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Association Between Peak Expiratory Flow Rate And Frequency Of Food Consumption Among School Children In The Union Territory Of Puducherry, India

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Abstract

Background:

The burden of low lung efficiency among children in India is increasing rapidly varying across different states and Union territories. The effect and frequency of food consumption on the functioning of respiratory system had received less attention when compared to other non-communicable diseases until the recent pandemic of Covid-19.

Aim:

This study aimed to find the association between Peak Expiratory Flow Rate (PEFR) and frequency of food consumption among school going children aged 10 to 14 years in the Union Territory (UT) of Puducherry.

Methods:

A total of 1926 school going children (10-14 years) were screened for lung efficiency using Food Frequency Questionnaire and Mini Wright Peak flow meter.

Results:

Results revealed that egg, musambi, grapes and strawberry resulted in a higher Peak Expiratory Flow Rate (PEFR) value that was statistically significant ($p<0.05$) when consumed weekly rather than daily. A highly significant PEFR value ($p<.001$) was noticed among those who included fish daily in their diet. Eating orange and banana daily was also found to have a positive effect on PEFR.

Conclusion:

Type of food as well as the frequency of intake strongly influences PEFR and has salutary effects on respiratory health.

Keywords: Food Frequency Questionnaire, Lung efficiency, Allergy

Introduction

The burden of low lung efficiency among children in India is increasing rapidly, and varies across states and Union territories. In the past three decades both the developed and the developing countries had been witnessing a surge in the incidence of allergic diseases [1]. World Health Organisation had confirmed that asthma is a serious public health problem worldwide with the prevalence rate gradually spiking among children in the last two decades [2]. Epidemiological reports on allergic and asthma prevalence among children in rural and suburban India are few [3]. In 2017 a study conducted in urban Puducherry revealed 45 % prevalence of respiratory symptoms among young children aged 10 - 12 years [4].

Prognosis of asthma has been strongly linked to diet [5] because of the strong multicollinearity between food and the nutrients present in them. Over the years, several studies have brought to light the positive effects of certain foods or nutrients in the manifestation and management of several non-communicable diseases such as cardiovascular diseases, diabetes and cancer across different age groups. But when compared to other organ systems, the effect and frequency of food consumption on the functioning of respiratory system had received less attention until the recent pandemic of Covid-19. Corona virus has been an eye opener to the world in realizing the salutary effects of certain foods on lung function thereby increasing the intake of specific foods especially fruits and herbs that promote lung health. Food Frequency Questionnaire is a cost-effective tool used in determining the dietary intake of large samples during epidemiological studies. Factor analysis is one of the best way of understanding the multidimensional property of food and disease [6-8].

Mini wright peak flow meter which measures the Peak Expiratory Flow Rate (PEFR) is considered to be an important screening tool to determine the magnitude of airway obstruction. This non-invasive device is not only easy to use but also less expensive, reliable and reproducible too. The results of this lung function test will indicate the ventilatory function of healthy as well as asthmatic children [9].

The Union Territory (UT) of Puducherry is very unique in its geographical status owing to its widely diversified territories namely Puducherry, Karaikal, Mahe and Yanam which are scattered across the states of Tamil Nadu, Kerala and Andhra Pradesh. These four territories exhibit varied socio-cultural characteristics, topography, climatic conditions, food habits and also lifestyle pattern. Very few studies have examined the effect of specific foods on PEFR among children.

Hence this study was carried out with the objective of finding out the association between PEFR and the frequency of consumption of certain foods believed to either increase mucous production in lungs or cause respiratory discomforts.

Materials and Methods

Study Population: A total of 1926 school going children (10-14 years) of both sexes from all 4 regions of the UT of Puducherry, India were screened for lung efficiency based on stratified random sampling method. Both government and private schools in rural and urban areas were covered. Data was collected from 14 schools in Puducherry, 5 in Karaikal, 3 schools each in Mahe and Yanam during school hours. This study was carried out after getting approval from the Directorate of Education, Puducherry. Children in the age group of 10-14 years giving written parental / guardian consent were included in the study. Exclusion criteria comprised of children over 14 years and those with known cardiovascular problems, deformities of the thorax or unable to perform the test. This observational study was non-invasive and approved by the Institutional Ethical Committee of Bharathidasan Government College for Women, Puducherry, India. The study period was from June 2015 to February 2017. The scope and objective of the study was explained in detail to the Head of the Institution, teachers and students before carrying out the study for better cooperation. Data pertaining to the socio-demographic profile, anthropometric measurements and frequency of food intake of selective foods perceived to increase mucous secretion or cause respiratory discomforts were collected through interview schedule. The questions were translated in vernacular language during interview.

Anthropometric measurements:

Anthropometric measurement which is a direct method for the assessment of nutritional status was used in the present study. Standardized methods were used to evaluate the height, weight and chest circumference of the sample with the aid of portable stadiometer, a calibrated weighing scale and non-stretchable measuring tape respectively. Height was measured without shoes to the nearest 0.5 cms and weight was measured in school uniform to the nearest 0.5 Kg. Chest circumference was measured to the nearest 0.5 cms at the level of nipple.

Assessment of Pulmonary Function:

Lung function test using Mini Wright Peak Flow Meter (PFM) of standard range was performed to find the peak expiratory flow rate. The correct procedure and technique of using this device was well explained to the enrolled students before the start of the lung function test followed by demonstration. Individual mouthpiece was given to each child in order to avoid cross contamination. The children were asked to practice few times with the PFM to ensure that they perform the test correctly. Each child was then made to take a deep breath and then blow forcefully into the PFM. This procedure was repeated thrice and the best out of the three values was recorded as their personal best value.

Assessment of Food Intake:

The frequency of dietary intake of certain foods of both plant and animal origin were elicited using a validated 19-item Food Frequency Questionnaire (FFQ). Individual response to the frequency of intake of each food was obtained through interview schedule. Each question consisted of 4 options namely daily,

weekly 2 to 3 times, once in a month and rarely. This FFQ comprised of 2 foods from the pulse group (green gram dhal and bengal gram), 3 foods from the vegetable group (gourd varieties, pumpkin and radish), 6 foods from milk and meat products food group (egg, chicken, mutton, fish, crab and milk) and 7 foods from fruits group (orange, musambi, guava, pomegranate, banana, strawberry and grapes). In addition to this, a general question on the intake of fried foods was also included. Since the children were too young, the quantity of foods consumed and the variety were not included in this FFQ.

Statistical Analysis

All the statistical analysis was done using Statistical Package for Social Science version 19.0. Results of PEFR was represented as mean and standard deviation (SD). Test of independence (chi-square) was used to test the association between foods and region. Multivariate factor analysis was used to identify factors from a set of variables.

Results and discussion

The socio-demographic profile of 1926 samples aged 10 to 14 years who participated in this respiratory health screening program are presented in Table 1. It is evident from this table that girls (1120) outnumbered boys (806). Majority of the sample (62.2 %) belonged to urban area. About 32 % of the samples were aged about 13 years representing the highest percentage followed by 14 years with 29.2 %. Children aged 10 years constituted the least (4.8 %).

Table 1 - Socio-demographic profile of the sample

Socio-demographic profile	Number	Percentage
Sex		
Boys	806	41.8
Girls	1120	58.2
Location		
Rural	727	37.8
Urban	1199	62.2
Age		
10	92	4.8
11	342	17.8
12	313	16.2
13	616	32.0
14	563	29.2

It is evident from figure 1 that the majority (96.8 %) of the samples were non-vegetarians. Only a negligible percentage of the samples in Puducherry (4.2 %), Karaikal (3.1 %) and Yanam (1 %) were vegetarians.

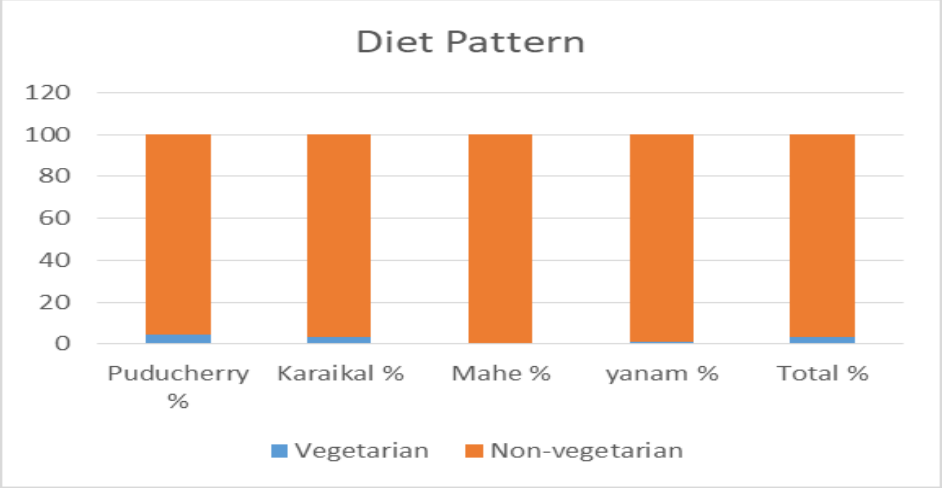

Figure 1- Dietary pattern of the sample with respect to region

Table 2 - Association between frequency of food intake and region
Test of Independence

Food		Chi-Square	Adjusted F	df1	df2	P-value.
Diet pattern * Region	Pearson	30.935	.610	1.154	27.695	.464
	Likelihood Ratio	45.245	.893	1.154	27.695	.368
Egg * Region	Pearson	70.835	2.646	5.294	127.046	.024*
	Likelihood Ratio	74.477	2.782	5.294	127.046	.018
Mutton * Region	Pearson	136.647	1.229	1.661	39.875	.297
	Likelihood Ratio	151.059	1.359	1.661	39.875	.266
Chicken * Region	Pearson	106.303	.969	1.746	41.895	.377
	Likelihood Ratio	121.206	1.105	1.746	41.895	.334
Crab * Region	Pearson	130.771	3.493	5.050	121.207	.005*
	Likelihood Ratio	150.265	4.014	5.050	121.207	.002
Fish * Region	Pearson	624.571	23.198	4.648	111.546	.000**
	Likelihood Ratio	474.411	17.621	4.648	111.546	.000
Milk * Region	Pearson	92.200	5.124	4.506	108.135	.000**
	Likelihood Ratio	82.284	4.573	4.506	108.135	.001
Green gram dhal * Region	Pearson	97.211	3.393	4.965	119.153	.007*
	Likelihood Ratio	106.085	3.703	4.965	119.153	.004
Bengal gram * Region	Pearson	137.691	3.398	3.053	73.277	.022*
	Likelihood Ratio	157.592	3.889	3.053	73.277	.012
Gourd varieties * Region	Pearson	163.057	8.765	5.404	129.693	.000**
	Likelihood Ratio	170.833	9.183	5.404	129.693	.000
Pumpkin * Region	Pearson	175.544	10.929	5.434	130.407	.000**
	Likelihood Ratio	199.001	12.390	5.434	130.407	.000
Radish * Region	Pearson	341.163	5.953	2.182	52.377	.004*
	Likelihood Ratio	353.464	6.168	2.182	52.377	.003
Guava * Region	Pearson	133.192	5.392	5.630	135.130	.000**

	Likelihood Ratio	144.907	5.866	5.630	135.130	.000
Grapes * Region	Pearson	79.408	1.728	3.230	77.511	.164
	Likelihood Ratio	85.190	1.854	3.230	77.511	.140
Pomegranate * Region	Pearson	62.814	.950	3.048	73.144	.422
	Likelihood Ratio	78.638	1.189	3.048	73.144	.320
Oranges * Region	Pearson	56.991	1.156	3.304	79.294	.334
	Likelihood Ratio	63.903	1.297	3.304	79.294	.281
Banana * Region	Pearson	29.901	1.369	6.223	149.352	.229
	Likelihood Ratio	32.366	1.481	6.223	149.352	.186
Musambi * Region	Pearson	77.551	2.280	2.957	70.958	.088
	Likelihood Ratio	96.182	2.827	2.957	70.958	.045
Strawberries * Region	Pearson	143.209	1.950	2.502	60.059	.141
	Likelihood Ratio	181.692	2.473	2.502	60.059	.081
Fried foods * Region	Pearson	101.142	2.122	3.254	78.104	.099
	Likelihood Ratio	103.276	2.167	3.254	78.104	.094

****Statistically highly significant (P<0.01)** ***statistically significant (P<0.05)**

Table 2 represents the relationship between frequency of food intake and region. The above table reveals that the chi-square test is statistically significant at p<.05 for egg, green gram dhal, bengal gram and radish thereby suggesting that these foods are dependent and related to region. Among the animal sources, fish and milk was found to be strongly associated with region at highly significant level (p<.000). Gourd varieties, pumpkin and guava were among the few vegetable sources which exhibited highly significant association with respect to region. Thus the results of this table concludes the diversified dietary pattern among the four regions of the UT of Puducherry.

Table 3 - PEFR with respect to frequency of food intake of the sample

Frequency of food intake	N	Mean (L/min)	Std. Deviation	Std. Error	p value
Egg					
Weekly 2-3 times	1285	278.08	72.627	2.026	0.003*
Daily	228	262.95	63.313	4.195	
Mutton					
Weekly 2-3 times	475	266.85	64.275	2.949	0.604 NS
Daily	2	293.26	128.561	101.358	
Chicken					
Weekly 2-3 times	865	274.47	71.650	2.436	0.097 NS
Daily	11	239.25	39.241	11.586	
Fish					
Weekly 2-3 times	978	274.97	67.055	2.144	0.000*
Daily	321	301.46	88.656	4.945	

Crab					
Weekly 2-3 times	331	272.34	73.401	4.036	0.676 NS
Daily	17	264.73	86.259	20.654	
Milk					
Weekly 2-3 times	208	274.05	75.409	5.225	0.525 NS
Daily	1494	277.42	71.250	1.844	
Green gram dhal					
Weekly 2-3 times	668	278.56	76.784	2.971	0.403 NS
Daily	249	283.24	71.732	4.543	
Bengal gram					
Weekly 2-3 times	693	278.49	75.837	2.882	0.995 NS
Daily	235	278.53	70.369	4.589	
Radish					
Weekly 2-3 times	592	270.11	67.994	2.794	0.339 NS
Daily	147	264.65	60.369	4.974	
Gourd varieties					
Weekly 2-3 times	474	274.96	75.541	3.470	0.811 NS
Daily	130	276.70	65.247	5.712	
Pumpkin					
Weekly 2-3 times	262	268.14	71.245	4.402	0.233 NS
Daily	46	254.74	64.384	9.473	
Orange					
Weekly 2-3 times	717	276.18	72.832	2.720	0.687 NS
Daily	210	278.52	76.536	5.285	
Musambi					
Weekly 2-3 times	397	281.51	72.646	3.647	0.005*
Daily	92	258.04	66.515	6.952	
Grapes					
Weekly 2-3 times	658	278.89	71.792	2.798	0.006*
Daily	137	260.52	65.360	5.581	
Banana					
Weekly 2-3 times	827	280.47	72.910	2.536	0.640 NS
Daily	642	278.68	72.411	2.859	
Pomegranate					
Weekly 2-3 times	615	273.59	68.862	2.777	0.394 NS
Daily	166	268.51	65.541	5.080	
Guava					
Weekly 2-3 times	734	275.49	70.588	2.605	0.341 NS
Daily	272	270.79	66.419	4.024	
Strawberries					
Weekly 2-3 times	134	274.25	82.558	7.139	0.000*
Daily	25	228.52	49.362	9.896	
Fried foods					
Weekly 2-3 times	643	284.37	74.369	2.932	0.106 NS
Daily	475	277.07	74.761	3.429	

****Statistically highly significant (P<0.01)** ***statistically significant (P<0.05)**

Table 3 shows the PEFR values of the samples based on weekly and daily food consumption. The values of PEFR are expressed in Litres per minute (L/min). Data are presented as mean, standard deviation and p value. It is evident from the table that egg, musambi, grapes and strawberries have a significant difference in PEFR at p<.005 with respect to frequency in food intake while the significance level is greater (p<.001) for fish. Daily consumption of chicken resulted in least PEFR value (239.25 L/min) while fish had the highest value (301.46 L/min) when compared to all other foods. A diet consisting of fish which is a good source of omega 3 fatty acids at least once a week was found to reduce asthmatic symptoms in children aged ≤14 years when compared to those who did not include fish [10]. It is also clear from the table that daily consumption of egg and chicken resulted in a lower PEFR value when compared to weekly intake with the result being

highly significant for eggs ($p<0.05$). Egg was found to be the second cause of food allergy in Korean children while cow's milk ranked next to it [11] Children eating mutton daily were found to have a higher PEFR (293.26 L/m) than its counterpart though not statistically significant. However studies have shown asthmatic symptoms among children aged 3-16 years who consumed red meat daily [12]. A comparison between the two seafoods (crab and fish) showed a significantly higher PEFR value ($p<0.05$) among fish eaters. There was no significant difference in PEFR between daily and weekly milk consumption. Consuming cow's milk was found to have no impact on bronchial constriction or any other respiratory discomfort in both asthmatic children as well as non-asthmatic children [13]. Milk is a vital source of protein and calcium which is necessary for the growth and development of children. Hence from these studies it can be inferred that there is no necessity to exclude or restrict milk from the diet of children unless and until they have been confirmed to be allergic to it through allergic test. Children in the age group of 3 to 14 years with mild to moderate asthma showed higher PEFR value when compared to the control group when egg and milk was eliminated from their diet for just 8 weeks [14]. In contrast, a weak but significant positive correlation ($p<0.05$) was found to exist between the forced expiratory volume in 1 second and intake of milk products and egg among school aged children [15]. Among the six animal sources namely egg, mutton, chicken, fish, crab and milk it was noticed that daily consumption of fish had a positive effect on the PEFR value.

A comparison between the intake of two pulses namely green gram dhal and bengal gram revealed that daily intake of green gram dhal had a positive effect on PEFR (283.24 L/min) when compared to bengal gram (278.53 L/min) though not statistically significant. Chickpea (bengal gram) and mung bean allergies are identified to be more prevalent among the Indian population especially in the paediatric group due to its IgE-mediated sensitization. However, even children with legume allergies were found to tolerate green beans or green gram much better [16] and our study exhibits higher PEFR among children consuming green gram dhal.

Children who consumed gourd varieties everyday had a higher PEFR (276.70 L/min) when compared to radish and pumpkin (264.65 L/m and 254.74 L/m respectively). However no significant difference was exhibited among all three vegetables.

A closer look at the frequency of intake of different fruits revealed that eating banana everyday had the highest PEFR value (278.68 L/min) when compared to other expensive fruits like musambi, grapes, pomegranate, strawberries and low cost vitamin C rich guava. Respiratory effect of bananas was found to be in par with that of orange (278.52 L/min) which is known to be a very good source of vitamin C. It is also the flavonoids in oranges that is responsible for supporting lung function and providing anti-inflammatory effects [17]. While daily consumption of orange had a beneficial effect on PEFR, musambi which belongs to the same citrus fruit family did not have the same effect. Interestingly, taking bananas even 2-3 times per week resulted in PEFR value as high as 280.47 L/min thus ranking very next to musambi (281.51 L/min) which is also a vitamin C rich fruit. The protective property of banana against wheezing in children was established in a study carried out in 2007 among school children aged 5 to 10 years in London [18]. The results confirmed that eating bananas atleast once a day improved lung efficiency in children. The present study has also projected the goodness of eating bananas over improved lung health. The increased water soluble content of phenolic acids [19], carotenoids [20, 21] and potassium in banana contributes to its beneficial effects on lung health. Studies [22, 23] have also stressed upon the antioxidant activities of this tropical fruit due to the presence of bioactive compounds such as carotenoids, flavonoids, phenolics, amines, vitamin C and vitamin E.

Children who included vitamin C rich fruits such as strawberries, grapes and musambi everyday had the lowest PEFR value. This may be due to the presence of certain allergens such as endochitinase 4 A in grapes [24 Cardinale] and Fra a proteins in strawberries. Strawberry fruit besides being loaded with vitamin C, folate and flavonoids they also contain potential allergens such as non-specific lipid transfer protein Fra a 3 and the profilin Fra a 4 [25]. Citrus fruits were known to improve the respiratory health in children [26]. But it can now be inferred from this study that although the judicious use of such fruits can help to increase the vitamin C content in the diet, its daily consumption can also trigger allergic episodes or cause respiratory discomforts in certain individuals thereby reducing PEFR.

Fried foods showed a tendency towards reducing PEFR (277.07 L/min) when taken daily rather than weekly. Thus parents need to be made aware of the fact that dietary intake can impact the lung functioning of the children and therefore they should keenly watch out for any respiratory symptoms when they provide food to their children (Cafferelli et al., 2016).

Factor analysis was applied on 19 variables expressing the frequency of food intake of 1926 samples from a school-based study. Table 4 depicts the descriptive statistics of food intake. Among the 19 foods selected the highest mean was observed in strawberries followed by crab, pumpkin, mutton, gourd varieties, musambi, bengal gram, radish, pomegranate, green gram dhal, chicken, fish, guava, orange, fried foods,

grapes, milk, egg and banana. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was used to test the uniformity of the sample. The KMO value was found to be very good with an adequacy of .910 which is much above the commonly recommended value of .6. The Bartlett test of sphericity of frequency of food intake in all four regions showed that the distribution was appropriate with chi-square being highly significant ($p<0.000$).

Communalities of all the variables were high with the lowest value being 15.9 % for milk and the highest being 70.6 % for egg. The screen plot clearly illustrates (Figure 2) three components with Eigen value greater than 1. The cumulative percentage of variance for first three components was 49.059 %.

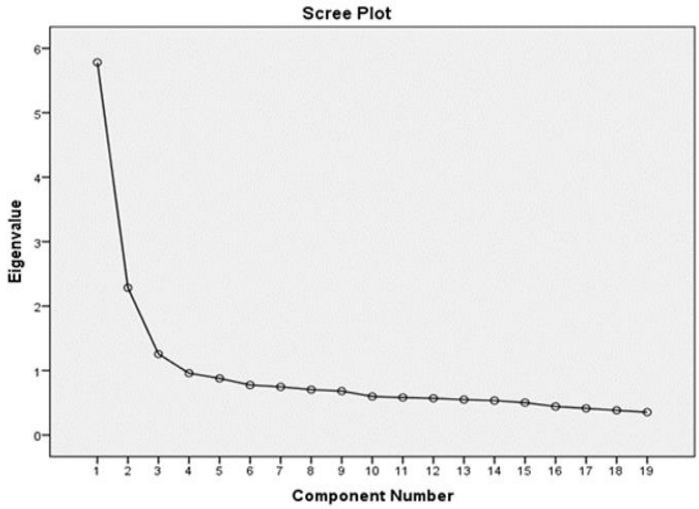

Figure 2. Screen plot showing Eigen value for each food

Table 4 - Descriptive Statistics of frequency of food intake

Food	Mean	Std. Deviation	Analysis N
1.Egg	48.41	208.054	1926
2.Mutton	149.48	354.126	1926
3.Chicken	74.84	258.813	1926
4.Crab	171.60	374.954	1926
5.Fish	74.24	256.980	1926
6.Milk	49.15	207.893	1926
7.Green gram dhal	92.97	286.505	1926
8.Bengal gram	114.74	315.175	1926
9.Gourd varieties	144.98	349.379	1926
10.Pumpkin	164.29	368.496	1926
11.Radish	111.40	311.416	1926
12.Guava	56.33	225.278	1926
13.Grapes	50.40	213.727	1926
14.Pomegranate	93.33	287.292	1926
15.Oranges	55.71	224.278	1926
16.Banana	45.43	201.139	1926
17.Musambi	140.72	345.159	1926
18.Strawberries	185.29	386.908	1926
19.Fried foods	52.41	216.865	1926

Table 5 Rotated Component Matrix

	Component		
	1	2	3
Gourd varieties	.760		
Bengal gram	.719		
Pumpkin	.716		
Radish	.666		
Green gram dhal	.598		
Strawberries	.421		
Oranges		.705	
Grapes		.666	
Banana		.638	
Guava		.609	
Pomegranate		.557	
Fried foods		.528	
Musambi		.441	
Milk		.325	
Egg			.837
Fish			.810
Chicken			.801
Mutton			.694
Crab			.580

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

After factor rotation using varimax rotation (Table 5) a change in the factor structure was exhibited. The first rotated factor was observed to be highly correlated to gourd varieties, bengal gram, pumpkin, radish, green gram and strawberry with factor loading of .760, .719, .716, .666, .598 and .421 respectively. Hence Factor 1 was labeled as fiber-rich foods. The second factor was found to be highly correlating with orange, grapes, banana, guava, pomegranate, fried foods and musambi and hence was labelled as micronutrient-rich foods and snacks as their factor loading was .705, .666, .638, .609, .557, .528 and .441 respectively. Variables such as egg, fish, chicken, mutton and crab had strong factor loading of .837, .810, .801, .694 and .580 respectively on factor 3 and hence labelled as animal protein foods. The internal consistency of the dimensions of FFQ was assessed and considered acceptable at levels of Cronbach's alpha >0.65.

Conclusion

Diet plays a key role in respiratory health. Certain vitamin C rich fruits which have been proved to have positive effects on non-communicable diseases such as heart disease, cancer and diabetes might have an adverse effect on lung efficiency in some individuals when consumed daily due to the effect of allergic components in it. Hence one should not go by just the nutrient content of foods but instead watch out for adverse respiratory signs and symptoms which might follow after its consumption. This study revealed that the frequency of intake of certain foods can alter lung efficiency drastically. Among the non-vegetarian food sources, fish has been proved to greatly increase lung efficiency. In contrast to the common belief that banana causes respiratory discomforts in children, this study has brought to light the fact that a banana a day improves lung health in children besides providing adequate calories, other essential micronutrients and fiber.

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Declaration of Conflicting Interests

The authors declares that there is no conflict of interest.

Ethics approval

The Institutional Ethical Committee of Bharathidasan Government College for Women, Puducherry had approved this study.

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