Results and Discussion

IV RESULTS AND DISCUSSION

The results pertaining to the study entitled **'Prevalence of micronutrient deficiency in Ramanathapuram district and impact of interventions'** are presented and discussed under the following headings.

A. PHASE I Prevalence of Micronutrient Deficiency among Different Age Groups of Population in Ramanathapuram District

1. Background information of the subjects
2. Health status of the subjects
3. Clinical signs and symptoms observed among the subjects
4. Food and nutrient intake pattern of the subjects
5. Nutritional status of the subjects

B. PHASE II Nutrient Profile and Acceptability of Micronutrient Rich Food Products

1. Nutrient composition of the developed food products
2. Acceptability of the developed food products
3. Shelf life study of the developed food products

C. PHASE III Impact of Interventions among School Going Children

1. Changes in anthropometric measurements of the children
2. Changes in biochemical profile of the children
3. Changes in cognitive parameters of the children
4. Changes in physical performance of the children
5. Changes in nutritional Knowledge, Attitude and Practice (KAP) of the parents

A. PHASE I PREVALENCE OF MICRONUTRIENT DEFICIENCY AMONG DIFFERENT AGE GROUPS OF POPULATION IN RAMANATHAPURAM DISTRICT

1. Background information of the subjects

Health status is highly sensitive to a broad range of determinant factors including biological, behavioural, environmental, psycho-social, socio-economic, availability, and utilization of health services (Nieto *et al.*, 2010). Action to reduce health disparities needs to start very early in life, and should also address socio-economic differences (Ruijsbroek, 2011). Data on the socio-economic and background information of the 15,400 subjects participating in the present study are presented below.

a. Education of the head of the family

Attention must be paid not only to the children and their nutrition but also to the immediate environment, parents and socio-economic status, as the environment in which a child lives determines the quality of nutrition (Avan and Kirkwood, 2009). Table III presents the educational status of the head of the family of the subjects.

TABLE III

EDUCATION OF THE HEAD OF THE FAMILY

Category	Uneducated		Primary		Secondary		H Sc		Degree		Professional	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Infants	307 (21.9)	354 (25.3)	231 (16.5)	249 (17.8)	526 (37.6)	449 (32.1)	159 (11.4)	172 (12.3)	124 (8.9)	136 (9.7)	53 (3.8)	40 (2.9)
Preschool	335 (23.9)	371 (26.5)	334 (23.9)	346 (24.7)	382 (27.3)	291 (20.8)	198 (14.1)	275 (19.6)	119 (8.5)	98 (7)	32 (2.3)	19 (1.4)
School going	406 (29.1)	432 (30.9)	322 (23)	351 (25.1)	362 (25.9)	345 (24.6)	153 (10.9)	148 (10.6)	131 (9.4)	107 (7.6)	26 (1.9)	17 (1.2)
Adolescent	457 (32.6)	492 (35.1)	330 (23.6)	321 (22.9)	386 (27.6)	344 (24.6)	119 (8.5)	148 (10.6)	97 (6.9)	82 (5.9)	11 (0.8)	13 (0.9)
Adult 1401	544 (38.9)	502 (35.9)	452 (32.3)	428 (30.6)	301 (21.5)	349 (24.9)	88 (6.3)	96 (6.9)	11 (0.8)	16 (1.1)	4 (0.3)	9 (0.6)
Pregnant women	-	435 (31.1)	-	406 (29)	-	258 (18.4)	-	215 (15.4)	-	68 (4.8)	-	18 (1.3)
Total	**2049 (29.3)**	**2586 (30.8)**	**1669 (23.8)**	**2101 (25.0)**	**1957 (28.0)**	**2036 (24.2)**	**717 (10.2)**	**1054 (12.5)**	**482 (6.9)**	**507 (6.0)**	**126 (1.8)**	**116 (1.4)**

Figures in parentheses indicate percentage

Majority of the heads of the families of the subjects in Ramanathapuram district were either uneducated (29.3 and 30.8%) or educated only up to secondary level of education (28.0 and 24.2%). The male and female adults had the maximum number of uneducated heads of the family. About 23 to 25 per cent of the heads of the families were educated up to primary level. Among all the age groups, less than 20 per cent of the heads of the families had higher secondary level of education. Very few heads of the families ranging from less than ten per cent and less than four per cent of the subjects were educated up to degree and professional education. Education has an important causal effect in explaining differences in many adult health outcomes and healthy behaviours (Cutler and Muney, 2010). The present study throws light on the overall poor educational status of the head of the family to be 33.8 per cent in India.

b. Education of the women of the family

The most prominent provider of the primary care for the family is the women and their understanding of basic nutrition and health measures that has a great influence on the care they provide (Abbi, 1998). Education of the women of the families of Ramanathapuram district is given in Table IV.

TABLE IV

EDUCATION OF THE WOMEN OF THE FAMILY

Category	Uneducated		Primary		Secondary		H Sc		Degree	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Infants	516 (36.9)	537 (38.4)	318 (22.7)	336 (24)	329 (23.5)	304 (21.7)	191 (13.6)	184 (13.1)	46 (3.3)	39 (2.8)
Preschool	601 (42.9)	577 (41.2)	381 (27.2)	369 (26.4)	212 (15.1)	219 (15.6)	165 (11.8)	182 (13)	41 (2.9)	53 (3.8)
School going	406 (29)	437 (31.2)	378 (27)	354 (25.3)	349 (24.9)	326 (23.3)	257 (18.4)	281 (20.1)	10 (0.7)	2 (0.1)
Adolescent	547 (39.1)	562 (40.1)	384 (27.4)	399 (28.5)	242 (17.3)	234 (16.7)	196 (14)	178 (12.7)	31 (2.2)	27 (1.9)
Adult	576 (41.4)	548 (39.1)	450 (32.1)	463 (33.1)	291 (20.8)	266 (19.0)	64 (4.6)	103 (7.4)	19 (1.4)	20 (1.4)
Pregnant women	-	502 (35.9)	-	397 (28.4)	-	275 (19.6)	-	198 (14.1)	-	28 (2)
Total 15128	**2646 (37.8)**	**3163 (37.7)**	**1911 (27.3)**	**2318 (27.6)**	**1423 (20.3)**	**1624 (19.3)**	**873 (12.5)**	**1126 (13.4)**	**147 (2.1)**	**169 (2.0)**

Figures in parentheses indicate percentage

Majority of the subjects belonging to the present study ranging from a maximum of 42.9 per cent among the male preschool children to a minimum of 29 per cent among the male school going children had illiterate women in the family. More than 25 per cent of the women in the families of the subjects had studied only up to primary level of education. About 24.9 to 15.1 per cent of the women of the families were educated up to secondary level of education. The quality of care and feeding offered to children is critically dependent on women's education, social status and workload (Anwar *et al.*, 2010). Education of the women of the family is very essential for the overall health and well being of the whole family. However, the women subjects participating in the present study seemed to be poorly educated which could negatively influence the family's health status. According to Kumar and Khan (2010) mother's education plays a significant role in deciding the level of malnutrition among her children and Children of illiterate mothers are three times as likely to be severely undernourished as children of mothers with at least a high school education or above.

c. Occupation of the head of the family

Table V reveals the occupation of the head of the family of the study population.

TABLE V
OCCUPATION OF THE HEAD OF THE FAMILY

Category	Government		Business		Private		Daily wages	
	M	F	M	F	M	F	M	F
Infants	43 (3.1)	34 (2.4)	347 (24.8)	346 (24.7)	851 (60.8)	855 (61.1)	159 (11.4)	165 (11.8)
Preschool	38 (2.7)	23 (1.6)	251 (17.9)	248 (17.7)	944 (67.4)	923 (65.9)	167 (11.9)	206 (14.7)
School going	32 (2.3)	21 (1.5)	294 (21)	269 (19.2)	826 (59)	893 (63.8)	248 (17.7)	217 (15.5)
Adolescent	39 (2.8)	36 (2.6)	266 (19)	322 (23)	791 (56.5)	854 (61)	304 (21.7)	188 (13.4)
Adult	41 (2.9)	29 (2.1)	128 (9.1)	163 (11.6)	920 (65.7)	867 (61.9)	311 (22.2)	341 (24.4)
Pregnant women	-	32 (2.3)	-	157 (11.2)	-	959 (68.5)	-	252 (18)
Total	**193 (2.8)**	**175 (2.1)**	**1286 (18.4)**	**1505 (17.9)**	**4332 (61.9)**	**5351 (63.7)**	**1189 (17.0)**	**1369 (16.3)**

Figures in parentheses indicate percentage

With the low background of education, the heads of the families were engaged mainly in poorly remunerative jobs. The heads of less than three per cent of the families belonging to Ramanathapuram district were employed in government service while a varying number of families from 9.1 to 24.8 per cent had business as their occupation. Except for the adolescent male subjects (36.4 %), all the other age groups had more than 59 per cent of the head of the families employed in private concerns. A study taken up among young children in Bangladesh reported that father's occupation could be an important risk factor for the prevalence of underweight among children aged six to 24 months (Nahar *et al.*, 2010). It is noteworthy that the Government of India has included the district of Ramanathapuram along with the underdeveloped areas of India with a large degree of underemployment and unemployment (Reddy, 2009).

d. Monthly income of the subjects

Among the commonly used socio-economic measures income has been recognized as one of the strongest predictors of health outcomes (Liu *et al.*, 2010). Table VI presents the monthly income of the subjects as per HUDCO classification (2008).

TABLE VI
MONTHLY INCOME OF THE SUBJECTS (HUDCO, 2008)

Group	EWS (≤ Rs. 3300)		LIG (Rs. 3301 to Rs. 7300)		MIG (Rs. 7301 to Rs. 14500)		HIG (Rs. 14501 and above)	
	M	F	M	F	M	F	M	F
Infants	184 (13.1)	283 (20.2)	286 (20.4)	243 (17.4)	757 (54.1)	730 (52.1)	173 (12.4)	144 (10.3)
Preschool	259 (18.5)	276 (19.7)	259 (18.5)	204 (14.6)	725 (51.8)	796 (56.9)	157 (11.2)	124 (8.9)
School going	262 (18.7)	303 (21.6)	371 (26.5)	407 (29.1)	622 (44.4)	584 (41.7)	145 (10.4)	106 (7.6)
Adolescent	283 (20.2)	170 (12.1)	276 (19.7)	244 (17.4)	709 (50.6)	872 (62.3)	132 (9.4)	114 (8.1)
Adult	342 (24.4)	375 (26.8)	334 (23.9)	296 (21.1)	597 (42.6)	628 (44.9)	127 (9.1)	101 (7.2)
Pregnant women	-	366 (26.2)	-	441 (31.5)	-	384 (27.4)	-	209 (14.9)
Total	**1330 (19.0)**	**1773 (21.1)**	**1526 (21.8)**	**1835 (21.8)**	**3410 (48.7)**	**3994 (47.5)**	**734 (10.5)**	**798 (9.5)**

Figures in parentheses indicate percentage; EWS- Economically Weaker Section; LIG-Low Income Group; MIG-Middle Income Group; HIG-High Income Group

Many of the families chosen in the present study ranging from 12.1 per cent to 26.8 per cent were economically weaker with a monthly income of less than Rs. 3,300. These findings are on par with the NNMB (2006) which has reported that the average monthly per capita income of 29 per cent of Indian households were less than Rs. 300. A similar number of subjects ranging from a minimum of 14.6 to a maximum of 31.5 per cent of the subjects belonged to low income group and less than 15 per cent of the subjects belonged to high income group. This data revealed that majority of the subjects in the present study belonged to lower socio-economic status. A study conducted among

preschool children in rural and urban areas of Pakistan (Khattak and Ali, 2010) inferred that child malnutrition was strongly related to family income. The findings of the present study is in line with the findings of Chakraborty *et al* (2009) who showed that monthly family income and had a significant impact on energy deficiency in India.

e. Dietary pattern of the subjects

The nutritional quality of the diet improves with the consumption of greater food diversity (Onyango *et al.*, 2009). The classification of subjects based on their dietary pattern is presented in Table VII.

TABLE VII

DIET PATTERN OF THE SUBJECTS

Group	Vegetarian		Non vegetarian		Ova vegetarian	
	Male	Female	Male	Female	Male	Female
Infants	298 (21.3)	56 (4)	1011 (72.2)	1258 (89.9)	91 (6.5)	86 (6.1)
Preschool	223 (15.9)	259 (18.5)	1130 (80.7)	1078 (77)	47 (3.4)	63 (4.5)
School going	334 (23.9)	246 (17.6)	1007 (71.9)	1112 (79.4)	59 (4.2)	42 (3)
Adolescent	277 (19.8)	244 (17.4)	994 (71)	1051 (75.1)	129 (9.2)	105 (7.5)
Adult	291 (20.8)	205 (14.6)	1066 (76.1)	1139 (81.4)	43 (3.1)	56 (4)
Pregnant women	-	270 (19.3)	-	1083 (77.4)	-	47 (3.4)
Total	**1423 (20.3)**	**1280 (15.2)**	**5208 (74.4)**	**6721 (80.0)**	**369 (5.3)**	**399 (4.8)**

Figures in parentheses indicate percentage

More than 70 per cent of the subjects in Ramanathapuram district followed non vegetarian diet pattern followed by less than ten per cent of the subjects ranging from three per cent among the school going girls to 9.2 per cent among the adolescent male subjects. Less than 25 per cent of the

subjects belonging to all the age groups in Ramanathapuram district followed vegetarian diet pattern. These findings are on par with the NFHS III (2005-06) reports that about two thirds of women and three fourths of men in India were non vegetarians.

f. Family type of the subjects

Table VIII reveals the data on the type of family of the subjects.

TABLE VIII

TYPE OF FAMILY OF THE SUBJECTS

Group	Joint		Nuclear	
	Male	Female	Male	Female
Infants	64 (4.6)	48 (3.4)	1336 (95.4)	1352 (96.6)
Preschool	97 (6.9)	112 (8)	1303 (93.1)	1288 (92)
School going	86 (6.1)	90 (6.4)	1314 (93.9)	1310 (93.6)
Adolescent	107 (7.6)	88 (6.3)	1293 (92.4)	1312 (93.7)
Adult	161 (11.5)	140 (10)	1239 (88.5)	1260 (90)
Pregnant women	-	63 (4.5)	-	1337 (95.5)
Total	**515 (7.4)**	**541 (6.4)**	**6485 (92.6)**	**7859 (93.6)**

Figures in parentheses indicate percentage

It is evident from the above table that a maximum number of infants with a total of 95.4 and 96.6 per cent among the male and female infants respectively lived in nuclear families. This was closely followed by pregnant women with 95.5 per cent of the subjects living in nuclear families. On the whole, more than 90 per cent of both male and female subjects were seen to be residing in nuclear families. Studies by Rao *et al* (2010) have also reported a similar picture of as many as 60 to 80 per cent of nuclear families in India.

g. Family size of the subjects

Family size of the subjects belonging to Ramanathapuram is presented in Table IX.

TABLE IX
FAMILY SIZE OF THE SUBJECTS

Taluk (n=2200)	2 to 4		5 to 7		Above 7	
	Male	Female	Male	Female	Male	Female
Infants	996 (71.1)	1052 (75.1)	171 (12.2)	163 (11.6)	233 (16.6)	185 (13.2)
Preschool	982 (70.1)	945 (67.5)	246 (17.6)	211 (15.1)	172 (12.3)	244 (17.4)
School going	1014 (72.4)	979 (69.9)	201 (14.4)	246 (17.6)	185 (13.2)	175 (12.5)
Adolescent	1059 (75.6)	1009 (72.1)	188 (13.4)	204 (14.6)	153 (10.9)	187 (13.4)
Adult	1077 (76.9)	992 (70.9)	191 (13.6)	248 (17.7)	132 (9.4)	160 (11.4)
Pregnant women	-	1015 (72.5)	-	223 (15.9)	-	162 (11.6)
Total	**5128 (73.3)**	**5992 (71.3)**	**997 (14.2)**	**1295 (15.4)**	**875 (12.5)**	**1113 (13.3)**

Figures in parentheses indicate percentage

Majority of the subjects among all the age groups ranging from a minimum of 67.5 per cent among female preschool children to a maximum of 76.9 per cent among the male adult subjects belonged to families having two to four members. Less than 20 per cent of the subjects among all the age groups had five to seven members in their family and less than 17 per cent of the subjects had more than seven members in their family. Large family size can aggravate inadequate feeding and repeated illness and the immediate causes of malnutrition in the family and therefore negatively influence health and nutritional status (Ajao *et al.*, 2010). These findings are in accordance with the report of NNMB (2006) that a 64 per cent prevalence of nuclear families in India.

2. Health status of the subjects

When a diet lacks micronutrients for a considerable period of time, body stores gradually become depleted. In some cases, a deficiency may develop in few weeks. Some investigators consider that an underlying condition linked to nutritional status may also cause vague symptoms such as insomnia,

lethargy, and difficulty in concentrating (Schoendorfer *et al.*, 2010). Data on specific information related to micronutrient deficiency such as health problems faced by the subjects, common illness, treatment undertaken and supplement intake are presented and discussed below.

a. Health problems faced by the subjects

Micronutrient status in foetal and early life may alter metabolism and organ growth and function, leading to increased risk of diseases (Christian and Stewart, 2010).Table X presents data on various health problems faced by the subjects belonging to different age groups.

TABLE X

HEALTH PROBLEMS FACED BY THE SUBJECTS

Group (n = 1400)	Diabetes		Heart disease		Ulcer		Others	
	M	F	M	F	M	F	M	F
Infants	0 (0)	0 (0)	24 (1.7)	20 (1.4)	0 (0)	0 (0)	16 (1.1)	12 (0.9)
Preschool	0 (0)	0 (0)	2 (0.1)	4 (0.3)	0 (0)	0 (0)	32 (2.3)	29 (2.1)
School going	0 (0)	0 (0)	0 (0)	0 (0)	3 (0.2)	7 (0.5)	2 (0.1)	4 (0.3)
Adolescent	0 (0)	0 (0)	0 (0)	0 (0)	12 (0.9)	29 (2.1)	3 (0.2)	5 (0.4)
Adult	297 (21.2)	326 (23.3)	193 (13.8)	158 (11.3)	371 (26.5)	279 (19.9)	178 (12.7)	89 (6.4)
Pregnant women	-	344 (24.6)	-	59 (4.2)	-	251 (17.9)	-	22 (1.6)
Total	**297 (4.2)**	**670 (8.0)**	**219 (3.1)**	**241 (2.9)**	**386 (5.5)**	**566 (6.7)**	**231 (3.3)**	**161 (1.9)**

Figures in parentheses indicate percentage

Diabetes was seen commonly among 21.2 and 23.3 per cent of the male and female adults and 24.6 per cent of the pregnant women. Though none of the school going and adolescent children was seen to be affected with heart diseases, less than two per cent of the infants and less than 0.5 per cent of preschool children were seen to be suffering from heart diseases. Among the

adults, 13.8 per cent and 11.3 per cent of male and female subjects and 4.2 per cent of the pregnant women were seen to be affected from heart diseases. Other illnesses such as arthritis, tuberculosis and asthma were seen among less than 1.5 per cent of infants, preschoolers, school going children and adolescent subjects. About 12.7 and 6.4 per cent of adult male and female subjects respectively and 1.6 per cent of pregnant women were seen to be suffering from other illnesses. Studies by Diesner (2011) reported that deficiencies in micronutrients especially zinc and iron, as well as vitamin D, in the elderly may also contribute to the development of allergies.

b. Morbidity pattern of the subjects

Morbidity pattern which is a marker of decreased immune function among the subjects of different age groups belonging to the present study are tabulated in Table XI.

TABLE XI
MORBIDITY PATTERN OF THE SUBJECTS

Illness	Diarrhoea		Respiratory illness		Worm infestation		Cough/ Cold		Fever	
	M	F	M	F	M	F	M	F	M	F
Infant	92 (6.6)	67 (4.8)	78 (5.6)	57 (4.1)	43 (3.1)	33 (2.4)	137 (9.8)	106 (7.6)	107 (7.6)	72 (5.1)
Preschool	103 (7.4)	96 (6.9)	53 (3.8)	44 (3.1)	15 (1.1)	23 (1.6)	61 (4.4)	79 (5.6)	138 (9.9)	149 (10.6)
School going	32 (2.3)	37 (2.6)	51 (3.6)	33 (2.4)	5 (0.4)	24 (1.7)	18 (1.3)	36 (2.6)	121 (8.6)	87 (6.2)
Adolescent	5 (0.4)	9 (0.6)	29 (2.1)	24 (1.7)	8 (0.6)	12 (0.9)	5 (0.4)	11 (0.8)	67 (4.8)	44 (3.1)
Adult	23 (1.6)	32 (2.3)	31 (2.2)	41 (2.9)	0 (0)	2 (0.1)	23 (1.6)	6 (0.4)	51 (3.6)	82 (5.9)
Pregnant women	-	36 (2.6)	-	39 (2.8)	-	4 (0.3)	-	19 (1.4)	-	121 (8.6)
Total	**255 (3.6)**	**277 (3.3)**	**242 (3.5)**	**238 (2.8)**	**71 (1.0)**	**98 (1.2)**	**244 (3.5)**	**257 (3.1)**	**484 (6.9)**	**555 (6.6)**

Figures in parentheses indicate percentage

Nutrition and immunity have a synergistic relationship and deficiencies in either can have serious health implications (Kindra *et al.*, 2011). Among the

15400 subjects chosen for the present study, infants (6.6 and 4.8%) and preschool children (7.4 and 6.9%) were seen to be more frequently affected by diarrhoea than any other age groups. This finding is supported by the Micronutrient Initiative (2010) which has stated that diarrhoea remains a leading cause of death, responsible for an estimated 1.9 million deaths in the world each year. In the post-neonatal period of infancy, infectious disease mortality is high although healthcare is accessible (Vaid *et al.*, 2007). However, there were less than three per cent of subjects suffering from diarrhoea among all the other age groups namely adolescents, adult and pregnant women. The overall occurrence of respiratory illnesses was less than six per cent with a maximum of 5.6 per cent among male infants and a minimum of 1.7 per cent among the female adolescents. Worm infestations were seen to be affecting more number of infants (3.1% male and 2.4% female) and preschoolers (1.1% male and 1.6% female) when compared to the other age groups. Further, cough and cold was also seen frequently among infants and school going children. Infants (6.4%) and preschool children (10.3%) were seen to be more frequently affected by fever as compared to the other age groups. These findings are on par with the NFHS 3 (2007) survey which reports a high prevalence of fever among children under the age of five years. Further 7.4, 4.0 and 4.8 per cent of school going, adolescent and adult subjects respectively and 8.6 per cent of pregnant women were seen to be frequently affected with fever. Preservation of a functionally youthful immune system throughout the years that involves ensuring adequate vitamin and mineral status, is the best way to preserve health throughout life and to gain longevity accompanied by good quality of life (Maggini, 2010).

c. Types of treatment undertaken

The various types of treatments undertaken frequently by the subjects belonging to the various age groups chosen for the study are presented in Table XII.

TABLE XII
TYPE OF TREATMENT FREQUENTLY UNDERTAKEN

Group	Home remedy		Consult Doctor		Pharmacy/Self medication		Neglect	
	M	F	M	F	M	F	M	F
Infant	383 (27.4)	342 (24.4)	621 (44.4)	522 (37.3)	155 (11.1)	263 (18.8)	241 (17.2)	273 (19.5)
Preschool	398 (28.4)	446 (31.9)	479 (34.2)	173 (12.4)	189 (13.5)	274 (19.6)	334 (23.9)	507 (36.2)
School going	293 (20.9)	271 (19.4)	767 (54.8)	513 (36.6)	67 (4.8)	236 (16.9)	273 (19.5)	380 (27.1)
Adolescent	309 (22.1)	273 (19.5)	453 (32.4)	357 (25.5)	302 (21.6)	311 (22.2)	336 (24.0)	459 (32.8)
Adult	337 (24.1)	263 (18.8)	311 (22.2)	174 (12.4)	163 (11.6)	276 (19.7)	589 (42.1)	687 (49.1)
Pregnant women	-	553 (39.5)	-	437 (31.2)	-	161 (11.5)	-	249 (17.8)
Total	**1720 (24.6)**	**2148 (25.6)**	**2631 (37.6)**	**2176 (25.9)**	**876 (12.5)**	**1521 (18.1)**	**1773 (25.3)**	**2555 (30.4)**

Figures in parentheses indicate percentage

Though majority of the male (41.2%) and female (39.4%) infants were taken to a physician to be treated for common illnesses faced by them, many of the male (24.5%) and female (26.6%) were treated with home remedies. About 11.1 and 18.9 per cent of male and female infants respectively were treated with the help of either pharmacy or through self medication by the parents while the illness of 17.2 and 21.6 percentages of male and female infants respectively were often neglected. A similar trend was also observed among the preschool children. Majority of adults neglected their common illnesses and relied on home medication. About 39.5 and 31.1 per cent of pregnant women followed home remedy and contacted physician respectively to be treated for common illnesses.

It was further observed that the number of subjects who either neglected or followed home treatment methods were more among female subjects than male subjects among all age groups. The increased frequency of ailments such as cough, cold, fever and diarrhoea among the poorly developed areas

of Ramanathapuram was probably one of the reasons for the increased negligence in terms of health care and treatment of these illnesses among the community. Further, increased health care cost and low socio-economic status of the people added up to the increased prevalence of home remedy and neglecting of such illnesses among the people.

d. Supplement consumption pattern among the subjects

Table XIII presents the trend seen in the consumption of various supplements among the subjects.

TABLE XIII

CONSUMPTION OF NUTRITIONAL SUPPLEMENTS

Group	Iron		Calcium		Folic acid		Multi-vitamin	
	M	F	M	F	M	F	M	F
Infant	228 (16.3)	172 (12.3)	53 (3.8)	29 (2.1)	176 (12.6)	243 (17.4)	371 (26.5)	409 (29.2)
Preschool	243 (17.4)	156 (11.1)	0 (0)	0 (0)	44 (3.1)	65 (4.6)	242 (17.3)	297 (21.2)
School going	0 (0)	2 (0.1)	0 (0)	0 (0)	0 (0)	0 (0)	34 (2.4)	26 (1.9)
Adolescent	0 (0)	52 (3.7)	0 (0)	3 (0.2)	0 (0)	106 (7.6)	0 (0)	243 (17.4)
Adult	0 (0)	96 (6.9)	0 (0)	0 (0)	0 (0)	112 (8)	47 (3.4)	124 (8.9)
Pregnant women	-	1322 (94.4)	-	88 (6.3)	-	1183 (84.5)	-	649 (46.4)
Total	**471 (6.7)**	**1800 (21.4)**	**53 (0.8)**	**120 (1.4)**	**220 (3.1)**	**1709 (20.3)**	**694 (9.9)**	**1748 (20.8)**

Figures in parentheses indicate percentage

The consumption of multivitamin supplements either in the form of capsules or syrups was seen to be more common among the male (26.5%) and female (29.2%) infants. Only few of the infants (less than 4%) consumed calcium supplements. Iron supplements were consumed by 17.4 and 11.1 per cent of the male and female preschool children respectively. Almost the same

number of male and 21.2 per cent of the female preschool children consumed multivitamin supplements. Less than three per cent of the school going children consumed multivitamin supplements. Iron supplements were consumed by none of the male and 0.1 per cent of the female school going children. However, none of them were seen to consume calcium or folic acid supplements. Though none of the adolescent boys were seen to consume any form of supplements and 17.4 per cent of the adolescent girls consumed multivitamin supplements. Similarly only multivitamin supplements were consumed by some (3.4%) of the adult men. However, 6.9, 8 and 8.9 per cent of female adults consumed iron, folic acid and multivitamin supplements respectively. Majority of the pregnant women consumed iron (94.4 %) and folic acid (84.5%) supplements. However, 6.3 and 46.4 per cent of the pregnant women consumed calcium and multivitamin supplements. On the whole, supplements of any kind were consumed by a total of 28.5 per cent of the subjects. The reasons for the consumption of nutritional supplements either in the forms of capsules, tablets or syrups were reported as doctors prescriptions, health problems or self interest. The Micronutrient Initiative (2006) has reported the percentage of Indian children under five years of age receiving vitamin A supplements to be 34 per cent per year.

e. Skin problems faced by the subjects

The various skin problems frequently faced by the subjects are presented in Table XIV.

TABLE XIV

FREQUENT SKIN PROBLEMS FACED BY THE SUBJECTS

Group	Rashes		Boil		Scar		Roughness		Dryness		Allergy	
	M	F	M	F	M	F	M	F	M	F	M	F
Infant	156 (11.1)	227 (16.2)	54 (3.9)	23 (1.6)	0 (0)	0 (0)	165 (11.8)	183 (13.1)	439 (31.4)	512 (36.6)	6 (0.4)	17 (1.2)
Preschool	288 (20.6)	274 (19.6)	9 (0.6)	163 (11.6)	0 (0)	_ (0)	331 (23.6)	314 (22.4)	296 (21.1)	265 (18.9)	11 (0.8)	14 (1.0)
School going	296 (21.1)	381 (27.2)	182 (13)	158 (11.3)	3 (0.2)	_ (0)	285 (20.4)	346 (24.7)	392 (28)	304 (21.7)	17 (1.2)	6 (0.4)
Adolescent	404 (28.9)	334 (23.9)	126 (9)	_ (0)	23 (1.6)	52 (3.7)	441 (31.5)	453 (32.4)	274 (19.6)	165 (11.8)	_ (0)	0 (0)
Adult	457 (32.6)	365 (26.1)	56 (4)	2 (0.1)	61 (4.4)	156 (11.1)	554 (39.6)	447 (31.9)	466 (33.3)	373 (26.6)	_ (0)	0 (0)
Pregnant women	_	242 (17.3)	_	_ (0)	-	192 (13.7)	-	493 (35.2)	-	382 (27.3)	-	8 (0.6)
Total	**1601 (22.9)**	**1823 (21.7)**	**427 (6.1)**	**346 (4.1)**	**87 (1.2)**	**400 (4.8)**	**1776 (25.4)**	**2236 (26.6)**	**1867 (26.7)**	**2001 (23.8)**	**34 (0.5)**	**45 (0.5)**

Figures in parentheses indicate percentage

Skin rashes were seen to be most common among adults by up to 32.6 per cent followed by adolescents, school going children, preschool children, pregnant women and infants. Boils were more commonly seen among school going boys (13%), preschool girls (11.6%) and school going girls (11.3%) followed by adolescent boys (9%). However, boils frequently affected less than five per cent of subjects among the rest of the groups. Scars were reported among 1.6 and 3.7 per cent of the adolescent, and 4.4 and 11.1 per cent of the adult male and female subjects respectively. Frequent roughness of the skin was reported by less than 40 per cent of subjects among all the age groups with a maximum of 39.6 per cent of adult male subjects and a minimum of 11.8 per cent among male infants. Frequent dryness of skin was reported by 31.4 and 36.6 per cent of male and female infants and 21.1 and 18.9 per cent of male and female preschool children respectively. Less than 30 per cent of subjects of all the other age groups and 33.3 per cent of adult male subjects reported frequent dryness of the skin. Frequent skin allergies were reported by less than two per cent of the infants, preschool children, school going children and pregnant women. However, none of the adolescent and adult subjects reported frequent skin allergy.

3. Clinical Signs and Symptoms Observed Among the Subjects

Specific nutritional deficiencies are associated with specific clinical signs. These signs are easy to identify and can be used by health workers to assess the degree of malnutrition among the subjects (Ahmed and Haboubi, 2010). Data on various clinical signs and symptoms faced by the subjects is presented below.

a. General nutritional status of the subjects

Percentage of subjects having good, fair and poor nutritional status among the different age groups is presented in Table XV.

TABLE XV

GENERAL NUTRITIONAL STATUS OF THE SUBJECTS

Group	Good		Fair		Poor	
	M	F	M	F	M	F
Infant	1024 (73.1)	1072 (76.6)	195 (13.9)	134 (9.7)	181 (12.9)	194 (13.9)
Preschool	887 (63.4)	906 (64.7)	299 (21.3)	266 (19.0)	214 (15.3)	228 (16.3)
School going	851 (60.8)	737 (52.6)	236 (16.9)	381 (27.2)	313 (22.3)	282 (20.1)
Adolescent	1207 (86.2)	1022 (73.0)	137 (9.8)	179 (12.8)	56 (4)	199 (14.2)
Adult	1123 (80.2)	1077 (76.9)	152 (10.9)	201 (14.4)	125 (8.9)	122 (8.7)
Pregnant women	-	866 (61.9)	-	212 (15.1)	-	322 (23)
Total	**5092 (72.7)**	**5680 (67.6)**	**1019 (14.6)**	**1373 (16.3)**	**889 (12.7)**	**1347 (16.0)**

Figures in parentheses indicate percentage; Poor:> 3 clinical signs; Fair: 1-3 clinical signs; Good: absence of clinical signs

About 13.9 and 9.7 per cent of male and female infants and 12.9 and 13.9 per cent of the male and female infants respectively had fair and poor nutritional status. Among the preschool children, more than 60 per cent of the male and female children had good nutritional status. Fair (16.9% male and 27.2% female) and poor (22.3% male and 20.1% female) nutritional status were seen to be most common among the school going children when compared to other age groups. Less than 15 per cent of the male and female subjects belonging to both adolescent and adult age groups were seen to be either fair or poor in nutritional status respectively. The percentage of pregnant women with fair and poor nutritional status were 15.1 and 23 per cent respectively. On the whole, while more than 70 per cent of the infants, adolescents and adults, and less than 60 per cent of the subjects in the groups of preschool children, school going children and pregnant women were seen to be having good nutritional status. In the present study, female subjects were seen to have poorer nutritional status than male subjects.

Findings of Maitra and Rammohan (2011) also reported that girl children had comparatively poorer nutritional status than their male counterparts in India where discrimination against girls resulting excess female child mortality has been documented.

b. Hair condition of the subjects

Table XVI presents the condition of hair of the subjects.

TABLE XVI
CONDITION OF HAIR OF THE SUBJECTS

Category	Normal		Brittle		Lustreless		Discoloured	
	M	F	M	F	M	F	M	F
Infant	1296 (86.1)	1185 (84.6)	29 (2.1)	53 (3.8)	161 (11.5)	193 (13.8)	94 (6.7)	116 (8.3)
Preschool	1124 (80.3)	1188 (84.9)	76 (5.4)	38 (2.7)	217 (15.5)	158 (11.3)	99 (7.1)	86 (6.1)
School going	944 (67.4)	863 (61.6)	52 (3.7)	81 (5.8)	502 (35.9)	527 (37.6)	18 (1.3)	109 (7.8)
Adolescent	1097 (78.4)	94 (67.5)	122 (8.7)	147 (10.5)	253 (18.1)	324 (23.1)	121 (8.6)	164 (11.7)
Adult	754 (53.9)	696 (49.7)	193 (13.8)	221 (15.8)	77 (19.8)	326 (23.3)	504 (36.0)	467 (33.4)
Pregnant women	-	939 (67.1)	-	89 (6.3)	-	185 (13.2)	-	166 (11.9)
Total	**5215 (74.5)**	**4965 (59.1)**	**472 (6.7)**	**629 (7.5)**	**1210 (17.3)**	**1713 (20.4)**	**836 (11.9)**	**1108 (13.2)**

*Figures in parentheses indicate percentage

Healthy appearing hair is a sign of excellent general health, and good hair care practices. Most nutritional deficiencies are often reflected in changes of scalp and hair. These changes in skin and hair can provide clues to the presence of an underlying vitamin deficiency (Goldberg and Lenzy, 2010).

More than 80 per cent of the infants and preschool children and more than 60 per cent of the school going children, adolescents and pregnant women had normal hair, while only 53.9 and 49.7 per cent of the male and female adults had normal hair. Less than 11 per cent of subjects belonging to

infant, preschool, school going, adolescent and pregnant women had brittle hair. However, brittle hair was seen among 13.8 and 15.8 per cent of adult male and female subjects. Lustreless hair was most common among school going children followed by adolescent and adult subjects. Discoloured hair was the most common among male (36%) and female (33.4%) adults followed by pregnant women (11.9%). Further, less than 12 per cent of the infants, preschool and school going children were seen to be having discoloured hair.

c. Degree of angular stomatitis

Oral health of the subject is extremely important for nutrition assessment because this is the typical entry point for adequate nutrition and hydration (Collins and Harris, 2010). The degree of angular stomatitis and the condition of lips of the subjects belonging to the various age groups is presented in Table XVII.

TABLE XVII

DEGREE OF ANGULAR STOMATITIS AMONG THE SUBJECTS

Group	Normal		AS mild		AS moderate		Cracked Lips	
	M	F	M	F	M	F	M	F
Infant	1385 (98.9)	1387 (98.9)	6 (0.4)	3 (0.2)	_ (0)	_ (0)	17 (1.2)	12 (0.9)
Preschool	1382 (98.7)	1373 (98.1)	12 (0.9)	17 (1.2)	_ (0)	4 (0.3)	8 (0.6)	11 (0.8)
School going	1384 (98.9)	1363 (97.4)	11 (0.8)	13 (0.9)	1 (0.1)	3 (0.2)	9 (0.6)	21 (1.5)
Adolescent	1385 (98.9)	1371 (97.9)	4 (0.3)	13 (0.9)	1 (0.1)	2 (0.1)	12 (0.9)	19 (1.4)
Adult	1348 (96.3)	1343 (95.9)	17 (1.2)	19 (1.4)	8 (0.6)	2 (0.1)	31 (2.2)	44 (3.1)
Pregnant women	-	1341 (95.8)	-	24 (1.7)	-	6 (0.4)	-	38 (2.7)
Total	**6884 (98.3)**	**8178 (97.4)**	**50 (0.7)**	**89 (1.1)**	**10 (0.1)**	**17 (0.2)**	**77 (1.1)**	**145 (1.7)**

Figures in parentheses indicate percentage

Mild angular stomatitis was observed among 0.4 and 0.2 per cent of the male and female infants and 0.9 and 1.2 of the male and female preschool children. Less than one per cent of the school going children and adolescents and more than one per cent of the male adults and pregnant women were affected with mild angular stomatitis. It was a heart warming observation that moderate angular stomatitis was absent among the infants and male preschool children. However, less than 0.5 per cent of the adolescents, adults and female preschool children had moderate angular stomatitis. Moderate angular stomatitis was also seen among 0.6 and 0.1 per cent of male and female adults and 0.4 per cent of pregnant women. Rao *et al* (2010) have reported the prevalence of angular stomatitis to be 1.1 and 0.8 per cent among tribal and rural women of India respectively. The findings of the present study also goes in line with the NNMB (2006) report according to which the prevalence of angular stomatitis among school going children of Tamil Nadu was 0.8 per cent.

d. Colour and texture of tongue of the subjects

The colour and texture of the tongue of the subjects chosen for the present study is presented in Table XVIII.

TABLE XVIII

TONGUE COLOUR AND TEXTURE OF THE SUBJECTS

Group	Normal		Pale		Red		Fissured	
	M	F	M	F	M	F	M	F
Infant	1107 (79.1)	1097 (78.4)	237 (16.9)	274 (19.6)	56 (4)	29 (2.1)	_ (0)	9 (0.6)
Preschool	1221 (87.2)	1259 (89.9)	168 (12)	117 (8.4)	11 (0.8)	23 (1.6)	_ (0)	_ (0)
School going	1202 (85.9)	1155 (82.5)	186 (13.3)	229 (16.4)	12 (0.9)	16 (1.1)	8 (0.6)	7 (0.5)
Adolescent	1059 (75.6)	1265 (90.4)	322 (23)	649 (46.4)	19 (1.4)	7 (0.5)	1 (0.1)	3 (0.2)
Adult	1262 (90.1)	1218 (87.0)	134 (9.6)	171 (12.2)	4 (0.3)	11 (0.8)	8 (0.6)	2 (0.1)
Pregnant women	-	642 (45.9)	-	743 (53.1)	-	16 (1.1)	-	_ (0)
Total	**5851 (83.6)**	**6636 (79.0)**	**1047 (15.0)**	**2183 (26.0)**	**102 (1.5)**	**102 (1.2)**	**17 (0.2)**	**21 (0.3)**

Figures in parentheses indicate percentage

Pale tongue was observed among 16.9 and 19.6 per cent of male and female infants respectively and 12 and 8.4 per cent of male and female preschool children respectively. Paleness of tongue was also seen among 13.3 and 16.4 per cent of male and female school going children respectively and 9.6 and 12.2 per cent of male and female adults respectively. Pale tongue was seen most commonly among pregnant women (53.1%) followed by adolescent girls (46.4%) and boys (23%). Redness of tongue was seen most commonly among infant boys (4%) and girls (2.1%), followed by preschool girls (1.6%) and adolescent boys (1.4%). Red tongue was seen among less than one per cent among the other groups. Paleness and redness of tongue are indicators of iron deficiency anemia. Paleness occurs as the body diverts oxygen-rich blood from the less vital areas to the heart, lungs and brain (Garrison, 2009). A smooth red tongue with a slick appearance is also indicative niacin or vitamin B12 deficiency (Collins and Harris, 2010). About 0.6 per cent of the female infants, male school going children, and adult male subjects were seen to be having fissured tongue. This condition could also be

observed among 0.5 per cent of school going female children, 0.2 per cent of adolescent girls and 0.1 per cent of adolescent male and adult female subjects. Mathew *et al* (2008) have reported the prevalence of fissured tongue to be 5.71 per cent in southern India.

e. Ocular manifestation of vitamin A deficiency

The eyes can provide reliable signs of particular nutrient deficiencies such as vitamin A, a crucial nutrient for the visual center of the body. A deficiency in vitamin A deficiency can show up as poor vision at night or in dim light (night blindness), impaired visual recovery after a glare, sensitivity to light, blurring, conjunctival inflammation, and excessive dryness, followed by progressive cloudiness and softening of the corneas (keratomalacia) (Bistrian, 2008). The various ocular signs of vitamin A deficiency evident among the subjects are presented in Table XIX.

TABLE XIX

OCULAR MANIFESTATION OF VITAMIN A DEFICIENCY

Group	Night blindness (XN)		Conjunctival Xerosis (CX)		Bitot's spot (BS)		Keratomalacia (K)	
	M	F	M	F	M	F	M	F
Infant	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Preschool	0 (-)	0 (-)	11 (0.8)	16 (1.1)	8 (0.6)	10 (0.7)	0 (-)	1 (0.07)
School going	0 (-)	1 (0.07)	21 (1.5)	23 (1.6)	11 (0.8)	6 (0.4)	2 (0.1)	1 (0.07)
Adolescent	0 (-)	0 (-)	4 (0.3)	6 (0.4)	6 (0.4)	4 (0.3)	1 (0.07)	0 (-)
Adult	0 (-)	1 (0.07)	9 (0.6)	11 (0.8)	12 (0.9)	9 (0.6)	1 (0.07)	0 (-)
Pregnant women	-	0 (-)	-	8 (0.6)	-	9 (0.6)	-	0 (-)
Total	**0 (0)**	**2 (0.02)**	**45 (0.6)**	**64 (0.8)**	**34 (0.5)**	**35 (0.4)**	**4 (0.1)**	**2 (0.02)**

Figures in parentheses indicate percentage

One female subject (0.07%) from each of the school going and adult age groups were found to be having night blindness. Maximum number of subjects affected with conjunctival xerosis belonged to the male (1.5%) and female (1.6%) school going children, followed by 1.1 per cent of female preschool children. Conjunctival xerosis was also seen among 0.3 and 0.4 per cent of male and female adolescents, 0.6 and 0.8 per cent of male and female adults and 0.6 per cent of pregnant women. Bitot's spot was most common among adult male subjects (0.9%) followed by adult female and preschool children. No cases of Bitot's spot were seen among the infants. The reason may be suggested that vitamin A requirement is relatively fulfilled by prolonged breast-feeding practice in Indian sub-continent leading to replenishment of hepatic storage of vitamin A breast-feeding may have sufficient prophylactic effect for vitamin A deficiency for children up to age two years of age (Pal, 2009). However, less than 0.7 per cent of subjects were affected with Bitot's spot among all the other age groups. Swami *et al* (2007) have also reported a prevalence of Bitot's spot ranging from 4.3 to 5.1 per cent among children between one to five years of age in Chandigarh. Keratomalacia, which is the most severe form of vitamin A deficiency, was observed among 0.1 per cent of male school going children and 0.07 per cent of preschool and school going female children and adolescent and adult male subjects. The findings of the present study provided shocking evidence that the prevalence of Bitot's spot exceeded the WHO cut-off levels of 0.5. Such high prevalence rates exceeding the WHO cut-offs has also been documented in Tamil Nadu by the NNMB survey (2006).

f. Condition of gums of the subjects

Scurvy is a deficiency disease resulting from the deficiency of vitamin C manifesting itself orally in the form of spongy gums and bleeding of the mucous membranes (Andersen *et al.*, 2009). Table XX presents the condition of gums of the subjects in the present study.

TABLE XX

CONDITION OF GUMS OF THE SUBJECTS (N = 1400)

Group	Normal		Recession		Pyorrhoea		Bleeding		Spongy	
	M	F	M	F	M	F	M	F	M	F
Infant	1400 (100)	1400 (100)	– (0)	– (0)	– (0)	– (0)	– (0)	– (0)	– (0)	– (0)
Preschool	1400 (100)	1400 (100)	– (0)	– (0)	– (0)	– (0)	– (0)	– (0)	– (0)	– (0)
School going	1341 (95.8)	1324 (94.6)	– (0)	– (0)	– (0)	– (0)	63 (4.5)	81 (5.8)	4 (0.3)	1 (0.1)
Adolescent	1328 (94.9)	1348 (96.3)	43 (3.1)	32 (2.3)	7 (0.5)	3 (0.2)	11 (0.8)	19 (1.4)	– (0)	– (0)
Adult	1239 (88.5)	1291 (92.2)	74 (5.3)	53 (3.8)	23 (1.6)	6 (0.4)	56 (4)	39 (2.8)	26 (1.9)	19 (1.4)
Pregnant women	-	1313 (93.8)	-	31 (2.2)	-	17 (1.2)	-	44 (3.1)	–	– (0)
Total	**6708 (95.8)**	**8076 (96.1)**	**117 (1.7)**	**116 (1.4)**	**30 (0.4)**	**26 (0.3)**	**130 (1.9)**	**183 (2.2)**	**30 (0.4)**	**20 (0.2)**

Figures in parentheses indicate percentage

The above Table demonstrates that a total of 4.5 and 5.8 per cent of school going male and female subjects had bleeding gums and 0.3 and 0.1 per cent had spongy gums. Recession of gums was seen among two to three per cent of the adolescent and three to five per cent of the adults and 2.2 per cent of the pregnant women. Pyorrhoea of the gums was noticed among 0.5 and 0.2 per cent of adolescent boys and girls and 1.6 and 0.4 per cent of male and female adults and 1.2 per cent of pregnant women. Bleeding gums was found among 0.8 and 1.4 per cent of male and female adolescents, 4.0 and 2.8 per cent of male and female adults and 3.1 per cent of pregnant women. About 1.9 and 1.4 per cent of male and female adults had spongy gums. Kaur *et al* (2010) reported a prevalence of bleeding gums of up to 66.67 per cent among pregnant women residing in Ludhiana. The present study was also in correspondence to the findings of NNMB (2006) according to which about 0.8 per cent adolescents in Tamil Nadu had bleeding gums.

g. Condition of teeth of the subjects

Malnutrition affects oral health and oral health affects malnutrition. Dietary factors are important in the structure of oral mucosa, oral microflora, integrity and quantity of the teeth (Uckardes *et al.*, 2009). Table XXI depicts the condition of teeth of the subjects.

TABLE XXI
CONDITION OF TEETH OF THE SUBJECTS

Group	Normal		Caries		Discoloured		Mottled enamel	
	M	F	M	F	M	F	M	F
School going	1293 (92.4)	1336 (95.4)	43 (3.1)	31 (2.2)	71 (5.1)	47 (3.4)	_ (0)	_ (0)
Adolescent	1236 (88.3)	1252 (89.4)	77 (5.5)	93 (6.6)	93 (6.6)	56 (4)	3 (0.2)	1 (0.1)
Adult	1099 (78.5)	1151 (82.2)	104 (4.4)	136 (9.7)	171 (12.2)	103 (7.4)	28 (2)	19 (1.4)
Pregnant women	-	1231 (87.9)	-	78 (5.6)	-	94 (6.7)	-	6 (0.4)
Total	**3628 (86.4)**	**4970 (88.9)**	**224 (5.3)**	**338 (6.0)**	**335 (8.0)**	**300 (5.4)**	**31 (0.7)**	**26 (0.5)**

Figures in parentheses indicate percentage

Dental caries was seen among 3.1 and 2.2 per cent of male and female school going children respectively and 5.1 and 3.4 per cent of the children had discoloured teeth. Less than seven per cent of the adolescent boys and girls had caries and discoloration of teeth and less than 0.3 per cent had with mottled enamel. Among all the age groups, discoloration of teeth was most common among adults. A total of two and 1.4 per cent of adult men and women respectively had mottled teeth enamel. Caries, discolouration and mottled enamel were seen among 5.6, 6.7 and 0.4 per cent of the pregnant women respectively. A study by Singh *et al* (2009) also reported that teeth complaints were high among adults in Rajasthan with the prevalence of dental caries up to 18.7 per cent and mottled enamel up to 8.9 per cent and caries along with mottled enamel up to 18.7 per cent. The findings of the present study are on par with the report of the NNMB (2006) according to which about the prevalence of dental caries among adolescents in Tamil Nadu was about 6.4 per cent.

h. Condition of skin of the subjects

Skin changes can provide important clues for lack or overabundance of individual nutritional components and can help clinicians to correctly detect, diagnose and consequently treat nutritional disease which can be confirmed by laboratory testing (Schmuth and Fritsch, 2011). The skin condition of the subjects chosen for the present study is presented in Table XXII.

TABLE XXII
CONDITION OF SKIN OF THE SUBJECTS

Group	Normal		Lustureless		Phrynoderma	
	M	F	M	F	M	F
Infant	1293 (92.4)	1240 (88.6)	107 (7.6)	160 (11.4)	(0)	(0)
Preschool	1279 (91.4)	1304 (93.1)	121 (8.6)	96 (6.9)	(0)	(0)
School going	1256 (89.7)	1296 (92.6)	125 (8.9)	93 (6.6)	19 (1.4)	11 (0.8)
Adolescent	1230 (87.9)	1195 (85.4)	157 (11.2)	197 (14.2)	13 (0.9)	6 (0.4)
Adult	1162 (83)	1215 (86.8)	221 (15.9)	174 (12.4)	17 (1.2)	1 (0.8)
Pregnant women	--	1229 (87.8)	--	171 (12.2)	--	(0)
Total	**6220 (88.9)**	**7479 (89.0)**	**731 (10.4)**	**891 (10.6)**	**49 (0.7)**	**18 (0.2)**

Figures in parentheses indicate percentage

Though none of the infants and preschool children in the present study had phrynoderma, 7.6 and 11.4 per cent of male and female infants had lustureless skin. About 8.6 and 6.9 per cent of male and female school going children had skin without lusture while 1.4 and 0.8 per cent of the male and female school going children had phrynoderma. The NNMB (2006) has also reported a 0.7 per cent prevalence of phrynoderma among school going children of Tamil Nadu. Less than 16 per cent of the subjects belonging to the other groups were also found to be having lustureless skin with a maximum number of 15.9 per cent among the adult men and a minimum of 11.2 per cent among the adolescent boys. It was a heartening observation that none of the pregnant women had phrynoderma. Rao *et al* (2010) reported a prevalence of phrynoderma up to 1.3 to 2.2 per cent among Indian women. Plates 24 and 25 show the clinical signs of micronutrient deficiency observed among the subjects.

i. Mental condition of the subjects

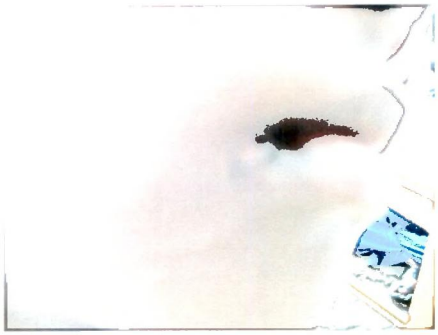
The clinical signs of vitamin deficiency in humans include mental changes such as apathy, decrease in short-term memory, confusion, and irritability (Malafaia and Talvani, 2011). Table XXIII presents the mental condition of the subjects participating in the present study.

TABLE XXIII
MENTAL CONDITION OF THE SUBJECTS

Group	Normal		Irritable		Apathy	
	M	F	M	F	M	F
Infant	1324 (94.6)	1307 (93.4)	76 (5.4)	93 (6.6)	_ (0)	_ (0)
Preschool	1378 (98.4)	1400 (100)	22 (1.6)	_ (0)	_ (0)	_ (0)
School going	1400 (100)	1400 (100)	_ (0)	_ (0)	_ (0)	_ (0)
Adolescent	1400 (100)	1400 (100)	_ (0)	_ (0)	_ (0)	_ (0)
Adult	1369 (97.8)	1356 (96.9)	30 (2.1)	44 (3.1)	1 (0.1)	_ (0)
Pregnant women	--	1373 (98.1)	--	27 (1.9)	_	_ (0)
Total	**6871 (98.2)**	**8236 (98.0)**	**128 (1.8)**	**164 (2.0)**	**1 (0.1)**	**0 (0)**

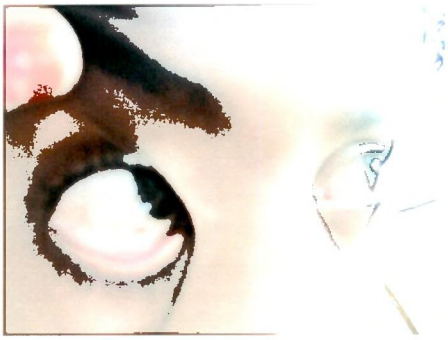
It was a welcome observation to find that all the preschool, school going, and adolescent subjects studied were in a normal state of mind. However, 5.4 and 6.6 per cent of infants were irritable as they were seen to be crying frequently and were highly sensitive. About 1.6 per cent of preschool boys, 2.1 and 3.1 per cent of male and female adults and 1.9 per cent of pregnant women were also found with irritable mental condition. Apathy was seen among one (0.1%) of the adult male subjects. Malnutrition directly damages the central nervous system resulting in severe impact on cognitive and emotional development. It also affects emotionality, irritability, and attention in young children and social and emotional responses in elders (Engle and Huffman, 2010).

PALE NAILS



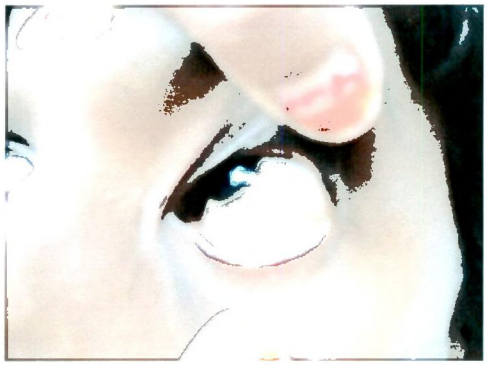
ANGULAR STOMATITIS

CONJUNCTIVAL XEROSIS



CONJUNCTIVAL XEROSIS

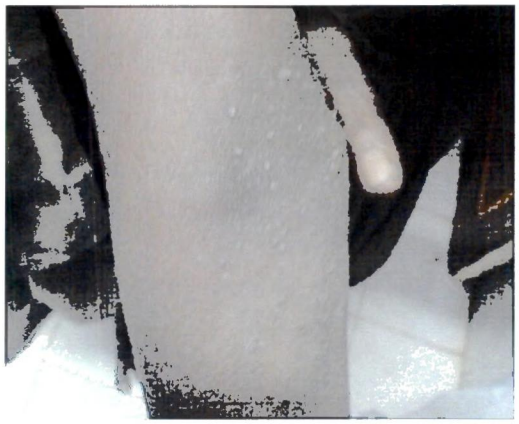
ENLARGEMENT OF THYROID



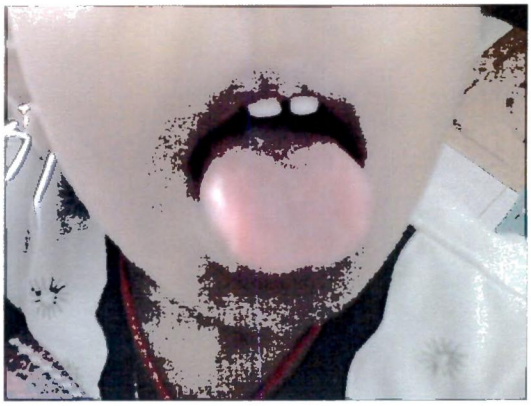
BITOT'S SPOT

PLATE 24

CLINICAL SIGNS OF MICRONUTRIENT DEFICIENCY AMONG THE SUBJECTS



PHRYNODERMA



REDNESS OF TONGUE

SPOON SHAPED NAILS

GOITRE

PLATE 25

CLINICAL SIGNS OF MICRONUTRIENT DEFICIENCY AMONG THE SUBJECTS

4. Food and nutrient intake pattern of the subjects

Knowledge of systematic nutrition assessment and appropriate diagnosis of malnutrition will help to guide proper interventions and achieve expected outcomes (Jensen *et al.*, 2012). Food intake data of the subjects belonging to different age groups are presented and discussed below.

a. Food intake of the children

The food intake pattern of preschool and school going children are presented in Table XXIV.

TABLE XXIV

FOOD INTAKE PATTERN OF CHILDREN

Group	Intake	Cereals and millets (g)	Pulses (g)	Leafy vegetables (g)	Other vegetables (g)	Roots and tubers (g)	Fruits (g)	Fleshy foods (g)	Milk and milk products (ml)	Fats and oils (ml)	Sugar and Jaggery (g)
Pre school	**RDA***	**60**	**30**	**50**	**50**	**50**	**100**	**--**	**500**	**25**	**15**
	Male	47.61	16.54	7.82	18.35	17.29	12.74	9.52	341.76	7.76	16.17
	SD	±38.92	±17.97	±11.28	±16.58	±9.54	±6.23	±3.54	±133.14	±2.38	±11.28
	% E/D	- 20.7	- 44.9	- 84.4	- 63.3	- 65.4	- 87.3	--	-31.6	- 69.0	+ 7.8
	Female	42.86	15.42	5.74	13.45	16.86	9.22	6.99	367.92	6.92	15.46
	SD	±54.83	±14.36	±9.47	±17.91	±11.21	±4.84	±4.81	±91.24	±3.13	±8.77
	% E/D	- 28.6	- 48.6	- 88.5	- 73.1	- 66.3	- 90.8	--	- 26.4	- 72.3	+ 3.1
School going	**Male**	146.11	24.86	17.74	53.19	34.21	20.56	23.46	258.11	19.14	23.82
	SD	±74.82	±13.2	±18.27	±27.92	±16.52	±11.94	±9.85	±34.26	±4.76	±16.92
	RDA*	**300**	**60**	**100**	**200**	**100**	**100**	**--**	**500**	**35**	**30**
	% E/D	- 51.3	- 58.6	- 82.6	- 73.4	- 65.8	-79.4	--	- 48.4	- 45.3	-20.6
	Female	138.92	21.95	13.31	46.52	28.72	21.33	19.97	264.79	15.52	21.47
	SD	±68.52	±18.64	±13.56	±24.37	±13.94	±13.56	±12.23	±37.91	±6.72	±14.76
	RDA*	**240**	**60**	**100**	**200**	**100**	**100**	**--**	**500**	**35**	**30**
	% E/D	- 42.1	- 63.4	- 86.7	- 76.7	- 71.3	- 78.7	--	- 47.0	- 55.7	- 28.4

* ICMR (2009)

Cereal and millet intake of the male and female preschool children were 47.61 and 42.86 g respectively which were 20.7 and 28.6 per cent deficit of the recommended allowances respectively. The pulse intake was 16.54 and 15.42 g among the male and female preschool children respectively while the RDA for the age was 30 g per day. These levels were seen to be even less than the intake of children between four to six years of age reported up to 22 g per day according to the recent report of the NNMB (2006). It was further disheartening to note that the deficit in the intake of green leafy vegetables and fruits which are abundant sources of micronutrients exceeded 80 per cent among both male and female preschool and there was a deficit greater than 60 per cent in the intake of other vegetables, fruits, roots and tubers. The NNMB (2006) has also reported an intake of less than 30 g per day of green leafy vegetables, other vegetables and fruits among children between four to six years of age. The consumption of milk and milk products was less than the RDA by 31.6 and 26.4 ml per day among the male and female preschool children respectively resulting in increased risk of vitamin A deficiency among families in India (Semba *et al.*, 2010).

The male and female school going children consumed only 146.11 and 138.92 g per day of cereals and millets respectively which was only about 50 per cent of the ICMR recommended allowances. Another matter of grave concern was that the intake of leafy vegetables was 17.74 and 13.31 g per day, other vegetables was 53.19 and 46.52 g per day and fruits was only 20.56 and 21.33 g per day among the male and female school going children respectively. A comparison of the intake of these nutrients with their respective RDA revealed that the deficit was more than 65 per cent. The NNMB (2006) data also revealed a similar trend of as low as four g per day of green leafy vegetables and less than 40 g of vegetable and fruit intake among school going children of Tamil Nadu. The present study reflects the fact that there existed a very poor dietary intake among the children of Ramanathapuram district. This shall have its direct consequences upon the nutritional status and health of the children if not given proper attention. Further, fruits and vegetables are the richest dietary sources of almost all the essential micronutrients which are also pitifully the most neglected food

groups in the present study population. This provides an insight that diet could be a major contributing factor for micronutrient deficiency in the study group. Hence, the importance of this study derives from the fact that the diets of the children are shockingly poor mainly due to lack of awareness.

b. Food intake of the adolescents and adults

The food intake pattern of adolescents and adults are presented in Table XXV.

TABLE XXV
FOOD INTAKE PATTERN OF ADOLESCENTS AND ADULTS

Group	Intake	Cereals and millets (g)	Pulses (g)	Leafy vegetables (g)	Other vegetables (g)	Roots and tubers (g)	Fruits (g)	Fleshy foods (g)	Milk and its products (ml)	Fats and oils (ml)	Sugar and jiggery (g)
Adolescent	Male	227.86	38.52	24.54	67.46	44.54	27.82	48.97	337.96	24.55	23.84
	SD	±98.92	±11.34	±13.86	±35.92	±29.86	±9.21	±28.54	±27.92	±11.90	±20.56
	RDA*	**450**	**90**	**100**	**200**	**200**	**100**	**--**	**500**	**50**	**30**
	% E/D	- 49.4	- 57.2	- 75.46	- 66.27	- 77.7	- 72.2	--	- 32.4	- 50.9	- 20.5
	Female	207.14	34.10	28.54	63.45	38.14	22.11	51.76	328.74	21.74	26.18
	SD	±106.31	±21.76	±10.94	±47.92	±32.84	±13.02	±17.44	±21.46	±8.44	±8.50
	RDA*	**330**	**75**	**100**	**200**	**200**	**100**	**--**	**500**	**35**	**25**
	% E/D	- 37.2	- 54.5	- 71.5	- 68.3	- 80.93	- 77.9	--	- 34.3	- 37.9	+ 4.7
Adult	Male	368.76	32.96	10.66	41.74	56.92	17.60	59.11	338.76	27.74	27.52
	SD	±117.21	±27.80	±14.42	±28.16	±41.61	±10.15	±26.17	±67.85	±10.18	±16.81
	RDA*	**450**	**90**	**100**	**200**	**200**	**100**	**--**	**300**	**30**	**30**
	% E/D	- 18.0	- 63.4	- 89.3	- 79.1	- 71.5	- 82.4	--	+12.9	- 7.5	- 8.3
	Female	348.76	27.49	13.58	39.10	52.86	8.42	54.91	304.82	21.36	26.58
	SD	±106.34	±22.92	±12.96	±21.97	±32.90	±12.84	±20.24	±90.15	±19.82	±13.86
	RDA*	**330**	**75**	**100**	**200**	**200**	**100**	**--**	**300**	**25**	**30**
	% E/D	+ 5.7	- 63.3	- 86.4	- 80.5	- 73.6	- 91.6	--	+ 1.6	- 14.6	- 11.4
Pregnant women	Mean	274.76	25.84	16.19	43.46	49.14	12.45	52.16	321.96	26.58	22.88
	SD	±123.16	±17.28	±12.22	±26.91	±37.12	±16.92	±28.7	±101.65	±16.74	±17.21
	RDA*	**330**	**75**	**100**	**200**	**200**	**100**	**--**	**300**	**25**	**30**
	% E/D	- 16.7	- 65.5	- 83.8	- 78.3	- 75.4	- 87.6	--	+ 7.6	+ 6.3	- 23.7

* ICMR (2009)

Assessment of the food intake pattern of the adolescents revealed an astonishing fact that both the male and female adolescents consumed all the foods less than the recommended dietary allowances. Their cereal intake was deficit of the RDA by 49.4 and 37.2 per cent among the male and female adolescents respectively. Pulse intake of the adolescents failed to meet even half the recommended allowances. Further, the intake of all forms of vegetables and fruits were less than 40 per cent of the daily recommendations among both male and female adolescents. NNMB (2006) reported the intake of vegetables and fruits to be less than 40 g per day among adolescent boys and girls in Tamil Nadu. Nutritional inadequacy seems to be one of the main causes of prevalence of malnutrition among the study population that can lead to higher incidence of diseases as authenticated by Parimalavalli and Sangeetha (2011).

The daily cereal and pulse intake of the male adults were 368.76 and 32.96 g per day respectively and and that of the female adults were 348.76 and 27.49 g per day respectively. The intake of male adults managed to meet only the RDA of milk while the intake of female adults managed to meet the RDA of cereals and milk products. Protein intake of the adults was 63 per cent less than the RDA. There was an astonishing deficit of more than 75 per cent in the intake of leafy vegetables, other vegetables, roots and tubers which are the most bounty dietary sources of micronutrients among the adult subjects of both sexes. According to estimates available from the M. S. Swaminathan Research Foundation (Swaminathan, 2011) a large proportion of the Indian population consumes less than 50 per cent of the recommended dietary intake of vitamin A from dietary sources.

The daily cereal consumption was 274.76 g per day and pulse intake was 25.84 g per day which were 16.7 and 65.5 per cent deficit of the respective RDA. There was a shocking deficit in the intake of leafy vegetables, other vegetables and roots and tubers of up to 83.8, 78.3 and 75.4 per cent respectively. These findings are supported by the findings reported by Arlappa *et al* (2010) that the intake of green leafy and other vegetables was deficit of the RDA by 95 and 60 per cent respectively in the

households of Tamil Nadu. Fruit intake of the pregnant women was only 12.45 g per day which was less than even 20 per cent of the recommended allowances. This condition shows that timely care is needed to prevent serious deficiencies for the going to be mothers as well as the infants. Milk and fat consumption of the pregnant women were 321.96 and 26.58 ml per day which were the only nutrients that met the RDA.

Adequate intake of foods and nutrients are a major contributing factor for the maintenance of good health throughout the life. The prevalence of chronic energy deficiency among one-third of the Indian population is attributed to inadequate consumption of nutrients (Venkaiah *et al.*, 2011).

c. Nutrient intake of the children

The nutrient intake pattern of the preschool and school going children are presented in Table XXVI.

TABLE XXVI

NUTRIENT INTAKE PATTERN OF CHILDREN

Group	Intake	Energy (K cal)	Protein (g)	Fat (g)	Calcium (mg)	Iron (mg)	Vitamin A (µg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)	Folic acid (µg)
Pre school	**RDA***	**1060**	**16.7**	**27.0**	**600**	**9**	**3200**	**0.5**	**0.6**	**8**	**40**	**80**
	Male	547.60	16.54	12.42	416.56	4.10	183.51	0.57	0.28	3.22	16.52	11.41
	SD	±34.52	±12.86	±3.84	±82.19	±0.92	±126.42	±0.14	±0.17	±1.06	±11.18	±6.52
	% E/D	- 48.3	- 1.0	- 54.0	- 30.6	- 54.4	- 94.3	+ 14.1	- 53.3	- 59.8	- 58.7	- 85.7
	Female	524.91	14.29	11.77	493.50	3.41	172.14	0.82	0.29	2.99	14.97	12.13
	SD	±28.31	±11.99	±5.10	±97.05	±1.16	±119.80	±0.16	±0.35	±1.83	±9.75	±10.96
	% E/D	- 50.5	- 14.4	- 56.4	- 17.8	- 62.1	- 94.6	+ 64.0	- 51.7	- 62.6	- 62.6	- 84.8
School going	**Male**	1386.74	31.92	26.54	384.79	12.16	722.41	0.74	0.24	10.74	33.46	58.64
	SD	±354.8	±24.38	±7.92	±72.54	±3.24	±96.22	±0.32	±0.19	±8.52	±11.42	±10.40
	RDA*	**2190**	**39.9**	**35.0**	**800**	**21**	**4800**	**1.1**	**1.3**	**15**	**40**	**140**
	% E/D	- 36.7	- 20.0	- 24.2	- 51.9	- 42.1	- 85.0	- 32.7	- 81.5	- 28.4	- 16.4	- 58.1
	Female	1258.17	29.66	23.27	263.20	10.87	509.76	0.69	0.36	9.86	27.74	63.27
	SD	±265.20	±20.24	±12.99	±306.07	±4.11	±65.97	±0.58	±0.14	±7.70	±9.60	±8.81
	RDA*	**2010**	**40.4**	**35**	**800**	**27**	**4800**	**1.0**	**1.2**	**13**	**40**	**140**
	% E/D	- 37.4	- 26.6	- 33.5	- 67.1	- 59.7	- 89.4	- 31.1	- 70.0	- 24.2	- 30.7	- 54.8

* ICMR (2009)

The energy intake of the male (547.6 kcal) and female (524.91 kcal) preschool children were deficit of RDA by 48.3 and 50.5 per cent less than the RDA respectively. Though the protein intake of the male children (16.54 g) almost met the RDA, the protein intake of female children (14.29 g) was deficit of RDA by 14.4 per cent contributing to high prevalence of underweight, stunting and wasting. The fat and iron intake of the male and female preschool children were less than the RDA by more than 50 per cent. There was a very high deficit in the intake of both vitamin A and folic acid as much as above 90 and 80 per cent respectively among both male and female preschool children. Though the thiamine intake of both male (0.57 mg) and female (0.82 mg) children were greater than the RDA, the intake of other important vitamins namely riboflavin, niacin, and vitamin were less than 50 per cent of RDA among both male and female preschool children. The food intake pattern of the school going children also reflected a deficit in all nutrients. Calorie intake of male (1386.74 kcal) and female (1258.17 kcal) school going children were more than 35 per cent short of RDA. Daily calcium and iron intake of the school going children failed to meet even half of the recommended allowances among both male and female school going children. A maximum deficit of 85 and 89.4 per cent was seen in the intake of vitamin A. This reflects the neglect of green leafy vegetables, fruits, and other vegetables in the diets of these subjects. The intake of thiamine, niacin, and vitamin C were below 60 per cent of RDA among both male and female school going children. Further, the deficit in riboflavin intake was 81.5 and 70.0 per cent short of RDA among the male and female children respectively. In general, the study population is subsisting on inadequate diet, where, the consumption of micronutrients was grossly deficient compared to the ICMR recommended intake for Indians. This is further supported by Mishra (2010) that besides the deficiency of macronutrients, there is enough evidence to substantiate a high magnitude of micronutrient deficiency disorders in India.

d. Nutrient intake of the adolescents and adults

The nutrient intake pattern of the preschool and school going children are presented in Table XXVII.

TABLE XXVII

NUTRIENT INTAKE PATTERN OF ADOLESCENTS AND ADULTS

Group	Intake	Energy (K cal)	Protein (g)	Fat (g)	Calcium (mg)	Iron (mg)	Vitamin A (µg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)	Folic acid (µg)
Adolescent	Male	1682.76	35.64	37.14	321.20	11.39	368.31	0.96	0.48	12.26	22.52	40.66
	SD	±307.10	±16.90	±7.98	±101.6	±2.14	±93.42	±0.32	±0.19	±9.82	±19.31	±10.94
	RDA*	**3020**	**61.5**	**50**	**800**	**28**	**4800**	**1.5**	**1.8**	**17**	**40**	**200**
	% E/D	- 44.3	- 42.1	- 25.7	- 59.9	- 59.3	- 92.3	- 36.0	- 73.3	- 27.9	- 43.7	- 79.7
	Female	1477.42	37.25	34.33	281.10	13.67	422.76	0.88	0.42	11.85	24.86	37.21
	SD	±324.91	±21.03	±8.65	±96.42	±3.10	±97.55	±0.57	±0.28	±10.44	±16.42	±14.57
	RDA*	**2440**	**55.5**	**30**	**800**	**26**	**4800**	**1.0**	**1.2**	**14**	**40**	**200**
	% E/D	- 39.5	- 32.9	+ 14.4	- 64.9	- 47.4	- 91.2	- 12.0	- 65.0	- 15.4	- 37.9	- 81.4
Adult	Male	2134.16	47.76	33.36	407.13	13.77	486.92	1.26	0.91	15.81	41.52	48.52
	SD	±471.42	±12.92	±16.42	±210.96	±6.34	±102.16	±0.88	±0.36	±9.46	±16.91	±21.70
	RDA*	**2320**	**60**	**25**	**600**	**17**	**4800**	**1.2**	**1.4**	**16**	**40**	**200**
	% E/D	- 8.0	- 20.4	+ 33.4	- 32.2	- 19.0	- 89.9	+ 5.0	- 35.0	- 1.2	+ 3.8	- 75.7
	Female	1722.69	46.72	28.42	347.91	10.74	467.62	1.08	0.82	11.10	38.14	43.54
	SD	±351.76	±24.57	±18.66	±264.35	±7.86	±93.11	±1.19	±0.49	±7.52	±19.20	±19.37
	RDA*	**1900**	**55**	**20**	**600**	**21**	**4800**	**1**	**1.1**	**12**	**40**	**200**
	% E/D	- 9.3	- 15.1	+ 42.1	- 42.0	- 48.9	- 90.3	+ 8.0	- 25.5	- 7.5	- 4.7	- 78.2
Pregnant women	Mean	1654.72	44.89	31.97	527.86	13.84	514.83	0.68	0.97	12.46	32.77	76.19
	SD	±401.12	±20.70	±13.42	±181.99	±7.19	±97.79	±9.74	±0.36	±10.14	±23.52	±20.12
	RDA*	**2250**	**82.2**	**30**	**1200**	**35**	**6400**	**1.2**	**1.4**	**14**	**60**	**500**
	% E/D	- 26.5	- 43.2	+ 6.6	- 56.0	- 60.5	- 92.0	- 43.3	- 30.7	- 11.0	- 45.4	- 84.8

* ICMR (2009)

The daily diets of the male and female adolescents provided 1682.76 and 1477.42 kcal of energy respectively which were less than their respective RDA by 44.3 and 39.5 per cent. Micronutrient deficiencies are often the result of lack of enough variety of food in the household rather than to the poor quality of such foods. When overall food intake becomes adequate enough to provide basic energy needs, needs of other nutrients would be met to a considerable extent even with the current diets (Kapil and Tyagi, 2010). Protein intake of the adolescent boys (35.64 g) and girls (37.25 g) were less than the respective RDA by 42.1and 32.9 per cent. Though the fat intake of the adolescent boys (37.14 g) was greater than that of girls (34.33 g), the boys had a deficit of 25.7 per cent as compared to their RDA due to increased requirements of 50 g/day. The calcium and fat intake of both adolescent boys and girls were less than half of the recommended allowances. The vitamin A intake of adolescent boys and girls were 368.31 and 422.76 µg respectively which failed to meet even 10 per cent of their RDA. There was a deficit ranging from 12 to 44 per cent in the intake of thiamine, niacin, and vitamin C among both adolescent boys and girls while the deficit in riboflavin and folic acid were more than 65 per cent in both the groups. Poor iron status is a concern for females, who might not consume adequate levels of dietary iron and could experience elevated iron loss from physiologic processes associated with physical activity (Bass and McClung, 2011).

Nutrient intake pattern of the adults revealed a deficit of less than 10 per cent in the intake of energy, thiamine and niacin. Protein intake of male (47.76 g) and female (46.72 g) adults were 20.4 and 15.1 per cent less than their respective RDA. The calcium and iron intake of the adult men were less than the RDA by 32.2 and 19 per cent respectively, while that of the adult women were 42 and 48.9 per cent less than the RDA respectively. Similar to the other age groups, there was a maximum deficit of 90 per cent in the intake of vitamin A among both male and female adults. The riboflavin intake of both adult men (0.91 mg) and women (0.82 mg) was less than three fourth of the RDA, while the intake of folic acid was less than one fourth of the RDA (200 µg) in both the groups. The energy, protein and fat intake of the pregnant

women were 1654.72 kcal, 44.89 g and 31.97 g respectively. The intake of calcium (527.86 mg) and iron (13.84 mg) were less than half of the RDA.

Findings of the present study shows the fact that the nutrient intake of all the age groups were far below the recommended levels for the respective groups. A similar report has been given by Rao *et al* (2010) that the intake of all the nutrients were lower than the recommended levels suggested by ICMR in all the physiological groups of India and the deficit was more with respect to micronutrients such as iron, vitamin A, riboflavin and free folic acid.

c. Consumption pattern of foods rich in micronutrients

Table XXVIII presents the frequency of consumption of foods rich in micronutrients among the school going, adolescent adult and pregnant women in the present study.

TABLE XXVIII
CONSUMPTION PATTERN OF FOODS RICH IN MICRONUTRIENT AMONG THE SUBJECTS

(n=12600)

Food sources	Daily	Weekly	Weekly once	Once in 2 weeks	Rarely
Green leafy vegetable	319 (2.5)	1847 (14.7)	3517 (27.9)	6435 (51.1)	482 (3.8)
Other vegetables	2117 (16.8)	5266 (41.8)	4864 (38.6)	353 (2.8)	0 (-)
Fruits	2217 (17.6)	2621 (20.8)	4271 (33.9)	3491 (27.7)	0 (0)
Meat and egg	2129 (16.9)	5254 (41.7)	1096 (8.7)	869 (6.9)	3252 (25.8)
Sea foods	2633 (20.9)	5544 (44.0)	1109 (8.8)	516 (4.1)	2798 (22.2)
Iodised salt	3793 (30.1)	- -	- -	- -	8807 (69.9)

It can be inferred from the above Table that the diet of the subjects in the present study has been very poor with reference to micronutrients. A little more than half of the subjects consumed green leafy vegetables only once in

two weeks. Few of them avoided this abundant supply of micronutrients blaming them to be hard to digest and nauseating. It has also been stated by Marmag *et al* (2010) that green leafy vegetables made a significant contribution towards total nutrient intake of the children for several of the micronutrients which can potentially be increased only if these vegetables are consumed more frequently. Other vegetable sources were consumed once weekly by majority of the subjects. Fruits were also equally neglected with most of the subjects consuming them on a weekly basis. Majority of the non vegetarian subjects consumed meat, egg and sea foods twice weekly. Another pathetic observation was that as many as 69.9 per cent of the subjects rarely consumed iodised salt either due to lack of awareness or due to its higher cost than non iodised local salt. Studies by Kabir *et al* (2010) supported that the habitual dietary pattern of poor consumption of milk, liver and leafy vegetables was the major factor contributing to micronutrient malnutrition in the community. These findings are on par with the findings of Singh *et al* (2010) that a high proportion of school children up to 81.5 per cent consumed salt having inadequate iodine content and overall, 43.5 per cent school children almost consuming no iodine through edible salt. Further, the Micronutrient Initiative (2005) has estimated that households consuming iodized salt declined from 50 per cent in 1999 to 37 per cent in 2003 at the global level.

5. Nutritional status of the subjects

a. Anthropometric parameters of the subjects

Malnutrition is a problem present at varying proportions in developing countries, and anthropometry is a simple tool for its assessment. It is universally applicable, inexpensive and non-invasive method to assess the size, proportion and composition of human body and can be sensitive indicators of health, growth and development (Hasan and Zulkifle, 2010).

i. Infants

Anthropometric parameters of the infants

The assessment of growth by anthropometric methods is crucial in child care to assess the nutritional status and for the identification of growth failure (Khadilkar *et al.*, 2009). Table XXIX presents the anthropometric parameters of the infants participating in the present study.

TABLE XXIX
ANTHROPOMETRIC PARAMETERS OF THE INFANTS

(n = 2800)

Parameter	Normal		Male	Female
	Male	Female		
Birth weight (kg)	2.5	2.5	2.9 ± 2.43	2.8 ± 18.75
Length* (cm)	65.9	64.3	56.41 ± 3.57	53.52 ± 3.11
Weight* (kg)	7.3	7.1	8.8 ± 5.26	7.6 ± 3.27
HC (cm)	-	-	41.6 ± 9.22	38.51 ± 8.57
MUAC@ (cm)	11.5	11.5	11.52 ± 6.42	10.97 ± 7.22
CC (cm)	-	-	33.57 ± 11.16	34.11 ± 8.16
PI$ (kg/m^3)	2.2	2.2	2.61 ± 0.72	2.47 ± 0.42

*ICMR (2010); HC-Head circumference; @MUAC-Mid Upper Arm Circumference (WHO, 2009); CC-Chest Circumference; $PI-Ponderal Index (Sankhyan *et al.*, 2009)

The mean birth weights of the male and female infants were 2.9 and 2.8 kg respectively and the weights at the time of study were 8.8 and 7.6 kg respectively. It was a heartwarming observation to find that the mean birth weight of the infants were higher than the WHO (2006) low birth weight cut-off of 2.5 kg. These findings are on par with the findings of Rehman *et al* (2009) who had reported the weight of male and female Indian infants to be 8.3 and 7.7 kg respectively. The crown heel length of the male and female infants measured 56.41 and 53.52 cm respectively which were also obviously far less than the standards. The head, arm and chest circumference of the male infants were 41.6, 11.52 and 33.51 cm respectively and that of the female infants were 38.51, 10.97 and 34.11 cm respectively. Comparing the MUAC levels with the WHO (2009) child growth standards cut-off of 11.5 cm revealed that the female infants had lower than desirable MUAC measurements thus

placing them at a highly elevated risk of death compared to those who are above. The ponderal indices of the male and female infants measured 16.19 and 15.27 kg/m^3 respectively. The WHO Immunization-Linked Vitamin A Supplementation Study Group (Vesel *et al.*, 2010) has recorded the prevalence of malnutrition in infancy assessed in terms of stunting, wasting and underweight to be high in India. The ponderal indices of the male and female infants measured 2.61 and 2.47 kg/m^3 respectively.

Classification of infants according to birth weight

The need for accurate birth weight statistics is acknowledged in population health studies mainly due to the usefulness of low birth weight measurement, a robust biomarker of both short and long term health conditions (Channon *et al.*, 2011). Table XXX gives the classification of the infants according to their birth weight.

TABLE XXX
CLASSIFICATION OF INFANTS ACCORDING TO BIRTH WEIGHT
(n = 2800)

Birth weight (g)	Male		Female		Total	
	No.	%	No.	%	No.	%
1500	28	2	17	1.2	45	1.6
500-1999	82	5.9	93	6.6	175	6.3
2000-2499	333	23.8	384	27.4	717	25.6
>2500	957	68.4	906	64.7	1863	66.5

Birth weight is arguably one of the strongest predictors of infant survival (Noor *et al.*, 2011). It is evident from the Table that only 68.4 and 64.7 per cent of the male and female infants respectively had desirable birth weight of more than 2500 g. Less than two per cent of male and female infants weighed less than 1500 g and about 5.9 and 6.6 per cent male and female infants weighed between 1500 and 1999 g. According to Tielsch *et al* (2009), low birth weight is a common and important risk factor for early infant death with 28 per cent of all neonatal deaths attributable directly to this condition. The data further revealed that the male infants showed a marginally better birth weight than the female infants. The findings of the present study are in line

with the findings of Channon *et al* (2011) who reported the low birth weight estimates ranging from 21.2 to 41.9 per cent in India. Such low birth weight might contribute to the increased risk of learning disabilities, such as behavioural problems and decreased cognitive ability in later years (Riberio *et al.*, 2011).

Classification of infants according to nutritional status

Table XXXI presents the classification of the infants according to their nutritional status.

TABLE XXXI
CLASSIFICATION OF INFANTS ACCORDING TO NUTRITIONAL STATUS

Category	Classification (WHO, 2006)	Male		Female		Total		χ^2
		No.	%	No.	%	No.	%	
Underweight	<-2SD weight for age	458	32.7	533	38.1	991	35.4	
Stunted	<-2SD weight for age	401	28.6	428	30.6	829	29.6	0.06^{NS}
Wasted	<-2SD weight for height	251	17.9	277	19.8	528	18.9	

^{NS} Not significant

It is evident from the above Table that about 32.7 per cent of male and 38.1 per cent of female infants were underweight. According to McCormick *et al* (2011) such infants experience substantial morbidity and mortality in the newborn period, which translate into significant medical costs. The percentage of stunted and wasted infants was high among the male infants by up to 28.6 and 17.9 per cent respectively as well as among their female counterparts by up to 30.6 and 19.8 per cent respectively. This wasting could be the result of inadequate nutrient intake, either from anorexia or food insecurity associated with poverty, a catabolic state induced by opportunistic infection or malignancy, or poor absorption of nutrients secondary to diarrhoea and malabsorption (Ndekha *et al.,* 2009). The findings of the present study are supported by the National Family Health Survey (NFHS, 2006) which reported the prevalence of underweight among children younger than three years in 2005-2006 to be nearly 46 per cent.

Chakraborty and Anderson (2011) have stated that the prevalence of low birth weight is a major public health issue in India and is the highest among South-Asian countries. Further, the USAID (2008) has pointed out that about 55 million, or one-third of the world's underweight children under age five live in India. Chi square analysis between male and female infants did not reveal any significant difference indicating that there existed no gender difference in malnutrition.

ii. Preschool children

Anthropometric parameters of the preschool children

Table XXXII presents the anthropometric parameters of the preschool children participating in the study.

TABLE XXXII

ANTHROPOMETRIC PARAMETERS OF PRESCHOOL CHILDREN

Parameters	Normal		Male	Female
	Male	Female		
Height* (cm)	95.1	104.8	87.45 ± 6.32	82.51 ± 5.74
Weight* (kg)	13.3	16.1	12.61 ± 1.17	12.04 ± 1.92
PI# (kg/m^3)	12.6	12.8	17.92 ± 14.13	19.49 ± 11.31
HC (cm)	-	-	43.51 ± 3.14	42.56 ± 4.56
CC (cm)	-	-	40.52 ± 4.11	40.18 ± 4.59
MUAC@ (cm)	11.5	11.5	12.64 ± 1.02	12.96 ± 1.17

*ICMR (2010); HC-Head circumference; @MUAC-Mid Upper Arm Circumference (WHO, 2009); CC-Chest Circumference; #PI-Ponderal Index (Agarwal *et al.*, 2001)

The mean height and weight of the male preschool children were 87.45 cm and 12.61 kg respectively, and that of the female children were 82.51 cm and 12.04 kg respectively. The ponderal indices of the male and female preschool children were 17.92 and 19.49 kg/m^3 respectively. The mean head circumference of the male and female preschool children measured 43.51 and 42.56 cm respectively. The average chest and mid arm circumference of the male preschool children were 40.52 and 12.64 cm respectively and that of the female preschool children were 40.18 and 12.96 cm respectively. It was an

encouraging observation that the mean MUAC levels of the children were above the WHO age specific cut-off levels of 11.5 cm for malnutrition (WHO, 2009). A similar study by Mohamed *et al* (2009) have reported the chest circumference of preschool children with vitamin deficiency to be 41.92 cm in the three to five year age group which was significantly lower than those of the corresponding normal children. This is a matter of grave concern since children with poor growth have high rates of mortality and morbidity and can suffer motor and mental developmental delay (Rehman *et al.*, 2009).

Classification of preschool children according to nutritional status.

Table XXXIII depicts the nutritional status of the preschool children in terms of their height for age and weight for age.

TABLE XXXIII
CLASSIFICATION OF PRESCHOOL CHILDREN ACCORDING TO NUTRITIONAL STATUS

Category	Classification*	Male		Female		Total		χ^2
		No.	%	No.	%	No.	%	
Underweight	<-2SD weight for age	437	31.2	559	39.9	996	35.6	
Stunted	<-2SD weight for age	373	26.6	368	26.3	741	26.5	0.499^{NS}
Wasted	<-2 SD weight for height	265	18.9	303	21.6	568	20.3	

*WHO (2006); ^{NS} Not Significant

The body weight of 31.2 and 39.9 per cent of male and female preschool children respectively were less than the desirable weight for age. About 26 per cent of both male and female preschool children were stunted and more than 18 per cent of the children were wasted. In India, weight for age has been the most widely used indicator for assessment of nutritional status, detection of undernutrition and monitoring the improvement (Ramachandran and Gopalan, 2011). The present study reflects the fact that malnutrition is a persistent problem among the preschool children of Ramanathapuram district. According to the National Family Health Survey, the proportion of underweight children has remained virtually unchanged between 1998-99 and 2005-06

(Deaton and Drèze, 2009). Chi square analysis revealed that both male and female children were equally affected by malnutrition.

iii. Anthropometric parameters of school going children

Table XXXIV presents the various anthropometric parameters of the school going children.

TABLE XXXIV
ANTHROPOMETRIC PARAMETERS OF SCHOOL GOING CHILDREN

Parameter (cm)	Normal		Male	Female
	Male	Female		
Height* (cm)	128.1	127.9	129.16 ± 10.52	124.72 ± 11.16
Weight* (kg)	24.4	24.4	39.12 ± 11.66	37.11 ± 8.64
BMI# (kg/m^2)	16.1	16.8	15.21 ± 2.51	14.52 ± 1.77
MUAC (cm)	18.5	18.5	17.82 ± 3.26	17.51 ± 4.19
CC (cm)	-	-	58.61 ± 7.39	56.42 ± 5.16
HC (cm)	-	-	49.51 ± 1.92	49.26 ± 3.64

*ICMR (2010); #BMI-Body Mass Index (Agarwal *et al.*, 2001); MUAC-Mid Upper Arm Circumference (ICMR, 2006); CC-Chest Circumference; HC-Head circumference

The male school going children were taller and heavier than their female counterparts with a height of 129.16 cm and weight of 39.12 kg. However, it has to be noted that both male and female children were shorter and thinner than ICMR (2010) reference values. The body mass indices of the male and female school going children were 15.21 and 14.52 kg/m^2 respectively. It is worth mentioning that these levels were far below the desirable standard levels for Indian children as given by Agarwal *et al* (2001). The degree of malnutrition was still more striking when these values were compared to the International cut-off points for BMI of 19.8 kg/m^2 as specified by Cole *et al* (2000). Similar observations have been reported by Jeemon *et al* (2009) who reported mean BMI levels between 15.5 and 17.1 among boys and girls between 10 and 12 years of age in India. Poor nutritional status of children may have long term consequences on school performance, learning, physical development and growth, educational performance and productivity (Rani *et al.*, 2011). The MUAC, chest and head circumferences of the male school

going children were 17.51, 56.42 and 49.26 cm respectively and that of female children were 17.82, 58.61 and 49.51 cm respectively. Similar values of head circumference at the range of 51.7 and 51.8 cm have been reported by Chaudhari *et al* (2008) for 12 year old male and female children respectively in India.

iv. Anthropometric parameters of adolescents

The anthropometric parameters of the adolescent subjects are presented in Table XXXV.

TABLE XXXV
ANTHROPOMETRIC PARAMETERS OF ADOLESCENTS

Parameter	Normal		Male	Female
	Male	Female		
Height* (cm)	153.9	148.3	155.21 ± 7.12	147.81 ± 6.86
Weight* (kg)	41.8	40.0	43.12 ± 9.34	46.87 ± 6.58
BMI (kg/m^2)	19.2	20.1	16.56 ± 6.14	17.98 ± 5.80
MUAC (cm)	21.5	21.5	24.17 ± 2.92	23.52 ± 3.21
CC (cm)	-	-	77.12 ± 4.26	78.49 ± 6.17
HC (cm)	-	-	54.96 ± 2.31	53.47 ± 1.96

*ICMR (2010); BMI-Body Mass Index; MUAC- Mid Upper Arm Circumference (ICMR, 2006); CC-Chest circumference; HC-Head circumference

The mean height of the male and female adolescents were 155.21 and 147.81 cm respectively. The male and female adolescents weighed 43.12 and 46.87 kg respectively and their respective BMI were 16.56 and 17.98 kg/m^3. Both the height and weight measurements of the adolescents were on par with the ICMR (2010) reference values. The circumference of the mid upper arm, chest and head of the adolescent male subjects were 24.17, 77.12 and 54.96 cm, respectively and that of the female subjects were 23.52, 78.49 and 53.47 cm respectively. It can be inferred from the above data that though he female adolescents were shorter than their male counterparts, they had slightly higher body weight, BMI and chest circumferences.

v. Anthropometric parameters of the adults

Anthropometric parameters of the adult subjects are presented in Table XXXVI.

TABLE XXXVI
ANTHROPOMETRIC PARAMETERS OF THE ADULTS

Parameters	Normal		Male	Female
	Male	Female		
Height* (cm)	162.5	151.4	163.52 ± 19.54	148.27 ± 11.49
Weight* (cm)	51.7	45.2	64.93 ± 11.18	52.11 ± 8.54
BMI# (kg/m^2)	20-24.9		24.71 ± 9.24	21.12 ± 12.11
MUAC@ (cm)	22.4	21.4	27.39 ± 5.11	24.96 ± 4.12
WC¤ (cm)	102	88	63.54 ± 8.62	56.11 ± 6.92
HC (cm)	-	-	72.54 ± 7.11	68.17 ± 7.48
WHR¤	0.95	0.8	0.86 ± 0.15	0.83 ± 0.23

*ICMR (2010); #BMI-Body Mass Index (WHO, 2004); @MUAC- Mid Upper Arm Circumference (UNHCR/WHO, 2011); WC-Waist circumference; HC-Hip circumference; ¤WHR-Waist Hip Ratio (WHO, 2008)

The adult male subjects in the present study were taller and heavier than the female adults with a height of 163.52 cm and a weight of 64.93 kg. The respective BMI of the male and female subjects were 24.71 and 21.12 kg/m^2, both being close to the normal range. The estimation of mean BMI for Indian women by the National family Health Survey III (2007) of 20.5 kg/m^2 corroborates the present findings. The upper arm waist and hip circumference of the adult male subjects were 27.39, 63.54 and 72.54 cm respectively and that of the adult female subjects were 24.96, 56.11 and 68.17 cm respectively. All these parameters were comparable with the respective reference standard values. The respective waist hip ratios of the male and female subjects were 0.86 and 0.83 indicating that the male subjects were well built than the female subjects with respect to almost all the anthropometric parameters. Similar mid upper arm circumference measurements of 28.3 and 29.5 cm among male and female adults respectively between 25 to 55 years of age have been recorded by Ayatollahi (2012).

The NFHS III (2007) has warned that the nutritional status of Indian women is inadequate with 33 per cent of married women aged 15 to 49 years too thin and 11 per cent too short. A matter of concern is that anthropometric indicators of nutrition in India, for both adults and children, are among the worst in the world. Furthermore, the improvement of these measures of nutrition appears to be slow relative to what might be expected in the light of

international experience and of India's recent high rates of economic growth (Deaton and Dreze, 2009).

Classification of adults according to Body Mass Index (BMI)

Table XXXVII presents the classification of the adults according to body mass index.

TABLE XXXVII
CLASSIFICATION OF ADULTS ACCORDING TO BODY MASS INDEX

Category	BMI Range#	Male		Female		Total		χ^2
		No.	%	No.	%	No.	%	
CED	>18.5	163	11.6	231	16.5	394	14.1	
Underweight	18.6-19.9	474	33.9	513	36.6	989	35.3	
Normal	20.0-24.9	438	31.3	461	32.9	899	32.1	6.33**
Overweight	25.0-29.9	274	19.6	179	12.8	453	16.2	
Obese	>30.0	51	3.6	16	1.2	67	2.4	

CED-Chronic Energy Deficiency; #WHO (2004); ** Significant at 1% level

A total of 11.6 and 16.5 per cent male and female adults respectively were in a state of chronic energy deficiency with the mean BMI less than 18.5. Not surprisingly, as a result of poor body weights, a majority of both the male (33.9%) and female (36.6%) adults were underweight and a total of 16.2 and 2.4 per cent male and female adults respectively were overweight and obese respectively. Less than 35 per cent of adults had normal body weight with their BMI ranging from 20.0 to 24.9 kg/m^3. It is a matter of alarm that almost half of the adult population in the present study are either underweight or with chronic energy deficiency. The findings of the present study are endorsed by a cohort study (Antonisamy *et al.*, 2009) taken up in Vellore which reported the prevalence of underweight among 39 and 44 per cent of adult men and women respectively. Gender differences in BMI were also evident with significantly (1% level) more women being underweight than men.

vi. Anthropometric parameters of pregnant women

The following Table XXXVIII presents the anthropometric parameters of the pregnant women participating in the present study.

TABLE XXXVIII
ANTHROPOMETRIC PARAMETERS OF PREGNANT WOMEN

Parameter	Normal	Mean
Height* (cm)	151.4	151.74 ± 4.74
Weight* (kg)	45.2	43.84 ± 6.11
MUAC@ (cm)	23.0	23.81 ± 1.12

*ICMR (2010); @MUAC- Mid Upper Arm Circumference (UNHCR/WHO, 2011);

The pregnant women in the present study were 151.74 cm tall and weighed 43.84 kg. It is worth mentioning that a nationally representative sample of households in India, Subramanian *et al* (2009) have reported that maternal height was inversely associated with child mortality. The poor nutritional status of pregnant women in the present study adds to the fact that women are generally vulnerable to under nutrition especially during pregnancy and lactation when the food and nutrient requirements are increased (Rao *et al.,* 2010). This is a very depressing situation since women in poor health are more likely to give birth to low weight infants. They also are less likely to be capable to provide food and adequate care to their children (Strully *et al.*, 2010)

b. Biochemical parameters

The following Tables present the meal haemoglobin, vitamin A and median urinary iodine levels of the subjects.

i. Blood haemoglobin levels of the subjects

Table XXXIX presents the mean haemoglobin levels of the subjects.

TABLE XXXIX
MEAN HAEMOGLOBIN LEVELS (g/dl) OF THE SUBJECTS

Age group	Cut-off*	Male	Female
Infants	11	11.9 ± 2.97	11.4 ± 2.72
Preschool	11	10.35 ± 1.64	9.54 ± 1.74
School going	11.5	10.74 ± 2.07	10.18 ± 2.05
Adolescent	12	11.53 ± 3.01	9.32 ± 2.16
Adult	13(M),12(F)	11.89 ± 2.75	10.05 ± 3.06
Pregnant women	12	---	9.67 ± 2.79

*UNICEF/UNU/WHO and INACG (2001)

The mean haemoglobin levels of the male and female infants were close to the INACG (2001) cut-off values of 11 g/dl. The haemoglobin level of the preschool children were however lower than the standards with mean values of 10.35 and 9.54 mg/dl among the male and female children respectively. The mean haemoglobin levels of the other age groups were also seen to be less than the recommended values for their respective age groups. It was observed that the female subjects had their haemoglobin levels less than male subjects among all age groups. These findings are in line with the NFHS III (2007) report which has declared the prevalence of anaemia to be very high among young children with as much as 72.9 and 81.2 per cent of the children up to the age of three. It further added that the overall prevalence has increased from 74.2 to 79.2 per cent in the past five years.

Such poor iron status can lead to worse consequences including impaired cognitive development, motor development and behavioural development as the structure of the most vital organ, brain can become abnormal due to iron deficiency (Rani *et al.*, 2011).

ii. Classification of subjects according to haemoglobin status

The classification of the subjects according to blood haemoglobin levels is presented in Table XL.

TABLE XL
CLASSIFICATION OF SUBJECTS ACCORDING TO HAEMOGLOBIN LEVELS (NNMB, 2006)

Age group	Normal (>12 g/dl)		Mild (10 – 12 g/dl)		Moderate (7 – 10 g/dl)		Severe (< 7 g/dl)		X^2
	M	F	M	F	M	F	M	F	
Infants	21 (30.0)	25 (35.7)	45 (64.3)	39 (55.7)	3 (4.3)	5 (7.2)	1 (1.4)	1 (1.4)	1.84 ^{NS}
Preschool	33 (47.1)	31 (44.3)	29 (41.4)	27 (38.6)	6 (8.6)	10 (14.3)	2 (2.9)	2 (2.8)	1.60 ^{NS}
School going	38 (54.3)	31 (44.3)	23 (32.9)	27 (38.6)	8 (11.4)	11 (15.7)	1 (1.4)	1 (1.4)	1.06 ^{NS}
Adolescent	47 (67.1)	36 (51.4)	13 (18.6)	18 (25.7)	9 (12.9)	14 (20.0)	1 (1.4)	2 (2.9)	5.27^{NS}
Adult	37 (52.9)	35 (50.0)	25 (35.7)	22 (31.4)	7 (10.0)	12 (17.2)	1 (1.4)	1 (1.4)	2.26^{NS}
Pregnant women	--	27 (38.6)	--	17 (24.3)	--	23 (32.8)	--	3 (4.3)	-

Figures in parentheses indicate percentage; ^{NS} Not Significant

Baseline haemoglobin levels of the adults confirmed the deficiencies predicted from the food intake data presented before. Based on the NNMB (2006) classification, it was seen that majority of the male (64.3%) and female (55.7%) infants had mild iron deficiency and 4.3 and 7.2 per cent of the male and female infants respectively had moderately deficient levels of haemoglobin. The NFHS Survey III (2007) found 82.5 per cent of children in the age group of five to 36 months to be anemic. Less than half of male (47.1%) and female (44.3%) preschool children had normal haemoglobin levels and a close percentage of male (41.4%) and female (38.6%) children had mild deficiency.

The number of adolescent girls with deficient haemoglobin status was seen to be more than that of boys though the difference was statistically not significant. Only half of the adult men (52.9%) and women (50%) had normal haemoglobin levels and more than 30 per cent of male and female adults had

moderate levels of deficiency. More than a quarter of the pregnant women had mild and moderate anaemia. This is a matter of serious concern since the incidence of low-birth-weight deliveries and perinatal mortality double with haemoglobin concentrations less than eight g/dl during pregnancy (Kalaivani, 2009).

iii. Serum vitamin A levels of the subjects

The mean serum vitamin A levels of the subjects is presented in Table XLI.

TABLE XLI
MEAN VITAMIN A LEVELS OF THE SUBJECTS (µg/dl)

Age group	Male	Female
Infants	27.90 ± 8.16	24.87 ± 9.11
Preschool	21.95 ± 7.39	23.49 ± 7.30
School going	23.54 ± 6.75	25.32 ± 7.22
Adolescent	20.43 ± 8.36	19.68 ± 6.80
Adult	19.57 ± 9.05	20.11 ± 8.22
Pregnant women	--	21.36 ± 6.83

*Acceptable levels 20 µg/dl; NS-Not significant

The mean vitamin A levels of male and female infants were respectively 27.9 and 24.87 µg/dl. However, the male and female preschool children had lower levels of 21.95 and 23.49 µg/dl respectively. The average serum vitamin A levels of school going children and adolescent boys were 23.54 and 20.43 µg/dl respectively and that of the girls were 25.32 and 19.2 µg/dl respectively. The adult male subjects had mean serum vitamin A levels of 19.57 µg/dl and the adult women and pregnant women had mean values of 20.11 and 21.36 µg/dl respectively.

iv. Classification (ICNND, 1963) of subjects according to serum vitamin A levels

The following Table XLII presents the classification of the subjects based on their serum vitamin A levels.

TABLE XLII

CLASSIFICATION OF SUBJECTS ACCORDING TO SERUM VITAMIN A LEVELS (%)

(n = 770)

Age group	Normal (>50µg/dl)		Acceptable (≥20µg/dl)		Low (10-19µg/dl)		Deficient (<10µg/dl)		χ^2
	M	F	M	F	M	F	M	F	
Infants	15 (21.4)	12 (17.1)	21 (30)	19 (27.1)	33 (47.2)	38 (54.3)	1 (1.4)	1 (1.4)	1.02^{NS}
Preschool	11 (15.7)	6 (8.6)	28 (40)	32 (45.7)	27 (38.6)	29 (41.4)	4 (5.7)	3 (4.3)	0.31^{NS}
School going	18 (25.7)	17 (24.3)	23 (32.9)	21 (30)	26 (37.1)	26 (37.1)	4 (5.7)	5 (7.1)	0.88^{NS}
Adolescent	7 (10)	11 (15.7)	14 (20)	14 (20)	44 (62.9)	42 (60)	5 (7.1)	3 (4.3)	0.79^{NS}
Adult	8 (11.4)	9 (12.9)	16 (22.9)	18 (25.7)	44 (62.9)	40 (57.1)	2 (2.8)	3 (4.3)	0.85^{NS}
Pregnant women	-	6 (8.6)	--	21 (30)	--	38 (54.3)	--	5 (7.1)	

It can be inferred from the above table that all the age groups had less than 60 per cent of subjects within normal levels of serum vitamin A with a maximum of 58.6 per cent among the male school going children and a minimum of 30.0 per cent among the male adolescents. Another very distressing point noted was that low levels of serum vitamin A were identified among more than half of the adolescents, adults, pregnant women and female infants. Serum vitamin A levels of less than 10 µg/dl indicating subclinical vitamin A deficiency was seen among less than eight per cent of the subjects in all age groups.

v. Urinary iodine

The median urinary iodine levels of the subjects are presented in Table XLIII.

TABLE XLIII
MEDIAN URINE IODINE LEVELS (µG/L)

Age group	Male	Female
Infants	114.70	121.83
Preschool	107.59	115.85
School going	113.42	111.54
Adolescents	132.53	126.73
Adult	164.34	157.85
Pregnant women	--	136.84

The median urinary iodine of male and female infants were 114.70 and 121.83 µg/l respectively. The urinary iodine levels of preschool boys (107.59 µg/l) was lesser than that of girls (115.85 µg/l) however, among the school going children the girls (111.54 µg/l) had lower levels than boys (113.42 µg/l). The adolescent boys and girls had median urinary iodine levels of 132.53 and 126.73 respectively. However the urinary iodine levels of adults were the highest among all the age groups with 164.34 mg/dl among the male and 157.85 µg/l among the female adults. The pregnant women had a median urinary iodine level of 136.84 µg/l. It is quite apparent from the findings of the above Table that the median urinary iodine levels of almost all the groups had levels just above the adequate deadline of 100 mg per dl which might be a caution for a possibility for iodine deficiency in near future.

vi. Classification of the subjects based on their urinary iodine levels

The classification of subjects based on their urinary iodine levels (WHO, 2007) is presented in the following Table XLIV.

TABLE XLIV
CLASSIFICATION OF SUBJECTS ACCORDING TO URINARY IODINE LEVELS (µg/l)

Age group	Adequate (> 100) (PW-150-249)		Insufficient (50.0-99.9) (PW-<150)		Insufficient (20.0-49.9)		Insufficient (< 20.0)		χ^2
	M	F	M	F	M	F	M	F	
Infants	51 (72.8)	43 (61.4)	10 (14.3)	19 (27.1)	7 (10.0)	6 (8.6)	2 (2.9)	2 (2.9)	5.031
Preschool	44 (62.9)	39 (55.7)	18 (25.7)	21 (30.0)	7 (10.0)	8 (11.4)	1 (1.4)	2 (2.9)	1.384
School going	37 (52.9)	38 (54.3)	30 (42.9)	29 (41.4)	2 (2.9)	3 (4.3)	1 (1.4)	-- (0)	1.717
Adolescent	42 (60.0)	40 (57.1)	25 (35.7)	26 (37.1)	3 (4.3)	2 (2.9)	-- (0)	2 (2.9)	3.271
Adult	48 (68.6)	42 (60.0)	16 (22.9)	25 (35.7)	2 (2.9)	3 (4.3)	4 (5.7)	-- (0)	9.343
Pregnant women	--	38 (54.3)	--	24 (34.3)	--	5 (7.1)	--	3 (4.3)	

Classification of the subjects based on their urinary iodine levels revealed that only 72.8 and 61.4 per cent of the male and female infants and 62.9 and 55.7 per cent of the male and female preschool children had adequate levels of urinary iodine. The urinary iodine levels of 14.3 and 27.1 per cent of the male and female infants and 25.7 and 30 per cent of the male and female preschool children were between 50 and 99.9 µg/l indicating insufficient iodine status. More than forty per cent of school going children had insufficient urinary iodine levels between 50 and 99.9 mg/dl.

About 22.9 to 35.7 per cent of the male and female adults had urinary iodine levels between 50 and 99.9 µg/l indicating poor iodine status. A little more than half (54.3%) of the pregnant women had adequate levels of urinary iodine, while 34.3 per cent of the pregnant women had levels between 50 and 99.9 µg/l. On the whole, about two (2.9%) to eight (11.4%) subjects from all the age groups had urinary iodine levels between 20 and 49.9 µg/l while about one (1.4%) to four (5.7%) of the subjects from all the age groups had urinary iodine levels below 20 µg/l.

vii. Correlation between nutrient intake and biochemical parameters

Table XLV provides the coefficient of correlation between nutrient intake of the subjects and biochemical parameters.

TABLE XLV
CORRELATION BETWEEN NUTRIENT INTAKE AND BIOCHEMICAL PARAMETERS

Parameters	Haemoglobin	Vitamin A	Iodine
Energy	0.236**	0.157**	0.213**
Protein	0.251**	0.219**	0.176**
Fat	0.054	0.126	0.107
Calcium	0.019	0.076	0.097
Iron	0.862**	0.544**	0.321**
Vitamin A	0.451**	0.761**	0.357**
Thiamine	0.224**	0.379**	0.271**
Riboflavin	0.426**	0.419**	0.386**
Niacin	0.10	0.021	0.026
Vitamin C	0.017	0.002	0.017
Folic acid	0.651**	0.473**	0.429**

** Significant at one per cent level

Coefficient of correlation between the nutrient intake and biochemical parameters of the subjects revealed that the energy and protein intake showed a positive correlation significant at five per cent level with haemoglobin, vitamin A and urinary iodine levels. A strong positive correlation was also evident between the intake of iron, vitamin A, thiamine, riboflavin,and folic acid and all the three biochemical indicators of haemoglobin, vitamin A and urinary iodine. Similar findings have also been reported by Jamieson *et al* (2012) who reported a strong correlation between dietary iron intake and blood haemoglobin levels.

viii. Correlation between anthropometric and biochemical parameters

Table provides the coefficient of correlation between anthropomentic and biochemical parameters of the subjects are presented in Table XLVI.

TABLE XLVI

CORRELATION BETWEEN ANTHROPOMETRIC AND BIOCHEMICAL PARAMETERS

Parameters	Haemoglobin	Vitamin A	Urinary iodine
Weight	0.326*	0.254*	0.027
Height	0.071	0.023	0.008
Mid upper arm circumference	0.354**	0.026	0.011
Head circumference	0.058	0.012	0.026
Chest circumference	0.074	0.029	0.017

** Significant at one per cent level

It is evident from the above Table that body weight showed a strong correlation with blood haemoglobin and vitamin A levels. These findings are supported by Netto *et al* (2012) who also reported a significant positive association between weight and vitamin A status. Berglund *et al* (2010) have also reported a positive correlation between body weight and iron status among infants. Further, the mid upper arm circumference correlated significantly with haemoglobin status. However no significant correlation could be achieved between head and chest circumferences and biochemical parameters.

ix. Prevalence of micronutrient deficiency among the subjects

Table XLVII depicts the clinical and sub clinical prevalence of micronutrient deficiency among the different age groups of population.

TABLE XLVII

PREVALENCE OF MICRONUTRIENT DEFICIENCY

Age group	Clinical (n=15400)		Sub clinical (n = 770)		
	VAD (Bitot's spot)	IDD (Goitre)	IDA (Hb < 12 g/dl)	VAD (Serum vitamin A< 20 µg/dl)	IDD (Urinary iodine < 20 µg/l)
Infants	-	-	94 (67.1)	2 (1.4)	46 (32.9)
Preschool children	18 (0.6)	2 (0.07)	76 (54.3)	7 (5.0)	57 (40.7)
School going	17 (0.6)	2 (0.07)	71 (50.2)	9 (6.4)	65 (46.4)
Adolescent	10 (0.4)	1 (0.04)	57 (40.7)	8 (5.7)	58 (41.4)
Adult	21 (0.8)	1 (0.04)	68 (48.6)	5 (3.6)	50 (35.7)
Pregnant women	9 (0.6)	0 -	43 (61.4)	5 (7.1)	32 (45.7)

It can be seen from the above Table that the prevalence of Bitot's spot which is the manifestation of vitamin A deficiency were obvious in all age groups of population except infants with a maximum of 0.8 per cent among the adults followed by preschool children and pregnant women. The prevalence of clinical signs were absent among infants probably due to the reason that clinical signs of Iodine deficiency disorder was most common among (0.07%). Two preschool children and one subject in each of the age groups of school going, adolescent and adults were identified with goitre, the typical clinical manifestation of iodine deficiency.

With reference to biochemical indicators, iron deficiency anemia was most common among infants followed by pregnant women with 67.1 and 61.4 per cent of the subjects showing deficient levels of haemoglobin. Less than eight per cent of the subjects had subclinical vitamin A deficiency with the majority among school going children and pregnant women. It was also astonishing to find that more than 40 percent of preschool children, pregnant

women and adolescent were seen to be having subclinical signs of iodine deficiency.

B. PHASE II NUTRIENT PROFILE AND ACCEPTABILITY OF MICRONUTRIENT RICH FOOD PRODUCTS

1. Nutrient composition of the developed food products

Jam is the product brought to a suitable consistency, made from whole fruit, pieces of fruit, unconcentrated and/or concentrated fruit pulp or fruit puree, of one or more kinds of fruit, which is mixed with foodstuffs with sweetening properties with or without the addition of water (Codex Stan, 296-2009). Table XLVIII presents the nutrient composition of 100 g of the developed biscuits and jam.

TABLE XLVIII

NUTRIENT COMPOSITION OF THE DEVELOPED FOOD PRODUCTS (/100 g)

Nutrient	Biscuit	Jam
Moisture (%)	6.4	28.6
Energy (K cal)	477	292
Carbohydrate (g)	67.34	54.5
Protein (g)	16.89	13.65
Fat (g)	15.56	2.12
β carotene (µg)	2412.6	6352.3
Thiamine (mg)	1.49	2.58
Riboflavin (mg)	2.14	2.74
Niacin (mg)	2.74	3.12
Vitamin C (mg)	7.92	6.84
Pyridoxine (mg)	1.77	3.26
Vitamin B12 (µg)	0.47	0.43
Folic acid (mg)	0.26	1.46
Calcium (mg)	126.4	179.3
Phosphorous (mg)	202.4	317.9
Iron (mg)	12.16	8.58
Iodine (mg)	1.39	2.9
Zinc (mg)	6.86	5.32

The moisture content of the developed biscuits was 6.4 per cent and that of the jam was 28.6 per cent. The energy provided by 100 g of biscuits and jam respectively were 477 and 292 kcal respectively. The total carbohydrate and protein content of 100 g of the biscuit was 67.34 and 16.89 of respectively while 100 g of the jam contained 54.5 and 13.65 g of carbohydrate and protein respectively. The biscuits had a higher amount of fat (15.56 g/100 g) than jam (2.12 g/100 g) due to the addition of hydrogenated fat during biscuit preparation.

The jam contained greater amount of β carotene, thiamine, riboflavin and niacin which were in the range of 6352.3 µg, 2.58 mg, 2.74 mg and 3.12 mg respectively than the biscuits which were in the range of 2412.6 µg, 1.49 mg, 2.14 mg and 2.74 mg respectively. The greater percentage of vitamins in the jam than the biscuits can be attributed to the presence of vegetables like sweet potato, tomato, beetroot and carrot. Both the products therefore ensured a good supply of micronutrients for the children which can be explained by the statements of Rai *et al* (2008) that technologies for various processing treatments, such as milling and dry heating reduce anti-nutritional factors and increase the digestibility and shelf life of various alternative food products thus enhancing the nutritional value and nutritional security of the undernourished vulnerable population and food-based health management. Sharma *et al* (2011) developed cookies incorporating *Tinospora cordifolia* leaf powder which resulted in increased protein, iron, calcium and β-carotene contents of the cookies. Singh *et al* (2009) added that consumption of such value added products may contribute in improving the nutritional status of the population especially the vulnerable section.

Apart from these, the pyridoxine and folic acid content of the jam were 3.26 and 1.46 mg per 100 g respectively and were greater than the biscuits which were 1.77 and 0.26 mg per 100g respectively. On the other hand, the biscuits contained greater amounts of vitamin C and B12 which were in the range of 7.92 mg and 0.47 µg respectively than the jam which were 6.84 mg and 0.43 µg respectively. The biscuits also contained greater amounts of folic acid and zinc than the jam. It was further noted that the content of calcium, phosphorus, iron and iodine of jam which were 179.3, 317.9, 8.58 and 2.9 mg

per 100 g respectively while the biscuits contained 126.4, 202.4, 12.16 and 1.39 mg per 100 g respectively.

The Central Food Research Institute (Cserhalmi *et al.*, 2009) developed innovative jam products of new composition which were reported to possess high polyphenol, antioxidant content and high radicals scavenging activities.

2. Acceptability of the developed food products

The organoleptic evaluation scores of the developed food products assessed using the nine point rating scale are presented below.

a. Acceptability scores of the biscuits

The mean scores obtained for the biscuits in sensory evaluation are presented in Table XLIX.

TABLE XLIX

MEAN SENSORY SCORES OF THE BISCUITS

Qualities	Mean Score
Crust colour	5.86 ± 0.78
Surface characteristics	6.21± 0.64
Crumb texture	5.97 ± 0.93
Crumb colour	4.33 ± 0.72
Taste	6.12 ± 1.06
Flavour	5.46 ± 0.92
Total score	**5.66 ± 1.06**

Subjecting the developed biscuits for organoleptic evaluation revealed that against a maximum score of nine, surface characteristics and taste received the highest scores of 6.21 and 6.12 respectively. Crumb texture, crust colour and flavour received almost similar scores of 5.97, 5.86 and 5.46 respectively. Crumb colour received the least score of 4.33. The overall acceptability score of the biscuits summed up to 5.66. It can therefore be understood that the biscuits scored between 'like slightly' to 'like moderately' in the sensory analysis.

b. Acceptability scores of the developed jam

The mean scores obtained for the developed jam in the organoleptic sensory evaluation are presented in Table L.

TABLE L

MEAN SENSORY SCORES OF THE JAM

Qualities	Mean Score
Appearance	5.49 ± 0.92
Colour	5.37 ± 0.91
Texture	5.51 ± 1.04
Flavour	6.00 ± 0.97
Taste	5.74 ± 0.92
Overall acceptability	5.91 ± 0.82
Total score	**5.67 ± 0.95**

Sensory evaluation of the developed jam revealed that the jam was assigned maximum score of six for flavour. Very close scores of 5.91 and 5.74 were obtained for overall acceptability and taste respectively. These were followed by taste, texture and colour. It was further evident that the jam scored more than five points in all the categories summing up to a total score of 5.67 which was slightly higher than the overall score obtained by the biscuit.

c. Distribution of responses for the developed products

The distribution of responses in the rating for the developed biscuits and jam are presented in Table LI.

TABLE LI

DISTRIBUTION OF RESPONSES IN THE RATING OF THE DEVELOPED FOOD PRODUCTS

Description	Assigned value	Frequency of responses	
		Biscuit	Jam
Like extremely	9	0	0
Like very much	8	10	6
Like moderately	7	23	28
Like slightly	6	2	1
Neither like nor dislike	5	0	1
Dislike slightly	4	0	0
Dislike moderately	3	0	0
Dislike very much	2	0	0
Dislike extremely	1	0	0
Total responses		**35**	**35**
Mean rating		**5.66**	**5.67**
Percentage 'like' responses		**100**	**97.1**
Percentage 'dislike' responses		**0**	**0**

A closer observation on the distribution of the responses provided by the panel members for the two products revealed that all the responses were between 'like very much' and 'neither like nor dislike'. The total 'like' responses were 97.1 per cent and interestingly, there were no 'dislike' responses for both the products indicating that the products were well accepted and suitable to be supplemented to children.

3. Shelf life study of the developed food products

Table VI shows the storage stability of the developed biscuits at baseline and after the six month storage period is presented in Table LII.

TABLE LII

MICROBIAL COUNT AND PEROXIDE VALUE OF BISCUITS (cfu/g)

Parameter	Initial	Final
Microbial count		
E. coli	BDL	BDL
Salmonella	BDL	BDL
Yeast	BDL	BDL
Mold	BDL	BDL
Peroxide value (meq/kg)	0.26	0.37

BDL-Below Detectable Limits

The microbial analysis of the developed biscuits with reference to the presence of bacteria, yeast and mold revealed that the microbial content showed negligible growth and the colony count was found to be below detectable levels. Storage of the biscuits for a period of 90 days did not result in any detectable microbial growth. This proved the microbial safety of the developed food formulation. The biscuit answered negative for *Escherichia coli*, Salmonella, Yeast and mould and had a shelf life of six months when stored air tight under room temperature. The peroxide value of the biscuits showed a slight increase from 0.26 to 0.37 meq/kg during the six month storage period which was found to be within the safe limits.

C. PHASE III IMPACT OF INTERVENTIONS AMONG SCHOOL GOING CHILDREN

The fourth phase of the present study involved the supplementation of school going children with micronutrient rich biscuits and nutrition education to the parents. The impact of the interventions was analysed by comparing the results obtained between supplementation group (Ex I), nutrition education group (Ex II) and with the control group The impact observed are discussed under the following headings.

I. Changes in anthropometric measurements of the children

a. Height

The mean height of the children at the beginning and at the end of the interventions is presented in Table LIII and Figure 8.

TABLE LIII

IMPACT OF INTERVENTIONS ON HEIGHT (cm) OF THE CHILDREN

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	133.37 ± 5.6	137.44 ± 5.6	4.07 ± 1.04	20.45**	Ex I vs control 10.59**
	F n=23	131.65 ± 4.52	135.48 ± 4.87	3.83 ± 0.94	19.59**	
Ex II	M n=29	132.10 ± 6.17	134.41 ± 6.20	2.31 ± 0.67	18.84**	Ex II vs control 2.00*
	F n=21	133.52 ± 5.60	136.14 ± 5.47	2.62 ± 2.06	5.82**	
Control	M n=27	132.70 ± 7.12	134.70 ± 7.08	2.00 ± 0.83	12.49**	Ex I vs Ex II 6.59**
	F n=23	133.48 ± 8.27	135.48 ± 7.86	2.01 ± 0.90	10.60**	

**Significant at 1 per cent level; * Significant at 5 per cent level

The mean initial height of the children belonging to the experimental and groups ranged from 131.65 to 133.52 cm. After the six month nutrition intervention period, an increment in height by 4.07 cm among the male and 3.83 cm among the female children was noted among the experimental group I supplemented with micronutrient rich biscuits. There was an increase in height by 2.31 and 2.62 cm among the male and female children belonging to the experimental group II whose parents were imparted nutrition education. The increment in height was the least among the children belonging to the control group by two cm. Statistical analysis of the increment in height using student 't' test revealed that the heights of the children in all the three groups evidenced significant ($p \leq 0.01$) improvements during the study period.

Upon statistical testing between the groups, it was found that both experimental group I (1% level) and group II (5% level) had significantly

greater improvements in terms of height than the control group. The children in experimental group I recorded far higher increments than group II which was significant at one per cent level.

Similar results have also been reported by Parikh *et al* (2010) that the provision of food supplements adjusted to provide optimal nutritional value evolved from oatmeal, milk powder and rice increased height for age *Z* score of children from zero to 18 years of age by 0.25.

b) Weight

The mean initial and final weights of the children belonging to the three groups is presented in Table LIV and Figure 9.

TABLE LIV

IMPACT OF INTERVENTIONS ON WEIGHT (kg) OF THE CHILDREN

Group	Sex	Initial (I)	Final (F)	Difference	't' value	
					I vs F	Between groups
Ex I	M	24.41±2.75	26.13±2.60	1.72±0.86	10.42**	Ex I vs control 12.69**
	F	25.33±3.14	26.89±3.12	1.52±0.53	14.19**	
Ex II	M	24.43±2.16	25.43±2.09	1.00±0.40	13.43**	Ex II vs control 8.40**
	F	23.95±2.62	24.79±2.53	0.83±0.53	7.17**	
Control	M	24.06±2.99	24.22±2.92	0.17±0.24	3.60**	Ex I vs Ex II 6.20**
	F	23.28±2.19	23.59±2.18	0.30±0.29	5.00**	

*Significant at 1% level

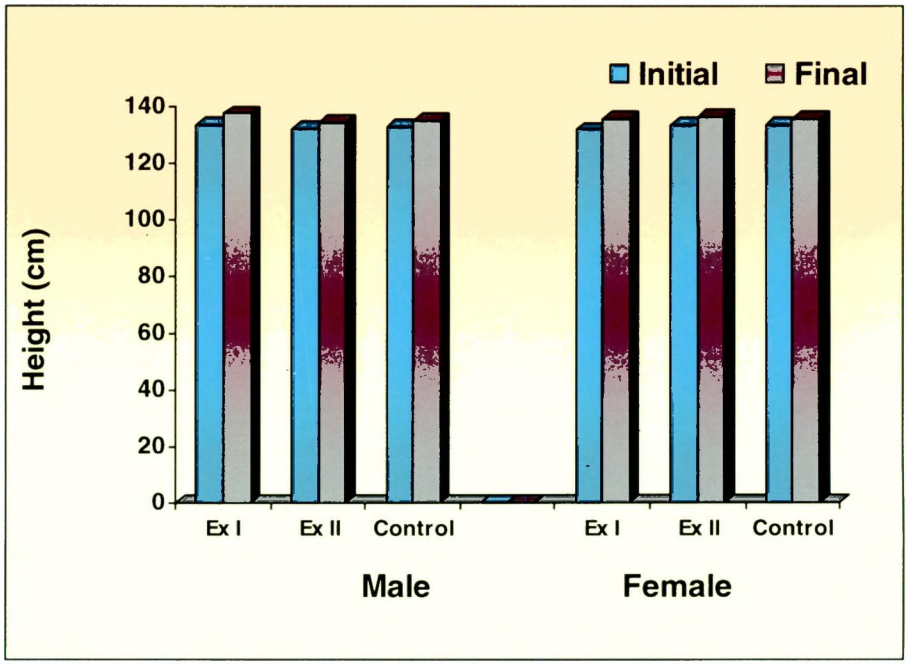


FIGURE 8

IMPACT OF INTERVENTIONS ON HEIGHT OF THE CHILDREN

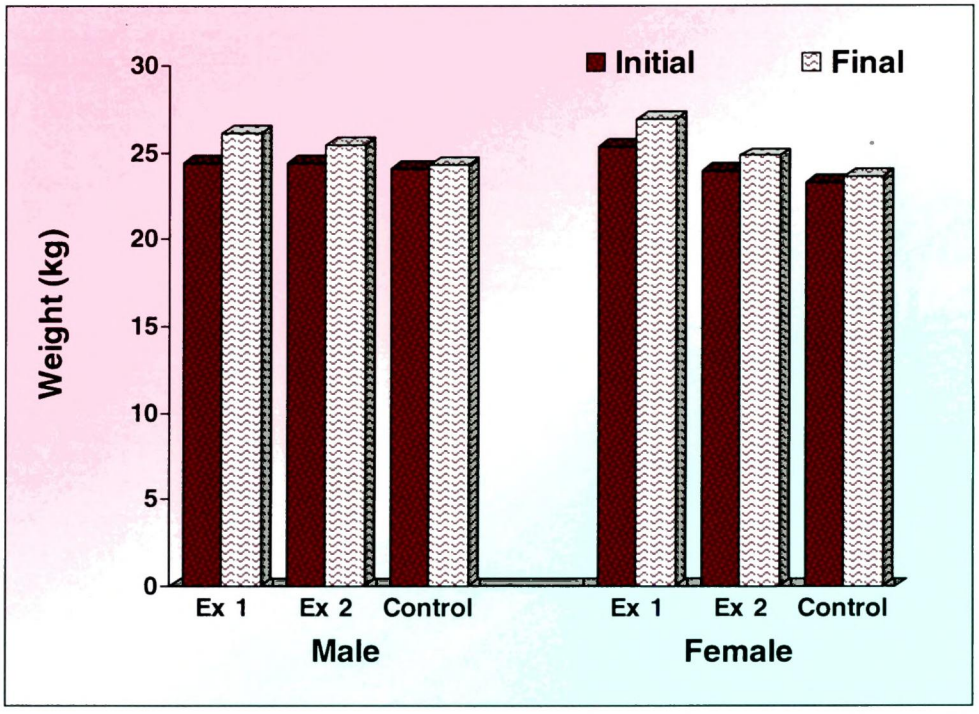


FIGURE 9

IMPACT OF INTERVENTIONS ON THE WEIGHT OF THE CHILDREN

The mean weight of the male children before nutrition intervention ranged from 24.06 kg to 24.43 kg and that of the female children ranged from 23.28 kg to 25.33 kg. The increment in weight after the six month intervention was the maximum among the male children belonging to the experimental group I with a mean difference of 1.72 kg followed by an increment of 1.52 kg among the female children of the same group. Amongst the experimental group II, the male and female children demonstrated an increment in weight by 1.00 kg and 0.83 kg respectively. Children belonging to the control group also showed an increment in weight by 0.17 and 0.30 kg among the male and female children respectively. This might be due to the fact that childhood is a period of rapid growth and development and a large percentage of growth occurs during this period. It has to be however noted that the increase in weight was the maximum among the experimental group I, followed by experimental group II and the least among the control group, all the differences being significant at one per cent level. This positive outcome reflects the impact of supplementation and education among the first and the second experimental groups. The results of t test between groups highlighted the increment in the experimental groups I and II to be greater than the control group. Further, the chest circumference in experimental group I showed greater improvements than group II. All the differences were significant at one per cent level.

A study by Phuka *et al* (2009) among infants of Malawian community reported that a twelve month intervention with a lipid based nutrient supplement developed from maize soy flour resulted in a positive and sustained impact on the weight of the infants by about 0.61 kg. A similar study by Hossain *et al* (2011) also reported significant increments in the weights of severely underweight children post three months feeding of cereal based supplementary foods.

C) Body mass index

Table LV reflects the body mass indices of the children before and after the intervention period.

TABLE LV

IMPACT OF INTERVENTIONS ON THE BMI OF THE CHILDREN

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	13.81±2.18	13.99±2.17	0.18±0.68	1.33^{NS}	Ex I vs control 4.51^{**}
	F n=23	14.65±1.95	14.70±1.93	0.05±0.42	0.58^{NS}	
Ex II	M n=29	14.07±1.62	14.15±1.56	0.07±0.27	1.50^{NS}	Ex II vs control 5.21^{**}
	F n=21	13.53±2.12	13.47±2.06	0.06±0.38	0.73^{NS}	
Control	M n=27	13.74±2.04	13.42±1.95	0.31±0.19	8.55^{**}	Ex I vs Ex II 1.17^{NS}
	F n=23	13.16±1.68	12.93±1.63	0.22±0.22	4.82^{**}	

NS- Not Significant; ** Significant at 1 per cent level

The initial BMI of the children belonging to the present study fell within the range of 13.16 to 14.65. The six month intervention period could make a small but positive impact on the BMI of the children belonging to the experimental group I. These male and female children showed an increment in BMI by 0.18 and 0.05 respectively. While on one hand, the BMI of the male children of experimental group II progressed from 14.07 to 14.15, on the other hand, the BMI of their female counterparts came down from 13.53 to 13.47. This could however be due to the rapid increase in height of these children with a difference of 2.62 cm during the supplementation period which has brought about this reduction. Both the male and female children of the control group recorded a decrease in BMI by 0.31 and 0.22 respectively. The improved BMI among the experimental groups showed no statistical significance though there was a significant (1% level) reduction in the BMI of children belonging to the control group. It has to be however noted that both the initial and final BMI of the children were less than the normal cut-off of 16.1 and 16.8 for male and female children (Agarwal *et al.*, 2001)

Comparison between groups revealed a significant difference (1%level) in the changes in BMI among the two experimental groups in comparison to the control group. However, the change in both the experimental groups did

not differ significantly. A similar supplementation study (Ndekha *et al.*, 2009) evidenced an increase in BMI by 2.2 kg/m^2 in wasted Malawian adults after an intervention of ready-to-use fortified spread.

d) Mid upper arm circumference

The changes in the MUAC of the children at the beginning and at the end of the interventions can be seen in Table LVI.

TABLE LVI

IMPACT OF INTERVENTIONS ON THE MUAC (cm) OF THE CHILDREN

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	18.93±2.38	19.04±2.37	0.11±0.21	2.73**	Ex I vs control 2.64**
	F n=23	19.65±1.79	19.74±1.78	0.09±0.19	2.15*	
Ex II	M n=29	19.14±2.03	19.17±2.01	0.04±0.13	1.44^{NS}	Ex II vs control 0.81^{NS}
	F n=21	18.45±1.66	18.48±1.64	0.02±0.11	1.00^{NS}	
Control	M n=27	18.19±1.56	18.19±1.56	0.00±0.14	0^{NS}	Ex I vs Ex II 2.19*
	F n=23	19.37±1.87	19.39±1.86	0.02±0.11	1.00^{NS}	

** Significant at 1 per cent level; * Significant at 5 per cent level NS- Not Significant

In this investigation, the mean MUAC of the children were found to be between 18.19 and 19.65 cm at the onset of interventions and between 18.19 cm and 19.74 cm at the terminal end of interventions. The male and female children belonging to the experimental group I recorded an increase in the MUAC by 0.11 and 0.09 cm respectively. These increments were found to be statistically significant at one and five per cent levels respectively. Among the second group, whose parents were imparted nutrition education, the mean increment recorded were 0.04 and 0.02 cm among the male and female children respectively. However, this increase had no statistical significance. The male children categorised under the control group had the same MUAC at the end as at the onset of the project, while their female counterparts recorded a marginal insignificant increase (0.02 ± 0.11 cm).

As observed through the comparison of increments between groups,the increment was significantly greater in the supplementation group than both the other groups and with a statistical significance of five per cent level. However, the experimental group II did not show significant difference from the control group.

e) Head circumference

Data on the head circumference of the children before and after intervention is presented in Table LVII

TABLE LVII

IMPACT OF INTERVENTIONS ON THE HEAD CIRCUMFERENCE (cm) OF THE CHILDREN

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	50.13±1.52	50.46±1.43	0.33±0.28	6.25**	Ex I vs control 7.43**
	F n=23	51.35±1.73	51.72±1.69	0.37±0.23	7.89**	
Ex II	M n=29	51.10±1.72	51.31±1.72	0.21±0.25	4.45**	Ex II vs control 3.07**
	F n=21	50.24±1.37	50.38±1.33	0.14±0.23	2.83**	
Control	M n=27	50.50±1.70	58.56±1.73	0.06±0.16	1.80^{NS}	Ex I vs Ex II 3.11**
	F n=23	50.70±1.83	50.73±1.84	0.04±0.14	1.45^{NS}	

** Significant at 1 per cent level; NS- Not Significant

Supplementation of micronutrient rich biscuits to the children belonging to experimental group I could bring about an increase in the head circumference of the male children from 50.13 to 50.46 cm and that of their female counterparts from 51.35 to 51.72 cm. Both the increments had a statistical significance at one per cent level. A likewise increment could also be observed among the children belonging to the experimental group II after imparting nutrition education to the parents, from 51.10 to 51.31 cm among the male and from 50.24 to 50.38 cm among the female school going children. Students ' t ' test revealed a significance of one per cent level among the

children. An increase in the head circumference could also be seen among the male and female children belonging to the control group. However, this increase was less than 0.1 cm and statistically not significant. On the whole, the children in the supplementation group (experimental I) recorded a maximum increase in head circumference followed by the children in the nutrition education (experimental II) group with an insignificant increase in the control group.

Statistical comparison between the groups by indicated significantly greater (1% level) improvements in both the experimental groups than the control group. Further, the children belonging to experimental group I evidenced significantly greater improvements in head circumference than experimental group II.

2. Changes in biochemical profile of the children

The impact of the nutrition interventions on the biochemical profile of the school going children are presented in the following Tables.

a) Haemoglobin

The impact of nutrition interventions on blood haemoglobin level, the most common haematological indicator of anaemia, is presented in Table LVIII and Figure 10.

TABLE LVIII

IMPACT OF INTERVENTIONS ON BLOOD HAEMOGLOBIN LEVELS (g/dl)

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	9.66±1.70	10.92±1.18	1.26±0.81	8.09**	Ex I vs control 8.29**
	F n=23	9.31±1.36	10.72±1.12	1.41±0.54	12.54**	
Ex II	M n=29	8.98±1.33	9.63±1.34	0.64±0.40	8.50**	Ex II vs control 4.49**
	F n=21	9.38±1.11	10.08±1.16	0.70±0.19	16.68**	
Control	M n=27	8.59±1.19	8.61±1.02	0.02±0.21	1.17^{NS}	Ex I vs Ex II 5.66**
	F n=23	8.54±1.47	8.55±1.47	0.01±0.04	2.02^{NS}	

Normal- 11 g/dl (WHO, 2007); ** Significant at 1 per cent level; NS- Not Significant

Analysis of the blood haemoglobin status of the children at the onset of investigation revealed that the children belonging to all three groups had less than optimal levels of haemoglobin which ranged between 8.54 to 9.66 g/dl. It is apparent from the data that these levels fall under the deficiency category according to the WHO (2007) cut-off levels for blood haemoglobin. This condition itself is indicative of the fact that the present interventions are the need of the hour among these children. A similar status of mean haemoglobin levels between seven to ten g/dl have been reported among school going girls in India by Batra and Grover (2011). Supplementation of micronutrient biscuits could bring about an increase in haemoglobin levels by 1.26 g/dl among the boys and 1.41 g/dl among the girls. It is also notable that nutrition education resulted in an increase in haemoglobin levels by 0.64 and 0.70 g/dl among the male and female children respectively in the experimental group II. The children belonging to the control group did not show any significant improvement in the haemoglobin levels after the study period. It is worth mentioning that the mean haemoglobin levels after intervention were still seen to be lower than the normal values which could perhaps have been achieved upon a longer intervention period. A similar study by Bokhari *et al* (2012) has reported an increase in haemoglobin levels by 2.4 µmol/l upon supplementation of bread incorporating cereals consumed in Ethiopia.

Comparison between the three groups revealed that there has been a statistically significant improvement in both the experimental groups as against the control group with the increment in the experimental group I significantly greater than experimental group II. All the differences were seen to be significant at one per cent level.

Classification of children based on haemoglobin levels

Table LIX presents the classification of the children based on their haemoglobin levels.

TABLE LIX
CLASSIFICATION OF CHILDREN BASED ON HAEMOGLOBIN LEVELS (g/dl)

Group		Normal		Mild		Moderate		Severe	
		Before	After	Before	After	Before	After	Before	After
Ex I	No.	3	14	18	24	25	12	4	0
	Mean ± SD	12.03 ±0.68	12.14 ±0.36	10.69 ±0.41	10.87 ±0.44	8.82 ±0.90	9.22 ±0.55	6.45 ±0.42	-
Ex II	No.	0	6	15	17	32	27	3	0
	Mean ± SD	-	11.92 ±0.20	10.52 ±0.55	10.59 ±0.32	8.74 ±0.79	8.87 ±0.81	6.33 ±0.29	-
Control	No.	1	3	7	11	36	33	6	3
	Mean ± SD	11.5	11.7 ±0.2	10.39 ±0.57	10.29 ±0.21	8.46 ±0.89	8.53 ±0.87	6.62 ±0.18	6.9 ±0.05

** Significant at 1 per cent level; NS- Not Significant

Classification of children based on their blood haemoglobin levels revealed a saddening picture that initially only three children in the experimental group I and one child from control group had normal levels of more than 11.5 g/dl. Majority of the children in all the three groups had moderate degree of anaemia with their mean haemoglobin values between 8.4 to 8.9 g/dl. A total of 13 children were also found to have severe anaemia in the study population. At the terminal end of the intervention, there was a great improvement in the haemoglobin levels of the children in experimental group I increasing the number of the children with normal levels to 14 with their mean haemoglobin levels of 12.14 g/dl. The number of children with moderate anaemia decreased by half with an increase in mean haemoglobin level by 9.22 g/dl. Experimental group II also evidenced a substantial improvement with six children having normal haemoglobin values. It was a delightful observation that both the experimental groups had none of the children with severe anaemia by the end of the supplementation period though the control group almost maintained their initial picture. The reason for the improvement in the experimental groups can therefore be attributed to the effectiveness of the intervention. These findings are endorsed by the findings of a school based intervention by Nga *et al* (2009) using multi-micronutrient

fortified biscuits for a period of four months resulted in reduced risk of anemia and deficiencies of zinc and iodine by more than 40 per cent.

b) Serum Iron

The serum iron levels of the children before and after the intervention is presented in Table LX and Figure 11.

TABLE LX

IMPACT OF INTERVENTION ON SERUM IRON LEVELS (µg/dl)

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	30.47±4.7	38.57±4.71	8.10±2.82	14.92**	Ex I vs control 22.45**
	F n=23	29.27±4.61	37.03±4.62	7.76±1.84	20.22**	
Ex II	M n=29	28.36±4.37	32.06±4.73	3.70±1.34	14.87**	Ex II vs control 20.05**
	F n=21	29.59±5.56	32.91±5.40	3.32±0.78	19.63**	
Control	M n=27	28.28±5.34	28.46±5.09	0.18±0.63	1.48^{NS}	Ex I vs Ex II 12.38**
	F n=23	29.21±4.31	29.16±4.26	0.05±0.58	0.43^{NS}	

Normal-50 µg/dl (WHO, 1999);

The mean initial serum iron levels of the children participating in the present study ranged between 28.28 and 30.47 µg/dl which were far below the WHO (1999) cut-off levels of 50 µg/dl. The group of children who received supplementation enjoyed highest increment in serum iron levels by 8.10 and 7.76 µg/dl among the male and female children respectively. The children whose parents were educated on the importance of diet and micronutrients had recorded an increase in serum iron levels by 3.70 µg/dl among the male and 3.32 µg/dl among the female children. During the study period, the serum iron levels of the male children of the control group had increased slightly by 0.18 µg/dl and that of their female counterparts had reduced by 0.05 µg/dl. Similar results have been reported by Hieu *et al* (2012) wherein the provision of biscuits fortified with multiple micronutrients was effective in reducing anaemia prevalence in school children by significant inprovements in serum iron status.

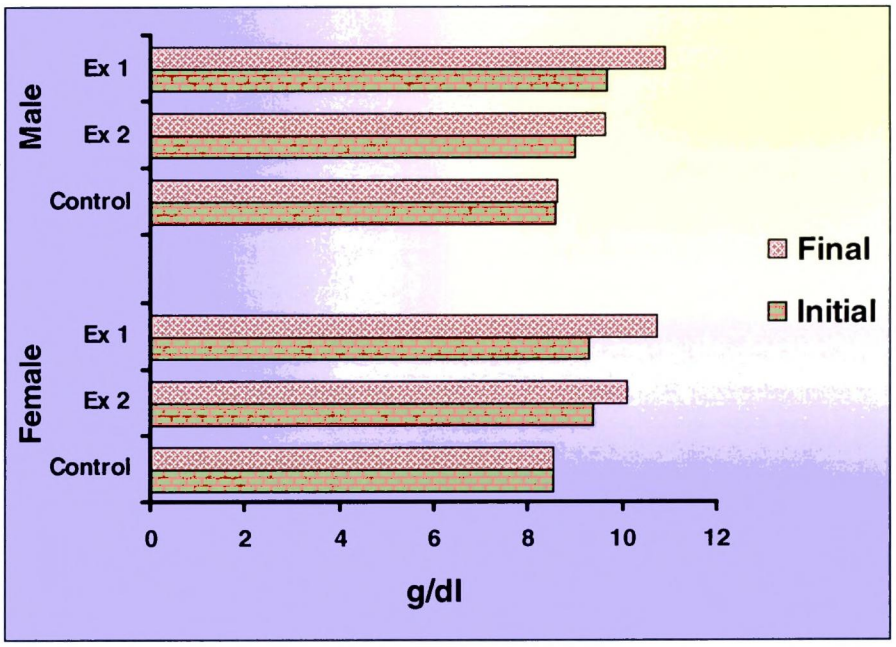


FIGURE 10

IMPACT OF INTERVENTIONS ON HAEMOGLOBIN LEVELS

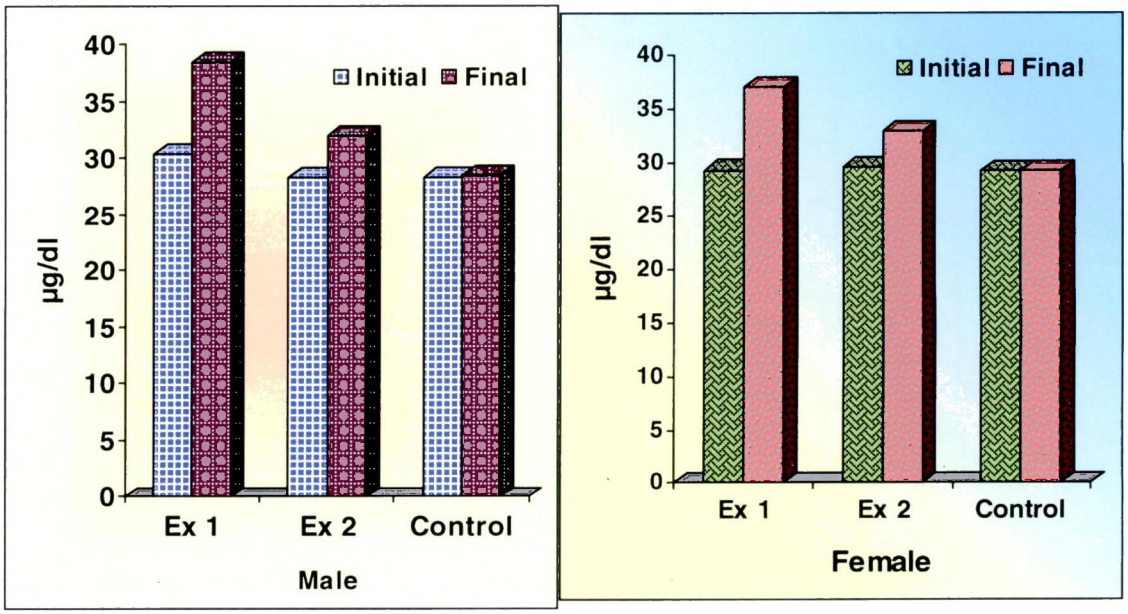


FIGURE 11

IMPACT OF INTERVENTION ON SERUM IRON LEVELS

Statistical comparison between groups revealed that the improvements in total iron levels of the experimental group I was significantly greater than both the other groups and experimental group II had significant improvements than the control group with the differences significant at one per cent level.

c) Protein

Table LXI reflects the mean serum protein levels of the children belonging to the different groups before and after the supplementation period.

TABLE LXI

IMPACT OF INTERVENTIONS ON SERUM PROTEIN LEVELS OF THE CHILDREN (g/dl)

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	6.11±0.61	7.04±0.49	0.93±0.33	14.57**	Ex I vs control 17.24**
	F n=23	6.03±0.65	7.09±0.43	1.06±0.31	16.18**	
Ex II	M n=29	5.68±0.65	6.54±0.65	0.68±0.11	33.37**	Ex II vs control 18.91**
	F n=21	5.74±0.45	6.42±0.43	0.68±0.05	60.97**	
Control	M n=27	6.23±0,78	6.30±0.86	0.07±0.19	1.95^{NS}	Ex I vs Ex II 6.59**
	F n=23	6.27±0.69	6.36±0.75	0.09±0.23	1.89^{NS}	

Normal-6.0 g/dl (Gopaldas and Sheshadri, 1987)

The mean initial serum protein levels of children belonging to the experimental group I and control group were normal with the mean levels more than 6 g/dl. However, the mean serum protein levels of the children belonging to the experimental group II was seen to be slightly below normal with mean values of 5.68 and 5.74 g/dl respectively among the male and female children. These results are in line with a study by Goyle and Prakash (2009) who reported the serum protein levels of 6.41 to 6.8 g/dl among school going girls of 10 to 12 years in India. The ample supply of proteins in the supplement provided resulted in an increase in the serum protein levels of the

experimental group I by 0.93 g/dl among the male and 1.06 g/dl among the female children. This increase was found to be statistically significant at one per cent level. The experimental group II recorded a similar increase in the protein levels among both the male and female groups of children by 0.68 g/dl each respectively. The male and female children of the control group evidenced a small and insignificant increase in protein levels by 0.07 and 0.09 g/dl respectively. Findings of the present study add strength to the statements of Blastbalg *et al* (2011) that nutrients from food are often superior to those from supplements. They can be more bioavailable and absorbable, as the presence of other food constituents often increases the availability of nutrients in ways that are not fully understood.

Statistical analysis between groups confirmed that both the interventions resulted in significantly (5% level) greater increments in serum protein levels as against the control group though the mean increments in the two experimental groups did not vary significantly.

d) Vitamin A

Changes observed in the serum vitamin A levels of the children before and after nutrition interventions has been presented in Table LXII.

TABLE LXII

IMPACT OF INTERVENTIONS ON VITAMIN A LEVELS (µg/dl)

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	28.60±5.04	32.5±5.23	3.90±1.37	14.86**	Ex I vs control 22.56**
	F n=23	28.57±4.56	32.65±4.67	4.08±1.07	18.34**	
Ex II	M n=29	31.08±6.58	32.10±6.48	1.02±0.62	8.83**	Ex II vs control 9.81**
	F n=21	29.36±5.43	30.59±5.79	1.23±0.72	7.85**	
Control	M n=27	28.03±5.59	28.01±5.50	0.02±0.38	0.28^{NS}	Ex I vs Ex II 14.59**
	F n=23	29.59±5.36	29.47±5.29	0.12±0.59	0.96^{NS}	

Normal-20 µg/dl (WHO, 2011); ** Significant at 1 per cent level; NS- Not Significant

A significant increase ($p < 0.01$) could be observed in the serum vitamin A levels of the children belonging to the experimental group I from 28.60 to 32.5 µg/dl among the male children and from 28.57 to 32.65 µg/dl among the female children. A similar increase, but to a lesser extent was evident among the male and female children belonging to the experimental group II indicating the effectiveness of nutrition education. Comparable results were obtained by Kabahenda *et al* (2011) who reported an improvement in vitamin A status resulting in the reduction in the prevalence of vitamin A deficiency from 47.5 to 25.0 per cent upon educating mothers of children between six and 48 months old. This increase was also found to be significant statistically at one per cent level. It was further evident from the data obtained that both the male and female children of the control group had almost retained their initial levels of serum vitamin A, with a difference of only 0.02 µg/dl and 0.12 µg/dl respectively. The present study goes in line with the statements of the Micronutrient Initiative (2010) that supplementation programs of staple foods and investments in micronutrient programming have proven to have positive and long-reaching effects in micronutrient status of children.

Statistical analysis between groups revealed that both the experimental groups showed significantly (5% level) greater increments in serum vitamin A levels in comparison to the control group. Similar results have also been obtained by Menegozzo *et al* (2010) Supplementing lactating women with pureed papaya and grated carrots improved vitamin A status in a placebo controlled trial

Classification of children based on serum vitamin A levels

Table LXIII and Figure 12 present the classification of the children based on their serum vitamin A levels.

TABLE LXIII
CLASSIFICATION OF CHILDREN BASED ON
SERUM VITAMIN A LEVELS (µg/dl)

Group		Normal (≥ 50)		Acceptable (20-50)		Low (10-19.9)		Deficient (≤ 10)	
		B	A	B	A	B	A	B	A
Ex I	No.	7	12	19	26	21	11	3	1
	Mean ± SD	53.29 ±2.90	54.93 ±4.32	33.87 ±9.73	28.01 ±6.34	16.54 ±2.22	17.42 ±2.58	7.94 ±1.58	8.15
Ex II	No.	11	14	25	30	9	4	5	2
	Mean ± SD	51.87 ±1.47	52.29 ±1.63	32.86 ±7.8	28.70 ±6.71	18.73 ±1.21	13.13 ±2.92	8.75 ±0.33	9.94 ±0.01
Control	No.	8	9	24	23	11	11	7	7
	Mean ± SD	53.35 ±2.78	53.07 ±2.21	29.84 ±7.04	28.63 ±5.68	16.49 ±3.71	16.21 ±3.95	8.54 ±0.98	8.93 ±0.83

In the present study, majority of the children had normal levels of serum vitamin A. After the supplementation period, the number of children with the deficient vitamin A status decreased from 13 to 4 in experimental group I and from 9 to 5 in experimental group II. It was an enchanting observation to find that among the deficient subjects the mean serum vitamin A levels had increased from 16.47 to 19.17 µg/dl. Carrot is the most important source of dietary β-carotene (Lee *et al.*, 2011). It can be inferred that supplementation with the multi nutrient biscuits and jam rich has brought about the maximum increment in the subclinical vitamin A status of the children. These findings are endorsed by another study by Maramag *et al* (2010) wherein the ingestion of carotene-rich yellow and green leafy vegetables for a period of nine weeks improved the total-body vitamin A pool size by twofold, Filipino school children. The findings of the present study endorses that considering the health risk of vitamin A supplementation and the easier acquisition and antioxidant value of dietary beta-carotene, dietary beta-carotene supplementation for intervening high prevalent of children vitamin A deficiency is recommended (Lin *et al.*, 2009).

e) Urinary Iodine

The effect of supplementation and education on the urinary iodine levels of the children is evident from Table LXIV and Figure 13.

TABLE LXIV

IMPACT OF INTERVENTIONS ON URINARY IODINE LEVELS (µg/l)

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	104.47±16.92	127.18±19.77	22.71±11.79	10.07**	Ex I vs control 16.04**
	F n=23	107.98±20.17	128.18±17.36	20.27±5.37	18.10**	
Ex II	M n=29	103.44±13.02	115.63±12.81	12.19±5.09	12.89**	Ex II vs control 15.21**
	F n=21	106.95±13.46	117.32±14.10	10.37±3.28	14.48**	
Control	M n=27	104.65±11.69	105.54±11.17	0.89±1.88	2.45*	Ex I vs Ex II 6.99**
	F n=23	105.14±11.06	106.12±10.69	0.98±2.67	1.76^{NS}	

Normal-100 µg/l (WHO, 2008); ** Significant at 1 per cent level; * Significant at 5 per cent level; NS- Not Significant

The urinary iodine levels of the children at the onset of interventions ranged between 103.44 µg/l and 107.98 µg/l. It could further be inferred that these were just in the borderline of the cut-off levels for iodine deficiency (WHO, 2008). Consuming the biscuits for a period of six months could bring

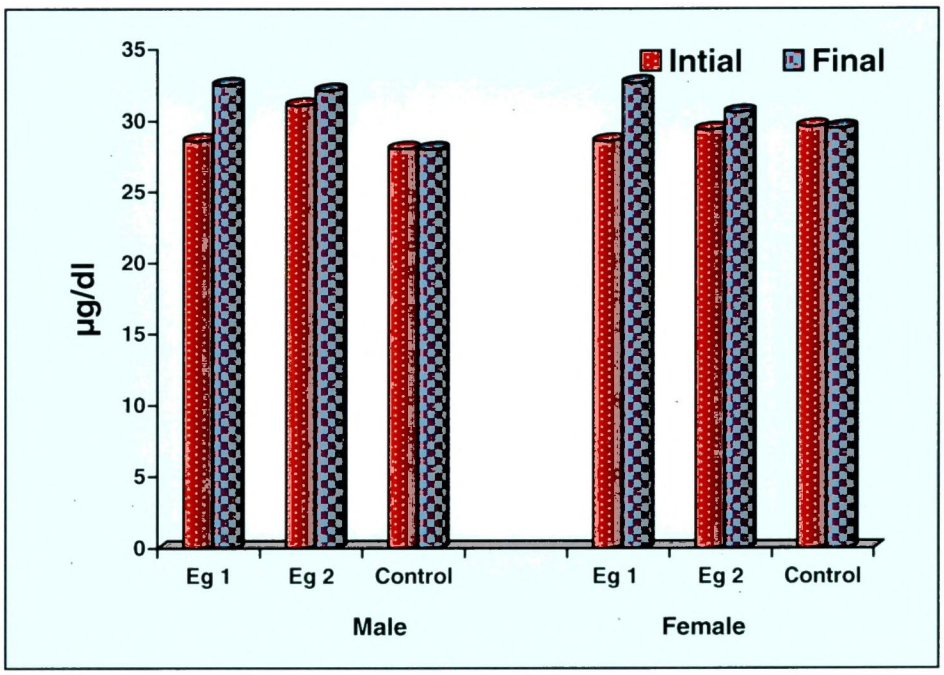


FIGURE 12

IMPACT OF INTERVENTIONS ON VITAMIN A LEVELS

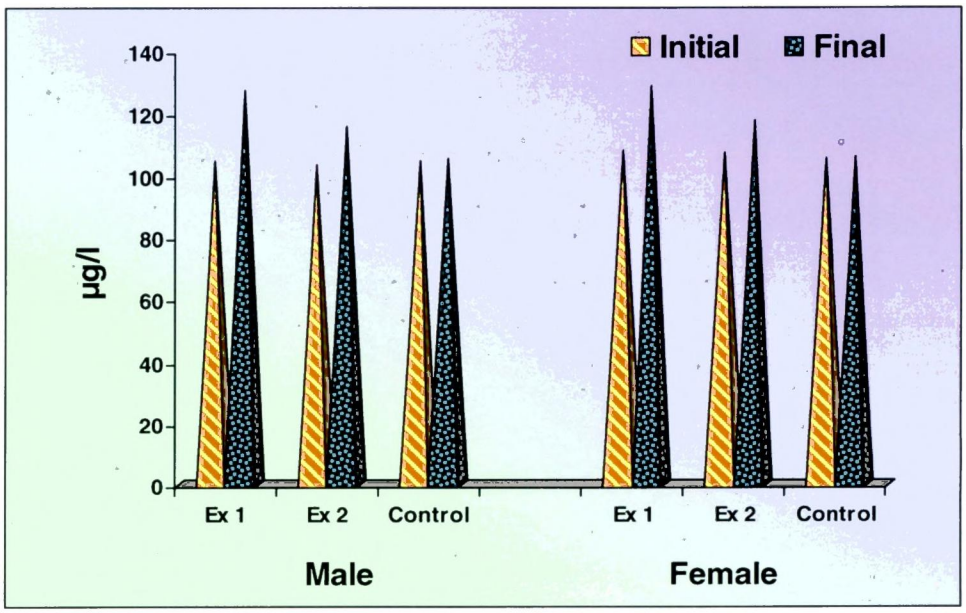


FIGURE 13

IMPACT OF INTERVENTIONS ON URINARY IODINE LEVELS

about a significant (1% level) increase in the urinary iodine levels from 104.47 to 127.18 µg/l among the male and from 107.98 to 128.25 µg/l among the female children belonging to experimental group I. A similar improvement was also evidenced among the experimental group II with a mean increase of 12.19 µg/l and 10.37 µg/l among the male and female children respectively. There was a small increase in the urinary iodine levels among the male children which was statistically significant at one per cent level accompanied with an insignificant increase among their female counterparts.Statistical comparison between groups confirmed that supplementation was the most effective in improving iodine status with a significance of five per cent level. There was also a significant difference between experimental group II and control group highlighting that nutrition education was also an effective strategy next to supplementation in improving iodine status.

Classification of children based on urinary iodine levels

Table LXV presents the classification of the children based on their serum vitamin A levels.

TABLE LXV

CLASSIFICATION OF CHILDREN BASED ON URINARY IODINE LEVELS (µg/dl)

Group		Adequate		Insufficient	
		Before	After	Before	After
Ex I	No.	26	50	24	0
	Mean ± SD	119.02 ±16.49	127.67 ±18.52	92.07 ±5.47	-
Ex II	No.	29	44	21	6
	Mean ± SD	113.24 ±10.82	118.88 ±12.03	93.41 ±4.73	97.72 ±1.52
Control	No.	30	32	20	18
	Mean ± SD	111.44 ±9.67	110.39 ±9.60	95.03 ±4.00	95.11 ±3.53

In the present study, it was an astonishing finding that almost half of the children in both experimental groups recorded inadequate levels of urinary iodine. However, the timely supplementation and nutrition education resulted in a tremendous improvement in the iodine status of the children and all the children in experimental group I attained adequate iodine status. Nutrition education also resulted in decreasing the number of children with insufficient urinary iodine status from 21 to 6 and improved their urinary iodine status from 93.41to 97.72 µg/dl.

f) Zinc

The impact of interventions on the serum zinc levels of the children is presented in Table LXVI.

TABLE LXVI

IMPACT OF INTERVENTIONS ON THE SERUM ZINC LEVELS (µg/dl)

Group	Sex	Initial (I)	Final (F)	Difference	't' value	
					I vs F	Between groups
Ex I	M n=27	56.52±3.03	82.18±4.49	25.66±5.36	24.87**	Ex I vs control 36.49**
	F n=23	53.83±2.00	77.68±3.02	23.85±3.82	29.96**	
Ex II	M n=29	54.87±2.05	77.39±2.98	22.53±3.77	32.20**	Ex II vs control 43.97**
	F n=21	55.19±2.14	75.30±2.15	20.11±2.24	49.06**	
Control	M n=27	54.32±2.09	54.44±2.00	0.12±0.82	0.76^{NS}	Ex I vs Ex II 3.87**
	F n=23	55.07±2.36	54.93±2.36	0.14±1.16	0.57^{NS}	

Normal-65 µg/dl (International Zinc Nutrition Consultative Group, 2009); ** Significant at 1 per cent level; NS Not Significant

The mean serum zinc levels of the children at baseline ranged from 54.32 to 56.52 µg/dl which are below normal levels according to the International Zinc Nutrition Consultative Group (2009). Subsequent to the supplementation programme, the serum zinc levels of the children belonging to the experimental group I increased immensely by 25.66 µg/dl among the male and by 23.85 µg/dl among the female children. There was also an

increase in serum zinc levels among the children belonging to the experimental group II by 22.53 µg/dl among the male children and by 20.11 µg/dl among the female children. Both these differences were statistically significant at one per cent level. The children belonging to the control group however failed to achieve any significant improvement in serum zinc levels during the intervention period, thus emphasizing that the increments in the first two groups could be as a result of the interventions provided to them. A similar study by Chiplonkar and Kawade (2012) reported significant improvements in serum zinc levels by 9.9 per cent among adolescent girls upon supplementation of a food supplement prepared using micronutrient rich foods for a period of ten weeks.

Statistical comparison between groups revealed that both the experimental groups showed significantly (5% level) greater increments in serum zinc levels in comparison to the control group. Further supplementation resulted in a significantly (5% level) greater increment than nutrition education revealing that it was significantly more effective.

3. Changes in cognitive performance of the children

The association between micronutrient deficiency and dopamine metabolism is highly relevant to children's early cognitive development, as dopamine clearance has strong effects on attention, perception, memory, motivation, and motor control (Benton et al., 2012). The cognitive performances of the children were assessed on the basis of information test, comprehension, arithmetic, vocabulary, digit span and digit symbol tests performed following the Malin's Intelligence Scale for Indian Children before and after the intervention programmes. The results obtained for each of these tests have been discussed in the following Tables.

a) Information test

The following Table LXVII and Figure 14 reflect the performance of the children belonging to the different groups in the information test before and after the six month intervention period.

TABLE LXVII

IMPACT OF INTERVENTIONS ON INFORMATION TEST

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	44.96±5.73	52.44±5.42	7.48±1.22	31.85**	Ex I vs control 25.81**
	F n=23	42.09±7.57	49.39±7.21	7.30±1.02	34.35**	
Ex II	M n=29	41.97±6.32	45.04±6.39	3.07±0.88	18.70**	Ex II vs control 7.55**
	F n=21	44.05±6.47	47.57±6.63	3.52±0.81	19.85**	
Control	M n=27	43.15±5.59	45.19±5.61	2.04±0.94	11.26**	Ex I vs Ex II 20.91**
	F n=23	43.04±0.71	44.83±7.34	1.78±1.09	7.88**	

** Significant at 1 per cent level

It is evident from the above Table that the initial information test scores of the children belonging to the three groups ranged from 41.97 to 44.96. The positive effect of supplementation of micronutrient rich biscuits on the cognitive performance of the children was evident from the increase in scores of the children belonging to experimental group I by 7.48 and 7.30. There was an increase of 3.07 and 3.52 among the male and female children respectively in the experimental group II. The least improvement in the cognitive test performance was recorded among the male (2.04) and female (1.78) children belonging to the control group. Students' 't' test of statistical significance revealed that the improvements in all the three groups were significant at one per cent level. A single-blind, controlled study by Chung *et al* (2011) revealed that intake of mixed grains among high school students for 9 weeks was beneficial in significantly improving cognitive performance through the prevention of cognitive deterioration.

Statistical comparison between groups revealed that the improvements in information test scores of the experimental group I was significantly greater than both the other groups and experimental group II had significant

improvements than the control group with both differences significant at one per cent level.

b. Comprehension test

Findings with regard to the comprehension abilities of the children both prior to and at the end of nutrition interventions are shown in Table LXVIII and Figure 15.

TABLE LXVIII
IMPACT OF INTERVENTIONS ON COMPREHENSION TEST

Group	Sex	Initial (I)	Final (F)	Difference	't' value	
					I vs F	Between groups
Ex I	M n=27	47.44±4.91	58.15±4.37	10.70±1.27	43.95**	Ex I vs control 24.71**
	F n=23	47.17±6.04	56.35±5.49	9.17±1.97	22.34**	
Ex II	M n=29	46.07±3.88	49.79±4.04	3.72±0.80	25.16**	Ex II vs control 6.47**
	F n=21	46.71±2.97	50.76±3.00	4.05±0.59	31.46**	
Control	M n=27	45.89±4.62	48.15±4.69	2.26±1.29	9.11**	Ex I vs Ex II 21.60**
	F n=23	48.26±4.91	51.09±4.57	2.83±0.89	15.28**	

** Significant at 1 per cent level

Assessment of the comprehension skills of the children before the interventions revealed the initial scores of 47.44 and 47.17 among the male and female children of the experimental group I; 46.07, and 46.71 among the male and female children of the experimental group II; and 45.89 and 48.26 among the male and female children belonging to the control group. After the supplementation period of six months, the experimental group I recorded as increase in scores by 10.70 among the male and 9.17 among the female children. After imparting nutrition education to the parents, children belonging to experimental group II performed better in comprehension tests scores to 49.79 and 50.76 among the male and female children, differing from the initial values by 3.72 and 4.05 respectively. The findings of the present study hence support the statements by World Bank (2005) that nutrition education is 14 to 69 times less expensive than direct food supplementation and has been

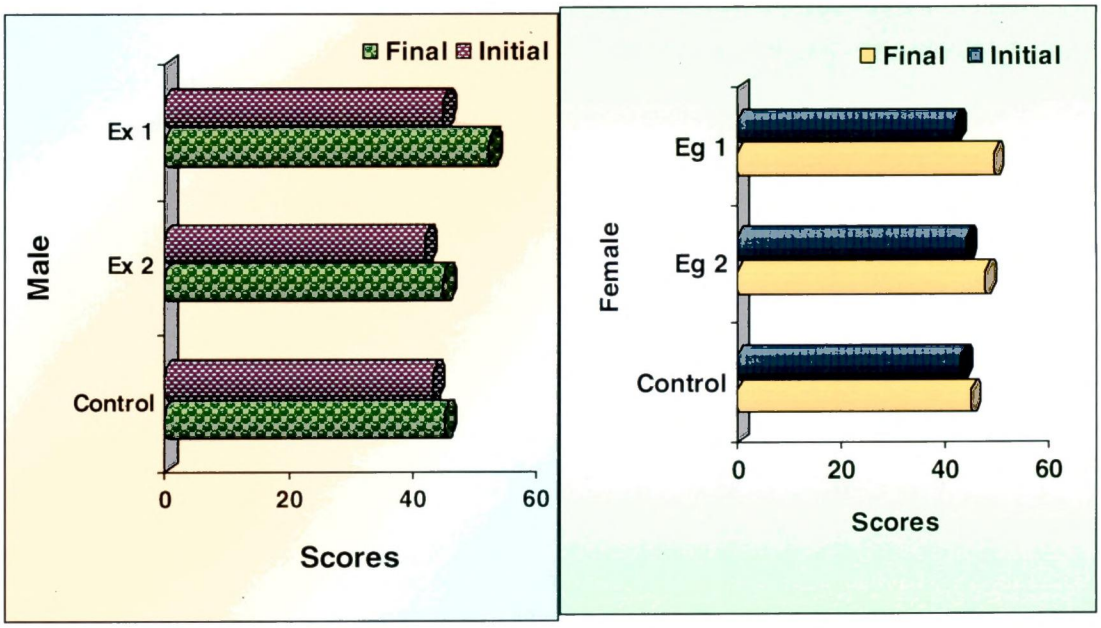


FIGURE 14

Impact of interventions on information test

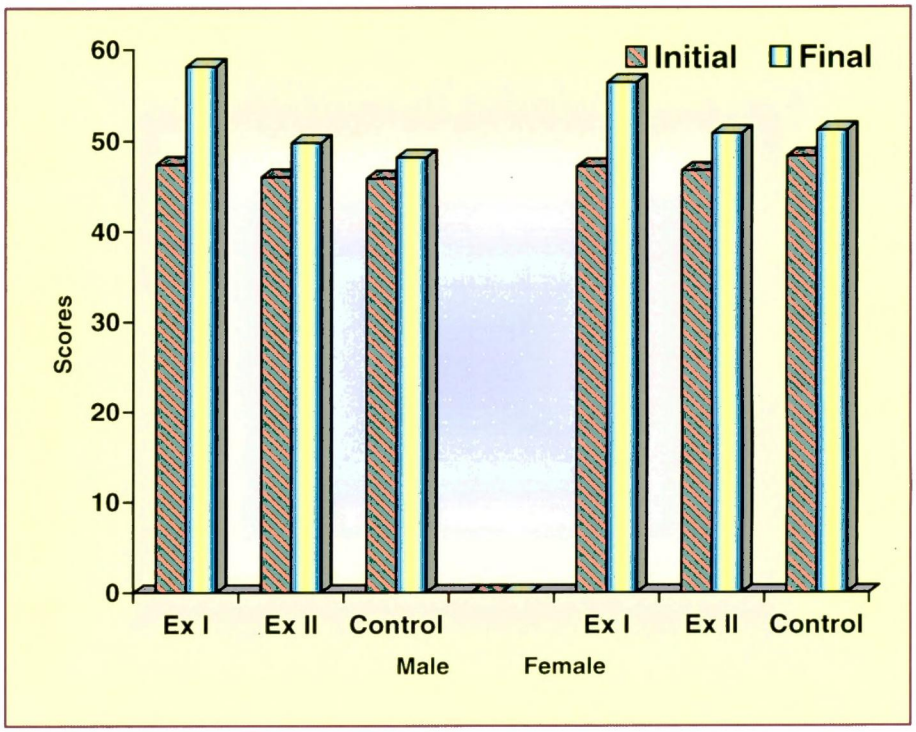


FIGURE 15

Impact of interventions on comprehension test

shown to have excellent results in the absence of any other form of intervention. The children belonging to the control group recorded an increase in test scores by 2.26 and 2.83 respectively among the male and female children. It was further noted that the differences achieved among all the three groups were significant at one per cent level. A comparison of the improvements in the comprehension skills of the children in the three groups revealed that the positive impact of both the interventions were significantly greater (1% level) than the control group.

A study conducted among Vietnamese primary school children revealed that a supplementation of milk fortified with vitamins and minerals for a period of three months significantly improved short term memory scores and learning indicators (Lien do *et al.*, 2009).

C) Arithmetic test

The impact of interventions on the numerical reasoning thing, concentration and memory of the Children assessed in terms of the arithmetic test is depicted in Table LXIX

TABLE LXIX

IMPACT OF INTERVENTIONS ON ARITHMETIC TEST

Group	Sex	Initial (I)	Final (F)	Difference	't' value	
					I vs F	Between groups
Ex I	M n=27	47.30±4.61	57.81±3.67	10.52±1.85	29.58**	Ex I vs control 18.33**
	F n=23	51.48± 4.51	60.91±4.01	9.44±3.29	13.77**	
Ex II	M n=29	50.66±5.48	55.83±5.22	5.17±2.02	13.79**	Ex II vs control 10.78**
	F n=21	48.86±4.95	55.19±5.47	5.33±1.32	18.56**	
Control	M n=27	46.96±3.75	48.67±3.84	1.70±0.72	12.23**	Ex I vs Ex II 10.21**
	F n=23	48.39±3.96	50.87±3.58	2.48±1.50	7.90**	

** Significant at 1 per cent level

The mean scores obtained by the children in the arithmetic test at the onset of the study were 47.30 (male) and 51.48 (female) in the experimental group I; 50.66 (male) and 48.86 (female) in the experimental group II and 46.96 (female) and 48.39 (female) in the control group. The male children belonging to the experimental group I recorded the maximum increase in their arithmetic abilities by 10.52 which was significant at one per cent level. This was followed by an improvement by 9.44 among the female children belonging to the same group which was also found be significant at one per cent level. An increase in test scores was also evident among the male and female children belonging to the experimental group II by 5.17 and 5.33 respectively. Though the male and female children belonging to the control group had also registered a statistically significant increase in the cognitive test scores on arithmetic abilities, the increment was the least among the male and 2.48 among the female children when compared to the other two groups. Analysis of difference between groups using't' test revealed that both the experimental groups showed significantly (1% level) greater increments in the performance in arithmetic test in comparison to the control group. Further supplementation resulted in a significantly (1% level) greater increment than nutrition education in terms of arithmetic test scores.

The suggestion that the multivitamin and mineral approach will be beneficial in terms of cognitive functioning has also been supported by Kumar and Rajagopalan (2008) who reported that children aged 7 to 11 years provided with school meals supplemented with multiple micronutrients showed improvements in performance in tests for memory and attention.

d) Vocabulary test

Findings with regard to the performance of the children belonging to the three groups in the vocabulary test is tabulated in Table LXX

TABLE LXX

IMPACT OF INTERVENTIONS ON VOCABULARY TEST

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	42.78±4.64	51.48±5.69	8.70±2.73	16.57**	Ex I vs control 10.33**
	F n=23	43.57± 3.70	51.52±4.27	7.96±1.22	31.17**	
Ex II	M n=29	43.04±4.74	47.10±4.83	4.07±0.80	27.43**	Ex II vs control 4.42**
	F n=21	44.19±3.78	48.81±4.74	4.62±2.22	9.52**	
Control	M n=27	43.56±3.67	45.51±3.88	1.59±2.00	4.13**	Ex I vs Ex II 10.41**
	F n=23	49.09±5.38	53.30±5.49	4.22±0.60	33.72**	

** Significant at 1 per cent level

It is evident from the Table above that the children belonging to the different groups scored between 42.78 and 49.09 as the initial scores in the vocabulary test. The final scores assessed after the six month nutrition intervention period fell between a minimum of 45.15 and a maximum 53.30. The children belonging to the experimental group I who were supplemented with the micronutrient rich biscuits recorded an increment in vocabulary test scores by 8.70 among the male and 7.96 among the female children. An increment was also observed in the performance of the children in experimental group II by 4.07 and 4.62 among the male and female children respectively. The abundant supply of micronutrients available through a period of six months through the biscuits has resulted in considerable improvements in the micronutrient status including that of iron which has brought about this prominent improvement. The present study therefore further authenticates the observations of Benton *et al* (2012) that iron deficiency seems to have long lasting irreversible effects in children below two years, but may have reversible consequences when it occurs later in childhood. The vocabulary test scores of the control group of male and female children had improved with a difference of 1.59 and 4.22 respectively.

Statistical analysis revealed significant improvements (P<0.01) among all the three groups, followed by experimental group II and finally, the control group. Results of a similar study by Haskell *et al* (2008) demonstrated consistent improvement in the accuracy of attention task performance during 12 weeks supplementation with vitamins and minerals in healthy 8 to 14 year old children.

e) Digit span test

The mean scores obtained by the children in the digit span test are tabulated in Table LXXI and Figure 16.

TABLE LXXI
IMPACT OF INTERVENTIONS ON DIGIT SPAN TEST

Group	Sex	Initial (I)	Final (F)	Difference	't' value	
					I vs F	Between groups
Ex I	M n=27	43.11±7.75	56.67±5.87	13.56±3.00	23.45**	Ex I vs control 15.49**
	F n=23	44.17± 7.26	55.44±6.35	11.26±2.73	19.75**	
Ex II	M n=29	46.93±6.80	52.14±6.55	5.20±2.16	12.98**	Ex II vs control 3.33**
	F n=21	44.19±7.46	49.62±7.34	5.43±0.87	28.59**	
Control	M n=27	45.44±4.35	49.22±4.77	3.78±1.40	14.06**	Ex I vs Ex II 13.81**
	F n=23	48.04±5.67	52.61±4.43	4.57±2.71	8.08**	

** Significant at 1 per cent level

The children belonging to the different group scored between 40 and 50 on an average at the onset of the interventions. The male children belonging to the experimental group scored 43.11 and 56.67 at the baseline and at the terminal end of the interventions. Their female counterparts scored 44.17 and 55.44 at the initial and final levels respectively. The improvements among the boys and girls of the experimental group II wad nearly half as compared ti the experimental group I. The male and female children belonging to the control group showed the test improvement of 3.78 and 4.75 respectively among the male and female children. All the three groups inclusive of both sexes were

seen to have improved significantly (P<0.01) in terms of digit span test. The Children's Health and Mental Performance Influenced by Optimal Nutrition (CHAMPION) Study (Muthayya *et al.,* 2007) showed that consumption of a mid morning snack improved the memory performance of school aged children even when the total amount of energy consumed during the morning was not altered. Jomaa et al (2011) also reported positive effects of school feeding of nutritious foods on the growth, cognition, and academic achievement of school-aged children in developing countries.

g) Coding test

The results obtained upon testing the coding (digit symbol) performance of the children at the onset and at the nutrition intervention among the children is presented in Table LXXII and Figure 17.

TABLE LXXII

IMPACT OF INTERVENTIONS ON CODING TEST

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	48.30±5.00	60.63±3.38	12.33±2.94	21.83**	Ex I vs control 19.42**
	F n=23	46.17± 4.31	57.52±4.27	7.96±1.22	31.17**	
Ex II	M n=29	48.04±3.70	53.10±4.83	4.07±0.80	27.43**	Ex II vs control 5.78**
	F n=21	47.14±3.58	52.81±4.74	4.62±2.22	9.52**	
Control	M n=27	46.93±2.89	50.51±3.88	1.59±2.00	4.13**	Ex I vs Ex II 17.87**
	F n=23	50.00±4.57	54.30±5.49	4.22±0.60	33.72**	

** Significant at 1 per cent level

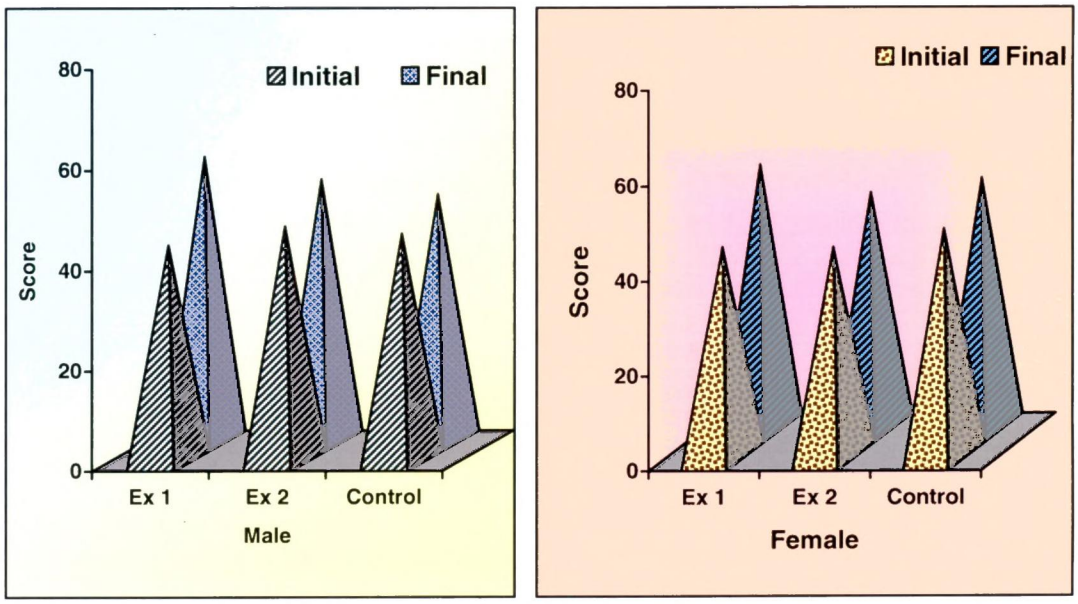


Figure 16
Impact of interventions on digit span test

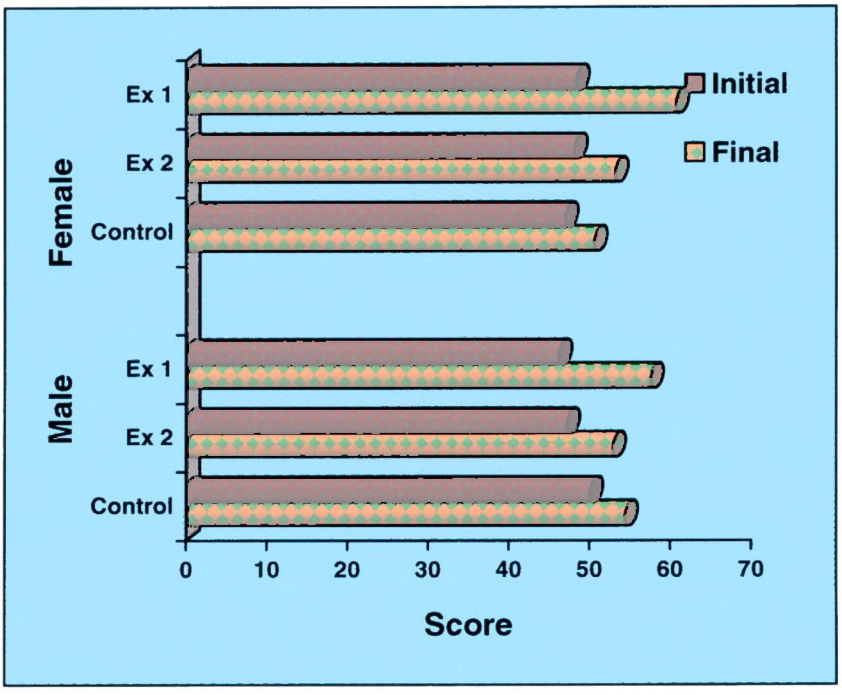


Figure 17

Impact of interventions on coding test

The initial scores of the children in the coding test ranged from a minimum of 46.17 ± 4.31 to a maximum of 50.00 ±4.57. Supplementation of micronutrient rich biscuits had a positive impact on the visual motor co-ordination and concentration of the children of experimental group I as evident from the improved coding test scores of 12.33 and 11.30 among the male and female children respectively after supplementation. Nutrition education imparted to the parents also brought about a positive impact on the coding test scores of the children belonging to experimental group II as evident from the increase in the scores by 5.41 ± 1.18 among the male and by 543 among the female children. The children belonging to the control group exhibited a least improvement of 389 and 4.09 among the male and female children respectively. Meta analysis conducted by Eilander *et al* (2010) supported the findings of the present study that multiple micronutrient supplementation in healthy school age children may be associated with a small increase in fluid intelligence. A similar double-blind, randomized controlled trial conducted by Muthayya et al (2009) revealed that a supplementation of combination of micronutrients to children aged 6 to10 years resulted in improved cognitive performance assessed through number recall and coding tests.

The findings of the present study further revealed that both the interventions succeeded in bringing about a significant positive change in the coding test abilities of the children as against the control group. However both the interventions did not yield any significant difference between the two experimental groups.

A study by Ogunlade *et al* (2011) also reported that supplementing of maize porridge with added micronutrients for 52 school days to preschool children aged 36 to 79 months resulted in significant improvements in the cognitive performance abilities of the children.

The link between micronutrient status and cognitive ability has been hypothesised to be mediated by pathways such as adenosine triphosphate production, alterations in dopaminergic function, myelination and hippocampus structure and function which has been associated with memory functions, learning, and attention (Gewa *et al.*, 2009). This could also have

been the case with the children provided with a rich supply of micronutrients in the experimental group I though the biscuits.

4. Changes in physical performance of the children

Impact of the supplementation of micronutrient rich biscuits among the children and nutrition education imparted to the parents were assessed based on the improvement in thee physical abilities of the children in terms of certain following performance parameters. The results obtained are as follows.

a. Squat thrust test

The performance of the children in the squat thrust test conducted before and after interventions is presented in Table LXXIII and Figure 18.

TABLE LXXIII

IMPACT OF INTERVENTIONS ON SQUAT THRUST TEST

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	7.22±0.92	8.65±5.69	1.42±0.20	37.79**	Ex I vs control 17.66**
	F n=23	6.33± 0.80	7.57±4.27	1.24±0.29	20.72**	
Ex II	M n=29	6.71±0.92	7.19±4.83	0.48±0.25	10.42**	Ex II vs control 4.41**
	F n=21	6.5±0.98	7.01±4.74	0.51±0.32	7.31**	
Control	M n=27	7.45±0.98	7.54±3.88	0.09±0.19	2.59**	Ex I vs Ex II 16.58**
	F n=23	6.48±0.91	6.89±5.49	0.41±0.45	4.40**	

** Significant at 1 per cent level

The mean scores obtained initially by the male children were 7.22, and female children were 6.33, 6.5 and 6.48 respectively among the experimental groups I, II and control group respectively. It is also significant to observe and note that after the six month supplementation, the performance of the children in group I had improved ($P< 0.01$) by 1.42 among the male and by 1.24 among the female children. The children belonging to the experimental group

II also improved in their scores by 0.48 and 0.51 respectively among the male and female children. Though an increase could be observed in the control group of children, this was much less as compared to the experimental groups.

Comparison between groups revealed that the increments in both the experimental groups were significantly (1% level) greater than the control group. Similar observations have been recorded by Thankachan *et al* (2012) among school children in Bangalore who reported significant improvements in physical performance parameters after six month supplementation of rice-based lunch meals fortified with multiple micronutrients.

b) 50 yard dash test

The performance of the children in the 50 yard test is presented in Table LXXIV and Figure 19.

TABLE LXXIV
IMPACT OF INVENTIONS IN 50 YARD DASH TEST

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	8.76± 2.46	8.23±2.32	0.53±0.20	14.02**	Ex I vs control 8.39**
	F n=23	9.54±0.73	8.99±0.75	0.55±0.20	11.17**	
Ex II	M n=29	8.99±0.38	8.75±0.40	0.24±0.20	6.56**	Ex II vs control 2.07*
	F n=21	9.04±0.47	8.81±0.47	0.23±0.11	9.92**	
Control	M n=27	8.53±2.42	8.42±2.39	0.11±0.23	2.38*	Ex I vs Ex II 8.44**
	F n=23	9.38±0.89	9.18±0.94	0.19±0.26	3.49**	

** Significant at 1 per cent level; * Significant at 5 per cent level

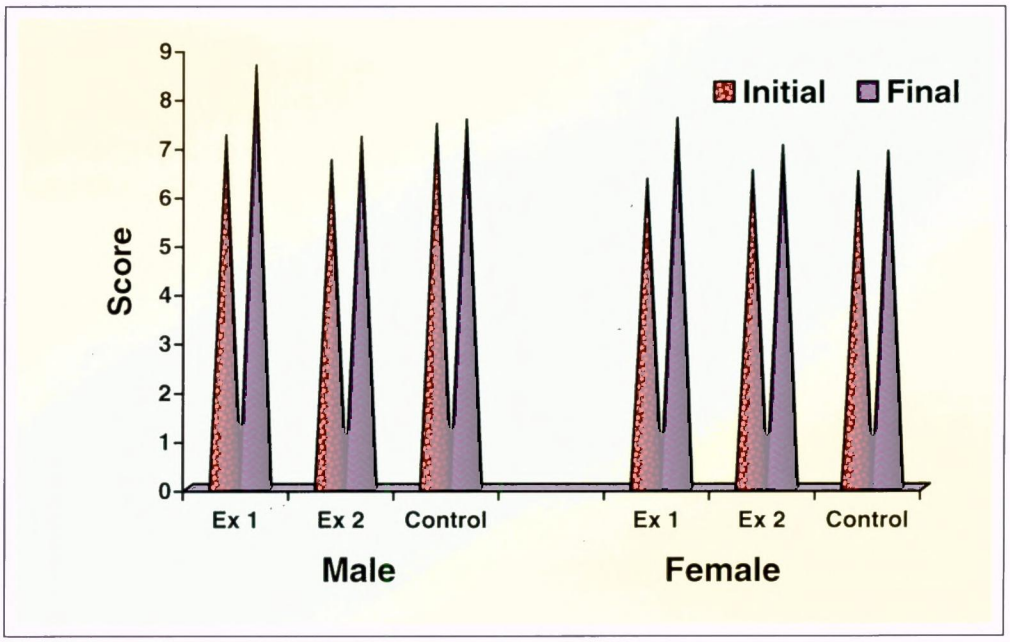


Figure 18

Impact of interventions on squat thrust test

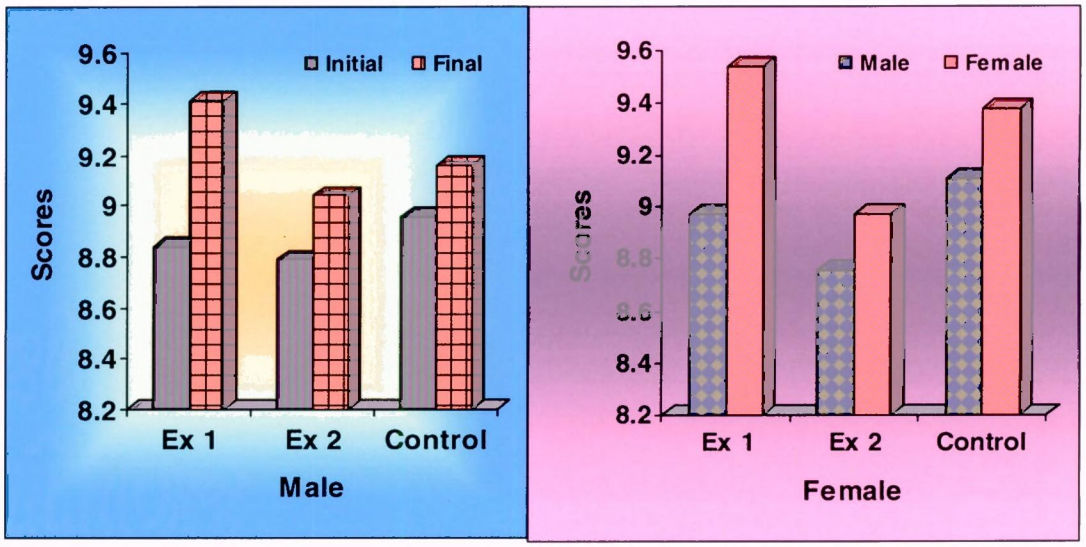


Figure 19

Impact of inventions in 50 yard dash test

It is evident from the above Table that the invention programmes had brought about substantial improvements in the performance of the children in the 50 yard dash test. The scores of the children belonging to the experimental group I improved by 0.57 and 0.55 among the male and female children respectively. The performance of the children belonging to the experimental group II in the same activity had improved by 0.25 and 0.21 among the male and female children respectively. Both the group showed differences that were statistically significant at one per cent level. An increase in performance was also observed among the control group by 0.20 among the male and 0.19 among the female children. Statistical analysis between groups revealed that supplementation yielded the highest improvements in the 50 yard dash performance of the children which was significant at one per cent level.

A study by Vaz *et al* (2010) demonstrated that a four months intervention with a multi micronutrient fortified nutritional beverage improved whole body endurance and predicted aerobic capacity assessed by the 20-m shuttle test among clinically healthy school aged Indian children.

c) Push up test

The results of the push up test conducted before and after the study period are presented in Table LXXV.

TABLE LXXV

IMPACT OF INVENTIONS IN PUSH UP TEST

Group	Sex	Initial (I)	Final (F)	Difference	't'value	
					I vs F	Between groups
Ex I	M n=27	4.83±0.59	5.41±0.51	0.92±0.22	21.90**	Ex I vs control 10.13**
	F n=23	4.29± 0.68	5.54±0.72	0.±0.35	11.95**	
Ex II	M n=29	5.06±0.70	5.04±0.71	0.25±0.33	6.43**	Ex II vs control 2.51**
	F n=21	4.31±0.69	4.97±0.75	0.21±0.23	17.13**	
Control	M n=27	5.20±0.78	5.16±0.77	0.20±0.3	5.60**	Ex I vs Ex II 8.38**
	F n=23	4.04±0.70	4.38±0.82	0.26±0.42	4.27**	

** Significant at 1 per cent level

Performance of the children in the push up test were seen to be much better among the children belonging to the experimental group I and II when compared to the control group of children indicating the beneficial effects of nutrition intervention. After the supplementation of micronutrient biscuits, the push up performance scores of the children increased by 0.92 and 1.01 among the male and female children of group I respectively. There was also an improvement in performance of the children in experimental group II by 0.48 and 0.45 among the male and female children respectively.

Statistical analysis between groups revealed that both the experimental groups showed significantly (5% level) greater increments in the performance in push up test in comparison to the control group. Studies by John and Narasimhan (2008) revealed significantly improved performance in strength of school children after consuming a healthy breakfast.

d) Toe touch test

The results of the nutrition intervention in terms of the performance of the children in toe touch test is presented in Table LXXVI and Figure 20.

TABLE LXXVI

IMPACT OF INTERVENTION ON TOE TOUCH TEST

Group	Sex	Initial (I)	Final (F)	Difference	't' value	
					I vs F	Between groups
Ex I	M n=27	6.28±0.69	7.92±0.65	1.64±0.42	20.38**	Ex I vs control 20.00**
	F n=23	5.21± 0.90	6.80±0.94	1.60±0.44	17.50**	
Ex II	M n=29	6.05±0.78	6.57±0.78	0.52±0.27	10.44**	Ex II vs control 6.15**
	F n=21	5.17±0.70	5.69±0.69	0.52±0.25	9.65**	
Control	M n=27	6.08±0.86	6.28±0.85	0.19±0.16	6.31**	Ex I vs Ex II 15.79**
	F n=23	5.73±0.86	6.02±0.81	0.29±0.25	5.72**	

** Significant at 1 per cent level

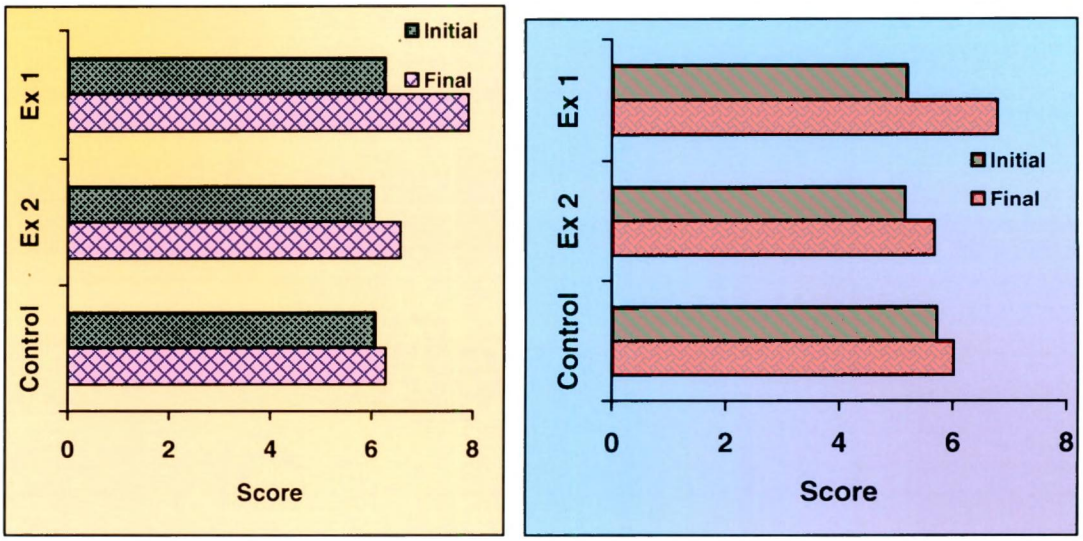


Figure 20

Impact of inventions in toe touch test

Evaluation of the performance of the children in the toe touch test revealed that initially all the male children scored more than six and all the female children scored more than five. After the six month supplementation period, all the groups evidenced improvements in the performance of toe touch test. However, the beneficial effect was the maximum in the supplementation group with a difference of 1.64 and 1.60 among the male and female children respectively. This was followed by the nutrition education group with a difference of 0.52 and the least among the control group. The improvement in the performance of the children can be attributed to the rich supply of micronutrients including iron enjoyed by the children in experimental group I through the supplement provided. A linear relationship has also been reported by Kapil (2011) between iron deficiency and work capacity where the work capacity returned rapidly to normal with iron supplementation.

The supplementation of micronutrient rich biscuits has therefore resulted in considerable improvements in the health parameters in accordance to the statement of WHO/FAO (2006) that programmes delivering micronutrient supplements often provide the fastest improvement in the micronutrient status of individuals or targeted population groups.

5. Changes in nutritional Knowledge, Attitude and Practice (KAP) of the parents

The changes in nutritional KAP of the parents before and after interventions are discussed below.

a. Changes in nutrition knowledge scores

The mean initial and final knowledge test scores of the parents are presented in Table LXXVII.

TABLE LXXVII

CHANGES IN KNOWLEDGE SCORES OF THE PARENTS

Group	Sex	Initial (I)	Final (F)	Difference	't' value	
					I vs F	Between groups
Ex I	M n=27	3.19±1.27	3.48±1.22	0.30±0.47	3.37**	Ex I vs control 1.71^{NS}
	F n=23	2.96±1.11	3.04±1.26	0.09±0.51	0.81^{NS}	
Ex II	M n=29	2.97±1.15	6.14± 0.99	3.17±1.26	13.61**	Ex II vs control 16.60**
	F n=21	2.62±1.12	6.67±1.28	4.05±1.40	13.29**	
Control	M n=27	3.00±1.21	2.96±1.06	0.04±0.81	0.24^{NS}	Ex I vs Ex II 16.60**
	F n=23	2.48±0.90	2.48±0.73	0±0.43	0^{NS}	

** Significant at 1 per cent level; NS Not Significant

The mean initial knowledge scores of the parents revealed a very poor picture of less than 3.5 all the three groups. The parents who received nutrition education demonstrated an increment in knowledge scores by 3.17 and 4.05 among the male female children respectively. The difference was found to be statistically significant. The parents in the control group however did not show any significant improvements in terms of nutrition knowledge.

Statistical comparison between the groups revealed that experimental group II had evidenced tremendous improvement in nutritional knowledge in relation to other groups which was significant at one percent level.

b. Changes in nutrition attitude scores

Table LXXVIII presents the changes of nutrition attitude scores of the parents before and after intervention.

TABLE LXXVIII

CHANGES IN ATTITUDE SCORES OF THE PARENTS

Group	Sex	Initial (I)	Final (F)	Difference	't' value	
					I vs F	Between groups
Ex I	M n=27	2.63 ±1.11	2.78 ±1.05	0.15 ±0.36	2.13*	Ex I vs control 0.41^{NS}
	F n=23	3.44 ±1.12	3.39 ±1.27	0.04 ±0.56	0.37^{NS}	
Ex II	M n=29	3.38 ±1.08	7.14 ± 1.43	3.76 ±1.83	11.09**	Ex II vs control 15.81**
	F n=21	2.81 ±1.03	6.86 ±1.96	4.05 ±1.20	15.14**	
Control	M n=27	3.07 ±1.14	3.04 ±0.98	0.04 ±0.52	0.37^{NS}	Ex I vs Ex II 15.07**
	F n=23	2.52 ±1.08	2.61 ±0.99	0.09 ±0.42	1.00^{NS}	

** Significant at 1 per cent level; NS Not Significant

In the present study, the mean initial attitude scores of the parents ranged between two and four. The initial assessment revealed a higher influence of superstitious beliefs and influences among the study groups. Post intervention assessment of the attitude scores of the parents revealed that the attitudes had greatly improved by 3.76 and 4.05 among the parents of boys and girls respectively belonging to the experimental group II. Confirming that this group had benefited from the nutritional education provided to them. Interestingly, the parents in the supplementation group also revealed significant improvements in attitude score. This could be the result of the awareness provided to them regarding the supplements given to their children and the improvements in the nutritional status and efficiency of their children evidenced by them during the course of supplementation. The control groups on the other hand did not show any significant changes in attitude scores.

Comparison of scores between the three groups highlighted that the experimental group II had improved tremendously than the other two groups, the difference being significant at one per cent level.

c. Changes in nutrition practice scores

The mean initial and final practice test scores of the parents are presented in Table LXXIX.

TABLE LXXIX

CHANGES IN PRACTICE SCORES OF THE PARENTS

Group	Sex	Initial (I)	Final (F)	Difference	't' value	
					I vs F	Between groups
Ex I	M n=27	2.52±1.12	2.63±1.08	0.11±0.42	1.36^{NS}	Ex I vs control 1.18^{NS}
	F n=23	2.00±0.85	2.26±0.69	0.26±0.54	2.31^{NS}	
Ex II	M n=29	2.62±1.12	6.66± 1.29	4.03±1.64	13.28**	Ex II vs control 16.76**
	F n=21	2.67±1.11	6.43±1.36	3.76±1.48	11.65**	
Control	M n=27	2.78±1.01	2.89±0.93	0.11±0.42	1.36^{NS}	Ex I vs Ex II 15.34**
	F n=23	2.26±0.96	2.26±0.75	0±0.67	0^{NS}	

** Significant at 1 per cent level; NS Not Significant

At baseline, the practice scores of the parents in all the three groups scored veryless. However, post nutritional education experimental group II revealed appreciable increase in practice index by 4.03 and 3.76 among the male and female children respectively. The parents of children in control group did not show any significant difference.

The parents in the supplementation group also retained their initial practice scores. It is worth mentioning here that these parents have been instructed at the onset of the study that they should make no major changes in the diet pattern of the children so as to attribute the changes in the various parameters wholly to the influence of the supplementation.

Comparison of increments between the groups revealed significant difference between the scores of experimental group II and both experimental group II and control group. However, no significant difference was observed between experimental group I and control group.

d. Changes in frequency of consumption of dietary sources of micronutrients

The frequency of consumption of foods rich in micronutrients before and after nutrition education among the children belonging to the experimental group II and control group are presented in Table LXXX

TABLE LXXX

FOOD FREQUENCY BEFORE AND AFTER INTERVENTIONS

Foods	Daily		Weekly once		Weekly twice		Once in 2 weeks		Rarely	
	B	A	B	A	B	A	B	A	B	A
Experimental group II (n=50)										
Green leafy vegetables	1	8	13	21	17	13	14	8	5	0
Other vegetables	2	19	22	24	15	6	10	1	1	0
Fruits	0	2	5	16	9	26	18	6	18	0
Meat	0	0	19	26	14	13	11	5	6	6
Sea foods	3	6	20	23	15	9	7	4	8	8
Iodised salt	7	50	0	0	0	0	0	0	43	0
Control group (n=50)										
Green leafy vegetable	2	2	8	9	21	19	17	17	2	3
Other vegetables	3	4	16	14	19	20	12	12	0	0
Fruits	0	0	2	2	17	18	20	20	11	10
Meat	0	1	13	14	12	12	13	11	12	12
Sea foods	2	2	28	26	9	10	1	3	9	9
Iodised salt	4	4	-	-	-	-	-	-	46	46

The food frequency schedule of the children in experimental group II and control group revealed very poor intake of all dietary sources of micronutrients. All the foods that had to be consumed daily were consumed only on a weekly basis. However, after nutrition education a very positive impact could be observed in the consumption of all the foods. The daily consumption of green leafy vegetables and other vegetables increased from one and two children to eight and 19 children respectively. Similarly, the

weekly consumption of fruits, sea foods improved from 19 and 20 children to 26 and 23 children respectively. This is could be on of the strong reasons for the tremendous improvements in micronutrient status of the subjects of experimental group II as even slight improvements intake of fruits for three months have been reported to significantly improve mean plasma levels of α- and β-carotene, retinol, α-tocopherol, vitamin C and vitamin B6 by Polidori *et al* (2009). Another delightful observation was that all the subjects realised the importance of iodised salt consumption and started consuming iodised salt after nutrition education. Palwala *et al* (2009) suggested that including nutrition education programs can be used to target the most immediate causes of under nutrition and reported significant improvements in child feeding practices of mothers after nutrition education.

e. Changes in clinical signs and symptoms

The following Table LXXXI presents the clinical signs and symptoms faced by the children participating in the present study at the initial and terminal stages of intervention.

TABLE LXXXI
CLINICAL SIGNS AMONG THE CHILDREN BEFORE AND AFTER INTERVENTIONS

Clinical signs	Experimental group-1 (N=50)		Experimental group-2 (N=50)		Control group (N=50)	
	B	A	B	A	B	A
Lustreless/ brittle hair	21	10	19	10	22	21
Angular stomatitis	6	3	8	4	5	5
Pale tongue	23	11	24	10	23	21
Conjunctival xerosis	8	2	7	4	7	7
Bitot spot	3	1	3	2	2	2
Bleeding gums	16	9	17	11	14	13
Dental caries	12	7	16	13	19	18
Phrynoderma	8	4	11	8	10	9
Fatigue	21	7	27	19	23	24
Loss of appetite	24	5	20	8	26	28

Clinical signs of the children in terms of paleness of tongue, fatigue, loss of appetite and lustreless brittle hair were more among the children belonging to all the three groups in comparison to other clinical signs of deficiency. The children belonging to the experimental group 1 showed excellent response in terms of clinical signs to the other two groups. Supplementation with doses of isolated nutrients can even mask the deficiencies in other nutrients (Blasbalg *et al.*, 2011). Marked reductions in all the clinical signs were therefore evident among the children belonging to the supplementation group. Conjunctival xerosis and Bitot spot which are typical signs of Vitamin A deficiency completely disappeared among six and two children respectively. Clinical manifestation among the children belonging to experimental group II were also obviously lesser after nutritional education to the parents. Signs of conjunctival xerosis and Bitot spot decreased from seven to four and from three to two respectively among these children.

f. Changes in morbidity pattern of the children

Table LXXXII provides the morbidity profile of the children before and after intervention.

TABLE LXXXII
MORBIDITY PATTERN OF THE CHILDREN BEFORE AND AFTER INTERVENTIONS

Morbidity	Experimental group I		Experimental group II		Control group	
	B	A	B	A	B	A
Diarrhoea	14	9	17	10	12	13
Respiratory illness	10	9	12	9	14	13
Worm infestations	23	16	19	11	21	20
Cough/ cold	27	16	29	20	26	27
Fever	11	6	6	4	8	8
Skin problems	26	17	21	13	20	20

At the onset of the study, morbidities such as cough and cold, skin problems and worm infestation were common among more the 20 subjects in all the three groups. The frequency of other illness such as diarrhoea,

respiratory illness and fever were also seen to be common among these children. The supplementation of micronutrient rich biscuit resulted in a considerable improvement in the immune status of the children belonging to the experimental group 1 as the incidence of most of the morbidities reduced almost by half considerable reduction in illness was also reported by the children belonging to the experimental group II revealing that the nutrition education has been fruitful. The control group however reflected very mild variations between the initial and final morbidity pattern.

From the foregoing results and discussion, it is evident that micronutrient deficiency emerges to be a serious problem among the population in Ramanathapuram district. The prevalence of Bitot's spot, the sign of Vitamin A deficiency was seen to be more than 0.5 per cent among school going children and pregnant women indicating it to be a public health problem. Iodine deficiency manifested as goitre was seen to the level of 0.7 percent among the preschool and school going children. Subclinical levels of iron, vitamin A and iodine deficiency were also seen among 40 to 70 per cent, three to seven per cent and 30 to 50 per cent of the subjects. The diets of the subjects also revealed inadequate intakes of micronutrients when compared to the RDA of ICMR.

Supplementation of the micronutrient biscuits enriched with the jam could bring about significant improvements in terms of anthropometry, clinical, biochemical, cognitive and performance parameters. Similar improvements were also observed among the children whose parents were imparted nutrition education. It was further observed that supplementation yielded best results followed by nutrition education in improving the micronutrient status of the children. It may be concluded that supplementation of locally available foods rich in micronutrients along with nutrition education can be an effective strategy in combating micronutrient deficiency.