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Association between dietary habits and recurrent respiratory infection in children: A case–control study

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Abstract *Objective:* To explore the association between dietary habits and recurrent respiratory infection (RRI) in children aged 0–14 years.
Methods: This case–control study compared dietary data of children with (cases) and without RRI (controls) collected via structured questionnaire. Participants were recruited from Chinese medicine clinics, hospitals, and children's learning institutions in Beijing. A logistic regression analysis and odds ratio (OR) calculations were conducted using SPSS 17.0 software.
Results: A total of 241 questionnaires were collected (case:control ratio: approximately 2:1). Frequent consumption of processed foods (OR = 2.988, 95% confidence intervals 1.375–6.491) and high-sugar foods (OR = 2.268, 95% confidence intervals 1.163–4.424), frequent picky eating (OR = 2.614, 95% confidence intervals 1.363–5.014), and a meat-heavy diet with fewer vegetables (OR = 1.830, 95% confidence intervals 1.358–2.467) correlated positively correlated with RRI. Additionally, 57.80% of the children with RRI were addicted to high-sugar foods, compared with 41.57% of the children without RRI ($P = .015$). Furthermore, 63.16% of the children with RRI were picky eaters, compared with 48.31% of the children without RRI ($P = .024$). Finally, 30.92% of the children with RRI frequently consumed processed foods, compared with only 17.98% of the children without RRI ($P = .027$).

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Conclusion: Although RRI correlates positively with several dietary habits, in the future, prospective cohort studies with larger samples are needed to generalize these findings.

Introduction

Influenza commonly occurs in children and it is often associated with a high incidence of complications.[1] For example, the morbidity of recurrent respiratory infection (RRI), which is characterized by reoccurrence of infection within a relative period of normalcy, is increasing in pediatric cases. The prevalence of acute upper respiratory tract infection is highest among children, with annual diagnosis rates of one in every two children aged 0–4 years and one in every 10 of those aged 5–9 years.[2] However, the true incidence of RRI is much higher, as parents normally do not consult doctors when their children develop an upper respiratory tract infection.[2]

A number of studies have explored the cause of RRI in children. Recurrent or persistent respiratory infection is suggestive of a deficiency in local or systemic host defense or an underlying pulmonary disorder that might have resulted from structural, functional, or environmental causes.[3] The reported causes of RRI vary and include a lack of nutrients or vitamins such as Vitamin A,[4] low serum levels of iron and zinc, an excess of heavy metal elements such as lead, and changes that weaken or dysregulate the immune system, such as a low or high serum level of immunoglobulin (Ig) or complement, a history of allergy, and the possibility of inherited allergies.[5,6] Additionally, the mother's dietary habits and health condition during pregnancy have been suggested as causes.[7] Furthermore, viruses, bacteria, and other pathogenic microorganisms have also blamed for pediatric cases of RRI. Chen[8] found that the frequencies of the promoter LXP haplotype and B allele were significantly higher in patients with RRI than in the controls, and noted that LXP and the B allele were the risk factors for this condition.

Through our work, we have observed that children with RRI often suffer from gastrointestinal disorders that might be attributable to an unhealthy diet, even before the occurrence of RRI, thus suggesting a potential causal role of dietary habits in the incidence of RRI.[9–11] Genetics, the mode of birth, infant feeding patterns, antibiotic usage, sanitary living conditions, and long-term dietary habits are all known to influence the composition of the gut microbiome.[12] However, few studies have examined the potential association between dietary habits and RRI in children. We therefore have hypothesized a potential association between dietary habits and pediatric RRI. To test this hypothesis, we have conducted a case–control study in which children (age 0–14 years) with RRI were compared to those without RRI, using data from the structured questionnaires.

Methods

Settings

This study was conducted at several locations in Beijing, China. The participants were recruited from the Guoyitang TCM Clinic Department of the Beijing University of Chinese Medicine, the Pediatric Clinic Department of Beijing Dongzhimen Hospital, the Respiratory Clinic Department of Xiyuan Hospital, and a children's learning institution in Beijing.

RRI diagnostic criteria

According to the diagnostic criteria[13] (Table 1), RRI cases were defined according to the participants' reports.

Statistical methods

Data were collected using the structured questionnaires that asked about dietary structure, dietary and related behaviors, and RRI in the previous year. Questions were submitted to children (>6 years old) and their (≤6 years old) parents and the questionnaires were filled by face to face interview.

Raw data were entered in the data extraction table using Epidata 3.10 database software (available at http://www.epidata.dk/index.htm). Using SPSS 17.0 software (SPSS, Inc. Chicago, IL, USA) the baseline data, sex, and age were compared between the case and control groups via a

Table 1 Recurrent respiratory infection diagnostic items.

Age (years)	Recurrent respiratory infections (times/year)	Repeated bronchitis (times/year)	Recurrent pneumonia (times/year)
0–2	7	3	2
3–5	6	2	2
6–14	5	2	2

Notes: (1) The interval time between two infections should be no less than 7 days. (2) Upper and lower respiratory infection frequencies should be pooled if the former fails to achieve the required standard. A diagnosis of repeated lower respiratory infections should be made if infections occurred repeatedly in the lower respiratory tract. (3) One year of follow-up is needed to determine the respiratory infection frequency. (4) Recurrent pneumonia refers to the development of pneumonia two or more times within one year; pneumonia must be diagnosed according to physical respiratory symptoms and medical imaging findings, and pathologic changes should disappear completely between the two infections.

t-test or a χ^2 test. SPSS 17.0 was also used to conduct logistic regression analysis and calculate odds ratios (ORs).

Participants

For the study population, children with RRI were recruited as cases, and pediatric patients without RRI and healthy children were recruited as the controls. Those who with endocrine metabolic disorders, severe digestive system disorders, or any other serious diseases or conditions involving organ failure were excluded.

We recruited participants from October 1, 2011 to October 1, 2012. All participants' age was between 1 and 14 years. A total of 280 children (or their parents if the participants were younger than 6 years) were asked to fill out the questionnaires by face to face interview; of these, 241 questionnaires were completed. Finally, 152 cases and 89 controls were included (case:control ratio: approximately 2:1) after matching participants from the control and case groups with respect to age and sex during recruiting.

Ethics

Research approval was obtained from the Ethics Committee of the Beijing University of Chinese Medicine. Children or their parents/guardians were given oral informed consent before filling out the questionnaires.

Results

Descriptive data

A total of 241 questionnaires were analyzed from the 152 and 89 participants assigned respectively to the case and control groups. The groups did not differ significantly with respect to sex and age ($P > .05$; Table 2).

Sample composition of each factor and comparison between the case and control groups

The following targeted dietary factors were analyzed and compared between the case and control groups: high-sugar foods (e.g. desserts and sweets), frequency of meat and vegetable intake (more vegetables and less meat, equal amounts, or less meat and more vegetables), picky eating habits (unbalanced eating habits with increased intake of favorite foods), and the intake frequency of juice or carbonated beverages, chocolate, western fast foods (e.g. hamburgers, fried chicken wings), puffed foods (e.g. French fries, potato chips, popcorn), processed foods (e.g. canned foods, pork floss, ham sausage), and ice cream.

In this study, 57.80% of the children in the case group were addicted to high-sugar foods, a significantly higher proportion than the 41.57% observed in the control group ($P < .05$). Similarly, the proportion of those with picky eating habits was significantly higher in the case group relative to the control group (63.16% vs. 48.31%, $P < .05$), as was the proportion of the participants with an excessive intake of processed foods (30.92% vs. 17.98%, $P < .05$). However, the proportion of those consuming juice or carbonated beverages was significantly lower in the case group than in the control group ($P < .05$). No other statistically significant differences were observed between the groups regarding other dietary factors (e.g. consumption of more meat and fewer vegetables, chocolate, fried foods, western fast food, puffed foods, and ice cream) (Table 3).

Dietary predictors of RRI

The following significant predictors of RRI ($P < .05$) were identified in the logistic regression analysis: an excessive intake of processed foods (OR = 2.988), frequent picky eating habits (OR = 2.614), intake of high-sugar foods (OR = 2.268), intake of more meats and fewer vegetables (OR = 1.830), and intake of ice cream (OR = 0.430). The intake of juice or carbonated beverages (OR = 0.473), chocolate (OR = 0.885), fried foods (OR = 0.748), western fast food (OR = 1.056), and puffed foods (OR = 1.055) were not found to differ significantly between the groups ($P > .05$) (Table 4).

Discussion

A case–control study, in which exposures are compared between the groups of people with and without the disease of interest, aims to derive a risk estimate for a particular exposure factor. When a prospective study is unfeasible, a case–control study may be a good alternative, provides that the cases and controls are selected appropriately. The current study is comprised a pilot Chinese medicine-based etiological study followed by a prospective cohort study, which is deemed to be the gold standard for risk factor analyses.

Generally, case–control studies are widely used in etiological research, especially before conducting a potentially expensive large sample cohort study to investigate the association between exposure factors and disease. However, the case–control study has not been widely applied in etiological studies in Chinese medicine. Nowadays, etiological theories in the field of Chinese medicine are predominantly initiated by the suggestions and/or clinical experiences of experts. As these suggestions and

Table 2 Sex and age distributions of the study groups.

Groups	n	Gender				Age range (years)				
		Male	Female	χ^2	P	0–2	3–5	6–14	χ^2	P
Cases	152	88	64	0.242	0.622	7	57	88	0.342	0.843
Controls	89	51	38			3	31	55		

$P > 0.05$, indicating a lack of statistical difference between the groups.

Table 3 Sample composition of each factor and analysis of the association between each dietary factor and recurrent respiratory infection.

Diet (quantitative values)	Cases (n = 152)	Control (n = 89)	χ^2/Z	P
High-sugar foods			$\chi^2 = 7.369$	0.001
Usually (1)	88 (57.80%)	37 (41.57%)		
Rarely (0)	64 (42.11%)	52 (58.43%)		
Collocation of meat and vegetable			Z = −0.533	0.063
Meat ≥80% (4)	5 (3.29%)	1 (1.12%)		
Meat 60–79% (3)	65 (42.76%)	31 (34.83%)		
Meat 50% (2)	28 (18.42%)	25 (28.09%)		
Meat 20–40% (1)	42 (27.63%)	30 (33.71%)		
Meat ≤20% (0)	12 (7.89%)	2 (2.25%)		
Picky eating			$\chi^2 = 3.923$	0.048
Yes (1)	96 (63.16%)	43 (48.31%)		
No (0)	56 (36.84%)	46 (51.69%)		
Juice or carbonated beverage			$\chi^2 = 4.532$	0.033
Usually (1)	82 (53.95%)	62 (69.66%)		
Rarely (0)	70 (46.05%)	27 (30.34%)		
Chocolate			$\chi^2 = 0.413$	0.520
Usually (1)	51 (33.55%)	30 (33.70%)		
Rarely (0)	101 (66.45%)	59 (66.30%)		
Fried food			$\chi^2 = 0.017$	0.896
Usually (1)	37 (24.34%)	21 (23.60%)		
Rarely (0)	105 (69.08%)	68 (76.40%)		
Western fast food			Z = −0.015	0.066
≥2 times/week (4)	4 (2.63%)	7 (7.87%)		
Once/week (3)	64 (42.11%)	29 (32.58%)		
Once/month (2)	47 (30.92%)	32 (35.96%)		
Once/3 weeks (1)	30 (19.74%)	12 (13.48%)		
None (0)	7 (4.60%)	9 (10.11%)		
Puffed food			$\chi^2 = -0.023$	0.064
Usually (1)	32 (21.05%)	21 (23.60%)		
Rarely (0)	120 (78.95%)	68 (76.40%)		
Processed food			$\chi^2 = 6.304$	0.012
Usually (1)	47 (30.92%)	16 (17.98%)		
Rarely (0)	105 (69.08%)	73 (82.02%)		
Ice cream			$\chi^2 = 7.495$	0.006
Usually (1)	42 (27.63%)	40 (26.32%)		
Rarely (0)	110 (72.37%)	49 (55.06%)		

experiences have not always been evaluated through scientific clinical trials, the development of evidence-based etiological research is a key step in achieving better patient outcomes with Chinese medicine.

From a traditional point of view, deficiency of healthy qi is thought to be the main factor that gives rise to the risk of RRI, especially in children. However, based on observations from years of clinical work and experiments, we have been expecting that improper eating habits would affect the onset and development of RRI. Accordingly, we designed this case–control study to explore the association between dietary bias and RRI in children.

In this study, 10 common dietary behaviors in children were evaluated to identify potential associations between children's dietary habits and RRI. Notably, diets containing larger proportions of meat and fewer vegetables, picky eating habits, and frequent consumption of high-sugar and processed foods were found to correlate with RRI. Although these dietary habits ensured higher amounts of energy in the form of calories, they were also more likely to cause dyspepsia, which is considered as a consequence of children's immature digestive system.

We have observed a greater morbidity of participants who consumed high amounts of processed foods (e.g. canned foods, ham, and other foods such as pickles) in the case group than in the control group. These foods contain preservatives and other additives, the nutritional contents differ significantly from those of staple foods.[14] Additionally, processed foods have less nutrients, so when staple foods are replaced by them, it is no good to children's health. Eventually the lack of staple foods results in deficiency of calories and/or protein, and leads to impairment of the immune system and infection.[15] As these foods weaken both the digestive and immune functions,[16–18] they increase the risk of RRI. Although the additives and preservatives presenting in processed food had met the necessary criteria, consumers are unlikely to know whether children are consuming excessive levels of these chemicals[19] which may bring some negative impact on their health.

Table 4 Logistic regression analysis of the association between dietary factors and RRI.

Diet (quantitative values)	B	S.E.	Wald	Sig.	OR	95% CI	
						Lower	Upper
High-sugar foods (always, 1; rarely, 0)	0.819	0.341	5.774	0.016	2.268	1.163	4.424
Collocation of meat and vegetable (meat ≥80%, 4; meat 60–79%, 3; meat <60%, 2; meat 20–40%, 1; meat ≤20%, 0)	0.604	0.152	15.770	0.000	1.830	1.358	2.467
Picky eating (Yes, 1; No, 0)	0.961	0.332	8.365	0.004	2.614	1.363	5.014
Juice or carbonated beverages (always, 1; rarely, 0)	−0.748	0.353	4.482	0.034	0.473	0.237	0.946
Chocolate (always, 1; rarely, 0)	−0.122	0.359	0.116	0.734	0.885	0.438	1.788
Fried foods (always, 1; rarely, 0)	−0.290	0.413	0.494	0.482	0.748	0.333	1.680
Western fast food (3 times/week, 4; Once/week, 3; Once/month, 2; Once/3 weeks, 1; None, 0)	0.055	0.395	0.019	0.890	1.056	0.487	2.292
Puffed foods (always,1; rarely, 0)	0.054	0.575	0.009	0.925	1.055	0.342	3.254
Processed foods (always, 1; rarely, 0)	1.094	0.396	7.645	0.006	2.988	1.375	6.491
Ice cream (always, 1; rarely, 0)	−0.845	0.361	5.470	0.019	0.430	0.212	0.872

Note: "Always" is defined as an addiction or consumed nearly every day; "rarely" is defined as rarely consumed or not at all. OR, odds ratio; CI, confidence interval.

Notably, preliminary culture-based and animal studies have demonstrated that the gut microbiome possesses the ability to metabolize artificial sweeteners. However, these results must be interpreted cautiously, as gut bacteria can process sweeteners into various short-chain fatty acids (SCFA) with a wide array of potential consequences.[20] Although some SCFA may be beneficial, their production may shift the bacterial balance,[9,10] potentially leading to inappropriate inflammatory processes and subsequent host cell damage and/or autoimmunity.[11]

Picky eating and partial addiction to certain foods are known to cause malnutrition,[21] a risk factor for RRI.[22–25] Our study corroborated those earlier findings, as the case group included a significantly higher percentage of picky eaters relative to the control group. We have found that participants who consumed more meat and sweet foods had a higher risk of RRI. In addition, in patients with RRI, meats, sweets, high energy proteins, and a high molecular weight diet might introduce antigens that could disrupt the immune system function and cause lesions to recur.[26] Accordingly, it is reasonable to expect that dietary factors are relevant to the risk of RRI in children.

As the living standard in China has increased dramatically, children are exposed to a greater selection of food options. However, healthy dietary habits remain very important during growth. An unbalanced diet rich in sugar, protein, energy, salt, and/or additives, which are difficult to digest completely and are not absorbed effectively, may lead to dyspepsia in children with an immature and vulnerable digestive system and subsequently cause RRI.[27] According to traditional Chinese medicine theory, an unhealthy dietary habit may block inner heat in the stomach and intestines, thus damaging the lung, which controls the defensive qi (wei qi), a type of healthy qi that can protect the body from exogenous evils. As a result, the body will not be attacked by pathogenic factors. A previous survey demonstrated that juice or sugar could aggravate "inner heat constitution" in the body of children, thus causing them to catch colds more easily.[28] An animal experiment[19] indicated that mice with stagnated heat in the lung and stomach maintained a persistent state of decreased immune function caused by an imbalance in cytokine levels[29]; this might be a potential mechanism by which individuals are rendered vulnerable to RRI. Studies have shown that an imbalanced diet or picky eating habits may cause vitamin or trace element deficiencies,[9,30] which can also reduce the immune function in children.[31,32] The reduced immune function may arise from the imbalance in the levels of immune factors, such as SIgA,[33] IgA, IgM, and IgG.[34,35]

Therefore, when following a child's preferences or aversions, even parents fail to realize the association between dietary habits and disease. Children nearly always prefer foods that are rich in sugar, protein, energy, salt, or additives, as these are delicious and attractive to children. However, a diet rich in these foods may be an underlying cause of RRI.[27] In this study, the participants of the case group were more likely to be addicted to sweet foods and to eat more meat and less vegetable. This finding corresponds to the type defined by dyspepsia and inner heat according to TCM theory,[36] or to stagnated heat in the lung and stomach.[37] Notably, another previous study found that snack foods comprised a factor influencing the risk of RRI in Chinese urban-dwelling children.[38]

We must note the limitations of our study. This is only a pilot multi-center etiological study of Chinese medicine based on the case–control study methodology. Our questionnaire includes only 10 questions, and many other dietary factors remain to be investigated in further studies. Furthermore, a case–control study can identify associations between exposure factors and a disease, rather than confirming a cause and effect relationship. Therefore, the present study will be followed up by a cohort study with a larger sample.

Conclusion

In conclusion, RRI may be associated with the dietary habits such as frequent consumption of processed or high-sugar foods, picky eating habits, and a high meat diet. In the future, a prospective cohort study with a larger sample will be needed to generalize our current findings.

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