

Effect of Micronutrient Supplementation on the Nutritional and Immune Status of School Going Children with Vitamin A Deficiency in the Urban Areas of Chennai District

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ABSTRACT Vitamin A deficiency is a major public health problem and is the cause of childhood blindness, with an estimated incidence of 250 000 – 500 000 per year. The present study was aimed to reduce the prevalence of Vitamin A in the community and also to improve the immune status through dietary supplementation with micronutrient rich foods (wheat germ, rice flakes, gingelly seeds, microwave oven dehydrated carrot powder, jaggery). The study was conducted on children in the age group of 7-9 years (N: 1675) from primary corporation schools located in the urban areas of Chennai district. Out of 1675 children, 73 children had symptoms of Vitamin A deficiency with anemia that were included in the supplementation study. They were further divided into three groups of 25 children each to receive the food based supplement (Micronutrient rich balls), synthetic supplement (Riconia tablet, a micronutrient fortified tablet) and 23 children in the third group formed the control group. The supplementation intervention by food or drug supplementation study was studied over a 6 -month period. The impact of supplementation was evaluated through anthropometric measurements, clinical picture, dietary assessment and biochemical analysis before and six months after intervention/supplementation. The results support dietary intervention as a better method of supplementation evidenced by significant improvement in the parameters studied. In conclusion, the study strongly favors a food- based approach will serve as an effective strategy to correct deficiencies, improve immune status, promote health and well-being of children and improve global health.

INTRODUCTION

Childhood malnutrition remains as a major public health problem worldwide and has been widely recognized as an important risk factor for child mortality. An estimated 2.8 million child deaths are reported each year in the nine low-income Asian countries including India. Attempts are underway to quantitatively estimate the extent to which all forms of childhood malnutrition - including deficits in protein and energy and the micronutrients namely iron, vitamin A, iodine and zinc contribute to these adverse outcomes. One of major public health problem is “Vitamin A deficiency” (VAD), facing some 200 million children. A study of National Nutrition Monitoring Bureau (NNMB 2001) has indicated that

among the schoolchildren in the urban slums, the prevalence of VAD was as high as 7.8 per cent. Immune suppression results in increased incidence of VAD and it also affect the physical and mental development of children (Bloem et al.1999). Supplementation of immuno nutrients like zinc and vitamin A in children not only improves immune status but also protects body from infections and also improves neuropsychologic function in children (Zinc Investigators’ Collaborative Group 1999). To combat the existing micronutrient deficiencies and infections, several intervention programmes have been initiated. The most commonly adopted strategy is the dietary supplementation. In this research, a micronutrient rich supplement was formulated using wheatgerm, rice flakes and carrot as the major ingredients for supplementation. Rice flakes are the most commonly used iron rich food Indian Council of Medical Research (ICMR 1989). Carrot is the richest source of beta carotene and supplementation of carrot has improved the serum retinol levels of individuals (Chandrasekhar et al. 2000). Wheat germ is unique sources of *highly* concentrated nutrients especially zinc, thiamine, riboflavin and niacin (Wade 1992). Being an

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antioxidant micronutrient, zinc improves the immune profile as well. Studies on school going children between the age group of 7-9 years old are sporadic in India. It is high time that the attention is shifted towards the promotion of nutritional status and immune profile of school going age group. Since these children will be entering the adolescent age group soon and the health and well-being of the adolescent stage has a direct bearing on the adult nutritional status.

Against this backdrop, the present study was aimed to reduce the prevalence of anemia and infections and also to improve the immune status of school going through supplementation with micronutrient rich food formulation. The present study focuses on the following objectives:

1. Screen children with infection or deficiency conditions.
2. Formulate a micronutrient rich supplement to combat VAD.
3. Study the impact of supplementation of micronutrient rich balls in terms of nutritional status and immune profile of children in school.
4. Study the effect of food supplementation against the supplementation of pharmaceutical preparation in the form of tablets.

METHODOLOGY

1. Selection of Schools and Grouping of Children

The children in the age group of 7-9 years from eight Corporation primary schools located in the urban areas of Chennai city were targeted for the study. All the available 1675 children were elicited for socio-economic background, dietary details, nutrition knowledge of the mothers and children and health practices of children using a pre -tested questionnaire.

A health checkup revealed that 1151(68.7%) children had exclusive signs of anaemia, 416 (24.8%) had symptoms of upper and lower respiratory tract infection (URI/LRI) + mild anaemia, 73 (4.3%) showed symptoms of vitamin A deficiency (VAD) + anaemia and 56 (3.3%) children had symptoms of URI/LRI + VAD. About 221 (13.1%) children showed signs like scleroderma, scaling, dermatitis etc. and only 268 (16%) children were normal and healthy. Out of these groups, 73 (4.3%) children who showed symptoms of vitamin A deficiency (VAD) +

anaemia were randomly selected for different treatments in the supplementation study.

2. Conduct of Supplementation Study

a. Formulation and Preparation of Micro-nutrient Rich Food Supplement: The existing nutrient deficits in the diets of the children were arrived through a three -day food weightment survey. The mean deficit of micronutrients in the diets of VAD children was found to be 7.81 mg iron, 7.86 mg zinc and 1537mcg of beta carotene. To bridge these existing deficits a food mix rich in iron, zinc and beta carotene was formulated with wheatgerm, a rich source of zinc and iron, carrot powder rich in beta carotene and gingelly seeds, a good source of iron and zinc. An ideal composition was arrived through permutation and combinations.

Weighed quantity of wheat germ (60g), gingelly seeds (5g) and rice flakes (15g) were roasted and cooled separately. Nine grams of carrot powder equivalent to 30g of fresh carrot (grated and microwave oven dried) was added. The mixture was ground to a fine powder. The dried powder was stored in air tight containers. Eleven grams of jaggery was mixed with water and boiled to thin syrup. The powder was added to the syrup and made into balls. The synthetic supplement chosen for comparison in the study was Riconia, a micronutrient fortified tablet, a product of Best Laboratories, New Delhi, India. The nutrient composition of the two supplements is presented in table 1. The cost of 100g food supplement was computed to be Rs.4.90/- and the cost of one tablet was Rs.4.75/- (one US \$=Rs.46.6).

b. Supplementation of Micronutrients: The children in VD group received 100g per day of

Table 1: Nutrient composition of the supplements

Nutrients	Food supplements (per 100g)	Riconia tablet
Protein(g)	19.5	-
Fat (g)	8.9	-
Energy(Kcal)	350	-
Calcium(mg)	150.0	162
Iron(mg)	9.29	10
Beta carotene(mcg)	2703	1500
Thiamine(mg)	1.14	1
Riboflavin(mg)	0.56	1.5
Niacin(mg)	3.76	2
Vitamin C (mg)	3.6	50
Zinc (mg)	10.64	15

the micronutrient rich food supplement prepared into two balls weighing 50g each. The balls were distributed one in the mid -morning and one in the mid- evening in their respective schools. The children in the VS groups received one Riconia tablet per day. The children in the control groups VC did not receive any supplements. The grouping of children for the supplementation study is shown in Figure 1. The supplementation was carried out for a period of six months. Care was taken to see that the children consumed the balls/tablet regularly even on holidays under the supervision of the investigator. Attendance record was maintained to ensure their regular participation. Those who could participate regularly alone were included as subjects for the final evaluation.

c. Evaluation of the Impact of Supplementation: The impact of supplementation was studied in all the 73 children in terms of anthropometric measurements (weight, height, skinfold thickness, arm circumference and chest circumference), clinical picture and food and nutrient intake. Biochemical assessment was done through analysis of blood haemoglobin,

serum biochemistry which included serum total protein, serum albumin and immunoglobulin viz., IgG, IgA and IgM, serum zinc and serum retinol. All the measurements were done initially and six months after supplementation. In addition, the nutrition knowledge of the mothers and children were studied for all the 73 children at the beginning, at the end of three months and finally at the end of six months of supplementation.

RESULTS AND DISCUSSION

A. Impact of Supplementation of Micronutrients

In this investigation a food supplement rich in iron, zinc and vitamin A was supplemented to vitamin A deficient children for a period of six months. The results obtained are compared against groups supplemented with synthetic tablets containing micronutrients. There were also a group of children who did not receive any supplements and served as controls. The impact observed is discussed under the following headings:

1. Anthropometric measurements

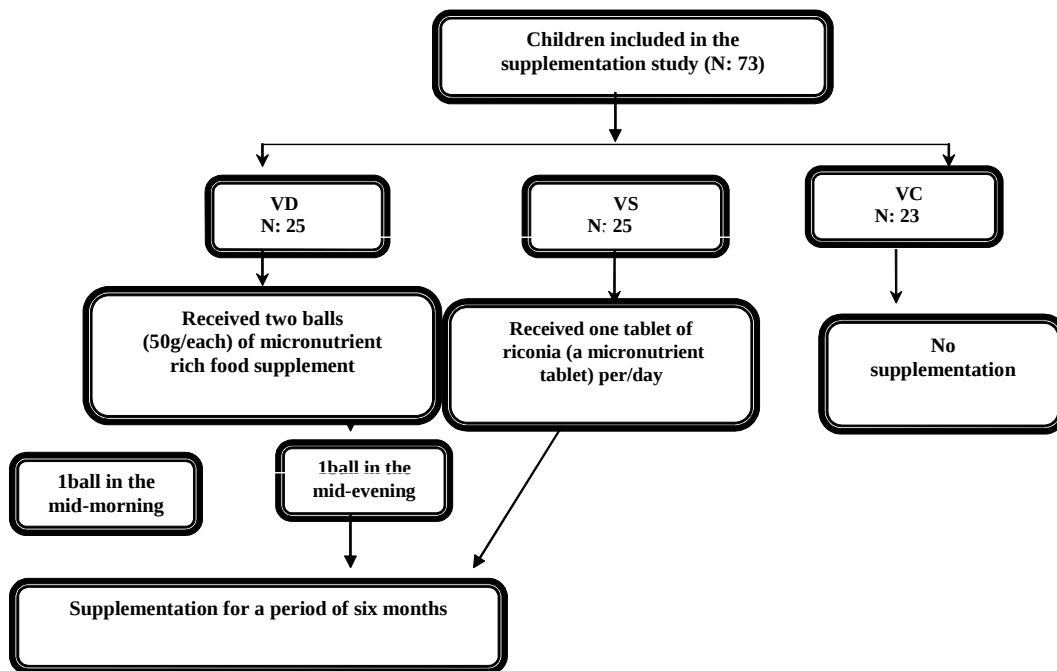


Fig. 1. Grouping of children for supplementation

2. Dietary intake
3. Morbidity pattern
4. Clinical picture
5. Biochemical picture
6. Immune profile

1. Anthropometric Measurements

a. Mean Height and Weight of the Children:

As far as the height and weight are concerned, tables 2 and 3 reveal that the children in the food supplemented group had recorded significantly greater increments when compared with their counterparts receiving micronutrients in the tablet form. Wheatgerm being the major component of the food supplement is not only rich in nutrients namely iron, zinc and B-complex vitamins but also contains a considerable amount of protein (17.4g) and the overall protein content of the food supplement was 19.56g/100g. Since adequate protein is essential during growth when new tissue proteins are being synthesized (ICMR 1989), this also could have attributed to the better growth performance of the children.

b. Mean Mid -Arm Circumference, Chest Circumference and Skinfold Thickness of the Children:

The mean mid- arm circumference, chest circumference and skinfold thickness of the children in all the groups showed slight increase or no increase in their measurements and most of them were nearing or well within the normal ranges even before the supplementation and statistically the changes were found to be not significant. Probably longer periods of supplementation would result in tangible impact in terms of these measurements.

2. Dietary Intake

a. Mean Food Intake of the Children:

Initially there was an inadequacy in the consumption of all the foods among the children studied. Over a period of six months the improvements in the food supplemented groups stood first followed by the groups supplemented with synthetic nutrients while the control groups evinced the least changes. In spite of these improvements, intake of all the foods were still

Table 2: Changes in mean height of the children

Group	Mean height (cm) $\pm$ SD			Initial Vs	Groups compared	't' Value
	Initial	Final	Difference	Final 't' Value		
Male						
VD	115.6 $\pm$ 2.7	118.6 $\pm$ 1.0	3.0 $\pm$ 0.7	15.1**	VD Vs VS	6.9**
VS	119.3 $\pm$ 1.5	121.4 $\pm$ 1.2	2.1 $\pm$ 0.5	2.0*	VS Vs VC	10.7**
VC	120.1 $\pm$ 2.2	120.2 $\pm$ 2.8	0.1 $\pm$ 0.2	1.34 ^{NS}	VD Vs VC	13.3**
Female						
VD	114.7 $\pm$ 2.2	117.6 $\pm$ 1.4	2.9 $\pm$ 0.6	14.3**	VD Vs VS	16.5**
VS	120.5 $\pm$ 2.5	122.4 $\pm$ 2.2	1.9 $\pm$ 0.2	2.5*	VS Vs VC	9.3**
VC	118.3 $\pm$ 1.2	118.5 $\pm$ 2.6	0.2 $\pm$ 0.9	1.5 ^{NS}	VD Vs VC	11.6**

** Significant at one per cent level; * Significant at five per cent level; NS: Not Significant
Std values: Male 121.7-132.2 cm, Female 120.6-132.2 cm (NCHS 1987)

Number in parenthesis indicate the number of children

Table 3: Changes in mean weight of the children

Group	Mean height (cm) $\pm$ SD			Initial Vs Final 't' Value	Groups compared	't' Value
	Initial	Final	Difference			
Male						
VD	17.3 $\pm$ 2.1	20.2 $\pm$ 2.9	2.9 $\pm$ 0.5	6.8**	VD Vs VS	21.9**
VS	16.5 $\pm$ 2.9	18.4 $\pm$ 1.5	1.9 $\pm$ 0.2	1.9*	VS Vs VC	2.3*
VC	17.9 $\pm$ 1.8	18.2 $\pm$ 2.1	0.3 $\pm$ 0	1.5 ^{NS}	VD Vs VC	19.7**
Female						
VD	17.8 $\pm$ 2.6	19.4 $\pm$ 1.2	1.6 $\pm$ 0.5	9.7 **	VD Vs VS	13.1**
VS	17.4 $\pm$ 2.8	19.5 $\pm$ 2.2	2.3 $\pm$ 0.2	2.95*	VS Vs VC	2.2*
VC	17.3 $\pm$ 1.6	17.5 $\pm$ 2.7	0.2 $\pm$ 0.9	2.3 ^{NS}	VD Vs VC	15.6**

** Significant at one per cent level; * Significant at five per cent level; NS: Not Significant
Std values: Male 22.9 – 28.1 Kg, Female 21.8 – 28.5 Kg (NCHS 1987)

Number in parenthesis indicate the number of children

found to be inadequate except in a few cases of cereals consumption and fat consumption. In the study conducted by NNMB (2001) on children in the age group of 5-12 years in eight States showed improvement in their food intake pattern on supplementation with foods rich in calories and micronutrients.

b. Mean Nutrient Intake of the Children:

Initially the intake of energy rose from 60.8 to 78 per cent of RDA (Reference Daily Intake) in all the children. At the end of the supplementation study all the children had evinced improvements in their intake of energy. Children receiving food supplements consumed more than 95 per cent of RDA for calories while the groups receiving synthetic supplements received 78.4 to 89.6 per cent of RDA. Control groups registered negligible change in the consumption of calories. In spite of all the improvements, none of the groups reached the RDA levels of calorie consumption. Initially, protein deficiency was around 50 per cent in all the groups except in the normal children whose deficit was around 30 per cent of RDA. Food supplementation and awareness creation could bridge the gap greatly in all the four groups followed by the groups receiving synthetic supplements.

Diets of VAD groups were found to be deficit in beta carotene. Rivera et al. (2001) showed that vitamin A deficiency in children not only alters the serum retinol levels but also decreases their food and nutrient intake. This condition could be reverted on supplementation of micronutrients or fortificants notably iron, zinc and vitamin A in combination. It has shown to improve their nutritional status as well as increase their food and nutrient intake thereby reducing the prevalence of the deficiency condition.

Zinc, ascorbic acid and calcium intakes were below 50 per cent of RDA among all the children. The final intake picture showed improvements in the intake of all the nutrients. However, they could not reach the RDA levels of consumption. Among the different vitamins, intake of thiamine and riboflavin were found to be more satisfactory.

3. Morbidity Pattern of the Children

The initial morbidity pattern of the VAD children revealed the occurrence of fever, measles/chickenpox and common eye problems like watering of eyes, pale conjunctiva and conjunctival xerosis in all the three groups. The reduction of

the above problems in the food supplemented group was statistically significant at one per cent level. Whereas the reduction among children in the tablet supplemented group were significant at five per cent level. The present finding is supported by D'Souza et al. (2002) who stated that children with hypovitaminosis A and low serum concentrations of vitamin A have higher rates of associated infections, such as fever and measles.

4. Clinical Picture

Clinical signs such as fatigue, giddiness and dental caries were prevalent among 30 to 60 per cent of the VAD children. Conditions such as fever, respiratory infections, deficiencies of iron and vitamin A, PEM and diarrhoea, adversely affect the nutritional status resulting in fatigue, giddiness and loss of appetite by inhibiting food consumption (Dorosty 2000). Conjunctival xerosis was prevalent among 21.5 to 32.0 per cent of the children with vitamin A deficiency. Bitot's spot was prevalent among eight per cent of the children with VAD. In a study conducted by Chandrasekhar and George (1990), the prevalence of bitot's spot was found to be 7.7 per cent in 6 to 9 years old children in the urban slums of Coimbatore. In the present study, the prevalence of bitot's spot in Chennai's urban slums was slightly greater. On supplementation with micronutrients for periods of six months, the symptoms observed in the children given food based supplement were greatly reduced compared to tablet supplemented groups. Symptoms such as dimness of vision and bitot's spot disappeared in the children in the VD group. Signs of conjunctival xerosis reduced from 24 to 8 per cent in the VD group of children. Devadas (1992) reported that dietary supplementation of vitamin A rich foods improved clinical profile and serum retinol levels of the children. Children in the control groups recorded only a mild reduction in the clinical signs and symptoms. Probably supplementation of micronutrients would have helped to improve their clinical picture.

5. Biochemical Status of the Children

The biochemical changes were studied in terms of blood haemoglobin levels, serum protein, albumin, globulin levels, serum zinc and retinol levels.

a. Mean Blood Haemoglobin Levels of the Children: The mean initial and final blood haemoglobin levels of the children are presented in Figure 2. Initially the blood hemoglobin levels of the VAD children ranged between 11.0 – 11.4 g/dl. At the end of the supplementation study, the VAD children who received iron supplements in the form of food recorded the highest increments (2.9g/dl) in blood haemoglobin level which were significant at one per cent level followed by the groups receiving the tablet supplementation which were significant at five per cent level. The children in the control group recorded a negligible difference which was not statistically significant. In the case of VAD children, there was an increment in the haemoglobin level, since the synergistic effect between vitamin A and iron has been well established. Sunhamo et al. (1993) have shown that supplementation with both iron and vitamin A on VAD children increases the haemoglobin level to a greater concentration than does iron supplementation alone. This can occur only in populations with low vitamin A status and that the effect may be more related to repletion in vitamin A status than a direct effect on iron absorption.

b. Mean Serum Total Protein Levels of the Children: Mean serum total protein levels of the children included in the supplementation study are presented in Figure 3. The mean initial serum

total protein levels of the VAD children belonging to the VD and VS groups were 5.6 and 5.9 g/dl. On supplementation of micronutrients, the levels increased to 7.0 and 7.1g/dl respectively. These increments were found to be statistically significant at one and five per cent levels respectively. It was observed that the mean serum total protein levels of the VAD children were much lower. This result is in accordance with the studies of Barelay et al. (2003), who conducted experiments on VAD children with a nutrient supplement and showed a significant increase in their serum total protein levels. The control group children showed a meagre or no increase in serum protein levels and the changes were not significant. The paired 't' test performed between the three groups of children revealed that the supplemented groups (both food and tablet form) had an appreciable impact on the serum protein level compared to the control groups.

On supplementation the children VD group registered a significant increase ($p < 0.01$) in the serum total protein level which could be attributed to the high content of protein (19.56g) in the food supplement. After six months supplementation period the children were well within the normal range which indicates good nutritional status which had enhanced the growth and development of children.

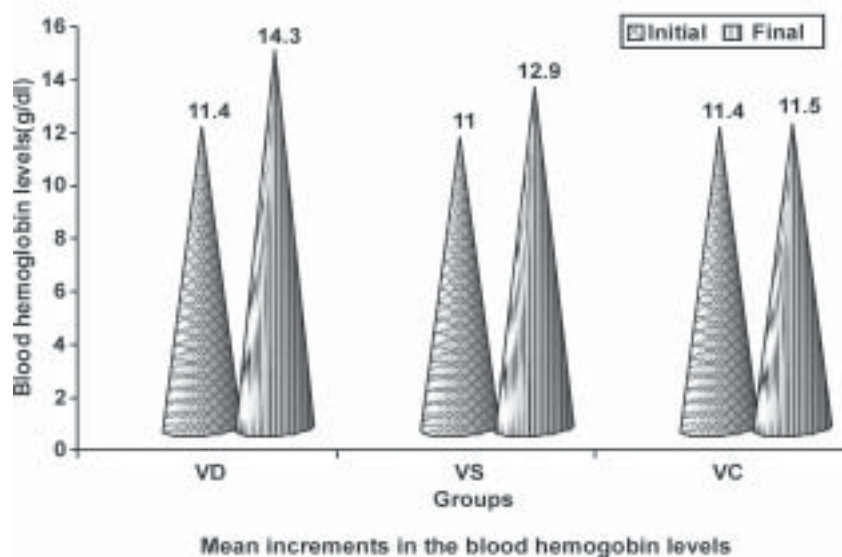


Fig. 2. Mean increments in the blood hemoglobin levels of the children

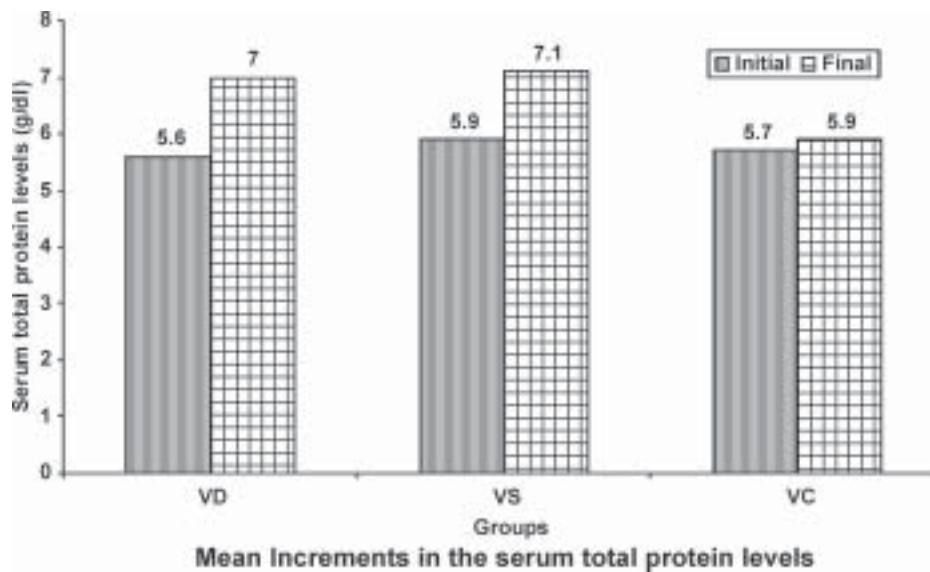


Fig. 3. Mean increments in the serum total protein levels of the children

c. Mean Serum Albumin and Globulin Levels of the Children: Initially, the mean serum albumin and globulin levels ranged from 3.2 to 4.3 and 2.0 to 2.8g/dl respectively. However, no perceivable changes were observed over the six months of supplementation in the serum albumin and globulin levels in all the groups of children and the values were well within the normal range of 3.5 to 5.0g/dl and 2.3 to 3.5g/dl respectively.

d. Mean Serum Zinc Levels of the Children: Mean serum zinc levels of the children included in the supplementation study are presented in Figure 4. The mean initial serum zinc levels of the VAD children in all the three groups were very low. After supplementation, maximum increment was registered in VD group children whose serum zinc levels increased from 45.6 to 107.6 mg/dl as against the VS group children whose mean

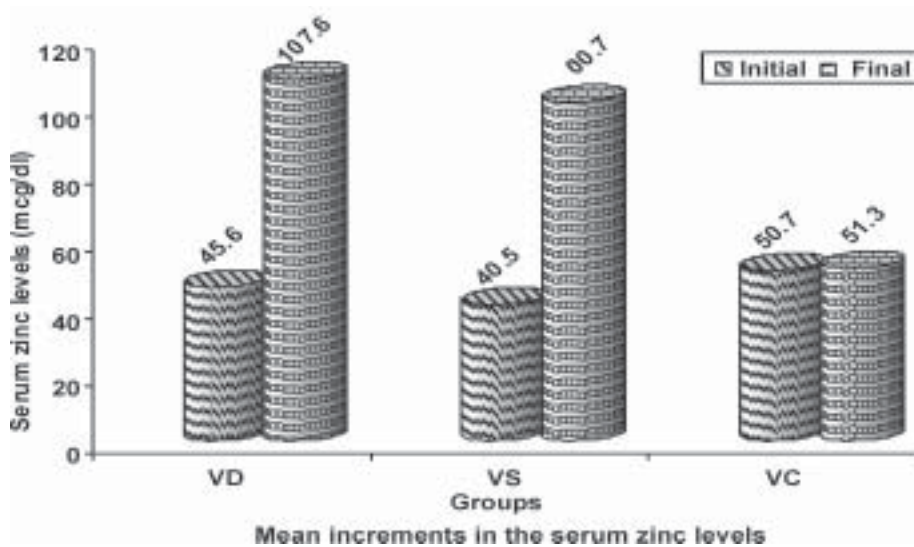


Fig. 4. Mean increments in the serum zinc levels of the children

increase (51.2 mg/dl) was significant at five per cent level. Christian et al. (2001) reported that VAD is associated with lower serum zinc levels. Supplementation with zinc rich diet caused an increase in the serum zinc levels along with slow disappearance of clinical signs of VAD.

The paired 't' test between the three groups showed that the increments of children in the food supplemented group were significantly greater than the control groups at one per cent level and synthetic supplement receiving groups at five per cent level. The children in the control groups did not show any appreciable improvement in their serum zinc levels.

The serum zinc levels in children are generally low especially in cases of infection / deficiency condition (Sivakumar et al. 2006). Their zinc intake is lower than the RDA of 8mg / day. Since the metabolisms are altered during infection or illness, the serum zinc levels are reduced. The food supplement given to children contains adequate amount of micronutrients especially zinc and good amount of protein which might have attributed towards increasing the serum zinc levels when compared to the children in the tablet supplemented group.

e. Changes Observed in the Retinol Levels of the VAD Children: Changes observed in the

retinol levels of the VAD children are presented in Figure 5. The mean initial serum retinol levels of the VD, VS and VC group children were found to be 15.0, 16.9 and 12.3mcg/dl which were lower than the normal values i.e. >20 mcg/dl. At the end of the supplementation study, the mean increment in the serum retinol levels of the children in the VD group (17.1mcg/dl) was statistically significant at one per cent level and that of VS group (8.7mcg/dl) was found to be significant at five per cent level. The children in the control group did not show any appreciable increase and therefore statistically found to be not significant. Studies reported by Hustead et al. (1998) revealed that vitamin A deficient children were associated with low serum zinc and retinol levels. Supplementation of vitamin A along with zinc significantly improved their serum zinc and retinol levels.

6. Immune Profile of the Children

In the present study, the immune profile of the children had considerably increased after supplementation of micronutrients and was well within the normal range mentioned. The immune profile changes in children were studied in terms of serum IgA, IgM and IgG levels which are shown in Figure 6. The children in the food supplemented

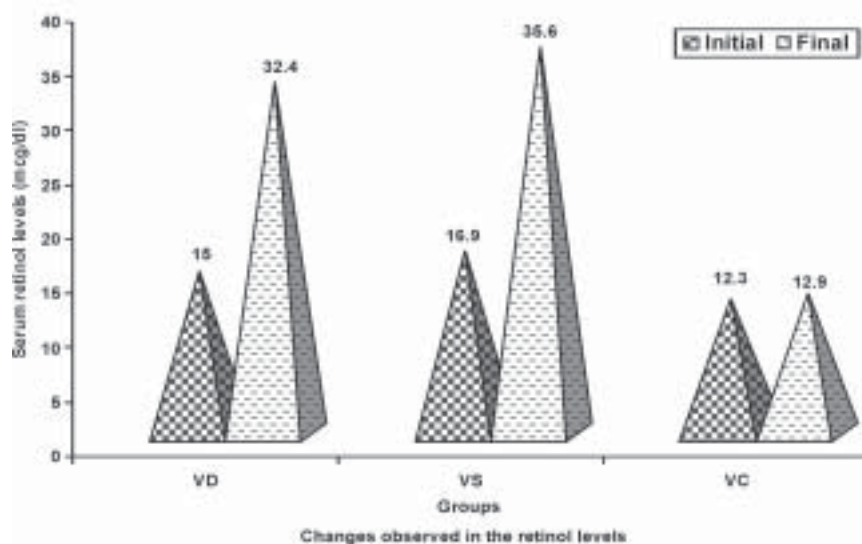


Fig. 5. Changes observed in the retinol levels

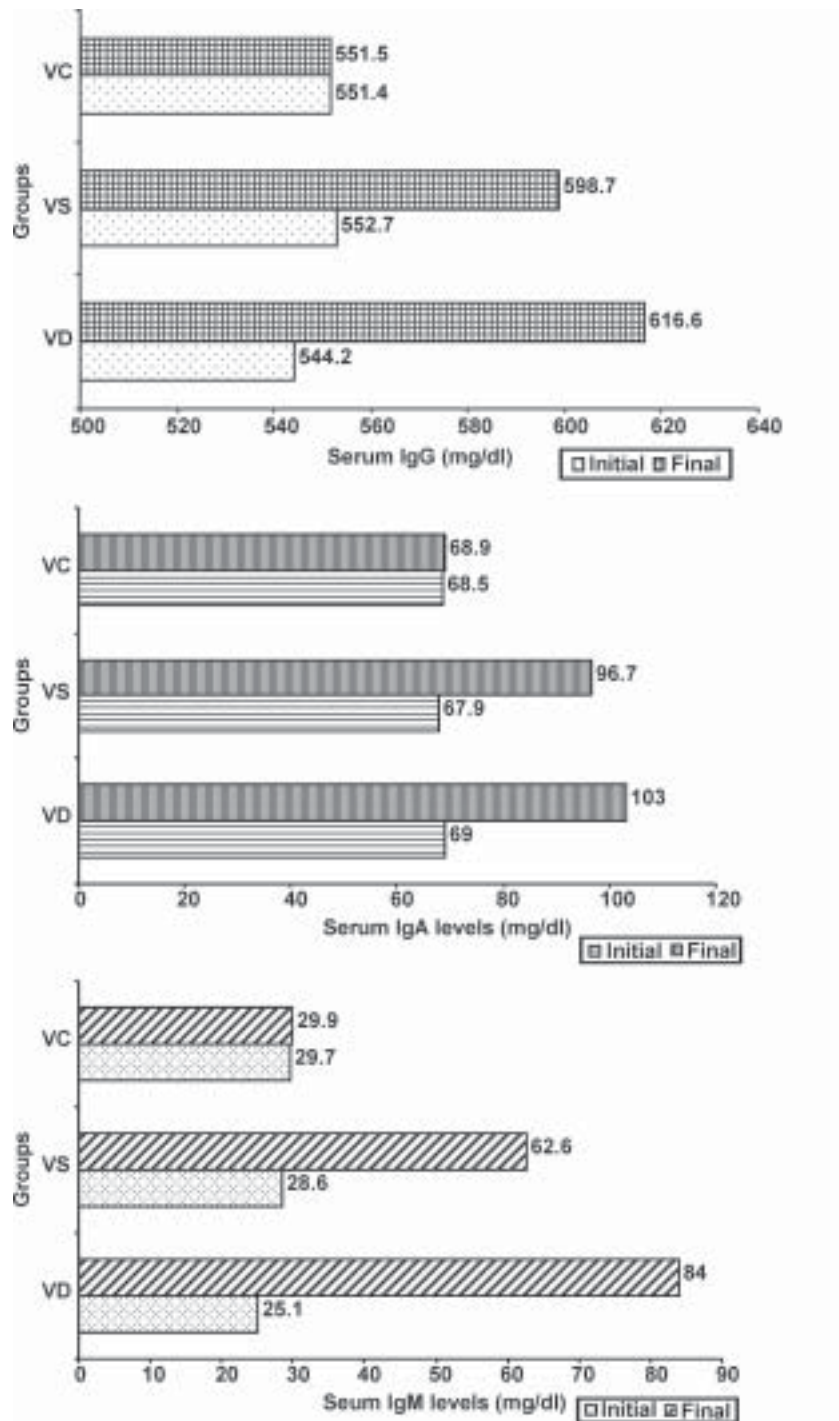


Fig. 6. Immune profile of the children

group had greater increase in their immunoglobulin levels since the food supplement contains adequate amount of micronutrients especially zinc, iron and vitamin A. In addition, the protein and calories contributed towards a positive impact. During infection / deficiency condition immuno depression is quite common. Zinc, an immunonutrient acts as an immunomodulator which increases the IgA, IgM and IgG levels. It improves the T-cells, enhances the repair of mucous membrane of the respiratory tract and gastrointestinal (GI) tract thereby increases the defence mechanism of the respiratory tract and GI tract for eliminating the organisms and viruses. Zinc also increases phagocytosis for engulfing organisms producing infection and increases polymorphs function (Singh 2004). The multi-roles played by zinc not only improve the serum zinc levels but also improves the immune function of the body during illness or normal condition. As a long term strategy, food based approach has proved to be beneficial in all aspects and hence in the present study zinc along with other micronutrients had helped to improve the immune status of the children irrespective of deficiency condition or illness.

CONCLUSION

In the present study, supplementation of micronutrients either in the food or in the tablet form resulted in significant improvement in the height, weight, lowering of morbidity, clinical picture and biochemical status among the children. The cost of the food supplement worked out to be Rs.4.90/- child per day and that of tablet was Rs.4.75/- child per day. Though the cost of food supplement was slightly higher than that of the tablet form of supplement, the children in the food supplemented group showed significantly greater improvement in all the parameters tested. The presence of additional nutrients, protein and calories in food supplement contributed to a greater benefit. In addition, sound nutrition knowledge imparted to mothers and children helped to promote their home food intake. In conclusion, the study strongly favors a food based approach will serve as an effective strategy to correct deficiencies, improve immune status, promote health and well being of children and improve global health.

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