maternal age, vegetable protein.
Follow-Up Study in Diet and BMI of Mothers

In this study, a follow-up survey was conducted on the dietary changes over time and change in BMI of FA mothers. Based on the results of the first profile survey, cases of egg as a causative food were most common. Therefore, we confirmed that the egg intake of the mothers was restricted to a small amount. However, in the second survey, the number of children with egg as the causative food was reduced; thus, the mothers’ amount of egg intake significantly increased. Furthermore, egg intake significantly increased or tended to increase in the egg-elimination group as well as in the decreased, unchanged, and increased groups. Therefore, the mothers continued to implement an elimination-substitution diet appropriately; however, we believe that over the years, their awareness of FA improved, which could have clarified the points to be considered. Thus, the family diet also improved. Furthermore, decreasing the degree of elimination and reintroduction helped clarify the type of allergy, which we believe led to mothers’ increased egg intake. Moreover, we found that the use of pulses as substitute foods and sweets to supplement the parts lacking in the three meals increased. In other words, these results suggested that the intake of pulses by mothers increased in accordance with the increase of intake in FA children. This is because pulses contain proteins and calcium and are recommended to be used as a substitute for eggs and milk. The increase in the intake of sweets seemed to be related to the easy continuation of eating habits and to alleviate stress. The content of sweets was grain-based sweets (e.g., rice confectionery) that did not use eggs or milk. Sweets are not preferred alternative foods in terms of nutritional assessment. Moreover, the intake amount of greenish yellow and other vegetables changed. We believe that this occurred because the number of foods requiring elimination decreased in conjunction with improved awareness of FA, which led to understanding of the tolerable level of foods to consider. In other words, this was thought to be due to a decrease in the frequency of use of pumpkins (green and yellow vegetables) and corn (other yellow vegetables), which have been used as substitutes for egg dishes, and sugars used in handmade desserts using these foods. Moreover, despite the increased reintroduction of milk, we found no changes in the intake amount. We believe that the amount of milk intake did not increase because of personal preferences. According to the 2017 Japanese Health and Nutrition Survey results, the mean amount of milk intake per day per person should be 104.8 g for women aged 30–39 y and 102.1 g for women aged 40–49 y (13). However, the milk intake is low nationwide. Furthermore, despite the increased reintroduction of wheat, its intake amount remained unchanged, which we thought was attributed to the fact that subjects had the custom of consuming rice as the staple food. Thus, although the increase in the intake of eggs was considered good, the increase in the intake of sweets was not acceptable, and an improvement in the intake of milk for which tastes were prioritized also seemed to be necessary. There is a concern that there may be discrepancies among the diets of typical mothers (13).

Thereafter, we evaluated how changes in the dietary characteristics of FA mothers affected their BMI. Factors related to BMI of FA mothers were extracted. As a factor affecting the BMI of FA mothers, a negative correlation was consistently observed between BMI and vegetable protein, that is, the lower the BMI, the higher the vegetable protein intake. A vegetable protein-predominant diet is a fundamental form of the elimination-substitution diet. When animal protein such as hen’s egg and cow’s milk is the causative food, processed soy products such as tofu and soy milk are used as the substitute food. Accordingly, we found that in synchronization with the elimination-substitution diet of the FA child, BMI is affected by the amount of vegetable protein intake. Moreover, we believe that low BMI and weight loss depend on the amount of physical activity. Increased physical activity increases the amount of energy consumed, and when the energy intake does not match the increased amount of energy consumed, it results in weight loss. Based on the results of this study, BMI of FA mothers increased slightly over the years; however, we observed no changes in the proportion of subjects with a BMI of <18.5 kg/m². The Ministry of Health, Labour and Welfare notes the target BMI range for women aged 18–49 y as 18.5–24.9 kg/m² (14). Furthermore, according to the 2017 Health and Nutrition Survey results, BMI was determined to be within the target range in 13.4% of women aged 30–39 y and in 10.6% of those aged 40–49 y (13). However, in our subject group, 35 mothers (24.0%) during the first survey and 25 (17.1%) during the second survey were within the target BMI range, with no significant changes; therefore, the prevalence of low BMI in FA mothers was higher than that in the aforementioned populations. To determine the target

CONCLUSION

In Table 4, as a result of model 1, the first survey showed a significant negative correlation of vegetable protein with BMI (p<0.001) and significant positive correlations of cereal, other vegetables, and egg with BMI (p<0.05 for all); however, the second survey showed that only vegetable protein was negatively correlated (p<0.001).

In model 2, the decreased group showed a significant negative correlation between BMI and vegetable protein in the first survey (p=0.047), whereas all items were excluded in the second survey. In the unchanged group, all items were excluded in both the first and second surveys. In the increased group, BMI was significantly negatively correlated with vegetable protein in both the first and second surveys (p<0.05 for both).

Identification of factors associated with BMI based on the multiple regression analysis results

In this study, a follow-up survey was conducted on the dietary changes over time and change in BMI of FA mothers. In the first survey, cases of milk intake significantly increased. The increase in the intake of milk for which tastes were considered good, the increase in the intake of sweets was not acceptable, and an improvement in the intake of milk for which tastes were prioritized also seemed to be necessary. There is a concern that there may be discrepancies among the diets of typical mothers (13).

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Based on the results of this study, BMI of FA mothers increased slightly over the years; however, we observed no changes in the proportion of subjects with a BMI of <18.5 kg/m². The Ministry of Health, Labour and Welfare notes the target BMI range for women aged 18–49 y as 18.5–24.9 kg/m² (14). Furthermore, according to the 2017 Health and Nutrition Survey results, BMI was determined to be within the target range in 13.4% of women aged 30–39 y and in 10.6% of those aged 40–49 y (13). However, in our subject group, 35 mothers (24.0%) during the first survey and 25 (17.1%) during the second survey were within the target BMI range, with no significant changes; therefore, the prevalence of low BMI in FA mothers was higher than that in the aforementioned populations. To determine the target

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range, the Ministry of Health, Labour and Welfare collectively considered BMI with the overall lowest mortality rate, with incidences of different diseases, with causes of death, and with the current BMI status among Japanese people reported in an observational epidemiologic study (14). Accordingly, considering the health of FA mothers and those with low BMI, in particular, improvement and support are needed to achieve a BMI closer to the target range.

Because the BMI of FA mothers related to vegetable proteins in their diets, the appropriateness of this dietary characteristic was evaluated. Vegetable proteins (soybean proteins) are involved in the decrease of visceral fat, improvement of serum lipids, control of blood pressure, and cardiovascular mortality (15–19).

Nutritionally, foods containing vegetable proteins have lower lipid content than foods containing animal proteins, and the intake of the B group of vitamins such as vitamins B₁ and B₂ and minerals such as calcium and phosphorus can be expected (20). In contrast, animal proteins are required for muscle synthesis and maintenance (21, 22). Vitamins B₉ and B₁₂ and folic acid are effective in maintaining good bone quality (23–25). Vitamin B₁₂ is rarely present in vegetable foods and should be consumed via animal foods (20). Muscle and bone health are important topics for all and not only for the elderly (26). Therefore, the balance between the intake of vegetable and animal proteins seems to be important in nutrition.

In terms of nutritional intake, animal protein containing a good balance of essential amino acids is needed; thus, the intake of animal and vegetable proteins should be balanced.

Therefore, the content of the mother’s diet should be changed in accordance with the degree of changes in causative food elimination in FA children. Furthermore, a significant trend was found in the number of causative foods for the FA child and the number of years elapsed; however, the appropriate dietary content remains to be evaluated. Thus, we believe that a considerable amount of time is needed to achieve a diet that ensures appropriate quality and quantity. Conversely, thorough support is needed for individuals with low BMI to achieve the target range, and as the child develops, the diet is suggested to be changed, which could help improve BMI. Therefore, long-term nutritional support is important for not only the FA children but also the FA mothers.

Study limitations

All survey questionnaires comprised open-ended questions. The height and weight of the mothers were also self-reported. Therefore, this could have resulted in a recall bias. Furthermore, neither the body component analyses of mothers, such as blood biochemistry, body weight, musculoskeletal mass, and body fat mass, nor the level of activity of daily living were analyzed. Consequently, we cannot rule out any limitations arising in the interpretation of the results.

To clarify the changes in dietary habit characteristics of FA mothers and their effects on the BMI, a follow-up survey was conducted after an interval of 2–5 y. No difference was observed in the intake amount such as energy-producing nutrients, and as the number of children with egg as the causative food decreased, the amount of FA mothers’ egg intake and the number of cases in which egg elimination continued significantly increased. However, despite the relaxation of prohibitions for milk in children’s diet, the intake of milk did not increase, whereas that of sweets increased.

Furthermore, BMI of FA mothers slightly increased; however, no changes were found in the proportion of mothers with a BMI of <18.5 kg/m². Moreover, regarding the nutritional factors that affect BMI of FA mothers, a negative correlation was consistently observed between BMI and vegetable protein. Thus, we showed the possibility that issues with food content and composition that constitute nutrient intake are associated with BMI. Therefore, long-term nutritional support is important for not only the FA children but also the FA mothers.

Disclosure of state of COI

We have no conflicts of interest to declare.

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