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Association between Food Intake, BMI and PEFR of School Children (10-14 years) in the Union Territory of Puducherry

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Abstract

Drastic transition in the dietary habits of children has resulted in an uprising trend in childhood respiratory morbidity. Diet being a modifiable risk factor for respiratory discomforts, the authors aimed to investigate the association between food intake, Body Mass Index and Peak Expiratory Flow Rate by examining cross-sectional data from 1926 school children (10-14 years) selected from the four regions of the Union Territory of Puducherry during 2015 to 2017. The results revealed that Chronic Energy Deficiency (CED) was prevalent and statistically significant among majority of the children in the Union Territory of Puducherry. The lowest minimum (228.2 L/min) and lowest maximum (330.9 L/min) PEFR values was noted among milk consumers while the highest maximum was seen among strawberry eaters (410 L/min). The minimum range of PEFR for fruit intake was found to be lowest for banana (235.8 L/min). Among the animal sources, fish eaters had the highest maximum PEFR (355.5 L/min). Those consuming fried foods had PEFR value of 353.8 L/min which was same as that of banana eaters. Of the 19 food items the highest difference in mean PEFR value within each food item was observed in strawberry (151.4 L/min) and the lowest in chicken (101.1 L/min). The implication of this study is that vegetarian diet consisting of more fresh fruits and vegetables have a stronger association with PEFR values when compared to non-vegetarian diet.

Keywords: BMI, Food Frequency Intake, PEFR, School Children, Union Territory of Puducherry

1. Introduction

The worldwide increase in allergic respiratory diseases has been of late mainly attributed to environmental and lifestyle factors (obesity, physical activity and dietary habits) rather than genetic influences[1].

The peak flow meter which is a simple and effective tool in the estimation of ventilatory capacity has been widely used in clinical practice and in the epidemiological surveys and has been proved to be a practical aid in the investigations of chest conditions[2]. The growth of airways during childhood is more vulnerable to oxidative exposures and a diet suboptimal in antioxidants might lead to oxidative airway damage, reductions in airway compliance or both[3].

In studies from several single centers across India, the prevalence of asthma in children ranged from 2.3% to 11.9%[4]. Diet has been cornered to be a potential modifiable risk factor for respiratory morbidity such as asthma and allergic disorders thereby leading to poor lung efficiency among children[5].

In the last few decades an altered eating pattern has been associated with asthma not only in the Indian adult population[6] but also among children and adolescents with major portion of their meals comprising of fried foods and

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fast foods which are loaded with energy and fats with a significant amount of saturated fat, cholesterol and sodium[7]. Fast foods have been taking a toll over the health of children because they replace the healthier food options such as fruits, vegetables, milk, breads and cereals[8] causing a suboptimal dietary intake of vitamins such as A, C, E and carotenoids as well as other antioxidants such as selenium and flavonoids which have an adverse effect on the modulation of oxidative lung stimuli. Studies by Devereux and Seaton[3] and McKeever and Britton[9] have proved the beneficial association of an antioxidant rich diet with asthma, wheezing symptoms and ventilatory function.

In a cross-sectional study of 2650 school children in England and Wales, fresh fruit consumption was found to be positively associated with ventilatory function (forced expiratory volume in 1 second) with the association being stronger among children with wheezing, although wheezing itself was not related to fresh fruit consumption[10].

The CESAR cross-sectional study of children in six Central European countries showed that fruit intake was negatively associated with cough - particularly winter cough - but not with wheeze[11]. Hijaziet al[12], in a case–control study of asthma in 12-year-old children, reported a little or no association with either vitamin C or vegetable intake. An inverse association with asthma related outcomes in children had been reported by Antovaetal[11] and Remes et al[13] for citrus fruits and vegetables respectively.

Several epidemiological studies have laid emphasis on the effects of dietary intake on asthma exacerbation and alleviation. But scientific data associating food intake to PEFR values in normal children in the four regions of the Union Territory of Puducherry has not been explored so far. Puducherry and Karaikal are situated close to Tamil Nadu, Mahe situated on the Western Ghats surrounded by Kerala and Yanam situated adjoining the East Godavari district of Andhra Pradesh, since this Union Territory stands out from other Union Territories in being geographically diversified with different climatic conditions, socio-cultural and dietary variations the present study was aimed to associate food frequency intake with BMI and PEFR of school children (10-14years) in the Union Territory of Puducherry.

2. Materials and Methods

A cross sectional survey was conducted between June 2015 to February 2017 in the four regions of the Union Territory of Puducherry. All school children comprising of both sexes aged between 10 and 14 years were invited to participate in the study. A total of 1926 school children from both rural and urban areas were selected by stratified random sampling method from the Union Territory of Puducherry namely Puducherry (1187), Karaikal (327), Mahe (209) and Yanam (207). The four districts in the Union Territory of Puducherry are disconnected to each other as they lie scattered in the Southern part of India with neighboring states such as Tamil Nadu, Kerala and Andhra Pradesh between them. Permission was obtained from the Institutional Ethical Committee.

Anthropometric measurements such as height and weight were measured using prescribed standardized tools (stadiometer and weighing machine respectively). Body Mass Index was calculated using the standard formula of weight in Kg/height in m^2 and their nutritional status was categorized using Khadilkar's Asian Indian guidelines for BMI[14]. The dietary habits of the school children were collected using a detailed Food Frequency Questionnaire (FFQ). A total of 19 food items were investigated to study eight food categories: vegetable, fruit, pulse, milk, meat, poultry, sea food and fried food. Interview schedule was used to elicit information regarding usual weekly food consumption during the previous 12 months. The food frequency was assessed using a four-level scale: daily, 2-3 times/week, occasionally and rarely.

The Peak Expiratory Flow Rate (PEFR) which is the dependent variable of the study was assessed using Mini Wright Peak Flow Meter (PFM). Disposable mouthpieces were used for all the samples to avoid cross-contamination. After explaining the purpose of the study and the technique of using PFM, PEFR of the children was measured by giving each student three trials. The mean of the three PEFR values was recorded as the actual PEFR value in cases where the difference among them was negligible. But when a wider difference was noticed, the highest value was noted. The collected data was subjected to statistical analysis using SPSS 19.0 version.

3. Results and Discussion

Dietary information about the food intake of 19 different foods comprising of six non-vegetarian sources, two pulses, three vegetables, seven fruits and fried foods was obtained from 1926 school children from the four regions of the Union Territory of Puducherry. ANOVA was done to find the association of the 19 different foods consumed 2-3 times per week with the four regions. Since one sample in Yanam did not consume one particular food item at all, only Puducherry, Karaikal and Mahe were taken into consideration for comparison. However, the data of all the four regions are depicted in the Table 1.

From Table 1 the association between food frequency, anthropometric measurements and PEFR of the sample according to region can be inferred. The table depicts the dietary intake of egg, mutton, chicken, crab, fish, milk, green gram dhal, bengal gram, gourd varieties, pumpkin, radish, guava, grapes, pomegranate, orange, banana, musambi, strawberry and fried foods.

Based on the classification of BMI for children and adolescents given by Khadilkar et al[14] all the children of Puducherry were found to have Chronic Energy Deficiency (CED) of either Grade 1 or Grade 2. BMI was within the normal range (18.5–22.9) in children of Karaikal who were consuming green gram dhal, radish, pomegranate, orange, egg, fish and milk about 2-3 times per week. In Mahe the children (lower than 50%) with normal BMI showed food intake of chicken, fish, musambi and oranges on a weekly basis. Only a negligible number of children consuming radish in Yanam (16) seemed to have normal BMI. In total, Chronic Energy Deficiency (CED) was found to be prevalent and statistically significant among majority of the children in the Union Territory of Puducherry with a BMI ≤ 18.5 except among those who included strawberry in their diet[15].

The PEFR values were found to be highly significant ($p = <.000$) among the four regions with respect to different food items. The minimum lowest PEFR value (228.2 L/min) was seen among milk consumers in Karaikal and the value was closer to those who consumed bengal gram (229.5 L/min) in the same region.

The ranking order of animal sources of food in relation to minimum PEFR value (ascending values) is recorded as milk, fish, chicken, egg, crab and mutton. Milk had the lowest PEFR value of 228.2 L/min whereas mutton had the highest value of 238.7 L/min. The difference in PEFR between fish and chicken intake was 2.5 L/min whereas the difference between milk and mutton intake was 10.5 L/min. Among the chicken, egg and crab consumers the PEFR showed variation of only 2 L/min. Further it was observed that the children of Karaikal exhibited the least PEFR value throughout. A study by Shelagh et al[16] on the effects of exclusion of dietary egg and milk in the management of asthmatic children revealed that an egg- and milk-free diet even for a short period of eight weeks can reduce atopic symptoms and improve lung function in asthmatic children.

Among the three vegetables included in the FFQ, radish had the least PEFR value of 234.4 L/min compared to gourd varieties (236.4 L/min) and pumpkin (236.7 L/min). Radish is an anti-congestive root vegetable that helps to decrease congestion of the respiratory system including irritation of the nose, throat, windpipe and lungs that can come from colds, infections, allergies and other causes[17]. The high water content, Vitamin C, zinc and phosphorus in radish helps the body to flush out toxins and also prevent viral infection. Phytochemicals such as indoles help to detoxify and the powerful antioxidant such as flavonoids zeaxanthin, lutein and beta carotene protect the body against oxidation reactions and by-products which may be cancerous or make the body prone to diseases. The minimum range of PEFR for fruit intake was found to be lowest for banana (235.8 L/min) and highest for strawberry (258.6 L/min). Among the citrus fruits the lowest and highest PEFR value was noted among those who ate orange and strawberry 2-3 times /week respectively. PEFR value of those who included pomegranates (240.3 L/min) in their diet was found to be higher than those who included fruits such as oranges, grapes and guava but lower than musambi (244.5 L/min). Fried foods (245.9 L/min) positioned itself just before strawberry (258.6 L/min) which was ranked first in the highest minimum PEFR value. Among the four regions, Karaikal was found to have the minimum PEFR value across all the food items except pumpkin.

On analyzing the maximum value of PEFR against each food item, the lowest and highest PEFR was exhibited in those who consumed milk (330.9 L/min) and strawberries (410 L/min) 2-3 times per week respectively. Among the animal sources, fish eaters had the highest maximum

Table 1. Association between food frequency, anthropometric measurements and PEFR of the sample

Food group / 2-3 times/week	Region	N	BMI		F	Sig	PEFR		F	Sig	Mean of 4 regions	Min & Max PEFR values	Mean Diff	Rank* order of min PEFR	Rank* order of max PEFR	Rank* order of mean diff
			M	SD			M	SD								
Egg	P	833	16.9	3.1	16.472	.000	281.5	64.0	79.701	.000	291.13	235.3 346.1	110.8	6	4	7
	K	213	18.6	3.9			235.3	62.0								
	M	127	17.9	3.0			346.1	84.7								
	Y	156	17.4	3.2			301.6	65.6								
Mutton	P	332	16.3	2.8	14.705	.000	271.8	62.6	21.668	.000	292.56	238.7 349.1	110.4	13	5	`6
	K	100	18.1	3.1			238.7	65.3								
	M	12	17.9	1.9			349.1	99.4								
	Y	53	18.4	4.0			310.6	54.0								
Chicken	P	560	16.6	2.9	21.266	.000	280.2	66.1	46.302	.000	287.82	235.2 336.3	101.1	5	2	1
	K	171	18.4	3.4			235.2	65.3								
	M	72	18.8	3.4			336.3	82.8								
	Y	127	17.6	3.5			299.6	61.1								

Food group / 2-3 times/week	Region	N	BMI		F	Sig	PEFR		F	Sig	Mean of 4 regions	Min & Max PEFR values	Mean Diff	Rank* order of min PEFR	Rank* order of max PEFR	Rank* order of mean diff
			M	SD			M	SD								
Crab	P	207	16.9	3.2	2.508	.059	279.7	68.8	18.606	.000	293.57	237.2 349.1	111.9	11	5	8
	K	72	17.4	3.1			237.2	72.7								
	M	21	18.4	3.9			349.1	69.5								
	Y	46	18.0	3.8			308.3	66.4								
Fish	P	689	16.9	3.1	14.355	.000	283.7	62.8	61.121	.000	294.2	232.7 355.5	122.8	3	14	17
	K	186	18.5	3.8			232.7	60.9								
	M	40	18.6	3.8			355.5	76.0								
	Y	111	17.8	3.5			304.9	59.8								
Milk	P	120	16.6	3.0	4.235	.006	268.6	60.6	21.713	.000	288.3	228.2 330.9	102.7	1	1	3
	K	45	18.5	4.5			228.2	54.1								
	M	39	18.3	3.1			330.9	70.1								
	Y	17	17.7	3.3			325.8	94.1								

*Rank order in ascending

Food group / 2-3times/ week	Region	N	BMI		F	Sig	PEFR		F	Sig	Mean of 4 regions	Min & Max PEFR values	Mean Diff	Rank* order of min PEFR	Rank* order of max PEFR	Rank* order of mean diff
			M	SD			M	SD								
Green gram dhal	P	360	17.0	3.3	8.017	.000	280.4	64.1	54.560	.000	292.05	236.0 349.6	113.6	8	7	9
	K	120	18.6	4.1			236.0	72.2								
	M	104	18.2	3.3			349.6	78.3								
	Y	83	18.0	3.3			302.2	62.2								
Bengal gram	P	364	16.9	3.0	9.339	.000	281.2	62.0	66.773	.000	287.07	229.5 346.3	116.8	2	6	14
	K	135	18.4	3.5			229.5	65.0								
	M	112	18.1	3.2			346.3	75.2								
	Y	82	17.4	3.3			291.3	60.9								
Gourd varieties	P	301	16.8	3.2	7.174	.000	276.5	62.9	41.269	.000	290.77	236.4 353.1	116.7	9	11	13
	K	85	18.3	3.6			236.4	70.7								
	M	72	18.1	3.0			353.1	84.7								
	Y	28	18.2	3.9			297.1	41.5								

Food group / 2-3times/ week	Region	N	BMI		F	Sig	PEFR		F	Sig	Mean of 4 regions	Min & Max PEFR values	Mean Diff	Rank* order of min PEFR	Rank* order of max PEFR	Rank* order of mean diff
			M	SD			M	SD								
Pumpkin	P	175	16.9	3.0	3.792	.011	271.0	56.8	25.269	.000	275.32	236.7 351.1	114.4	10	9	11
	K	60	18.3	3.2			242.5	70.7								
	M	40	18.0	3.0			351.1	75.7								
	Y	3	15.4	4.1			236.7	75.7								
Radish	P	424	16.9	3.0	9.284	.000	283.6	62.2	35.499	.000	294.97	234.4 365.7	131.3	4	16	18
	K	134	18.5	3.4			234.4	69.08								
	M	22	18.4	4.0			365.7	73.83								
	Y	16	18.5	5.1			296.2	62.80								
Guava	P	462	17.0	3.2	5.551	.001	281.9	62.1	46.156	.000	220.09	238.8 356.3	117.5	15	15	15
	K	124	18.3	3.5			238.8	68.1								
	M	56	17.5	3.2			356.3	79.7								
	Y	107	17.2	3.1			303.6	66.4								

Food group / 2-3 times/ week	Region	N	BMI		F	Sig	PEFR		F	Sig	Mean of 4 regions	Min & Max PEFR values	Mean Diff	Rank* order of min PEFR	Rank* order of max PEFR	Rank* order of mean diff
			M	SD			M	SD								
Grapes	**P**	371	17.0	3.0	4.484	.004	280.4	61.0	45.704	.000	294.95	238.0 353.4	115.4	14	12	12
	K	108	18.3	4.0			238.0	68.3								
	M	61	17.7	3.1			353.4	82.0								
	Y	112	17.2	3.5			308.0	67.81								
Pomegranate	**P**	345	17.0	3.2	7.963	.000	276.8	61.1	34.286	.000	292.75	240.3 342.9	102.6	16	15	2
	K	119	18.8	3.9			240.3	65.7								
	M	42	18.4	3.3			342.9	91.5								
	Y	83	17.7	3.6			311.0	64.6								
Orange	**P**	382	16.9	3.19	12.893	.000	277.7	61.9	61.043	.000	293.37	237.5 351.2	113.7	12	10	10
	K	138	18.7	4.0			237.5	63.3								
	M	89	18.8	3.7			351.2	75.8								
	Y	93	17.4	3.4			307.1	65.5								

Banana	**P**	493	17.0	3.0	8.973	.000	284.7	65.5	61.960	.000	295.15	235.8 353.8	118	7	13	16
	K	143	18.4	4.0			235.8	63.8								
	M	93	18.3	3.2			353.8	81.7								
	Y	96	17.1	3.1			305.3	59.2								
Musambi	**P**	261	16.7	2.9	7.969	.000	281.7	62.7	23.122	.000	292.9	244.5 350.9	106.4	17	8	4
	K	75	18.1	3.4			244.5	78.1								
	M	43	18.7	3.2			350.9	79.3								
	Y	49	17.4	2.4			294.5	63.5								
Strawberries	**P**	95	16.8	3.2	1.100	.351	270.9	70.1	11.547	.000	314.37	258.6 410.0	151.4	19	17	19
	K	38	18.0	3.7			258.6	87.3								
	M	10	17.3	2.8			410.0	62.5								
	Y	5	16.7	1.6			318.0	117.7								
Fried foods	**P**	448	17.1	3.2	5.752	.001	285.6	66.4	37.943	.000	299.75	245.9 353.8	107.9	18	13	5
	K	94	18.2	3.9			245.9	75.0								
	M	83	18.4	3.4			353.8	83.5								
	Y	46	17.5	3.0			313.7	63.9								

PEFR (355.5 L/min). Oily fish has been reported to have potential protective effects to childhood asthma[18] because of the n-3 polyunsaturated fatty acids eicosapentanoic acid and docosahexaenoic acid[19] but studies by Wijga et al[20] and Cook et al[10] was conflicting because they had observed that consumption of fish had no association with respiratory symptoms and lung function respectively. Children who consumed mutton and crab shared the same PEFR value (349.1 L/min) and were in the twelfth position. While egg (346.1 L/min) ranked fourteenth, chicken (336.3 L/min) ranked sixteenth and a difference of 9.8 L/min between the two was noted. The difference in the highest and lowest maximum PEFR value among animal source (between fish and milk) is 24.6 L/min. In 2016, Kumar et al[21] in his study among children (<18 years) in rural Delhi concluded that higher consumption of non-vegetarian food was associated with an increased risk of asthma. Agrawal et al[4] in a study on risk factors for asthma in adults, concluded that consumption of a non-vegetarian diet, daily or even occasionally, were more likely to report asthma than those who were strictly vegetarian. But studies by Koolwalet al[22] and Huang et al[23] on the contrary, proved that non-vegetarian diet reduces asthma among children when compared to vegetarian diet.

Vegetable proteins such as green gram dhal (349.6 L/min) seemed to have a slightly better effect on the PEFR value when compared to bengal gram (346.3 L/min) with a difference of 3.3 L/min. Out of the three vegetables mentioned in the FFQ, the overall ranking of radish was second and had the highest maximum PEFR value (365.7 L/min) when compared to gourd varieties (353.1 L/min) and pumpkin (351.1 L/min). The values between the highest and lowest maximum PEFR in vegetables differed by about 14.6 L/min.

Strawberry eaters had the highest maximum as well as the highest minimum PEFR values. The PEFR of children who consumed banana (353.8 L/min) was found to be higher than those who consumed citrus fruits such as grapes (353.4 L/min), oranges (351.2 L/min) and musambi (350.9 L/min). The results of a British research revealed that there was a 34% lesser chance of children developing asthmatic symptoms by eating one banana a day. Another study by the Imperial College of London found that bananas could reduce breathing problems like wheezing among children (5 to 10 years) by one-third[24] and also help to prevent childhood asthma by increasing its consumption[25].

Reversetol (3,49,5-trihydroxystilbene), a polyphenolicstilbene found in the skins of grapes, has the ability to inhibit cytokine-stimulated inducible nitric oxide synthase expression and nitrite production in human primary airway epithelial cells[26]. Guava (356.3 L/min) had PEFR value much closer to that of fish eaters (355.5 L/min). Pomegranate was found to have the lowest (342.9 L/min) of maximum PEFR value among fruits. The difference in the highest and lowest maximum PEFR value between strawberry and pomegranate is 67.1 L/min. A cross-sectional study by Chatzi et al[27] demonstrated a negative association between dietary intake of grapes, oranges, apples and fresh tomatoes with atopy but protective effect for wheezing and rhinitis in children aged 7–18 years in rural Crete. The study also highlighted that a diet rich in antioxidants may have a protective effect on the inflammatory response from early childhood to adolescence thereby preventing the expression of allergic diseases in this population group.

Those consuming fried foods had PEFR value of 353.8 L/min which was same as that of banana eaters.

Of the 19 food items the highest difference in mean PEFR values was observed in strawberry (151.4 L/min) and the lowest in chicken (101.1 L/min).

Overall this study reveals that milk contributes to lower PEFR value. This may be due to the increased use of A1milk and processed milk among majority of the population. A1 milk is responsible for increased mucous production and produces opiate-like effect in the human gut. Even in rats[28] and mice[29] A1 beta-casein was found to be associated with increased levels of the inflammatory marker myeloperoxidase (MPO) in the colon. In contrary to the present study, a cross-sectional study conducted in Guangzhou, China among children (Grade 3 and Grade 4) found that high consumption of milk had higher lung function values than children with low consumption, although the differences were not statistically significant[30].

The PARSIFAL study (2007), which involved 15,000 children, found that the consumption of raw milk was inversely associated with asthma and offered protection against asthma and allergy[31]. Consumption of unprocessed cow's milk was inversely associated with rhinitis, respiratory tract infections, and otitis media, with a 30% reduction

noted among infants thereby revealing its strong protective effect than boiled cow's milk[32].

This study concludes that vegetarian diet consisting of more fresh fruits and vegetables have a positive effect on the PEFR of children (10-14 years) when compared to non-vegetarian diet.

4. Conclusion

The results have brought to the spotlight that higher intake of a vegetarian diet has a strong positive association with PEFR values in normal children. These results add support to the hypothesis regarding the protective effect of vegetables and fresh fruits on the respiratory health of children. Childhood is a critical period during which food habits are formed and carried over to adulthood. Hence, children should be encouraged to make healthy food choices by including a variety of fresh fruits and vegetables in plenty in their daily diet so that their lung efficiency increases and reaches the maximum potential. Phenolic acids and polyphenols present in fruits and vegetables possess anti-inflammatory and anti-allergic properties and act as nutraceuticals. Although milk consumers were found to have the lowest PEFR values this food group cannot be excluded as it is an important source of protein and calcium for the growing children. It is the need of the hour to realize the benefits of A1 milk in human nutrition and to increase the breeding of A1milk producing cows. Further, procuring unaltered milk from reliable milk farms and consuming it raw (without processing) could help to alleviate respiratory allergies and improve lung efficiency due to the presence of live probiotic bacteria in it. However, the fodder, breed and hygienic practices during milking should be a matter of serious concern. Further studies can be carried out to consider the effect of sweets and junk foods on PEFR among normal children. Thus, diet plays an important role in maintaining health and preventing the burden of respiratory diseases.

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