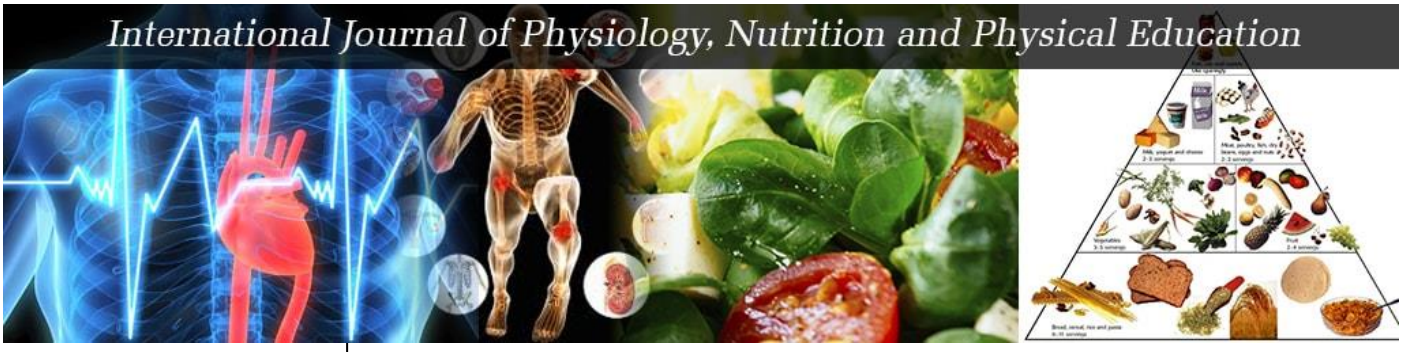

ISSN: 2456-0057
IJPNPE 2019; 4(1): 1905-1909

www.journalofsports.com
Received: 15-11-2018
Accepted: 20-12-2018

Simran Sanjay Khandagale
Student of Master's in Specialized Dietetics, Department of Food, Nutrition and Dietetics, Sir Vithaldas Thackersey College of Home Science Autonomous, S.N.D.T. Women's University, Juhu Tara Road, Mumbai, Maharashtra, India

Dr. Rekha Battalwar
Associate Professor, Department of Food, Nutrition and Dietetics, Sir Vithaldas Thackersey College of Home Science Autonomous, S.N.D.T. Women's University, Juhu Tara Road, Mumbai, Maharashtra, India

Dr. Jagmeet Madan
Principle, Department of Food, Nutrition and Dietetics, Sir Vithaldas Thackersey College of Home Science Autonomous, S.N.D.T. Women's University, Juhu Tara Road, Mumbai, Maharashtra, India

Shobha A Udipi
Hon Director, Integrative Nutrition and Ayurceuticals, Kasturba Health Society's Medical Research Centre, Khandubhai Desai Road, Vile Parle West, Mumbai, Maharashtra, India

Rama A Vaidya
Hon Director, Division of Endocrinology and Metabolic Disorder, Kasturba Health Society's Medical Research Centre, Khandubhai Desai Road, Vile Parle west, Mumbai, Maharashtra, India

Correspondence
Simran Sanjay Khandagale
Student of Master's in Specialized Dietetics, Department of Food, Nutrition and Dietetics, Sir Vithaldas Thackersey College of Home Science Autonomous, S.N.D.T. Women's University, Juhu Tara Road, Mumbai, Maharashtra, India

Assessment of the dietary nutrient pattern and Phytochemical index in Diet of adolescents and Young adults in Mumbai city

Simran Sanjay Khandagale, Dr. Rekha Battalwar, Dr. Jagmeet Madan, Shobha A Udipi and Rama A Vaidya

Abstract
Introduction: The dietary patterns of adolescents and youth has changed with time. Due to lack of diversity in their diets, adolescents miss out on various essential nutrients and phytochemicals. Phytochemicals are bioactive non nutrient chemicals found in plant sources but monitoring the intake is impractical and expensive and hence McCarty has proposed the concept of phytochemical Index (PI). According to the reviews, the best PI score is 100 that is achieved through a vegan diet.
Objective: To study the nutrient pattern of adolescents and youth in correlation with the recommended dietary intake and to assess the dietary phytochemical index score of their diets.
Methods: A cross sectional study was conducted in Mumbai on 239 subjects aged 17years to 25 years with the mean age of 19 years. Sample included 75% (n=178) of females and 25% (n=61) of male subjects. The tool used was a questionnaire that included Demographic, Anthropometric details and one day 24 hours diet record. 22 nutrients and dietary PI was calculated according to gender, age and body mass index (BMI). Student t-test and ANOVA was used to study the data. The data is expressed as mean ± standard deviation.
Results and Discussion: The carbohydrate consumption was found to be higher among the younger subjects i.e aged less than 20years (p= 0.06). The consumption of alpha tocopherol and magnesium was higher among the older subjects i.e aged more than 20years with a high standard statistical significant difference (p= 0.001, p= 0.01). The dietary PI score was better among the older subjects (mean PI of females was 51.9 and of males was 47.1) than the younger subjects (mean PI of females was 46.1 and of males was 45.5). The consumption of nuts and seeds was seen to be high among the older with a high statistically significant difference (p = 0.017).
Conclusion: The macro nutrient pattern across age group was found to be better among the younger subjects and the pattern of micro nutrients was seen to be better in the older subjects. The dietary PI score was found to be lower, almost 50% of the best score considered among all the subjects. The PI score improves with age and a better score was found in the older subjects.

Keywords: Body mass index (BMI), phytochemical, phytochemical index score (PI)

1. Introduction
As per WHO, an estimated 2.6 million young people aged 10 to 24 year die each year and a much greater number of young people suffer from illnesses. This shows that nutritional status of adolescents and youth are compromised. Adequate nutrition at this stage of life is very crucial for optimum growth and development and a failure to this can lead to impaired growth and organ remodelling [1]. The dietary patterns of this population has changed with time. The consumption of vegetables and fruits has witnessed a decreasing trend from childhood to adolescence and consumption of energy dense, high fat, high sugar foods has increased. Due to lack of diversity in the diets, adolescents miss out on various essential nutrients and phytochemicals as well. Phytochemical's are bioactive non nutrient chemicals that refers to a variety of plant-derived compounds with therapeutic activities such as anticarcinogenic, antimutagenic, anti-inflammatory, and antioxidant properties. Phytochemicals provide protection against many chronic conditions like cancer, cardiovascular disease and diabetes. These phytochemicals help to protect cellular systems from oxidative damage and lower the risk of chronic diseases [2].

A cross sectional study conducted in Japan showed that there was an inverse correlation between intake of flavonoids and plasma total cholesterol and plasma LDL cholesterol [3]. A case control study in Hawaii showed an inverse association between intake of quercetin and risk of lung cancer [4].

But monitoring the intake of phytochemicals in a population based study is impractical, expensive and laborious, hence McCarty has proposed a simple and a practical method to quantify the intake of phytochemicals by characterizing diet as 'Phytochemical Index' [5]. Phytochemical index is defined as percentage of dietary calories supplied by foods typically high in phytochemicals [6]. Phytochemical Index is a ratio of Calories from Phytochemical rich sources to Total Calories x 100. According to the reviews, the best PI score is 100 that is achieved through a vegan diet. Phytochemical rich sources considered for calculation were fruits, vegetables (except potato), nuts and seeds, whole grains, pulses, olive and olive oil.

In a prospective study conducted in Iran, the mean dietary PI across first, second, third and fourth quartile was 12.6, 18.6, 22.6, and 29.9, respectively [7]. Higher intakes of phytochemical-rich foods are associated with a lower risk of abdominal obesity and hyper triglyceridaemia as the main cardiometabolic risk factors [8]. A case-control study conducted in Iran concluded that a higher dietary phytochemical index (DPI) score was related to lower Prediabetes odds ratio and a higher DPI score can help prevent prediabetes [9].

Most of the studies have assessed the dietary Phytochemical index score of the diets of adults. There is a very less literature on the assessment of dietary phytochemical index score of diets of adolescents and youth. Assessment of various nutrient status of adolescents and youth is also needed as there are evidences of micronutrient deficiencies. Hence this study objectifies to assess the quality of diet through the nutrient content and dietary phytochemical index of adolescents and youth living in Mumbai city.

2. Methods

A cross sectional study was conducted in Mumbai city on 239 subjects aged 17years to 25 years. The mean age of the sample was 19years with 75% (n=178) of females and 25% (n=61) of male subjects. The subjects were divided as per their age into two groups, subjects aged below 20years and subjects aged 20years and above. The tools used for data collection was a pre tested questionnaire that included Demographic, Anthropometric details and one day 24 hours diet record. Standardized kit was used to assess the diet recall. The dietary intake was calculated using a software named 'DietCal'. Twenty two nutrients according to age, gender and Body Mass Index of the subjects were calculated using this software. Dietary Phytochemical index score was calculated using the given formula.

Phytochemical Index = Calories from Phytochemical rich sources / Total Calories x 100

Phytochemical rich sources considered for the calculations were Whole grains, Pulses and Legumes, Fruits, Vegetables, Nuts, Seeds, Olive Oil. Calories from phytochemical rich sources was calculated manually using the 'Indian Food Composition Table (IFCT)' given by National Institute of Nutrition in 2018.

3. Statistical Analysis

The software used for data analysis was Statistical Package for Social Sciences (SPSS) (version 20, SPSS Inc., Chicago, IL, USA). All the data was expressed as mean +/- standard deviation (SD) along with 95% confidence intervals (CI). Descriptive statistics such as mean, standard deviation and range values were computed for quantitative variables. Student t-test was used to study the difference in nutrition and phytochemical index by gender and age group and ANOVA was used to study the difference in nutrition and phytochemical index by Body Mass Index (BMI). The p values that were lower than 0.05 were considered to be significant.

4. Results and Discussion

The study sample included a total of two thirty nine subjects. The mean age of the sample was 19.7 +/- 2.1 years.

4.1 Nutrient pattern across age and gender

One hundred and forty two subjects (59%) were below or equal to 19 years of age, out of this 69% (n= 98) were female subjects and 31% (n=44) were male subjects. Ninety seven subjects (41%) were above or equal to 20 years of age. In this group, 82% (n = 80) subjects were females and 18% (n=17) were males. The detailed consumption of nutrients is shown in table no. 1.

Table 1: Nutrients Consumption across Age and Gender

Nutrients	Over all mean intake	17 years to 19 years		20 years to 25 years		RDA	*p* value
		Female	Male	Female	Male		
Total Energy (kcals)	1870 +/- 659.7	1737.9 +/- 585.9	2350.6 +/- 860.6	1742.5 +/- 516	1998.5 +/- 495		0.106
Protein (g)	55.17 +/- 20.8	51.67 +/- 17.5	68.17 +/- 28	50.14 +/- 16	65.3 +/- 20.3		0.149
Carbohydrate (g)	231.6 +/- 85.4	214 +/- 79	297.7 +/- 99.8	210.5 +/- 67.9	260.2 +/- 64.8		0.06
Fat (g)	78 +/- 32.9	72.9 +/- 27.6	96.34 +/- 48.6	75.2 +/- 26.6	73.7 +/- 23.2		0.231
Thiamine B1 (mgs)	0.76 +/- 0.37	0.69 +/- 0.33	0.86 +/- 0.42	0.73 +/- 0.35	1.04 +/- 0.41	1- F 1.2- M	0.461
Riboflavin B2 (mgs)	0.53 +/- 0.28	0.53 +/- 0.33	0.56 +/- 0.24	0.51 +/- 0.24	0.60 +/- 0.26	1.1- F 1.4- M	0.83
Niacin B3	7.54 +/- 3.9	7.16 +/- 4.1	8.53 +/- 4.6	7.2 +/- 3.4	8.73 +/- 3.3	12 – F 16- M	0.81
Total B6 (mgs)	0.88 +/- 0.47	0.82 +/- 0.42	0.95 +/- 0.50	0.89 +/- 0.53	0.99 +/- 0.36	2	0.43
Total folates B9 (ug)	172.7 +/- 95.7	162.69 +/- 89.4	184.76 +/- 111.3	170.9 +/- 94.6	208.3 +/- 89.6	200	0.52
Vitamin B12 (ug)	0.14 +/- 0.18	0.20 +/- 0.27	0.09 +/- 0.06	0.10 +/- 0.10	0.15 +/- 0.6	1	0.371
Total Ascorbic acid (mgs)	46.4 +/- 36	47.85 +/- 36.3	38 +/- 32.6	49.66 +/- 39.2	44.66 +/- 25.2	40	0.40
Retinol (ug)	143.7 +/- 123.9	139.8 +/- 120.8	118 +/- 98.8	163.4 +/- 135.8	143.1 +/- 142.2	600	0.115
Alpha Tocopherol (mgs)	7.32 +/- 6.8	5.97 +/- 6.6	6.34 +/- 6.8	9.47 +/- 6.8	7.54 +/- 6.6	8 –F 10- M	0.001*
Alpha Tocotrienols (mgs)	0.31 +/- 0.23	0.31 +/- 0.25	0.32 +/- 0.21	0.31 +/- 0.24	0.29 +/- 0.21		0.84
Phylloquinones Vit K1 (ug)	76.13 +/- 109.3	86.6 +/- 130.2	57.85 +/- 89	70.98 +/- 89.6	86.8 +/- 110.6	55ug	0.78
Carotene (ug)	1410.17 +/-	1519.35 +/-	1313.25 +/- 1761.1	1298.45 +/-	1557.32 +/-	4800	0.635

	1780.5	2041.3		1288.4	2275.2		
Calcium (mgs)	427.6 +/- 259.3	414.51 +/- 272.5	383.07 +/- 237.8	468.11 +/- 239.7	428.2 +/- 314.8	600	0.09
Iron (mgs)	9.8 +/- 4.7	9 +/- 4.5	10.75 +/- 5	9.75 +/- 4.4	12.7 +/- 4.7	21- F 17-M	0.236
Magnesium (mgs)	318.45 +/- 151.4	278.6 +/- 134.3	342.2 +/- 171.9	335.7 +/- 148.5	404.88 +/- 150.6	310- F 340- M	0.013*
Selenium (mgs)	73.2 +/- 50.8	61.87 +/- 36.1	93.2 +/- 62.5	67.7 +/- 49.5	112.9 +/- 64.6		0.540
Zinc (mgs)	6.6 +/- 2.9	5.85 +/- 2.3	7.85 +/- 3.5	6.4 +/- 2.7	9 +/- 3.4	10- F 12- M	0.239
Total Polyphenols (mgs)	131.1 +/- 83.9	126 +/- 94	119.1 +/- 76.6	141.76 +/- 79.3	141.25 +/- 54.4		0.108

*p= 0.05 is considered to be statistically significant

The mean consumption of total calories in females was similar across both age groups, and in males the total energy intake was seen to be higher among the younger population. But the difference between the age groups was not statistically significant (p= 0.106). The protein and carbohydrate consumption was found to be higher among the younger subjects. The differences of carbohydrates consumption across age groups was close to statistical significant difference (p= 0.06). The micro nutrient pattern of the older subjects was found to be better than the younger subjects. The consumption of alpha tocopherol was evident to be higher among the subjects aged above 20years with a high statistical significant difference (p= 0.001). The magnesium intake was also found to be better among the older subjects as compared to the younger subjects with high significant difference (p= 0.01).

A review on surveys on nutritional intake in adolescents living in Western Europe concluded that the average daily energy intake was found to be adequate, the intake of fat specially saturated fat was found be high and the consumption of fiber was low. The consumption of calcium and iron was found to be low particularly in girls [10].

A study conducted in Malaysia on young adults stated that male subjects showed significantly higher mean intakes of energy and all nutrients than female subjects except for vitamin C and iron [11].

4.2 Nutrient pattern across Body Mass Index (BMI) categories

The subjects were divided into four groups according to the Asian BMI cut offs. The number of subjects in group 1, group 2, group 3 and group 4 were 45, 82, 41 and 71 respectively. The macro nutrient and micro nutrient intake is shown in table no. 2.

Table 2: Nutrient Consumption across BMI Categories

Nutrients	**<18.50 kg/m^2 (n- 45)**	**18.5 kg/m^2 –22.99 kg/m^2 (n-82)**	**23 kg/m^2 – 24.99 kg/m^2 (n-41)**	**> 25 kg/m^2 (n-7)**	***p* value**
Total Energy (kcals)	1782.9 +/- 675.2	1868.9 +/- 600.9	1929.4 +/- 585.6	1894.8 +/- 756	0.752
Protein (g)	53.29 +/- 20	54.8 +/- 21.6	57.6 +/- 22.6	55.2 +/- 20.3	0.816
Carbohydrate (g)	219.7 +/- 92	227.9 +/- 75.1	238.9 +/- 81.7	239.1 +/- 94.7	0.599
Fat (g)	74.8 +/- 32.8	79.6 +/- 30.3	80 +/- 26.9	77.2 +/- 39	0.84
Thiamine B1 (mgs)	0.70 +/- 0.34	0.74 +/- 0.35	0.77 +/- 0.43	0.81 +/- 0.37	0.461
Riboflavin B2 (mgs)	0.48 +/- 0.23	0.50 +/- 0.24	0.59 +/- 0.37	0.57 +/- 0.28	0.136
Niacin B3	6.69 +/- 3.5	7.79 +/- 4.26	7.30 +/- 3.9	7.93 +/- 3.95	0.365
Total B6 (mgs)	0.74 +/- 0.34	0.94 +/- 0.56	0.82 +/- 0.45	0.92 +/- 0.43	0.08
Total folates B9 (ug)	155.6 +/- 78.9	176.01 +/- 102	169.34 +/- 106	181.85 +/- 92	0.528
Vitamin B12 (ug)	0.14 +/- 0.122	0.11 +/- 0.112	0.21 +/- 0.298	0.11 +/- 0.119	0.401
Total Ascorbic acid (mgs)	37.85 +/- 33	48.49 +/- 35.8	43.62 +/- 37.7	51.08 +/- 36.7	0.236
Retinol (ug)	154.49 +/- 140.5	139.63 +/- 124.7	157.42 +/- 127.6	133.64 +/- 111.08	0.731
Alpha Tocopherol (mgs)	5.47 +/- 6.47	8.02 +/- 6.96	6.68 +/- 6.77	8.06 +/- 7.03	0.154
Alpha Tocotrienols (mgs)	0.30 +/- 0.206	0.28 +/- 0.218	0.33 +/- 0.261	0.33 +/- 0.240	0.541
Phylloquinones Vit K1 (ug)	69.56 +/- 105.5	77.69 +/- 105.01	68.91 +/- 84.05	82.67 +/- 129.4	0.859
Carotene (ug)	1449.5 +/- 2127.17	1593.32 +/- 1893.13	1444.05 +/- 1823.93	1154.11 +/- 1333.73	0.501
Calcium (mgs)	404.81 +/- 265.35	392.35 +/- 217.9	456.29 +/- 329.08	466.31 +/- 252.4	0.268
Iron (mgs)	9.18 +/- 4.9	9.78 +/- 4.49	9.32 +/- 5.25	10.64 +/- 4.5	0.333
Magnesium (mgs)	278.76 +/- 141.9	322.79 +/- 151.9	297.66 +/- 161.5	350.59 +/- 146.1	0.06
Selenium (mgs)	73.02 +/- 48.5	73.68 +/- 53.9	73.51 +/- 58.3	72.78 +/- 44.63	1.00
Zinc (mgs)	6.17 +/- 2.5	6.70 +/- 3.18	6.50 +/- 3.27	7.02 +/- 2.8	0.498
Total Polyphenols (mgs)	112.76 +/- 70.1	137.45 +/- 83.4	112.07 +/- 68.4	146.46 +/- 96.95	0.067

*p= 0.05 is statistically significant

The macronutrient consumption across the four BMI categories was found to be in the similar range. The higher total energy and protein intake was seen in the over-weight subjects. The carbohydrate consumption was found to be higher in the obese subjects and higher fat intake was evident in the over-weight subjects. However the difference was not statistically significant. The pattern of micro nutrient intake was found to be in the similar range across the BMI categories. The consumption of vitamin B6 was found to be higher among the normal weight category of subjects but the difference was not statistically significant (p=0.08). The intake of magnesium and total polyphenols was seen to be the higher among the obese subjects and second highest among the normal weight subjects with a difference that was close to statistical significance difference (p=0.06, p=0.06).

A study conducted on adolescents of Northern Greece stated that the total energy consumption of over-weight subjects was lower as compared to the normal weight subjects. Mean daily carbohydrate, protein and fat intake were also found to be lower in over weight subject in comparison to the normal weight category subjects [12].

4.3 Dietary Phytochemical Index (PI) score across Age and Gender

Dietary PI score was calculated according to the concept given by McCarty. The best PI score considered is 100 which

is achieved through a vegan diet and the lowest PI score considered is 20 which is seen in a western diet. Dietary PI score across age groups and gender is given in table no. 3.

Table 3: Phytochemical index across age groups

Variables	Group 1 (17 years to 19years)		Group 2 (20years to 25 years)		*p* value
	Male	Female	Male	Female	
Phytochemical Index	45.5 +/- 14.5	46.1 +/- 23.6	47.1 +/- 22.1	51.9 +/- 18.7	0.07
Total calories (Kcals)	2179.5 +/- 770.4	1755.06 +/- 586.2	2295.1 +/- 988.9	1741.5 +/- 502.7	0.795
Calories from phytochemical rich sources (Kcals)	958.35 +/- 359.4	749.8 +/- 357	961.1 +/- 506.5	877.5 +/- 334	0.09
Calories from Vegetables (Kcals)	45.6 +/- 54.7	33.2 +/- 25.7	44.0 +/- 31.3	44.1 +/- 38	0.134
Calories from Fruits (Kcals)	150.4 +/- 233.6	75.44 +/- 78.5	71.7 +/- 21.5	152.8 +/- 240.3	0.226
Calories from Nuts and seeds (Kcals)	281.5 +/- 107.6	284.2 +/- 161.6	303.3 +/- 125.9	344.3 +/- 102	0.017*
Calories from whole grains (Kcals)	668.4 +/- 233.3	460.1 +/- 231.4	688.7 +/- 262.5	460.6 +/- 216	0.619
Calories from legumes (Kcals)	103.4 +/- 68.9	147.1 +/- 117	157.2 +/- 90.1	137.2 +/- 76.4	0.655

*p= 0.05 is statistically significant

A better dietary Phytochemical Index (PI) score was evident in the older age group of subjects in the age range of 20 years or above with close to statistical significant difference (p= 0.07). The calories from phytochemical rich sources was also found to be higher among the older subjects than the younger subjects, but the difference was not statistically significant (p= 0.09). The consumption of nuts and seeds was seen to be better among the older subjects as compared to the younger group of subjects. There was a high statistical significant difference seen in the consumption of nuts and seeds across age groups (p = 0.017). Thus the PI score increases with age.

4.4 Dietary Phytochemical Index (PI) score across Body Mass Index (BMI) categories

The sample was divided into groups as per the Asian BMI cut offs. The dietary PI score across the BMI categories in mentioned in table no.4.

Table 4: Consumption of phytochemical rich food groups across BMI categories

Variables	<18.50 kg/m^2	18.50 – 22.99 kg/m^2	23 – 24.99 kg/m^2	>25 kg/m^2	*p* value
Phytochemical Index	48.88	48.1	43.5	49.9	
Total calories (Kcals)	1695.9 +/- 549.1	1886.5 +/- 647.4	1886.9 +/- 585.2	1935.6 +/- 781.9	0.312
Calories from Phytochemical rich sources (Kcals)	773.6 +/- 305	858.5 +/- 357.2	818.29 +/- 438	881.9 +/- 390.8	0.484
Calories from Vegetables (Kcals)	29.6 +/- 20.6	44.4 +/- 43.6	32 +/- 23.7	44.3 +/- 36	0.061
Calories from Fruits (Kcals)	75.6 +/- 71.4	139.1 +/- 241.2	39.67 +/- 34.6	146.9 +/- 161.9	0.452
Calories from Nuts and seeds (Kcals)	296.7 +/- 170.6	303.6 +/- 122	311.3 +/- 103.3	322.9 +/- 135.9	0.872
Calories from whole grains (Kcals)	483 +/- 184.8	510.7 +/- 231.9	522 +/- 307.4	532.9 +/- 263.4	0.791
Calories from legumes (Kcals)	163.2 +/- 129.9	140.6 +/- 98.5	119.6 +/- 74.8	128.1 +/- 82.2	0.294

*p< 0.05 is statistically significant

The phytochemical index score across BMI categories was seen to be in the similar range, the highest seen in the obese category and lowest seen in the over-weight category of subjects. The difference of PI score across BMI categories was not statistically significant (p=0.516). But the consumption of vegetables was found to be highest in the normal weight category of subjects. The difference was close to statistical significance difference (p=0.06).

A study done on "Phytonutrient intake and body composition" with fifty individuals from Thibodaux, Louisiana also stated that the subjects with an overweight BMI had a higher PI average than those with a healthy BMI [13].

5. Conclusion

The present study revealed that the nutrient pattern across male and female subjects was found to be lower than the recommended intakes. The macro nutrient pattern across age group was found to be better among the younger subjects and the pattern of micro nutrients was seen to be better in the older subjects. The dietary phytochemical index score was found to be better among the female subjects as compared to the male subjects. The PI score improves with age and a better score was found in the older subjects.

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