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Dietary pattern and asthma in India

The authors declare no financial disclosure

Abstract

Introduction: The study aimed to evaluate the association between food consumption pattern and asthma in Indian population.

Material and methods: 125 asthma and corresponding age and sex matched healthy controls were recruited for the purpose of a study. A self-reported food-frequency questionnaire (NNR-Dietary Pattern in Asthma Questionnaire) comprising of 80 food and drink items, belonging to 15 groups, was developed based on routine dietary habits and ISAAC phase two and phase three questionnaires.

Results: There was no significant difference of gender, height, weight, BMI and socioeconomic status between asthma and control groups ($p > 0.05$). The consumption of fast food, salted snacks, fried snacks; nuts and dry fruits were significantly higher in asthmatics ($p < 0.05$). Similarly, there was a tendency to higher consumption of fats and oil, sugar and carbonated drink in asthmatics ($p > 0.05$). On the contrary, consumption of cereals, milk and milk products, non-vegetarian food, fruits and fruit juice tends to be higher in healthy controls, though neither of them could reach a statistically significant ($p > 0.05$).

Conclusion: Consumption of fast food, salted snacks, fried snacks, fats and oils nuts, dry fruits, carbonated drinks may be associated with asthma in India. Hence, it is imperative to reduce consumption and increase awareness of influence of fast food on asthma through public health policies.

Key words: asthma, dietary patterns, India, fast food, questionnaire

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Introduction

Asthma is a worldwide problem, with an estimated 300 million affected individuals and global prevalence which range from 1% to 18% in different geographical regions [1, 2]. Studies suggest that the prevalence of asthma has been rising in recent decades in developing countries. In studies from several single centers, the prevalence of asthma in children in India ranged from 2.3% to 11.9% while the prevalence of asthma in adults varied from 0.96% to 11.03% [3]. Although the etiology of this increase is not clear, it is likely to be an alliance of genetic predisposition, environmental factors and lifestyle changes including dietary habits [4].

Diet has been recently established as a potential risk factor for asthma and allergic disorders [5–7]. The most widely used method to assess the dietary pattern in asthma patients is food frequency questionnaire (FFQ) since it applies to large cohorts, provides information on wide ranges of foods, assesses long-term diet and easy to administer [8, 9]. A shorter questionnaire (under 100 food items) makes querying respondents easier and a smaller chance of response bias due to prior knowledge of diet–disease relationships.

The link between diet and asthma has been by and large derived from western literature. The change in social-demographic factors has led to the increasing predilection towards fast foods, packed snacks and fried snacks as a popular,

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convenient and very consumed product among the Indian population. Thus, a change in dietary pattern may be postulated, as one of the unknown factors associated with the rise in prevalence of asthma in India. It is imperative that each population investigates the potential interactions under its unique lifestyle and the living environment. The present study was undertaken to assess the association of diet with asthma in a representative Indian population.

Material and methods

Study design and demographics

The study is a prospective analysis of dietary pattern in asthma cases and healthy controls performed in one year, between 2014–2015.

Diagnosis of asthma

Patients diagnosed with asthma (in line with the Global Initiative For Asthma (GINA) guidelines) were enrolled from the outpatient clinics [2]. The study cohort consisted of 125 subjects (55 females and 70 males), aged between 6 and 40 years. The exclusion criteria were: inability to fill the questionnaire, pregnant and lactating females.

Healthy controls

Similarly, 125 (55 females and 70 males), age and sex-matched healthy subjects were enrolled from the community. The healthy subjects were inquired if they previously had an episode of asthma or any previous physician-based diagnosis of asthma; only those with negative answer were included for the study.

Pulmonary function test (PFT)

PFT was performed on a dry, rolling-seal spirometer of the benchmark model lung function machine (P.K. Morgan, Kent, UK). Maximal Expiratory Flow Volume curves were obtained as per the ATS recommendations. Measurement of dynamic lung volumes like forced vital capacity (FVC) and forced expiratory volume (FEV₁) was performed as per guidelines [10].

NNR-Dietary Pattern in Asthma Questionnaire (NNR-DPAQ)

A food frequency questionnaire (NNR-DPAQ) was formulated by combining routine dietary habits of Indian population and global findings from the International Study of Asthma and Allergies in Childhood (ISAAC) phase two and phase three questionnaires [9, 11–14]. The details of the questionnaire have been provided in

Table 1. The description of 80 food and drink items included in NNR-Dietary Pattern in Asthma Questionnaire

Food group	Constituents
Cereals	Rice, roti, puti, prantha, bread, corn-flakes, noodles, dalia
Fats and oil	Vegetable oil, hydrogenated fat, butter, ghee, cream
Sugar	Sugar, jaggery, honey, jam
Milk and milk products	Yogurt, buttermilk, tea, paneer, cheese
Non-vegetarian	Egg, mutton, fish, chicken and beef
Vegetable	Fenugreek, amaranth, spinach leaves, cabbage, potato, sweet potato, tomato, onion, parmal, brinjal, gourd, cluster bean, ladyfinger, cauliflower, drumstick, carrot, cucumber, radish
Fruit	Apple, banana, guava, custard apple, orange, grapes, pomegranate, mango, dates, sapota, papaya, sugarcane, pine apple, tender coconut, sweet lemon, jamun,
Fast-food	Ice cream, chocolate, cake, sweets, pudding, burger, pizza, toast
Salted snacks	Popcorn, potato chips, mathri, namkeen
Fried snacks	Samosa, pakora, papad
Nuts & dry fruits	Almonds, peanut, walnut, cashewnut
Carbonated drinks & fruit juices	Non-alcoholic beverages

supplementary material. Each subject was asked to indicate in a pictorial based questionnaire his/her self-estimated consumption frequency of each cereal food, fats and oils, sugars, milk and milk products, non-vegetarian food, vegetables, fruits, fast food, snacks, salted snacks, fried snacks, nuts, dry fruits, carbonated drinks and fruit juices according to the following scale: “never/occasionally eat”, “1–2 times/week”, “≥ 3 times/week”.

Overall, 80 food and drink items, belonging to 15 groups were included in the questionnaire (Table 1).

All subjects gave a written informed consent to take part in the study. The institutional ethical committee approved the study protocol.

Statistical analysis

Data analysis was performed using SPSS statistical package version 15.0 for Windows (SPSS, Chicago, IL, USA). The distribution and homogeneity of variances was checked before applying parametric tests. Quantitative variables were

compared between three groups using ANOVA/Kruskal-Wallis test and between two groups using unpaired t-test/Mann-Whitney test. Qualitative variables were compared using Chi-square/Fisher's exact test. Statistical significance was set at the conventional 5% level ($p < 0.05$).

Results

125 asthma patients had an age range from 6 to 40 years, the mean duration of symptoms of

9.02 ± 6.53 years and age of onset of symptoms of 11.93 ± 7.66 years. There was no statistically significant difference of age and gender between asthma and control groups ($p > 0.05$). Table 2 summarizes demographic details of these patients and the corresponding healthy controls. Table 3 shows comparative analysis of the consumption of different food categories. None of the asthma patient's as well as healthy controls had comorbidities like diabetes and hypertension.

Table 2. Demographic characteristics of bronchial asthma and healthy controls

Variable	Bronchial asthma n = 125	Healthy controls n = 125	p-value
Male/Female	70/55	70/55	NS
Height (cm) (mean \pm SD)	159.31 \pm 10.15	160.22 \pm 8.86	NS
Weight (kg) (mean \pm SD)	60.56 \pm 12.87	57.12 \pm 12.07	<0.0001
BMI (kg/m ²) (mean \pm SD)	23.56 \pm 3.43	22.05 \pm 3.28	<0.0001
Modified Kuppaswamy scale	n (%)	n (%)	
Upper	4 (3.20)	6 (4.80)	NS
Upper Middle	16 (12.80)	17 (13.60)	NS
Lower Middle	35 (28.00)	32 (25.60)	NS
Upper Lower	46 (36.80)	43 (34.40)	NS
Lower	24 (19.20)	27 (21.60)	NS

NS — not significant

Table 3. Differences in diet group consumption in bronchial asthma and healthy controls

Diet group	Bronchial asthma n = 125 Mean \pm SD	Healthy controls n = 125 Mean \pm SD	p-value
Cereals	6.26 \pm 2.37	6.46 \pm 2.43	NS
Fats&oils	3.86 \pm 2.34	3.81 \pm 2.21	NS
Sugars	2.87 \pm 1.31	2.83 \pm 1.41	NS
Milk & Milk products	5.68 \pm 2.77	5.78 \pm 2.15	NS
Non-vegetarians	1.48 \pm 2.02	2.03 \pm 1.90	0.013
Pulses	4.12 \pm 2.31	4.11 \pm 2.38	NS
Vegetables	16.78 \pm 6.42	16.78 \pm 6.11	NS
Fruits	12.96 \pm 7.61	13.57 \pm 6.79	NS
Fast food	4.80 \pm 3.11	3.88 \pm 2.46	0.001
Salted snacks	0.89 \pm 0.70	0.64 \pm 0.69	0.003
Fried snacks	0.86 \pm 0.62	0.69 \pm 0.73	0.026
Nuts	0.90 \pm 0.79	0.56 \pm 0.72	0.000
Dry fruits	0.97 \pm 0.80	0.62 \pm 0.66	0.000
Cool drinks	0.79 \pm 0.65	0.74 \pm 0.65	NS
Fruit juice	0.78 \pm 0.63	0.83 \pm 0.72	NS

NS — not significant

Table 4. Details of food items, which have significant positive association with asthma

Food groups	Con- sumption/ week	Case		Controls		p-value	Odds ratio	95% CI for odds ratio	
		n	%	n	%			Lower	Upper
Fast food									
Burger*	0	58	46.40	80	64.00	0.003	2.054	1.241	3.400
	1 & 2	39	31.20	37	29.60	0.392	0.927	0.541	1.590
	≥ 3	28	22.40	8	6.40	0.000	0.237	0.108	0.519
Pizza*	0	61	48.80	79	63.20	0.011	1.802	1.089	2.980
	1 & 2	21	16.80	20	16.00	0.432	0.943	0.483	1.843
	≥ 3	43	34.40	26	20.80	0.008	0.501	0.285	0.880
Toast*	0	39	31.20	51	40.80	0.057	0.658	0.392	1.105
	1 & 2	27	21.60	17	13.60	0.048	0.571	0.295	1.106
	≥ 3	69	55.20	47	37.60	0.003	2.045	1.237	3.380
Salted snacks*	0	38	30.40	60	48.00	0.002	0.473	0.283	0.792
	1 & 2	63	50.40	50	40.00	0.049	1.524	0.924	2.513
	≥ 3	24	19.20	15	12.00	0.050	1.743	0.871	3.488
Fried snacks*	0	29	23.20	53	42.40	0.001	0.410	0.239	0.704
	1 & 2	58	46.40	51	40.80	0.186	1.256	0.761	2.072
	≥ 3	38	30.40	21	16.80	0.006	2.163	1.190	3.931
Nuts*	0	45	36.00	71	56.80	0.000	0.428	0.258	0.709
	1 & 2	47	37.60	38	30.40	0.115	1.380	0.816	2.332
	≥ 3	33	26.40	16	12.80	0.003	2.444	1.280	4.665
Dry fruits*	0	42	33.60	59	47.20	0.014	0.566	0.340	0.942
	1 & 2	45	36.00	54	43.20	0.122	0.740	0.445	1.229
	≥ 3	38	30.40	12	9.60	0.000	4.113	2.096	8.072
Fats and oil									
ghee	0	44	35.20	54	43.20	0.098	0.714	0.429	1.188
	1 & 2	24	19.20	22	17.60	0.372	1.113	0.587	2.110
	≥ 3	57	45.60	49	39.20	0.153	1.300	0.787	2.149
Butter	0	46	36.80	62	49.60	0.021	0.592	0.358	0.979
	1 & 2	52	41.60	42	33.60	0.096	1.408	0.843	2.352
	≥ 3	27	21.60	21	16.80	0.168	1.364	0.725	2.567
Vegetable oil	0	34	27.20	38	30.40	0.288	0.855	0.495	1.480
	1 & 2	18	14.40	23	18.40	0.197	0.746	0.381	1.461
	≥ 3	73	58.40	64	51.20	0.126	1.338	0.812	2.204
Sugar*	0	12	9.60	18	14.40	0.121	1.584	0.732	3.429
	1 & 2	17	13.60	26	20.80	0.066	1.668	0.858	3.245
	≥ 3	96	76.80	81	64.80	0.018	0.556	0.32	0.965

*Food items with consumption ≥ 3 times/week significantly associated with asthma

The authors classified the patient at presentation on the basis of GINA assessment of asthma control in adults, adolescents and children 6–11 years into well controlled (n = 49), partially controlled (n = 48) and uncontrolled (n = 28). Appropriate therapy was introduced

to diagnosed cases in line with the GINA guidelines [2].

The consumption frequency of food items associated with asthma and those having protective associations with asthma has been summarized in Tables 4 and 5 respectively.

Table 5. Details of food items, which have protective association with asthma

Food groups	Consumption /week	Case		Controls		p-value	Odds ratio	95% CI for odds ratio	
		n	%	n	%			Lower	Upper
Cereals									
Rice	0	13	10.40	7	5.60	0.081	1.957	0.764	5.012
	1 & 2	55	44.00	65	52.00	0.103	0.725	0.441	1.193
	≥ 3	57	45.60	53	42.40	0.305	1.139	0.691	1.877
Roti	0	16	12.80	21	16.80	0.187	0.727	0.360	1.467
	1 & 2	16	12.80	14	11.20	0.349	1.164	0.542	2.498
	≥ 3	93	74.40	90	72.00	0.334	1.130	0.646	1.979
Milk	0	38	30.40	25	20.00	0.029	1.747	0.981	3.113
	1 & 2	72	57.60	81	64.80	0.121	0.738	0.443	1.229
	≥ 3	14	11.20	19	15.20	0.175	0.704	0.337	1.471
Non-vegetarian									
Fish*	0	117	93.60	93	74.40	0.000	5.032	3.567	15.353
	1 & 2	7	5.60	22	17.60	0.002	0.278	0.119	0.648
	≥ 3	1	0.80	10	8.00	0.003	0.093	0.017	0.497
Fruits									
Apple*	0	24	19.20	24	19.20	0.500	1.000		
	1 & 2	55	44.00	70	56.00	0.029	0.617	0.375	1.016
	≥ 3	46	36.80	31	24.80	0.020	1.766	1.027	3.037
Banana	0	29	23.20	24	19.20	0.220	1.271	0.692	2.335
	1 & 2	58	46.40	70	56.00	0.064	0.680	0.414	1.119
	≥ 3	38	30.40	31	24.80	0.161	1.324	0.760	2.310
Mango	0	32	25.60	24	19.20	0.112	1.448	0.796	2.633
	1 & 2	51	40.80	54	43.20	0.350	0.906	0.548	1.498
	≥ 3	42	33.60	47	37.60	0.254	0.840	0.500	1.410

*Consumption ≥ 3 times/week is significant in healthy controls

Food group with higher consumption in asthmatics

The consumption of fast food (burger, pizza and toast) three or more times a week was significantly higher in asthmatics ($p < 0.05$). Similarly, three or more times a week consumption of salted snacks, fried snacks, nuts and dry-fruits was significantly higher in asthmatics ($p < 0.05$). Sugar consumption ≥ 3 time per week was also significantly higher in asthmatics. Although, consumption of fats and oil, sugar and carbonated drinks was higher in asthmatics, the result failed to reach statistical significance.

Food group with higher consumption in healthy controls

The consumption of cereals, milk and milk products, non-vegetarian food, fruits and fruit

juice was higher in healthy controls though neither of them could reach statistical significance.

Food items with equivalent consumption

The consumption of pulses and vegetables was equivalent in both groups; hence, the causality or protective effect could not be evaluated.

Discussion

The rise of asthma prevalence in developing countries has largely been associated with modification of lifestyle behaviors (eg. dietary transition) and environmental changes (eg. urbanization) [15, 16].

Notably, the change from a traditional to a modern diet is characterized by an increased intake of preserved foods, salt, refined sugar, and

saturated fat, and a decreased intake of fruit, vegetables, milk, and dietary fiber [17]. Association of western diets and asthma is postulated on two aspects. First, an increased intake of processed foods, mainly vegetable oils and margarine, and a decrease in butter, milk and fish consumption, increases the n-6/n-3 polyunsaturated fatty acids (PUFA). Second reduction intake of vegetables and fruits reduces the intake of antioxidants and micro nutrients [18]. The literature on the effect of dietary patterns on asthma is at variance. Whereas, the Mediterranean diet has been reported to be beneficial in asthma control and symptoms, Westernized diet has been related to asthma symptoms in children and young adults [19–22]. Henceforth, the present study was designed to define major dietary pattern and their association with asthma prevalence in a representative Indian population.

Increase in fast food consumption has been suggested as a factor underlying the rising prevalence of asthma [23]. ISAAC phase III study showed that fast food intake was positively associated across all centers and many regions of the world with current and severe symptom prevalence of wheeze, rhino conjunctivitis and eczema in adolescents and for males and females, for affluent and non-affluent countries [11]. However, data about consumption of these foods and their health effects is still inadequate in India. In the present study, a significantly higher consumption of fast food has been documented in asthma patients and it correlated with increased frequency leading to higher odds of asthma. In ISAAC phase II study, comparing with none or occasional consumption, the consumption of burgers over three times per week was associated with higher lifetime asthma prevalence [12]. Koolval *et al.* [24] in an observational study among 554 school children in India, reported a significant correlation (OR: 1.643, $p = 0.004$) between fast food and asthma. The plausible explanation mechanism for the relationship between fast food consumption and asthma and allergic diseases could be related to higher saturated fatty acids, trans-fatty acids, sodium, carbohydrates, sugar levels and possibly preservatives in fast food [23].

Another significant finding in the present study showed salted snacks and fried snacks consumption three or more times per week was significantly higher in asthma patients. Arvaniti *et al.* [25] documented an association between consumption of salty snacks (> 3 times/week vs never/rare) with a 4.8-times higher likelihood of having asthma symptoms (95% confidence interval: 1.50 to 15.8), irrespective of potential confounders.

Salty foods are rich in sodium, leading to increasing the risk of bronchial hyper-responsiveness and wheezing symptoms in children [26]. Also, sodium alters muscle function, and can affect modification of membrane sodium transport, which impacts the contractile properties of the airway smooth muscles [27]. Similarly, in a Brazilian study, evaluating factors associated with asthma in adolescents, fried snacks three or more times per week were independently and positively associated with asthma [28]. This has been attributed to the amount of trans-fats presence in fried snacks. Thus, consumption of fried snacks and salted snacks may have a definite causal association with asthma.

In the present study, the consumption of carbonated drinks was higher in asthma patients. Shi *et al.* [29] reported daily soft drink consumption of more than half a litre per day, had an odds ratio (OR) for asthma, 1.26 (95% confidence interval (CI): 1.01–1.58) after adjusting for socio-demographic and lifestyle factors. The association may be linked to large amounts of sugar, which increases susceptibility to allergic airway inflammation and activates the innate immune system in the lung [30]. The current study documents significantly higher consumption of nuts and dry fruits in asthma patients, which is in accordance with the results of ISAAC phase III study [11].

The present study demonstrated among fats and oil group, increased consumption of ghee and vegetable oil intake in asthma patients compared to control. In a cross-sectional study of 638 Spanish school children, the energy derived from lipids, saturated fatty acids (SFAs), myristic, palmitic acid and butter was independently associated with current asthma [31]. Hodge *et al.* [32] also supported increased dietary consumption of fats may explain the increased prevalence of asthma.

Barros *et al.* [20] described an association of high fat, sugar, and salt dietary pattern with asthma prevalence (OR = 1.13, 95%CI = 1.03–1.24) and current severe asthma (OR = 1.23, 95%CI = 1.03–1.48). The present study showed positive association of high sugar consumption and bronchial asthma, although the association is weak.

ISAAC phase III showed cereal ≥ 3 times per week were inversely associated with severe asthma in children [11]. The present study demonstrated decreased consumption of cereals in bronchial asthma patients, thus highlighting the inverse association of cereal consumption and asthma. On the contrary, increased calorie intake as well as higher protein content of cereals has been strongly associated with increased asthma symptoms [27].

Hijazi *et al.* [5] reported inverse linear relationships between intake of milk and vegetables and having asthma and wheeze in the past 12 months to 12-year-old children in Saudi Arabia. Von Ehrenstein *et al.* [33] observed an association between consumption of full cream, milk and a lower prevalence of asthma and hay fever in German children aged 5–7 years. The presence of saturated fatty acids in milk is said to be responsible for the protective effect on atopic diseases [34]. The current study documents this inverse relationship, with the presence of higher consumption of milk and milk products in healthy controls.

In the present study among non-vegetarian foods, the frequency of fish intake was significantly higher in healthy controls. This indicates fish intake may have a protective effect in asthma incidence. Fish rich in n-3 PUFAs counter-balance pro-allergic T helper (Th2) activity [35]. Barros *et al.* [20] reported protective association of fish consumption with current asthma and currently treated asthma.

Fruit consumption has been postulated to have a protective association with asthma. ISAAC phases III and II showed fruit consumption was protective in asthma [4, 11]. In the present study, intake of fruits as a group was higher in healthy control in comparison to asthma. Fruit contains antioxidants and other biologically active factors which may contribute to the favourable effect of fruit consumption in asthma [36]. In particular, foods rich in vitamin C have been reported to relate to better lung function and fewer asthma symptoms [36, 37]. The present study showed a higher consumption of fruit juices in healthy controls, which is in contrast to a study by Barros *et al.* [20] where a positive association of fruit juice consumption with current asthma prevalence has been found.

Garcia *et al.* documented association of current asthma symptoms with the intake of pulses and three or more times per week [38], on a contrary protective link between consumption of vegetables and asthma, have been reported in the literature [20]. The present study showed equivalent consumption of pulses in both groups.

In contrast, Tabak *et al.* [39] in their study documented a lack of association between vegetable intake and asthma among Dutch children. One possible explanation for an inverse association between the consumption of cooked green vegetables and wheeze could be the differential selection of vegetables and the preparation method as well as possible differences in the wheeze phenotype. The present study also failed to docu-

ment the association of vegetables with asthma, as consumption was equivalent in the two groups.

To the best of our knowledge, the present study is the first population-based study to identify dietary patterns among asthmatic individuals in India. The small number of subjects enrolled is the major limitation of our report. Also, the broader age group and cultural diversity may have led to certain food preferences, which may have influenced the results. The study can provide the basis for further longitudinal studies that would allow better knowledge about the influence of dietary patterns on the development of asthma in India. In conclusion, consumption of fast food, salted snacks, fried snacks, fats and oil, nuts, dry fruits, carbonated drinks may be associated with asthma in India. On the contrary, increased consumption of dish, fruits, milk and milk products and fruit juices may have a protective role. With growing evidence of increase association of asthma and fast food consumption, it is imperative to reduce exposure as well as the occurrence of these factors through public health policies, may have an impact on the prevalence of asthma in Indian population.

Conflict of interest

The authors declare no conflicts of interest.

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