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RESEARCH ARTICLE

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Adult-onset asthma, allergy, and aspirin hypersensitivity associate with self-reported food avoidance

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ABSTRACT

Background: The adoption of avoidance diets by adult-onset asthmatics has not previously been studied. We hypothesized that avoidance diets would associate with adult-onset asthma, allergy, and aspirin-exacerbated respiratory disease (AERD).

Methods: A total of 1247 subjects with adult-onset asthma (age range: 31–91) from the Finnish national registry, and age- and sex-matched controls ($n = 1970$) participated in a questionnaire study in 1997. We estimated the association between asthma/allergy/AERD and avoidance diets, adjusting for potential confounding factors and validated the results in two retrospective cohorts of 5080 rhinitis/rhinosinusitis patients and 167 AERD patients from 2019 to 2020.

Results: The presence of asthma positively associated with adoption of any avoidance diet (adjusted OR [CI95%] 1.24 [1.02–1.51], $p = 0.029$) as did allergic disease and self-reported AERD within the asthmatic group (1.79 [1.29–2.48], $p = 0.001$ and 1.69 [1.15–2.49], $p = 0.007$, respectively). Asthmatics and allergic asthmatics were more likely to report avoidance of fish, fruits and vegetables, and spices ($p \leq 0.03$) compared to controls and non-allergic asthmatics. The adjusted OR for multiple diets among AERD patients was 2.57 [1.34–4.95] $p = 0.005$. In the validation, 26.2% of the allergic asthmatics and 10.8% of AERD patients had documented avoidance diets.

Conclusions: Our study shows a positive association between avoidance diets and adult-onset asthma, and with allergic disease or AERD within asthmatic patients. Although we lack information on the reason patients chose to observe a specific diet, our results reinforce the importance of asking patients about their diet and if needed, giving dietary advice for adult asthma patients to help them avoid the adoption of unnecessarily restrictive diets.

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Introduction

Food allergy affects nearly 5% of adults and the prevalence seems to be growing; efforts to decrease the development of food allergies are underway, with current recommendations shifting from early avoidance towards early incorporation of potentially allergenic foods [1]. In the western world, shellfish (1.9%), fruits (1.6%), and vegetables (1.3%) are the most prevalent allergies among adults [2,3], but up to 25% of adults self-report reactions to foods, which may not all be due to Immunoglobulin (Ig)E-mediated food allergies [4]. Many of these reported reactions are likely related to decreased activity of lactase enzyme and cross-reactions with pollen allergies. In children, there is an association between food allergies and atopic conditions, which are more prevalent in childhood-onset asthma (50%) than in adult-onset asthma [5]. Children with comorbid asthma and food allergies have a greater risk of severe asthma, but the exact interplay between these two conditions is not fully understood [6].

Severe asthma [7,8] is also common among patients with coexisting chronic rhinosinusitis with nasal polyps (CRSwNP) and aspirin hypersensitivity (aspirin-exacerbated respiratory disease i.e. AERD) [9]. The aspirin (acetylsalicylic acid) dose that triggers a reaction is on average 60 mg (10-300 mg), and provocation of the reactions is attributed to aspirin's

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ability to inhibit the COX-1 enzyme [10]. Salicylic acid, without the synthetically added acetyl group, is a plant hormone that occurs naturally in some foods [11], but is considered to be a very weak inhibitor of COX-1. The derived amounts of salicylic acid in foods are small and depend on food production techniques, culturally linked diets, and geographic origin of the products [12]. According to a Scottish review, average daily intake of salicylic acid was 4.42 mg and 3.16 mg for men and women, respectively [13]. Dietary products containing relatively high amounts of salicylates are vegetables (tomato, asparagus, corn), fruits (apple, cherry, strawberry, currant, raisin, peach, nectarine, kiwi, melon), berries, spices, coffee, tea, and alcohol [11]. Although there are suggestions that a low-salicylate diet can improve respiratory symptoms, the results are inconsistent, and these diets are generally not recommended by physicians, but are still adopted by some patients [14].

Although many studies have addressed food allergies and cross-reactivity among childhood asthmatics, there is little previous research about the observation of specialized diets adopted by patients with adult-onset asthma. The aim of this work was to study the prevalence of avoidance diets among adult-onset asthmatics. We hypothesized that having asthma, allergy, or aspirin-exacerbated respiratory disease (AERD) would be associated with adoption of restrictive diets.

Methods

Study design

This is a cross-sectional population-based case-control study of patients with adult-onset asthma in Finland. We used results from a questionnaire of childhood and adulthood factors performed in 1996–97 and validated the result in two retrospective cohorts from 2019 to 2020, respectively.

Primary study population

The primary study population has previously been described and is shown in Figure 1 [15,16]. Asthmatics gathered from three different registers or previous surveys took part in this population-based, case-control matched cohort study ‘Adult Asthma in Finland Survey’ conducted in 1997. This study included asthmatics both from a longitudinal, population-based ‘Total Mini Finland Health’ survey and from a random sample drawn from the Finnish Drug Reimbursement register, which is maintained by Social Insurance Institution of Finland. To be eligible for asthma drug reimbursement, the diagnosis had to be verified first by the patient’s physician based on symptoms, clinical-exam results, and lung-function tests (mainly spirometry and peak expiratory flow) before treatment and after a treatment period of 6 months, and then confirmed by an independent authority. All

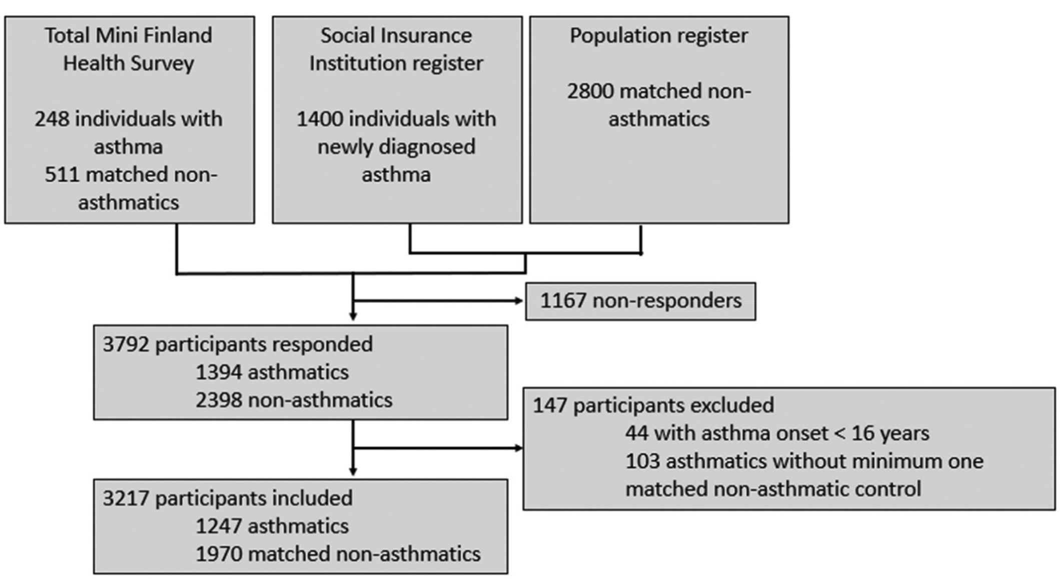

Figure 1. Flowchart of the study population.

'Mini Finland Health Survey' was conducted 1977-1980 by the National Institute for Health and Welfare. Altogether it consisted of a sample of 8000 Finnish people aged 30 or over. The study included an interview and a health examination. Asthmatics drawn from the Social Insurance Institution register were over 30-year-old asthmatics diagnosed within 2 years, that were entitled to asthma medication reimbursement. Asthma was defined as adult onset if the subject responded that the asthma symptoms and/or asthma diagnosis was set at age 16 years or later. All participants took part in the population-based, case-control matched cohort study ‘Adult Asthma in Finland Survey’ in 1997.

patients fulfilled criteria for asthma as previously described and validated [17,18]. The asthmatics were matched for gender, age (±2 years), and living region (area of residence by postal code) with two controls drawn from two National Registers: the 'Total Mini Finland Health' survey, and a population register [15]. Selected controls did not have a valid drug-imbursed asthma diagnosis at the timepoint of the study questionnaire. After excluding 1167 non-responders and patients with self-reported onset of asthma symptoms and/or diagnosis before 16 years of age we were left with 3217 study subjects (Figure 1).

Questionnaires for the primary study population

The broad questionnaire, distributed in 1997, consisted of demographic questions (for both groups), asthma-specific questions, and questions on allergic diseases as previously described [9,15]. All data was self-reported. Asthmatics were asked about aspirin hypersensitivity as follows: 'From the following list, select the factors that you have identified as exacerbating or causing your asthma or wheezing', with 'aspirin' as one choice and 'other medications, please specify' as another. If the answer included aspirin or any kind of non-steroidal anti-inflammatory drug (NSAID), patients were considered to have AERD. Non-asthmatics were not asked this question. Data on specific allergens causing allergic rhinitis (AR), allergic conjunctivitis (AC), or allergic dermatitis (AD) were not provided.

Both asthmatics and non-asthmatics were asked the question 'Do you have to follow a special diet because of an illness or because your body does not tolerate a substance in your diet?'. If the answer was positive, there was an open follow-up question on what kind of diet. A nutritionist classified the answers into classes: 9 specific avoidance diets (milk protein, egg, fish, meat, gluten, some grains, some fruits or vegetables, some spices, and low sugar) and five groups of typical diets for medical conditions or preferences: cardiovascular disease (CVD) (avoiding salt, cholesterol, fat), reflux, gallbladder disease, gout, and vegetarian diet. Lactose intolerance was specifically reported, but excluded in the analysis, as it is not an allergy and is a genetically common variant in the Finnish population. Low-salicylate diet was not specifically inquired in the questionnaire, but hypothetically these patients would avoid fruits, vegetables, and spices. Patients were asked if they had any of the following comorbidities: hypertension, CVD, diabetes mellitus (DM), rheumatoid diseases, psychiatric disease, glaucoma, back pain, or arthrosis. In the analysis, these diseases were analyzed as one group. Eating disorders were not reported.

From the questionnaire, we selected eight covariates to analyze, based on their potential impact on asthma and/or diets previously reported in literature. The definitions of these covariates have previously been described in our publications and sensitivity analysis for missing variables has been performed [9,15,19].

- Subject characteristics: sex, age (< vs. ≥50 years), and body mass index (BMI) (<30 vs. ≥30 kg/m^2).
- Education level (secondary education vs. primary school).
- Smoking (never vs. ever, defined as at current or a history of more than one pack-year).
- Chronic comorbidities: at least one allergic disease ever (AR, AC), and/or AD), aspirin hypersensitivity, nasal polyps (NP), and one or more other chronic disease.

Validation cohorts

We validated the prevalence of avoidance diets in two retrospective cohorts. The first cohort was a retrospective registry-based follow-up study on 5080 rhinitis/rhinosinusitis patients diagnosed during 2005–2019 and followed-up longitudinally in randomized cohorts during years 2005, 2007, 2009, 2011, 2013, and 2019 [20]. The second validation cohort consisted of 167 AERD patients that underwent ENT consultation during the years 2001–2017 with follow-up data collected during 2018–2020. Patients had a documented history of a reaction to NSAID or aspirin and/or a positive aspirin challenge. Their CRSwNP was diagnosed according to European Position Paper criteria and asthma according to Global Initiative for Asthma criteria [21]. Avoidance diets were retrospectively, identified manually from electronic health record data in the second cohort and by using the following word algorithms: special diet, diet, avoid*, hypersensitivity (AND name of food), allergy (AND name of food), anaphyla*, and food allergy in the first cohort.

Study approval and statistical analyses

Approval for the primary study was obtained from the ethical committee at Tampere University Hospital (2/1996) and written consent was obtained from all subjects. The secondary studies were approved by the research committees of the hospital districts and granted institutional research permission (31/13/03/00/2015) at the Department of Allergy at Helsinki University Hospital and at the Departments of Otorhinolaryngology – Head and Neck Surgery of Helsinki-, Tampere-, and Kuopio University Hospitals.

The comparisons of demographic data and special diets between asthmatic and control groups were performed by conditional logistic regression adjusting for age, gender and living region. The comparisons of demographic data within the asthmatic group were performed by binary logistic regression in stratified data analyses where the models were adjusted for gender and age, and factors possibly affecting diets. The results are reported as odds ratios (OR) with 95% confidence intervals (CI). A p-value <0.05 was considered statistically significant. Statistics were performed with IBM SPSS version 25 (Armonk, NY: IBM Corp.).

Results

Subject characteristics, primary population

Results from 3217 people who responded to the questionnaire were included: 1247 with adult-onset asthma and 1970 matched controls (Table 1, Figure 1). The response rates were 86.1% and 73.2% in the asthma and control groups, respectively. The subjects were on average (mean ± SD, min-max) 54.5 ± 11.7, 31–91 years old, and 63% were women. Among asthmatics, the proportions of other self-reported allergic diseases were 50.3% for AR, 39.9% for AC, and 33.7% for AD. In the control group the respective proportions were 25.5%, 19.6%, and 22.6%. The allergic diseases were treated as one uniform comorbidity with a higher prevalence in the asthmatic group (66.7%, $n = 832$) compared to 41.8% ($n = 1021$) among controls (OR 2.95, 95% CI 2.51–3.47, $p < 0.001$). Asthmatic patients were more likely to have smoked > 1 pack-year, have BMI ≥ 30, and have CRSwNP, comorbidities, and a lower education level compared to controls (Table 1). The overall prevalence of avoidance diets was 20.7% in this cohort, 17.7% in the non-asthmatic control group and 25.5% among asthmatics.

Asthma and avoidance diets

When we stratified by gender, age, and region, asthmatics were more likely to follow some type of avoidance diet. The OR for one avoidance diet was 1.47 ((95% CI 1.22–1.77), $p < 0.001$), and for 2–4 diets was 2.35 ((1.56–3.56), $p < 0.001$) (Table 1) when compared to non-asthmatic gender, age, and region-matched controls. The association between avoidance diets and asthma remained also after adjusting for BMI, allergic diseases, smoking, education level, CRSwNP, and other diseases (Table 1). When stratified by female sex, presence of ≥1 allergic disease (AR/AC/AD), BMI < 30, and lack of CRSwNPs, the association between any avoidance diet and asthma remained significant ($p < 0.008$).

When looking at specific dietary choices (Figure 2(a)) we saw that asthmatics were significantly more likely to follow diets that avoided fish (4.88 (2.53–9.40), $p < 0.001$)), grains (3.90 (1.19–12.79), $p = 0.03$), fruits and vegetables (3.36 (1.80–6.25), $p < 0.001$), and spices (4.07 (2.00–8.28), $p < 0.001$) compared to controls. Diets

Table 1. Association between self-reported demographic factors and asthma diagnosis in the primary study population. Odds ratio (OR) was calculated using conditional logistic regression fitted on the entire cohort of asthmatics matched with controls by gender, age, and region.

	Control		Asthma		Univariate			Multivariable		
	n	%	N	%	OR	95% CI	p	OR	95% CI	p
Avoidance diets							<.001			0.029
No	1620	82.2	929	74.5	1			1		
One or more	350	17.8	318	25.5	1.57	1.33–1.87		1.24	1.02–1.51	
Body mass index ≥ 30							<.001			<.001
No	1541	84	874	76.6	1			1		
Yes	294	16	266	23.3	1.54	1.27–1.87		1.04	1.02–1.06	
Any allergic disease							<.001			<.001
No	1147	58.2	415	33.3	1			1		
Yes	823	41.8	832	66.6	2.95	2.51–3.47		2.7	2.27–3.21	
Smoking							<.001			.01 cl
Never	949	48.2	506	40.6	1			1		
Ever	1021	51.8	741	59.4	1.38	1.18–1.61		1.26	1.06–1.50	
Education level							<.001			<.001
Secondary school	823	42.7	445	36.7	1			1		
Primary school	1104	57.3	769	63.3	1.43	1.20–1.71		1.43	1.17–1.73	
Nasal polyps							<.001			<.001
No	1891	96	1107	88.8	1			1		
Yes	79	4	140	11.2	2.96	2.20–3.97		2.61	1.88–3.62	
Other diseases							<.001			<.001
No	848	43	385	30.9	1			1		
Yes	1122	57	862	69.1	1.86	1.57–2.20		1.56	1.29–1.89	

CI= confidence interval.

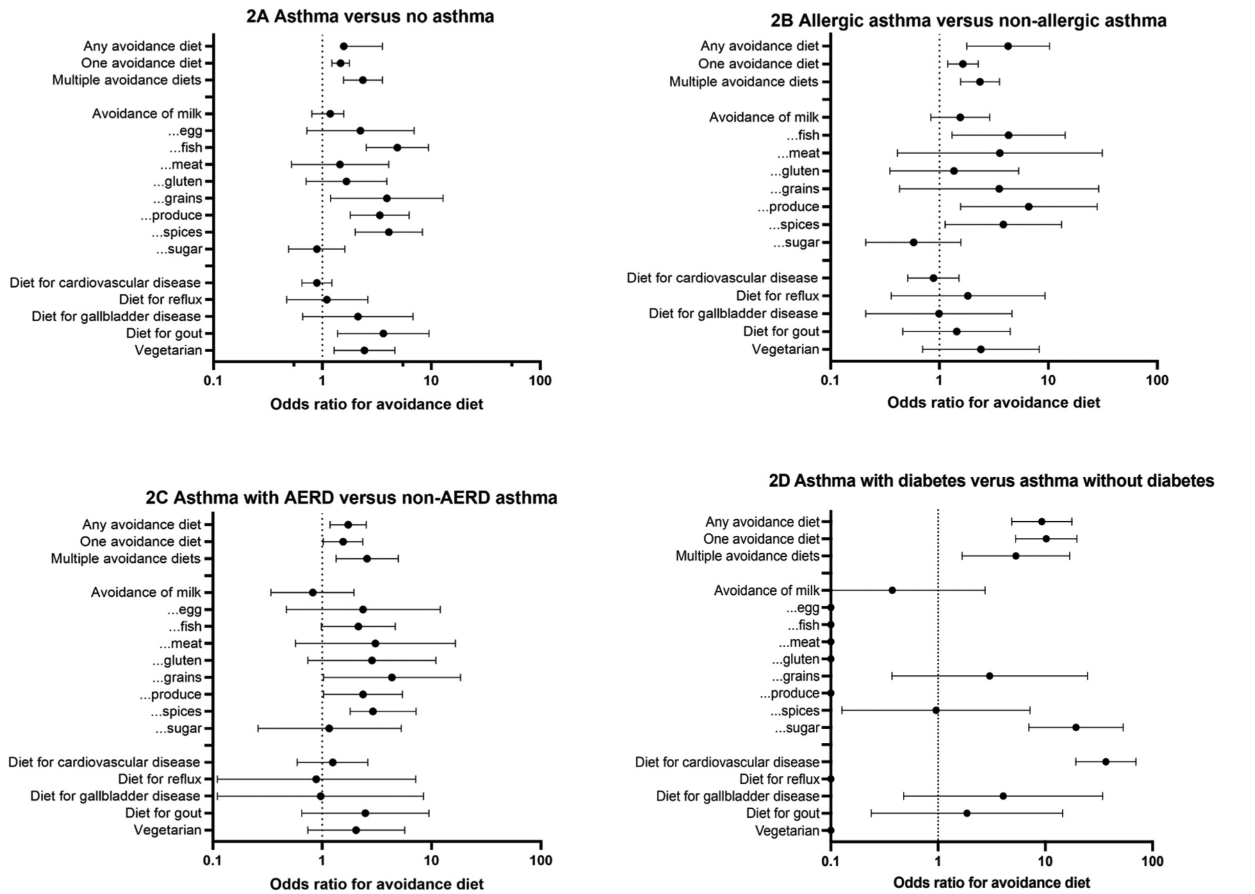

Figure 2. Adjusted or and 95% CI of the risk of (a) asthma vs. no asthma, (b) allergic asthma vs. nonallergic asthma, (c) asthma with AERD vs. asthma without AERD, and (d) asthma with diabetes vs. asthma without diabetes are presented for self-reported amount of avoidance diets, and for the diet types on a logarithmic X-axis. Models were adjusted for (a) gender, age and living region, and (b-d) gender and age. No avoidance diet was the reference value with OR = 1.

specific for gout and vegetarianism were more common among asthmatics (3.62 (1.38–9.53), $p = 0.009$) and (2.43 (1.28–4.63), $p = 0.007$), respectively. Asthmatics did not avoid milk, eggs, meat, gluten, or sugar, and did not follow CVD, reflux, or gallbladder-specific diets more than controls (Figure 2(a), data not shown).

Allergic asthma and avoidance diets

Allergic asthmatics were younger than non-allergic asthmatics and more often women (Table 2). They had a significantly higher OR for BMI ≥ 30 (1.46 (1.07–2.00), $p = 0.019$), CRSwNP (1.92 (1.25–2.96), $p = 0.003$), AERD (1.85 (1.17–2.91), $p = 0.008$), and for other diseases (1.41 (1.07–1.87), $p = 0.02$), compared to non-allergic asthmatics when adjusted for gender and age. Allergic asthma was associated with a higher education level (0.72 (0.53–0.97), $p = 0.03$), but not with smoking ($p = 0.93$). There was no statistically significant difference between genders (adjusted p-value for interaction was 0.8) (Table 2).

Within the asthmatic group, allergic asthmatics followed more specialized diets than nonallergic asthmatics (1.79 (1.29–2.48), $p < 0.001$) (Table 2), and the OR was even higher for following numerous specialized diets (4.27 (1.78–10.24), $p = 0.001$ for 2–4 diets) (Figure 2(b)). When looking specifically at the 14 different types of diets (Figure 2(b)), allergic asthmatics avoided significantly more fish (4.30 (1.30–14.25), $p = 0.017$), fruits and vegetables (6.59 (1.56–27.91), $p = 0.01$), and spices (3.85 (1.13–13.16), $p = 0.03$). Allergic asthmatics did not observe a vegetarian diet or diets for gout, gallbladder disease, reflux, or CVD more than non-allergic asthmatics. When stratified by female sex, age < 50, BMI < 30, ≥1 allergic disease, no CRSwNP, ≥1 other disease, the association between any avoidance diet and allergic asthma remained significant (data not shown, $p < 0.02$). The p-value of interaction for any allergic disease and any avoidance diet was not significant.

Table 2. Association between allergic asthma and avoidance diets or other self-reported demographic factors. Allergic asthma was defined as presence of asthma combined with at least one of the following: allergic rhinitis, allergic conjunctivitis, allergic dermatitis. Odds ratio (OR) by binary logistic regression.

	Nonallergic asthma		Allergic asthma		Unadjusted			Multivariable		
	n	%	N	%	OR	95% CI	p	OR	95% CI	p
Avoidance diets							<.001			0.001
No	342	82.4	587	70.6	1			1		
One or more	73	17.6	245	29.2	1.96	1.46–2.62		1.79	1.29–2.48	
Gender							<.001			<.001
Men	216	52	254	30.5	1			1		
Women	199	48	578	69.5	2.47	1.94–3.15		2.04	1.55–2.68	
Age ≥50 years							<.001			<.001
No	93	22.4	341	41	1			1		
Yes	322	77.6	491	59	0.42	0.32–0.54		0.47	0.34–0.64	
Body mass index ≥ 30							0.48			0.004
No	300	80.2	574	74.9	1			1		
Yes	74	19.8	192	25.1	1.36	1.00–1.84		1.6	1.16–2.21	
Smoking							0.13		Not entered	
Never	156	37.6	350	42.1	1					
Ever	259	62.4	482	57.9	0.83	0.65–1.06				
Education level							<.001			
Secondary school	100	25	345	42.4	1					
Primary school	300	75	469	57.6	0.45	0.35–0.59				
Nasal polyps							0.003			0.002
No	384	92.5	732	86.9	1			1		
Yes	31	7.5	109	13.1	1.87	1.23–2.84		2.06	1.30–2.34	
AERD							0.001			0.12
No	388	93.5	725	87.1	1			1		
Yes	27	6.5	107	12.9	2.12	1.37–3.29		1.46	0.91–2.34	
Other diseases							0.91		Not entered	
No	129	31.1	256	30.8	1					
Yes	286	68.9	576	69.2	1.02	0.79–1.31				

CI = Confidence interval. P for gender*≥1 avoidance diet(s) interaction is 0.8.

Asthmatics with aspirin intolerance and avoidance diets

Asthmatics with self-reported aspirin or NSAID intolerance were considered to have AERD. These patients were more often women (OR 3.07 (1.94–4.84), $p < 0.001$), and had more allergic diseases (2.12 (1.37–3.29) $p = 0.001$) compared to the NSAID-tolerant asthmatics (Table 3). They were more often never smokers (p = 0.02), although this was not significant when confounding factors were considered. The age and education level were similar in both groups as were the comorbidities ($p = 0.21$).

Within the asthmatic group, those with AERD reported following significantly more avoidance diets ($n = 51$, 38.1%) than did the aspirin-tolerant asthmatics ($n = 267$, 24.0%) (OR 1.95 (1.34–2.83), $p < 0.001$) even when adjusted for confounding factors (1.69 (1.15–2.49), $p = 0.007$) (Table 3). There was no statistically significant difference between genders (adjusted p-value for interaction was 0.6) (Table 3). Ten percent ($n = 14$) of the AERD patients followed two or more avoidance diets. The OR for following one specialized diet was 1.55 ((1.02–2.35), $p = 0.04$), and for 2–4 diets was 2.57 ((1.34–4.95), $p = 0.005$), compared to the NSAID-tolerant asthmatics when adjusted for gender and age (Figure 2(c)). The AERD patients avoided the following dietary components more than non-AERD asthmatics (Figure 2(c)): grains (OR 4.34 (1.03–5.41), $p < 0.05$), fruits and vegetables (OR 2.36 (1.03–5.41), $p = 0.04$), and spices (OR 2.91, (1.8–7.19), $p = 0.02$). The OR for avoidance of fish was not significant (2.14 (0.98–4.66), $p = 0.06$) and the other diets did not differ significantly from NSAID-tolerant asthmatics. When stratified by female sex, BMI < 30, lack of CRSwNP, and no AERD, the association between any avoidance diet and allergic asthma remained significant (data not shown, $p < 0.026$). The p-value of interaction for AERD and any avoidance diet was not significant.

Asthmatics with diabetes or cardiovascular disease

To confirm that our results were not a consequence of diets for DM or CVD we formed a variable that included these diets and compared it to all other diets reported. Asthmatics, compared to controls, reported significantly more other kinds of diets (OR 1.98 (CI 1.59–2.48), p < 0.001) as did allergic asthmatics compared to non-allergic ones (2.55, (1.74–3.73), $p < 0.001$) and AERD compared to non-AERD (2.16, (1.42–3.27), $p < 0.001$). Asthmatics without DM had more other avoidance diets

Table 3. Association between aspirin-exacerbated respiratory disease (AERD) and avoidance diets or other self-reported demographic factors. Odds ratio (OR) by binary logistic regression.

	Asthmatics without AERD n = 1048		Asthmatics with AERD n = 134%)		Unadjusted			Multivariable		
	n	%	n	%	OR	95% CI	P	OR	95% CI	p
Avoidance diets							<.001			0.007
No	846	76	83	61.9	1			1		
One or more	267	24	51	38.1	1.95	1.34–2.83		1.69	1.15–2.49	
Gender							<.001			<.001
Men	446	40.1	24	17.9	1			1		
Women	667	59.9	110	82.1	3.07	1.94–4.84		2.61	1.60–4.23	
Age ≥50 years							.75			0.34
No	389	35.0	45	33.6	1			1		
Yes	724	65.0	89	66.4	1.06	0.73–1.55		1.21	0.81–1.81	
Body mass index ≥ 30							.66	Not entered		
No	777	76.5	97	78.2	1					
Yes	239	23.5	27	21.8	0.91	0.58–1.42				
Any allergic disease							.001			0.03
No	388	34.9	27	20.1	1			1		
Yes	725	65.1	107	79.9	2.12	1.37–3.29		1.66	1.05–2.63	
Smoking							.019			0.46
Never	439	39.4	67	50	1			1		
Ever	674	60.6	67	50	0.65	0.46–0.93		0.87	0.59–1.27	
Education level							.94	Not entered		
Secondary school	397	36.7	48	36.4	1					
Primary school	685	63.3	84	63.6	1.01	0.70–1.48				
Nasal polyps							.011			0.018
No	997	89.6	82.1	82.1	1			1		
Yes	116	10.4	17.9	17.9	1.88	1.16–3.04		1.82	1.11–3.00	
Other diseases							.21	Not entered		
No	350	31.4	26.1	26.1	1					
Yes	763	68.6	73.9	73.9	1.30	0.87–1.95				

Confidence interval. P for gender*≥1 avoidance diet(s) interaction is 0.6.

compared to asthmatics with DM, but the difference was not significant (OR = 2.22, (CI 0, 79–6.25), $p = 0.13$). Looking at the 14 types of diets, the only difference between asthmatics with DM compared to those without was significantly more sugar-free and CVD-diets (OR 19.32, (CI 7.01–53.20), $p < 0.001$, and 36.80 (19.30–70.17), $p < 0.001$, Figure 2(d)).

Validation cohorts

We validated the prevalence of avoidance diets in two sets of hospital registry data. In the cohort of 5080 patients with rhinitis or rhinosinusitis, the proportion of patients with at least one avoidance diet among the non-asthmatics was 3.08% (87/2823), while it was 20.6% (465/2257) among asthmatics. If the asthmatic suffered from allergy the proportion was 26.2% (459/1750), whilst only 1.2% of those without any allergies had avoidance diets (6/507).

In the AERD patient sample ($n = 167$), 18 patients (10.8%) had documented avoidance diets. All these patients were allergic. The patients reported avoiding milk ($n = 1$), grains ($n = 1$), gluten ($n = 2$), fish ($n = 3$), meat ($n = 2$), vegetables ($n = 2$), nuts ($n = 7$), fruit ($n = 5$), egg ($n = 2$), chocolate ($n = 1$), others ($n = 5$; preservatives and additives, garlic oil, mushrooms, alcohol, 'AERD-diet').

Discussion

Living with asthma can cause limitations on quality of life, substantial concern, distress, and fear [22,23]. One way of processing these emotions is by attempting to gain control of the disease through self-management. Asthmatics develop personal strategies by adjusting their medication, limiting steroid use, eliminating exposure to irritating agents, and by avoidance of physical activities and aliments believed to be either allergenic or increasing mucus production [24–26]. In this large questionnaire-based, cross-sectional, population-based, case-control study we sought to study the prevalence of self-reported dietary restrictions in adult-onset asthmatics and in a subgroup of patients with allergic disease or AERD since we found that information on avoidance diets in adult-onset disease is limited. Here, we show that avoidance of certain dietary aliments was more common among asthmatics compared to non-asthmatic controls, and even more so in allergic asthmatics compared to non-allergic asthmatics, and in asthmatics with AERD compared to NSAID/aspirin-tolerant asthmatics. As reported in literature, adult-onset asthmatics were more likely to be women, have a BMI of at least 30, have a history of smoking, and have other chronic diseases and more allergic disease compared to non-asthmatic controls [9,27]. To our knowledge, the prevalence of avoidance diets among adult-onset asthmatics has not been reported before. The prevalence was higher among allergic asthmatics (29%), than among asthmatics overall (25.5%), which might be explained in part by avoidance of certain foods because of food-pollen-allergy syndrome (FPAS) and cross-reactions due to pollen allergy. In the validation cohort the prevalence (20.6%) was similar to the estimated prevalence of food allergies among US asthmatic adults (20.9%) according to a population-based survey of 40 000 adults [28]. The overall prevalence of food avoidance, including non-asthmatics, was higher (20.7%) in our study than in a European review where the self-reported point prevalence of food allergy among adults was 12.3% [29]. In the review, the estimates for Northern Europe were slightly higher (15.3%) than in many other parts of Europe, but the latter number included children and can therefore not be compared to our material. Unfortunately, to our knowledge, there is no systematic data on food allergies in Finnish adults.

The most common allergies in the US-based survey were shellfish or fish, nuts, and milk [28]. Avoidance of milk and fish were also seen in our asthmatic cohort, but surprisingly none reported the elimination of nuts. The reason might be that neither tree nuts nor peanuts are part of the traditional Finnish diet, or because the material is from 1997 and the incidence of tree nut and especially peanut allergy has increased since then [30,31]. Unfortunately, asthmatics avoided many kinds of fruits, vegetables, spices, and grains more often than controls did. FPAS could be one explanation for the adoption of these diets, but in this large cohort, dietary avoidances were also significant after adjusting for AR, AD, and AC, indicating that the dietary changes were unlikely to be predominantly due to allergies.

It is known that cultural habits affect diet. The Finnish population is, however, very culturally and genetically homogeneous, we find culture unlikely to explain the dietary differences. Other explanations for the dietary choices could be comorbidities or obesity. DM did explain most of the sugar free and CVD diets but not the multiple avoidance diets. Asthma, but not AERD was associated with at least one other disease and asthmatics did report an almost four-fold prevalence of a gout-specific diet[22] than controls, but no other typical comorbidity-diet was overrepresented. The association between asthma and avoidance diets was also significant when considering BMI and other comorbidities as confounding factors, indicating these are not the sole explanatory factors for the dietary choices.

The allergic asthmatics typically avoided certain fruits, vegetables, and fish. This study does not specify if patients avoided just one fruit or vegetable or all fruits and vegetables. From a nutritional perspective, both fish and vegetables are essential in maintaining a healthy diet, as they are rich in dietary fibers, complex carbohydrates, polyunsaturated fatty acids, vitamins, and minerals [32,33]. It has been suggested that consumption of fruits and vegetables can both reduce risk of developing asthma and reduce asthma symptoms [34] as anti-inflammatory markers increase and pro-inflammatory cytokines decrease with a rise in fruit and vegetable intake [34,35]. High-fat and low fiber intake have been associated worse lung function and airway eosinophilia in asthmatic patients and therefore diets emphasizing vegetables and whole grains may be preferred and perhaps should be recommended for most patients with asthma [34]. Dairy products have been associated with worsening asthma course [34] through the interleukin-17 pro-inflammatory pathway [36], but in our studied population, milk was not an ailment that was frequently restricted.

In the subgroup that had self-reported AERD, we saw 1.7 times increased OR for the presence of any avoidance diet, compared to non-AERD patients, with an even higher risk for two or more diets. The AERD patients avoided grains, fruits, vegetables, and spices, but not fish, as was seen among the allergic asthmatics. This could be due to following a low-salicylate-diet, even though only three patients (2.2%) reported so specifically, and avoided onions, peppers, tomato, and kale. Allergic diseases were, however, also associated with AERD and the prevalence (80%) was higher than expected in a Finnish adult population (40%) at the time [37]. In the interaction model, diets were not significantly associated with gender, age, BMI, allergic diseases, or chronic diseases, indicating that diets could be an AERD-dependent phenomenon in this group. Physicians do not generally recommend low-salicylate diet due to both the lack of evidence-based efficacy and the resulting restriction of healthy fruit and vegetable consumption [11,13,14,38]. The salicylate intake in western-type of low-spice food is low [12,13] and the adherence to this diet is also difficult as it affects quality of life [14], further arguing against actively promoting low-salicylate diets. A strict diet, high in omega-3 and low in omega-6-fatty acids, has been shown to lead to improved upper respiratory symptoms and decreased production of arachidonic acid-derived inflammatory lipids relevant to AERD [39]. However, none of the patients in this cohort reported following this low omega-6-based diet.

This study is based on a large, population-based material, diminishing potential for sampling bias. The responder rate was high, and the age range of the population wide. A large number of confounding factors could be analyzed, but the downside is the self-reported data and the lack of food allergy testing. The diets were unsystematically reported in various ways and the diets had to be categorized retrospectively by a nutritionist. Another limitation is that patients did not report their reasons for choosing a specialized diet and therefore it was not clear whether it was based on FPAS or a professional´s advice, or if the diet had been followed since childhood. A limited statistical power of some multivariable model analysis on subgroups, is another weakness of the study. Additionally, the questionnaire distributed in 1997 might not reflect today's prevalence of food allergies or asthma and caution needs to be taken in the interpretation of the results. However, the new validation cohorts showed similar results and with the start of the Finnish allergy program that started in 2008 and that aimed at changing the treatment strategy from avoidance to tolerance and resilience, the atopic march has been halted and the number of special diets, especially in children, decreased by half [40]. As we are comparing diagnostic groups in a large sample, we appreciate trends affect both asthmatics and non-asthmatics equally. Avoidance diets seem to be enriched in subjects with asthma and allergy as compared with subjects with inflammatory upper airway disease without asthma or allergy.

A limitation of the validation data set is the lack of information of the patient's own avoidance diets, instead focusing on tested food allergies. The non-asthmatics might also less frequently have been asked for food allergies or avoidance diets, which might partly explain the lower proportion of avoidance diets in the validation data.

Taken together we showed that the choice to follow an avoidance diet was more common among asthmatics compared to controls, as well as among allergic asthma patients and AERD patients as compared to non-allergic asthma, and non-AERD asthma patients. Though chronic respiratory inflammation may be modulated by dietary intake [41] and many studies discuss the beneficial effect of dietary counseling in asthma [34,41,42], specific food restrictions are not part of the overall treatment algorithm for asthma or AERD. Food avoidances are also associated with considerable economic consequences [43] and impact quality of life [44]. Greater patient education regarding differences between food intolerances, allergies, and healthy diets are warranted [45] and individuals who suspect they may have a food allergy should receive appropriate confirmatory testing and counseling in order to prevent the adoption of unnecessarily restrictive diets. A prospective study in confirmed asthma that differs between self-inflicted diets and tested food allergies could be interesting. To achieve a broader diet for the patients, non-allergic aliments could be added to the patient diet, whilst following-up that the asthma remains stable.

Conclusions

Our study shows a positive association between specialized diets and adult-onset asthma, as well as with allergic disease and AERD within the asthmatic group. The most common food restrictions included aliments that are essential for maintaining a healthy, anti-inflammatory diet. Our findings suggest the importance of asking patients with asthma or other inflammatory airway disease, about their dietary choices and other methods of self-managing their disease. Patients should be given nutritional advice to help prevent the adoption of unnecessarily restrictive diets, promoting a healthy, exercise-filled lifestyle with a Mediterranean-type of diet emphasizing the consumption of fruits, vegetables, and grains while reducing animal products. This can best be achieved engaging the patient and connecting with a multidisciplinary team of nurses, dietists, experts on physical training, and physicians.

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Competing interests

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TL has served on scientific advisory boards for Regeneron, Sanofi, AstraZeneca, and GlaxoSmithKline, and has received research grant support from Regeneron and GlaxoSmithKline.

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All competing interests are outside of this work. All other authors declare no conflicts of interest.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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