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Diet among Japanese female university students and asthmatic symptoms, infections, pollen and furry pet allergy

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Summary

Objectives: To study associations between diet, respiratory symptoms and allergy among female university students in Japan.

Methods: A standardised questionnaire was distributed to students in Kobe and Kamakura ($N = 153$). Multiple logistic/linear regression was applied, controlling for age, smoking, heredity and diet.

Results: Totally 15.7% reported doctor-diagnosed asthma, 3.3% current asthma medication, 56.9% pollen allergy, 15.7% cat allergy, 11.1% dog allergy, 25.0% wheeze, 24.2% daytime and 9.3% nocturnal attacks of breathlessness. Meat consumption was related to wheeze (OR = 2.00; 95% CI 1.12–3.60) and respiratory infections (OR = 2.10; 95% CI 1.08–4.09). Fish consumption was related to less respiratory infections (OR = 0.49; 95% CI 0.28–0.86), seafood to less pollen allergy (OR = 0.66; 95% CI 0.44–0.99), and milk consumption to less daytime breathlessness (OR = 0.72; 95% CI 0.55–0.95). Fast food consumption was related to wheeze (OR = 1.89; 95% CI 1.23–2.91), daytime breathlessness (OR = 1.50; 95% CI 1.00–2.28) and pollen allergy (OR = 1.69; 95% CI 1.07–2.65). In total, 23.0% used butter, 21.7% margarine, 40.1% olive oil and 55.3% rapeseed oil. Those consuming butter (OR = 2.65; 95% CI 1.11–6.32) and rapeseed oil (OR = 2.35; 95% CI 1.03–5.38) had more wheeze. Those consuming margarine had more nocturnal breathlessness (OR = 4.40; 95% CI 1.42–13.7). An asthma symptom score was related to fast food ($p < 0.05$) and margarine consumption ($p < 0.01$). Factor analysis identified five dietary patterns. A pattern including fast food, juice and soft drinks was related to wheeze and respiratory infections.

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Conclusion: Fish, seafood and milk consumption seems to be beneficial, while butter, margarine, rapeseed oil, fast food and soft drinks could be risk factors for allergy and respiratory health.

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Background

Since there has been a rising prevalence of asthma and allergy worldwide,^{1,2} especially in the younger generation, there is a need to identify both risk factors and protective factors for asthma and allergy development. Initially, the increase was most pronounced in industrialised Western countries, but recent trends indicate a greater increase in Asia and middle-income countries, and a more stable situation in Western countries.³ It has been proposed that the increase in asthma and allergies is related to changes in a number of factors related to modern and Western lifestyle,⁴ where risk factors are added and protective factors are lost.⁵ One possible risk factor could be dietary changes related to Western lifestyle. There are global changes in dietary habits, with increased consumption of fast food and soft drinks,⁶ and frequent fast food consumption has been associated with a higher prevalence of childhood asthma in Saudi Arabia,⁷ New Zealand,⁸ China⁹ and Sweden.¹⁰ A high intake of antioxidants (e.g. selenium, vitamin C and vitamin E) and a high intake of fruits and vegetables may be beneficial to respiratory health.^{11,12} Moreover, there is some evidence that dietary lipids may influence asthma and allergy. It has been suggested that a high intake of omega-3 essential fatty acids which comes mainly from fatty fish, can be protective for various diseases, including asthma,^{11,13,14} but experimental studies with increase of omega-3 fatty acids have not given a clear evidence with respect to asthma treatment. Moreover, recent studies suggest a protective effect from a higher consumption of milk,^{15,16} milk fat or butter^{10,17} and yoghurt¹⁵ on asthma and allergy. Recent studies suggests that diet in the very early childhood, or even the mothers dietary habit may influence the development of asthma and allergies in the offspring.^{18,19}

Japan is one of the major industrialised countries in the world, with a combination of Western and Japanese diet, but we found relatively few epidemiological studies on associations between dietary habits on the one hand and asthma and allergic disorders on the other in Japan. One placebo-controlled single-blind study of adults with cedar pollen allergy showed that a daily intake of not less than 2×10^{10} *Lactobacillus acidophilus* (L-92) cells reduced allergic symptoms during the pollen season.²⁰ One study on Japanese pregnant women in Osaka concluded that a high intake of soy and isoflavones may reduce the risk for allergic rhinitis,²¹ and that fish consumption and a high ratio between omega-3 and omega-6 fatty acids are associated with a reduced prevalence of asthma.²² The same study concluded that a high dietary intake of seaweed, calcium, magnesium and phosphorus may reduce the prevalence of allergic rhinitis.²³ Another study suggested that a high intake of energy and lipids during pregnancy may accelerate

allergic disease in infants.²⁴ In contrast to most other studies, one study of junior high school students in Tokorozawa city found that the frequency of fish intake was positively related to the prevalence of asthma.²⁵

The main aim was to study associations between current dietary habits and the prevalence of self-reported asthma, asthmatic symptoms, respiratory infections and pollen and furry pet allergy among Japanese female university students. The following hypothesis was tested in a cross-sectional study: Doctor-diagnosed asthma, current asthmatic symptoms, airway infections, pollen allergy and furry pet allergy are related to current dietary habits, including frequency of meat, fish, seafood, fruits, vegetable, milk, yoghurt, fast food, and soft drink consumption, as well as types of fats and oils consumed.

Material and methods

Study population

The study was performed among students at Kamakura Women University and Kobe College in 2005–2006. A standardised questionnaire was translated into Japanese and distributed among students at the universities participating in a basic course in, respectively, nutrition and human science. Both universities are for female students only. The study had approval from an ethical committee and subjects gave their informed consent.

Assessment of health data

We used a self-administered questionnaire previously used in Swedish, Korean and Chinese school studies.^{10,26} It contained questions obtained from the large international ISAAC study,³ the European Respiratory Health Survey (ECRHS),²⁷ about doctor-diagnosed asthma, allergies and current asthma and respiratory symptoms with additional questions.¹⁰ This publication is using questions from the ECRHS study, since these symptoms have been validated by other researchers against asthma diagnosis in the Japanese adult population.²⁸ There was one set of questions about asthma, including doctor-diagnosed asthma (cumulative incidence), current asthma medication and asthma attacks during the last 12 months. Current asthma was defined as either currently taking asthma medication or having had an asthma attack during the last 12 months, a definition previously used in the ECRHS study.²⁹ In addition, there was another set of questions about airway symptoms related to asthma during the last 12 months, without using the phrase 'asthma'. These symptoms included (1) wheezing or whistling in the chest, (2) at least one day-time attack of shortness of breath during exercise or while resting and

(3) at least one night-time awakening with attacks of breathlessness or tightness in the chest.³⁰ The question about wheeze during the last 12 months is identical in the ECRHS and the ISAAC study.³ Moreover, the questionnaire contained questions on current smoking, allergy to cat, dog and pollen, and parental allergy/asthma. The question on cat allergy asked: Do you have allergy to cats (yes, no, do not know); The question on dog allergy asked: Do you have allergy to dogs (yes, no, do not know); The question on pollen allergy asked: Do you have allergy to pollen (yes, no, do not know). Not know and yes was coded 0, yes was coded 1 in the statistical analysis. Finally, there was one question about the number of respiratory infections during last 3 months and another about the number of respiratory infections during last 12 months that required antibiotic treatment. There were no questions on body mass index (BMI); use of dietary supplements or social class.

Asthma symptom score

An asthma symptom score (0–8) was constructed, following a previous definition,³¹ by adding the number of yes responses to the following yes/no questions:

1. Wheeze or whistling in your chest during the last 12 months, combined with breathless when wheezing sound is present?
2. Woken up with a feeling of chest tightness during the last 12 months?
3. Attack of shortness of breath at rest during the last 12 months?
4. Attack of shortness of breath after exercise during the last 12 months?
5. Woken by attack of shortness of breath during the last 12 months?
6. Have you ever had asthma?
7. Attack of asthma during the last 12 months?
8. Current asthma medication?

Assessment of current diet

Dietary questions used were taken from previous studies on current diet,^{9,10} including 11 food frequency questions (FFQ) on consumption of meat, fish, seafood/shellfish, fruit, fruit juice, raw vegetables, cooked vegetables, fresh milk, yoghurt/fermented milk, fast food including hamburgers, and carbonated soft drinks. The two latter served as indicators of fast food consumption. There were five alternatives given for each type of food item, 0 = never, 1 = rarely, 2 = once a week, 3 = more than once a week, 5 = almost daily, measuring the frequency of consumption). In addition, there was one question on the type of oil used for cooking (yes/no answers for each type of oil/fat). Dietary patterns were identified by factor analysis, and dietary pattern scales were constructed.

Statistical methods

Correlations between different FFQ scales or dietary pattern scales were analysed using Kendall's tau beta. Initially, associations between dichotomous health variables and FFQ

scales were calculated by multiple logistic regression analysis, adjusting for age, current smoking and parental asthma/allergy, and keeping all 11 FFQ scales simultaneously in the models. Since the number of variables analysed in the models was relatively large, stepwise multiple logistic regression was applied as a next step (backward elimination, Wald), including age, parental asthma/allergy, smoking, all FFQ scales and the five questions on type of oils/fat. The stepwise regression models only include statistically significant or almost significant variables, following an automatic iterative process. Results achieved by the reduced stepwise models were compared with the initial logistic regression models. The associations were expressed as odds ratios (OR) with a 95% confidence interval (CI). For FFQ scales, the ORs were calculated for one unit increase on the four unit scales (0–4). Associations between the asthma symptoms score and FFQ scales were calculated by multiple linear regression analysis, adjusting for age, current smoking, and parental asthma/allergy, and keeping all 11 FFQ simultaneously in the models. Additional analysis was performed by stepwise multiple linear regression analysis (backward elimination) in the same way as in the logistic regression analysis.

As a next step, factor analysis was applied to all dietary questions, in order to identify dietary patterns, using principal component analysis and rotated component matrix (varimax with Kaiser normalisation). For each identified factor, a dietary pattern scales was constructed by adding the scores on the FFQ scales included in the factor. These factors were included in stepwise multiple logistic regression (backward elimination, Wald), including both age, parental asthma/allergy, smoking, all dietary pattern scales and remaining dietary questions not included in the scales. For dietary pattern scales, the ORs were calculated for one unit increase on the scales. Associations between the asthma symptoms score and dietary pattern scales were calculated by stepwise multiple linear regression analysis (backward elimination) in the same way as in the logistic regression analysis. In all statistical analysis, two-tailed tests and a 5% level of significance were applied.

Results

The participation rate of the female students was 95.6%. Totally 153 students participated, 26 from the nutrition course in Kamakura and 127 from the environmental course in Kobe. Mean age were 21 y, data on smoking and self-reported allergy is given in Table 1, and data on asthma and respiratory symptoms in Table 2. The asthma symptom score among the students ranged from 0 to 8, with 59% scoring '0', 24% scoring '1', 12% scoring '2' and 10% scoring '3' or more.

The majority consumed meat (84%), fish (72%), seafood (48%), fruits (66%), raw vegetables (85%), cooked vegetables (67%), milk (60%) and yoghurt (58%) at least twice a week. Consumption of seafood (48%), fast food/hamburgers (17%) and carbonated soft drinks (31%) at least twice a week was less common (Table 3). In total, 23.0% used butter, 21.7% margarine, 40.1% olive oil, 55.3% rapeseed oil and 24.3% other types of oils (mainly poly-unsaturated oils).

Initially, multiple logistic regression analysis was applied, controlling for age, current tobacco smoking, and parental

Table 1 Prevalence of demographic and medical data among female Japanese students.

	N = 153 (%)
Current tobacco smoker	4.7
Doctors' diagnosed asthma	15.7
Pollen allergy	56.9
Cat allergy	15.7
Dog allergy	11.1
Furry pet allergy (cat or dog)	28.3
Food allergy/intolerance	24.2
Parental asthma/allergy*	38.6

*Father or mother has asthma or allergic rhinitis.

Table 2 Prevalence of asthma and respiratory symptoms among female Japanese students.

	N = 153 (%)
Questions on asthma	
Ever had asthma*	17.0
Ever had doctors' diagnosed asthma [†]	15.7
Attack of asthma last 12 months*	3.9
Current asthma medication*	3.3
Respiratory symptoms (12 months)	
Wheeze or whistling in the chest [†]	25.0
Wheeze combined with breathlessness*	14.7
Daytime attacks of shortness of breath at rest*	13.9
Daytime attacks of shortness of breath after exercise*	19.2
Any daytime breathlessness (rest or exercise) [†]	24.2
Woken up with a feeling of chest tightness*	4.6
Woken up by nocturnal attacks of shortness of breath*, [†]	9.3
Respiratory infections	
Any airway infection last 3 months	50.0
Airway infection with antibiotic treatment last 12 months [†]	21.5

*Included in respiratory symptom score (0–8).

[†]Analysed in logistic regression analysis.

asthma/allergy, keeping all 11 FFQ scales simultaneously in the models. Those consuming meat more often had more wheeze (OR = 2.24; $p = 0.02$) and respiratory infections that needed antibiotic treatment (OR = 2.37; $p = 0.02$). Those consuming fish more often had less respiratory infections requiring antibiotic treatment (OR = 0.43; $p = 0.02$). Those consuming fruits more often had less wheeze (OR = 0.57; $p = 0.01$) and those consuming milk more often had less daytime attacks of breathlessness (OR = 0.73; $p = 0.04$). Those with frequent consumption of fast food, such as hamburgers, had more wheeze

(OR = 1.68; $p = 0.04$), nocturnal attacks of breathlessness (OR = 2.26; $p = 0.03$) and pollen allergy (OR = 1.66; $p = 0.04$). Finally, those with frequent consumption of carbonated soft drinks had more often respiratory infections requiring antibiotic treatment (OR = 1.93; $p = 0.02$) (Table 4).

When adding the fat/oil variables one by one to the statistical models, including age, smoking, parental heredity and all 11 FFQ items, some associations were found between respiratory symptoms and type of oil consumed. Butter was associated with wheeze (OR = 3.01; $p = 0.02$). Rapeseed oil was associated with wheeze (OR = 2.73; $p = 0.03$) and margarine was associated with nocturnal breathlessness (OR = 5.87; $p = 0.02$). In this statistical analysis there were no associations between daytime breathlessness, respiratory infections treated with antibiotics, pollen allergy or pet allergy and any type of fat/oil consumption.

Stepwise regression (backward elimination, Wald method) was applied to reduce the models, including age, smoking, parental asthma/allergy, the 11 food frequency items, and the five types of fat/oils. Similar results to those in the previous statistical models were obtained (Table 5). The same analysis was performed for doctor-diagnosed asthma. There were no significant associations between doctor-diagnosed asthma and any dietary factors, not in the logistic regression of FFQ nor in the stepwise regression including the questions of fat/oils.

In the multiple linear regression analysis, controlling for age, current tobacco smoking, parental asthma/allergy, and keeping all 11 dietary factors simultaneously, only fast food was significantly related to asthma score ($p < 0.05$). In the reduced models, obtained by stepwise regression, both fast food ($p < 0.05$) and margarine consumption ($p < 0.05$) were positively related to asthma score.

Correlations analysis showed that many of the protective food items (fish, seafood, fruit, raw vegetables, milk) were inter-correlated. Fish consumption was correlated to seafood (tau beta 0.53; $p < 0.001$), fruit (tau beta 0.22; $p < 0.002$) and raw vegetables (tau beta 0.28; $p < 0.001$). Seafood consumption correlated to fruit (tau beta 0.24; $p = 0.001$) and raw vegetables (tau beta 0.24; $p = 0.001$), while fruit consumption correlated to raw vegetables (tau beta 0.36; $p < 0.001$). Milk consumption was not related to any other protective dietary factors. In contrast, only a few of the risk items (meat, fast food, soft drinks, margarine, butter, rapeseed oil) were inter-correlated. Fast food and soft drink consumption were related (tau beta 0.42; $p < 0.001$), as were butter and rapeseed consumption (tau beta 0.24; $p = 0.003$). None of the other risk items were correlated to each other.

As a next step, factor analysis was applied to identify dietary pattern, including all dietary questions. Five factors, reflecting five different dietary patterns were identified. The first factor consisted of fruit, raw vegetable and cooked vegetable consumption. These FFQ scales were added to a F1 dietary pattern score (0–12). The second factor consisted of fast food, soft drink and juice consumption, added to a F2 dietary pattern score (0–12). The third factor consisted of meat, fish and seafood consumption, added to a F3 dietary pattern score (0–12). The fourth factor consisted of milk and yoghurt consumption, added to a F4 dietary pattern score (0–8). The fifth factor consisted of butter and rapeseed oil consumption, added to a F5 dietary pattern score (0–2).

Table 3 Consumption of different types of food products, among Japanese female students.

Type of food products	Frequency of consumption				
	Never	Less than once a week	Once a week	More than a week	Every day
Meat	0	4.6	11.2	63.8	20.4
Fish	1.3	9.9	17.1	61.8	9.9
Seafood/shellfish	1.3	19.7	30.9	42.1	5.9
Fruits	0	17.1	17.1	35.5	30.3
Raw vegetables	0.7	6.6	7.2	50.0	35.5
Cooked vegetables	3.9	11.2	17.8	40.8	26.3
Milk	15.1	15.1	9.9	27.6	32.2
Yoghurt	1.3	20.4	20.4	30.3	27.6
Fast food/hamburgers	8.6	48.7	25.7	14.5	2.6
Fruit juices	12.5	35.5	21.1	18.4	12.5
Carbonated soft drinks	13.2	37.1	18.5	22.5	8.6

Table 4 Associations between current diet and asthmatic symptoms and allergy.

	Wheeze	Daytime breathless, OR (95% CI)	Nocturnal breathless, OR (95% CI)	Airway infection [†] , OR (95% CI)	Pollen allergy, OR (95% CI)	Furry pet allergy, OR (95% CI)
Meat	2.24* (1.16–4.33)	0.77 (0.43–1.37)	1.54 (0.54–4.36)	2.37* (1.15–4.88)	1.01 (0.59–1.75)	0.88 (0.46–1.69)
Fish	0.67 (0.34–1.29)	0.55 (0.28–1.10)	1.49 (0.51–4.33)	0.43* (0.20–0.94)	0.76 (0.41–1.42)	0.86 (0.42–1.74)
Shellfish	1.22 (0.71–2.12)	1.49 (0.82–2.69)	1.16 (0.52–4.36)	1.29 (0.65–2.56)	0.70 (0.41–1.19)	1.00 (0.53–1.91)
Fruits	0.57* (0.36–0.89)	0.70 (0.45–1.09)	0.62 (0.31–1.23)	0.90 (0.53–1.52)	0.81 (0.55–1.21)	1.21 (0.72–2.02)
Raw vegetables	1.74 (0.99–3.07)	1.76 (0.98–3.17)	0.77 (0.33–1.79)	0.97 (0.53–1.80)	1.22 (0.75–1.98)	0.56* (0.32–0.97)
Cooked vegetables	0.99 (0.66–1.49)	1.40 (0.86–2.26)	1.23 (0.61–2.52)	1.51 (0.90–2.55)	1.01 (0.69–1.49)	1.35 (0.82–2.20)
Fresh milk	0.84 (0.62–1.15)	0.73* (0.52–0.99)	0.90 (0.54–1.51)	0.93 (0.65–1.32)	1.23 (0.94–1.61)	0.98 (0.70–1.39)
Yoghurt	1.42 (0.96–2.09)	1.12 (0.76–1.73)	1.19 (0.66–2.15)	0.98 (0.63–1.53)	0.92 (0.65–1.30)	0.69 (0.44–1.06)
Fast foods	1.68* (1.02–2.78)	1.63 (0.98–2.18)	2.26* (1.06–4.79)	0.73 (0.40–1.33)	1.66* (1.03–2.68)	1.49 (0.85–2.16)
Fruit juices	1.14 (0.77–1.68)	1.15 (0.61–1.54)	1.10 (0.59–2.04)	0.93 (0.59–1.45)	0.99 (0.68–1.43)	1.00 (0.64–1.56)
Soft drinks	1.02 (0.66–1.57)	0.97 (0.61–1.54)	0.79 (0.41–1.51)	1.93* (1.14–3.28)	0.81 (0.54–1.21)	0.98 (0.59–1.61)

Adjusted OR calculated for one step on the food frequency scale (0–4), keeping age, current smoking, parental asthma/allergy, and all 11 food items simultaneously in the multiple logistic regression models.

* $p < 0.05$.

[†]Any respiratory infection treated with antibiotics the last 12 months.

Margarine, olive oil and other oils was not included in any factors. Correlations between the dietary pattern scores and the remaining three fats/oils is given in Table 6.

The five dietary pattern scores and the remaining three fats/oils were included in new stepwise logistic regression models, including age, parental asthma/allergy and smoking (Table 7). The fast food and juice/soft drink factor was related to both wheeze ($p = 0.01$) and respiratory infections ($p = 0.05$). The butter and rapeseed oil factor was related to wheeze, only ($p = 0.003$). In addition, the animal protein scale (meat, fish, seafood) was negatively associated with pollen allergy ($p = 0.04$). In a similar way, associations between the dietary pattern scales and the asthma symptom score was analysed, using stepwise linear regression

analysis. The fast food and juice/soft drink scale was numerically but not significantly related to the asthma score ($p = 0.06$).

Food allergy/intolerance may influence dietary habits by avoidance behaviour. In our study, totally 24.2% reported some type of food allergy/intolerance. Reactions were against egg (3.9%), soy bean (2.6%), buckwheat (2.6%), nuts (2.6%), milk (2.0%), kiwi (2.0%), taro (2.0%), mackerel (2.0%), apple (1.3%) and wheat (1.3%). In order to study possible selection effects, dietary habits were compared between those with and those without self-reported food allergy/intolerance, using the same multiple logistic regression models as for the asthma variables. There was no significant association between any of the FFQ or fat/oil

Table 5 Significant variables (age, heredity and 16 food items) identified in reduced multiple models, obtained by backward stepwise regression.

	OR (95% CI)	p-Value
Wheeze		
Meat	2.00 (1.12–3.60)*	0.02
Fruit	0.73 (0.51–1.04)	0.08
Fast food	1.89 (1.23–2.91)**	0.004
Butter	2.65 (1.11–6.32)*	0.03
Rapeseed oil	2.35 (1.03–5.38)*	0.04
Daytime breathlessness		
Age	0.72 (0.50–1.03)	0.07
Raw vegetables	1.66 (0.99–2.78)	0.05
Milk	0.72 (0.55–0.95)*	0.02
Fast food	1.50 (1.00–2.28)*	0.05
Nocturnal breathlessness		
Margarine	4.40 (1.42–13.68)**	0.01
Airway infections/antibiotics		
Age	1.08 (1.02–1.15)*	0.01
Meat	2.10 (1.08–4.09)*	0.03
Fish	0.49 (0.28–0.86)**	0.01
Cooked vegetables	1.50 (0.95–2.39)	0.09
Carbonated soft drinks	1.69 (1.15–2.48)**	0.007
Pollen allergy		
Age	1.15 (0.95–1.41)	0.16
Parental asthma/allergy	2.63 (1.25–5.52)**	0.01
Seafood	0.66 (0.44–0.99)*	0.04
Fast food	1.69 (1.07–2.65)*	0.02
Carbonated soft drinks	0.78 (0.56–1.09)	0.15
Furry pet allergy		
Age	1.06 (1.00–1.18)	0.07
Parental asthma/allergy	2.47 (1.01–6.05)*	0.05
Raw vegetables	0.64 (0.40–1.03)	0.06
Yoghurt	0.72 (0.59–1.05)	0.09
Butter	2.57 (0.98–6.71)	0.05

* $p < 0.05$.** $p < 0.01$.

questions and food allergy/intolerance in general. Moreover, the negative association between milk consumption and daytime breathlessness remained significant even when excluding those three subjects reporting milk allergy/intolerance. In addition, the negative association between fish consumption and airway infections remained significant even when excluding those three subjects reporting fish allergy/intolerance.

Choosing to study nutrition could be related to dietary habits. In order to study this potentially bias, we compared dietary pattern and fat/oil consumption in nutrition course and environmental course students. There were no significant differences in any dietary patterns, besides a higher consumption of other oils in nutrition students ($p = 0.04$).

Discussion

Despite the small study size, we could demonstrate that dietary factors in Japanese female university students were associated with respiratory symptoms, airway infections and a history of atopic sensitisation. Dietary factors associated with impaired health, such as fast food, carbonated soft drinks, butter, margarine and rapeseed oil, did not belong to traditional Japanese food culture. Among five dietary patterns identified by factor analysis, a pattern including fast food, soft drinks and juice was related to respiratory symptoms. There are few similar epidemiological diet studies available from Japan.

Epidemiological studies can be affected by selection bias. In this study, we included all students in two particular courses in two Japanese universities for females only, with no prior information on the student's health status or diet. The participation rate was high (95.6%). Thus, an individual selection bias within the study population is fairly unlikely, but the study population might not be representative for all types of students. It could be assumed that including dietary students could cause a selection bias, since these students might have special dietary habits. However, we found no significant difference in dietary pattern between dietary course and environmental course students, except for other types of oils (mainly polyunsaturated oils) which was more often consumed by nutrition students. This type of oil was not related to the health parameters.

Information bias is another problem in epidemiological studies. Self-reported and doctor-diagnosed asthma are commonly used in epidemiological studies and have a high specificity but lower sensitivity. Thus, a majority of those reporting asthma in our study could be expected to actually have asthma, but some underestimation of the true prevalence could be expected. Questions on wheeze might be difficult to interpret to some languages, since the concept of wheeze might not exist in some cultures, but this should not be a major problem in Japanese. One validation study from Japan concluded that the ECRHSII questions on asthma and asthmatic symptoms used in our study had a sufficiently good correlation with asthma diagnosis in adult Japanese.²⁸ One limitation is that we used self-reported allergy, with no allergy testing to common allergens. There are some validation studies available on self-reported pollen and pet allergy in adults. One Swedish study in adult males showed that questionnaire data on pollen allergy ('hay fever') had 52% sensitivity and 90% specificity, when using allergy a positive skin prick test to birch, timothy or mugwort as the golden standard.³² A Dutch study in females showed that questionnaire data on atopy had 55% sensitivity and 89% specificity when using at least one positive specific IgE to common allergens as the golden standard.³³ A Danish validation study in the general adult population showed that questionnaire data on pollen allergy had 28% sensitivity and 98% specificity, when using specific IgE to birch, grass or mugwort as the golden standard. Questionnaire data on furry pet allergy had 32% sensitivity and 97% specificity, using specific IgE to cat or dog as the golden standard.³⁴ Thus a majority of those reporting pollen or furry pet allergy could be expected to actually have atopic sensitisation, and an underestimation rather

Table 6 Correlation (Kendal tau beta) between five dietary pattern scales, identified by factor analysis, and three types of fat/oils not included in the factors.

	F1	F2	F3	F4	F5	Margarine	Olive oil	Other oils
F1	1	0.00	0.16**	0.33***	0.03	0.15*	0.13	0.03
F2		1	0.04	0.01	−0.03	0.01	0.03	−0.05
F3			1	0.11	0.13*	−0.03	0.14	0.10
F4				1	0.03	0.15*	0.13	−0.03
F5					1	0.00	0.05	−0.06
Margarine						1	0.12	0.15
Olive oil							1	0.01
Other oils								1

F1, vegetable and fruit scale (fruit, cooked vegetables, raw vegetables) (score 0–12); F2, fast food and quick sugar scale (juice, soft drinks, fast food) (score 0–12); F3, milk product scale (milk, yoghurt) (score 0–8); F4, animal protein scale (meat, fish, seafood) (score 0–12); F5, butter and rapeseed oil scale (score 0–2).

* $p < 0.05$ by Kendal tau beta.

** $p < 0.01$ by Kendal tau beta.

*** $p < 0.001$ by Kendal tau beta.

Table 7 Significant variables (age, heredity, five dietary pattern scales, and three fats/oils) in reduced multiple models, by backward stepwise regression.

	OR (95% CI)	p-Value
Wheeze		
Fast food and quick sugar factor (F2)	1.19 (1.04–1.37)**	0.01
Butter and rapeseed oil factor (F5)	2.17 (1.31–3.59)**	0.003
Daytime breathlessness		
Age	0.77 (0.55–1.06)	0.11
Nocturnal breathlessness		
Margarine	4.40 (1.42–13.68)**	0.01
Airway infections/antibiotics		
Age	1.07 (1.01–1.14)*	0.02
Fast food and quick sugar factor (F5)	1.17 (1.00–1.36)*	0.05
Pollen allergy		
Age	1.16 (0.94–1.43)	0.17
Parental asthma/allergy	2.55 (1.24–5.24)*	0.01
Animal protein factor (F4)	0.83 (0.69–0.99)*	0.04
Furry pet allergy		
Parental asthma/allergy	2.60 (1.13–6.00)*	0.03

* $p < 0.05$; ** $p < 0.05$.

than an overestimation of the true prevalence of sensitisation could be expected.

Information bias can be a potential problem in questionnaire studies, when no clinical measurement is performed. The study shares this weakness with other large questionnaire studies on asthma, e.g. phases I and III of the

ISAAC study.³ A systematic classification error in a diet questionnaire is of importance only if it is associated with the disease, otherwise it would most likely lead to non-differential misclassification. Our food frequency questionnaire have been previously used in both primary school, junior high school and senior high school students in Sweden, Korea and China,^{9,10} as well as school personnel and general population in Sweden (unpublished data). Our FFQ have not been validated in Japanese population, but other FFQ have been validated in different populations, e.g. for fish and fruit consumption against dietary records.^{35,36} Moreover, fish consumption questions have been validated against omega-3-fatty acids measurements in serum in Japanese population³⁷ a spouse vs. husbands report on fish consumption in American population,³⁸ with acceptable agreement. Some authors have concluded that since the associations between FFQ and dietary records are moderate, in general, only strong associations between diet and health can be detected using FFQ. When performing a number of statistical tests, there is a risk for mass significance. However, we found mostly similar results using different types of statistical models. Finally, a cross-sectional study has certain limitations, e.g. if there are selection effects over time in relation to dietary habits. Food allergy/intolerance could be one such factor, leading to avoidance behaviour, but we found no indications of such selection effects in our study. Such avoidance behaviour probably influences the consumption of specific food products, but it would appear to have less influence on the general dietary pattern. In conclusion, we consider the study to have sufficient internal validity, but since the study was relatively small and included only students at specific courses in two universities, the results may not be generalised to other Japanese students.

There was a high prevalence of different types of allergies as well as respiratory symptoms possibly related to asthma among the female students, and 15.7% had a history of doctor-diagnosed asthma, but few were on current asthma medication and few reported current asthma attacks. This

may indicate an unawareness of current asthma, with respiratory symptoms not interpreted as asthmatic symptoms. Reports on pollen allergy were most common, cat allergy and dog allergy was less common. Parental asthma/allergy was associated with pollen allergy and furry pet allergy but not related to asthma, asthmatic symptoms or respiratory infections. An association between parental asthma/allergy and allergic rhinitis in Japanese school children has previously been reported.³⁹

We found few previous studies on asthma and allergies in Japanese university students. One study on 447 university students from Nagasaki concluded that house dust mite allergy, especially the species *Dermatophagoides farinae* is important for the pathogenesis of airway hyper-responsiveness in young adults in Japan.⁴⁰ Another study of a sample of 100 Japanese medical students showed that 90% had a positive skin prick reaction to at least one of 11 allergens tested, the highest prevalence of allergy being against house dust mites (*D. farinae*) (71%), while 39% had cat allergy.⁴¹ There are other Japanese studies on younger adolescents, such as one recent study in children in Suita city, aged 12–15y, where 5.7% of females had wheeze and 24% allergic conjunctivitis.⁴² In the phase three of the international ISAAC study, performed between 2002 and 2003, children aged 13–14y had 18.2% wheeze (Apter et al., 2006). In another study in junior high school students in Wakayama prefecture, 11.3% had asthma diagnosis, 48.6% specific IgE antibodies against Japanese cedar pollen, 44.2% against house dust mites (*D. farinae*) and 29.6% against timothy.⁴³ In a meta-regression analysis of Japanese cedar pollinosis, the most common pollen allergy in Japan, it was estimated that 28.7% of adolescents in urban areas would have cedar pollen allergy in 2004.⁴⁴ Less data is available on furry pet allergy in adolescents in Japan. One study in junior high school students in Wakayama prefecture reported that 57% were pet keepers, among which 3.6% had cat allergy and 3.6% dog allergy, measured as specific IgE.⁴⁵ Thus, even if our prevalence of asthma and allergies is higher than in many other Japanese studies, some other studies have demonstrated a high prevalence of allergies in some groups of university students or adolescents in Japan.

The food frequency questionnaire showed that consumption of meat, fish, seafood, fruits, vegetables, milk and yoghurt was common. Moreover, consumption of various types of fats/oil, including butter, olive oil and margarine was common, with 17% consuming fast food/hamburgers at least twice a week. This illustrates the current globalisation of food culture in the younger generation in Japan, with influence from both Japanese and Western culture. We could identify five dietary pattern, one related to fruit and vegetable consumption, one related to milk products, one related to animal protein consumption, one related to butter and rapeseed oil consumption, and one related to fast food and quick sugar (fast food, soft drinks, juice) consumption. Fast food pattern and butter/rapeseed oil pattern was associated with respiratory symptoms while animal protein consumption was protective. It is likely that animal protein consumption in Japan have a higher proportion of fish and seafood, as compared to many other countries.

We found that current dietary habits were related to asthmatic symptoms, airway infections and reports on

pollen and furry pet allergy. We focused on findings that were consistent in both statistical models. There was no association between doctor-diagnosed asthma and any dietary factors, but fish, seafood, fruit, raw vegetable and milk consumption were beneficial, while consumption of butter, margarine, rapeseed oil and frequent consumption of meat, fast food and carbonated soft drinks were risk factors for self-reported allergy and respiratory symptoms. We found no previous studies on dietary habits in relation to asthma and allergy in Japanese university students. Previous studies using the same food frequency questionnaire in younger school children have found a protective effect of fish consumption, in both Sweden¹⁰ and China.⁹ A high intake of omega-3 essential fatty acids, a fatty acid mainly from fatty fish, has been shown to be protective for asthma.^{11,14} In Japan fatty fish is a significant part of the fish consumption, but we have no information on how much the university students consumed fatty fish. A protective effect of fish consumption has been demonstrated in previous studies with respect to asthma^{46–48} and bronchial hyper-responsiveness.⁴⁹ In contrast to other studies, a previous Japanese study showed a higher prevalence of fish consumption in younger children (6–15y) with asthmatic symptoms.²⁵ To our knowledge, there are no previous publications on the protective effect of seafood consumption. The mechanism behind the observed protective association for fish and seafood remains unclear, but it has been shown that the selenium level in blood is related to intake of oily fish, shellfish and white fish.⁵⁰

The observed protective effect of fruit consumption for respiratory symptoms, statistically significant in one statistical model only, is in agreement with the previous Chinese study,⁹ as well as a number of other studies as reviewed.¹¹ A protective effect of milk consumption^{10,15,16} has previously been reported from Western countries but not from Japan. In addition, margarine has previously been shown to be a possible risk factor for asthmatic symptoms.^{10,51,52} In contrast to the findings in our study in Japan, butter has been negatively associated with respiratory symptoms in Europe.^{10,17} The reasons for the discrepancy remain unclear, but it should be noted that butter is not traditionally used in Japanese cooking. Positive association between fast food consumption and asthmatic symptoms has previously been reported from Saudi Arabia,⁷ New Zealand,⁸ Sweden¹⁰ and China,⁹ but to our knowledge not from Japan.

In conclusion, respiratory symptoms and different types of allergies were common among the Japanese female university students. Many had previous doctor-diagnosed asthma but few had current asthma medication. The dietary habits had both Japanese and Western influence. Dietary factors were related to respiratory health and a history of atopic sensitisation. Frequent fruit, fish, seafood and milk consumption may reduce the risk for asthma and atopic sensitisation, and frequent consumption of fast food, butter, margarine and the omega-6 rich rapeseed oil may increase it. The associations were most consistent for fast food and margarine consumption. Future larger studies on associations between asthma and allergy and dietary habits in Japanese children and young adults are needed to draw final conclusions, and should be given high priority.

Conflict of interest statement

Neither authors have any financial or personal relationships with other people or organisations that could inappropriately influence their work.

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