IRON DEFICIENCY AND BEHAVIOUR PATTERN IN PRESCHOOL CHILDREN

BY

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THESIS

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RESULTS AND DISCUSSION

DECLARATION

I hereby declare that this thesis, entitled **"Iron deficiency and behaviour pattern in preschool children"** is a bonafide record of research work done by me during the course of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or society.

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CERTIFICATE

Certified that this thesis entitled **"Iron deficiency and behaviour pattern in preschool children"**, is a record of research work done independently by **ANNIE VERGHESE** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Dedicated

to

My Grandfather

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INTRODUCTION

"Every man, woman and child has the inalienable right to be free from hunger and malnutrition, inorder to develop fully and maintain their physical and mental faculties". Children are the valuable assets of a nation who are to be the potential parents of tomorrow. The quality of life they enjoy today would ultimately determine the quality of future population. Therefore, prime importance should be given to their health and nutritional, recreational and educational facilities *(Pathak and Saxena, 1979).*

Among the various nutritional problems prevalent in India, a serious consequence following child malnutrition is iron deficiency anaemia. Iron is highly essential and is involved in cellular respiration and regulation of many biological and chemical reactions occurring in the body. Iron deficiency anaemia is a problem of serious public health significance, given its impact on psychological and physical development, behaviour and work performance. *(DeMaeyer, 1989).*

Infants and children upto the age of 5 years, who constitute as much as 15 per cent of the total population are easily affected by iron deficiency anaemia. ICMR reports (1989) reveal that in India about 50 to 60 per cent of our children are anaemic probably due to low family income, undiversified local production, urbanisation, prolonged breast feeding, low intake of protein and iron and prohibited consumption of most animal foods due to taboos.

Iron deficiency is found to have an effect on cognitive functions in addition to affecting human behaviour, work performance and psychological development (Ghosh, 1979 and Agarwal, 1989). According to Nair (1990), iron deficiency anaemia reduced the attention span and also impaired physical efficiency. As the duration of the deficiency is prolonged the chances of tangible and persistent handicaps increase. Mild iron deficiency which do have an effect on child behaviour is also reported to be reversible with iron therapy (Pollitt, 1989).

A systematic and comprehensive investigation on "Iron deficiency and behaviour pattern in preschool children" is an attempt to examine the possible role of iron deficiency on the intelletual behaviour development in preschoolers.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Under nutrition is the most common health problem in the world specially in the third world countries. According to *DeMaeyer (1989)*, among the vulnerable population, young children especially preschoolers are at greatest risk of developing the nutritional deficiencies. In India about 150 million children under 5years old are underweight and more than 20 million suffer from severe malnutrition *(UNICEF, 1990)*. A serious consequence concerned with malnutrition is iron deficiency anaemia *(Dallman, 1989)*.

Iron deficiency anaemia is a problem of serious public health significance given its impact on psychological and physical development, behaviour and work performance. As reported by *ICMR (1989)* about 50 to 60 per cent of our children are anaemic. Studies conducted by *Ghosh (1979)* and *Agarwal (1989)* have also revealed that iron deficiency does have an effect on cognitive function and intellectual performance of an individual. Iron deficiency, as stated by *NIN (1991)*, is most common among infants and preschoolers who constitute 15 per cent of our population.

Earlier studies pertaining to "Iron deficiency and behaviour pattern in preschool children" are reviewed under:

2.1. Prevalence Of Anaemia Among Preschoolers

2.2. Factors Influencing Development Of Anaemia

2.3. Availability Of Food Iron And Its Influence On Blood Profile

2.4. Consequences Of Anaemia

2.1. Prevalence Of Anaemia Among Preschoolers

The nations current threat to its growth and development is malnutrition due to inadequate diet. According to *Badowal (1982)*, in recent years, the prevalence of iron deficiency and iron deficiency anaemia in children from 6 months to 3 years old are still high in developed countries.

Iron depletion continues to be one of the major nutritional deficiency among preschoolers as observed all over the world, with a very high prevalence rate in India *(Maeyer and Tegman, 1985)*. *Sarala (1989)* reveals that nearly 35 to 50 per cent of children in rural India belonging to low income groups have iron deficiency anaemia.

Another observation in a study by *Kripke and Sanders (1970)* is that anaemia is most frequent in children between 12 and 27 months old.

As reported by *Calvo (1990)*, a total of 182 children under 5 years old investigated in a slum area of Pune, India, in relation to nutritional state and dietary history were found to have anaemia. The prevalence was 43 per cent with morphology suggestive of iron deficiency. According to *Uberol et al (1972)* of 508 preschool children surveyed in 6 villages in Punjab, 417 children had haemoglobin values below 10gm/100ml and incidence and severity were observed to increase significantly with age.

Levi et al (1970) observed that anaemia was found in 52 per cent of the 247, 6year old healthy children in a survey conducted in Israel. *Kripke and Sanders (1970)* had reported that among the 580 Iowa children of 6 months to 3 years old, the mean haemoglobin concentration was less than 12gm/100ml. *Pollitt and* co-workers *(1978)* studied 23 children of mean ages 45 and 44 months respectively who were iron deficient having mean haemoglobin levels of 12g/dl.

2.2. Factors Influencing Development Of Anaemia

Metabolic, genetic, nutritional and dietary causes bring about anaemia. Anaemia can persumably be produced by an excessive loss or destruction of blood in the presence of a normally acting marrow, by a failure of marrow to produce normal red blood cells in quality or quantity or by a combination of these two factors.

Anaemia may be caused due to genetic disorders, sickle-cell diseases, thalassemia, infections including malaria and increased loss of blood caused by parasites like hookworm. Menstrual losses, blood donation, expansion of blood volume in growth stages like infancy, adolescence, pregnancy and lactation, diarrhoea, protein-calorie malnutrition, chronic diseases, tuberculosis and ulcer lead to anaemia *(Robinson et al , 1986)*. Cancer, kidney diseases, bowel disorders, arthritis, juvenile rheumatoid and lead poisoning also lead to anaemia.

In developing countries, small adult stature is a common feature and this has been attributed to chronic malnutrition during the period of active growth.

Anaemia is most frequent in children who had weighed less than 5.5 lb at birth *(Kripke and Sanders, 1970)*. They further reported that the incidence of iron deficiency was not correlated with any socio, economic factor analysed nor was it associated with multiple birth or multiparity.

Judisch and co-workers (1988) examined the heights and weights of 156 iron deficient patients, all of whom were less than 3 years of age. In this group the heights were normally distributed, but a disproportion number of these infants were under weight for both age and height.

De Maeyer (1984) had reported that iron deficiency may be due to inadequate iron intakes, reduced bioavailability of dietary iron, increased needs for iron or due to chronic blood loss. *Fleming (1982)* had stated that anaemia occurs due to lack of haemopoietic nutrients such as iron, folic acid, ascorbic acid, protein, cyanocobalamine, copper and calcium in the diet. Even though iron rich sources such as green leafy vegetables are inexpensive and available in large quantities in India, they are not widely included in the daily diet. This is due to the ignorance of mothers about their nutritive value.

NIN(1990) further reilerates that folate and vitamin B_{12} are important nutrients for the production of red blood cells in our body and with the lack of these nutrients the blood cells thus produced are defective and early destructable. Dietary factors play an important role in the development of iron deficiency anaemia in the Indian subjects. Although most habitual diets consumed in different regions of the country contain apparently adequate amount of iron, the poor absorbtion of this dietary iron is a serious limiting factor in fulfilling iron requirement.

Dr.Yona (1986) says that the practice of feeding tea to young children should be discouraged as it causes anaemia in children. In a study of 467 healthy infants by *Jerry (1984)*, results indicate that upper respiratory and other mild antecedent infections commonly pre-dispose to iron deficiency probably because of a decrease in iron absorption. *Sanders (1990)* reported that infestations by worms and repeated episodes of infections predisposed to iron deficiency anaemia.

An analogous study of 383 village preschool children by *Damsdaran (1979)* in India show only a small haemoglobin difference between an iron-plus-folate treated group and a placebo treated control group and no significant difference in frequency or duration of respiratory or enteric infections. According to *Ronald (1978)*, many physicians believe that patients with iron deficiency anaemia have an increased susceptibility to infections. It seems clear that the inflammatory response when assessed by skin reactivity is diminished in iron deficiency. Normal functions are usually restored following iron depletion. *Reeves et al (1984)* found that mild infection that occured upto 3 months before hematological assessment adversely affected several iron status indicators in currently healthy 3 year old infants.

According to *Hutchison (1991)*, iron deficiency can also occur as a result of chronic blood loss following post operative conditions. *Ghosh (1979)* and *Kaplan (1972)* are of the opinion that poor nutritional status affects the physical growth and cognitive development in children. *Eiser (1986)* revealed that malnutrition increases the susceptibility to infection, which adversely affects the nutritional status and inturn affects the intellectual and physical development.

2.3. Influence Of Food Iron On Blood Profile

Nutritional anaemia is characterised by inadequate erythropoeisis and reduced haemoglobin concentration, which is due to inadequate supply of nutrients like iron, folic acid and vitamin B_{12} *(Agarwal, 1991)*.

Studies conducted by *Sarala (1989)*, indicate that besides being a hemopoietic factor, iron plays an important role in modulating several cellular functions. Iron deficiency has shown to reduce the activity of iron containing and iron dependent enzymes, thus interfacing with the oxidative metabolism of tissues. The effects of iron deficiency on immune function, mental function and physical performance are of practical importance. According to *Patiroglu* and *Dogan (1991)*, in anaemic condition disordered cerebral oxidative metabolism was found to be secondary to suboptimal levels of various haeme containing and iron dependent enzymes. *Hogan (1970)* in his study established the association of iron deficiency with certain epithelial and mucosal changes in infants and children. Koilonychia, angular stomatitis and glossitis have been noted in cases of children with iron deficiency.

ICMR (1986) reported that in subjects who have levels of haemoglobin below 10g/100ml both the cell mediated immune response and the bactericidal capacity of leukocytes showed impairment. *ICMR (1986)* has also illustrated that cell mediated immune response was impaired in children suffering from iron deficiency anaemia. *Levi et al* in *(1970)* observed that in case of anaemic children, the subnormal serum concentrations and blood folacin activity were found to be 41 and 53 per cent.

Kripke and *Sanders (1970)* reported that hypochromic red cell is a characterization of iron deficiency. *Pollitt* and *co-workers (1978)* studied anaemic and normal children of which the iron deficient group had a mean haemoglobin level of 10.5g/dl while the iron sufficient group had a mean haemoglobin level of 12g/dl. The groups differed in the fact that the iron deficient group had hypoferremia. According to *Opoenheimer (1981)* there is now a general agreement that the combination of anaemia, low serum ferritin and an additional laboratory abnormality (MCV, transferrin saturation or protoporphyrin) constitutes a strong evidence of iron deficiency. A low serum ferritin by itself merely indicates low iron reserve.

In an experiment conducted by *Jerry et al (1981)* initial screening for anaemia was performed on a capillary blood sample in 800 apparently healthy two years old and 26 per cent had a low haemoglobin or MCV below the estimated 10th percentile of normal.

Hancock and Harrison (1982) suggest the serum ferritin utility as a measure of latent iron deficiency. As revealed by *Cook (1982)* serum ferritin has been suggested as a sensitive indicator of iron status as it reflects the storage iron.

Gopaldas et al (1983) has reported that blood lactate level is sensitive parameter for evaluating the impact of iron supplementation on physical work capacity. In the study of 467 healthy born infants by *Jerry (1984)* seen for routine one year health maintenance examination, he determined the influence of mild prior infection on the concentration of haemoglobin and other laboratory evidence of iron deficiency. According to *Carol (1984)*, in the case of children with anaemia, assay of serum components indicated that α - antitrypsin and α_2 macroglobulin levels were normal and slightly elevated. However there was a markedly elevated activity of an elastase like serum enzyme.

The haemoglobin levels according to *Rajajee (1989)* for characterisation of anaemia recommended by a WHO group of experts on nutritional anaemia for children between six months and six years is below 11g /dl.

Sarala (1989) had revealed that the estimation of haemoglobin, serum iron ,transferrin saturation and Total Iron Binding Capacity of the serum are useful investigations to confirm the extent of iron deficiency. Serum iron is used as the parameter to assess iron stores. *Leela Raman (1991)* has reported that serum ferritin levels have been found to be proportional to the size of the body iron stores and thus reflects iron stores. Serum ferritin level of 12 μg/dl is considered as indicative of depleted iron stores and a level between 12 to 20 μg/dl as latent iron deficiency.

Mauer (1969) revealed that the iron deficient infant is typically characterized as "irritable" and demonstrating "a lack of interest in surroundings". These characteristics are believed to disappear within several days of the institution of iron therapy, thus preceeding any significant rise in haemoglobin level. Only proven way through which anaemia can be alleviated is to increase the iron intake either by providing medicinal iron supplementation or by increasing the intake of iron rich foods like spinach, amaranth and drumstick leaves which contain high amount of iron which will help in treating anaemia which is one of the biggest public health problems of India today. Recommendation as iron therapy include promotion of breast feeding, delaying the introduction of cow's milk until six months old, improvement in hygiene, use of iron supplements and food fortification.

WHO (1980) reported that industrialised countries have successesfully prevented iron deficiency by administering oral iron supplements or by fortifying with an iron compound in widely consumed foods. Iron depleted and iron deficient anaemic preschool children face functional consequences. Supplementation with 10 mg iron sulphate per kg body weight for three months resulted in an apparent improvement in anaemic subjects hematological status and learning achivement scores.

Seshadri and Gopaldas (1989) reported the impact of iron supplementation on school children of various ages and both sexes through various studies. The first study investigated impact of iron and folic acid supplements for sixty days on cognition in 94 boys and girls aged five to eight years. Improvement in total scores of anaemics was significantly higher than the non-anaemics in seven to eight years.

The second study assessed impacts of supplementation on cognition in 14 pairs of five to six years old anaemic boys with clear beneficial effects on cognitive function.

A report in the American Journal of Clinical Nutrition by *Ronal (1978)* revealed that iron supplements given for three months improved the performance on achievement tests of anaemic children. According to *Hogan (1970)*, the various epithelial and mucosal changes associated with iron deficiency showed rapid clinical improvement following iron therapy. *Basta et al (1974)* have reported that the iron supplementation in addition to improved haemoglobin concentration, significantly improves the serum iron levels.

Oski and *Honig (1983)* demonstrated that iron deficient and anaemic infants of 9 to 26 months of age had increased mental development index scores within 5 to 8 days. After intramuscularly administered iron therapy the treated group beacame more alert and responsive and showed improvement in tests of gross and fine motor-coordination. In an attempt to examine the relationship between iron deficiency and behaviour in human subject, *Honig (1978)* performed a study that demonstrated that iron deficient infants when treated with iron showed a significant increase in their scores on the Bayley Scales of Infant Development within five to seven days of therapy. *Oski and Honig (1978)* also further reported that iron deficiency in infants and children produced developmental alteration and these changes following iron therapy.

Sheshadri (1984) found that iron-supplementation not only raised haemoglobin level but also the work performance. According to a recent publication by *Walter et al (1983)*, after a trial of orally administered iron therapy, the anaemic group showed improvement and the control group did not. A study conducted by *Vijayalekshmi* and *Selvasundari (1983)* reveals that iron-supplementation is an effective way of combating anaemia and for increasing the work output of the population. Reports published by *Nutrition Reviews (1983)* were also on the same line.

Lars and Ragnor (1984) has reported that iron supplementation is universally recognized as a means of preventing late anaemia in pre-term infants. A common recommendation is to start oral administration of iron at the age of 6 weeks and to continue for 6 months. The accepted regimen is ferrous succinate with ascorbic acid in a daily dose of about 10 mg elemental iron. *Pollit et al (1985)* presented results on the positive effects of iron supplements on cognitive performance in Egyptian children with anaemia. A report in the Indian Journal of Nutrition and Dietitics *(1986)* revealed that ability to perform an activity under resistance for an increased amount of time in all groups after supplementation may be due to iron supplementation. In all groups, the energy expended was more before supplementation and the same decreased after supplementation. A study conducted by *Agarwal et al (1989)* revealed that children receiving iron supplementation showed marginal increment in full scale, verbal and performance IQ. It appears that nutritional supplementation is beneficial for better school attendance and reduction in dropout rate and it also improves intelligence and cognitive function to a marginal extent.

2.4. Consequences Of Anaemia

It has been reported by *Patiroglu and Dogan (1991)* that patients with iron deficiency anaemia complained of fatigue, weakness and lack of ability to concentrate. These clinical reports further indicated that they were irritable and anorexic. According to *De Maeyer (1989)*, the major signs and symptoms of anaemia include pallor of the skin and of the conjuctiva, fatigue, shortness of breath, and lack of appetite most of which are non-specific and difficult to detect.

Chavez et al (1974) reported that poor nutritional status affects social, physical and intellectual development of an individual. According to *Marian (1989)* mild to moderate malnutrition does appear to affect the child's development adversely even when other environmental characteristics, which also relate to development are considered.

In a report in the Journal of Pediatrics*(1989)*, severe malnutrition during the early years of life is associated with retarded physical and mental development and behavioural disturbances that persist into adult life. Futhermore severe malnutrition has a detrimental effect on the child's development beyond the effects of social and cultural deprivation that typically accompany it. Other studies show lower IQ scores among more malnourished individuals within quartile groups and significant relationships between nutritional indices and cognitive, motor and behavioural outcomes even after the effects were co-varied or held constant by partial correlation methods.

Monckeberg (1972) stated that poor nutritional status and socio-cultural factors are reflected in poor mental performance. *Klein et al (1972)* was of the view that there is a close relationship between malnutrition and cognitive development. *Sulzer* and his associates*(1973)*, in their study of 4 to 5 year old black children observed that the anaemic subjects had lower scores on IQ tests, vocabulary tests and measure of latency and associative reactions.

ICN (1992) has reported that iron deficiency in infancy and childhood can impair learning and the ability to resist diseases. Malnutrition affects the growth of the brain, the most vital organ in the body if it occurs during the period of rapid brain growth *(Sathi et al, 1991)*. Performance of malnourished children is reported to be poor in a variety of intelligence tests than normal children *(Sarala, 1990)*. *Waterlow et al (1980)* showed that malnourished children did not perform well on verbal tasks. In a study conducted by *Nuruga (1988)* he has reported that preschool children who were hospitalised for severe malnutrition at the age of 1 to 3 years, had affected short-term memory with specific reference to visual memory tests.

A report by *Ronal (1978)* in the American Journal of Clinical Nurition has revealed that iron deficiency anaemia affects children's ability to concentrate and thus their performance on achievements tests. He has concluded that iron deficient anaemic children do not perform as well as their non-anaemic peers on scholastic achievments. The findings on memory tests by *Nair (1978)* indicates that nutrition had significant effect on immediate and delayed memory, however it was of marginal degree. Studies about the effects of iron deficiency anaemia on human behaviour conducted by *Patiroglu* and *Dogan (1991)*, has focussed on alternation in mental and psychomotor developmental indices. In this experiment, working efficiency of children show that iron deficiency anaemia might adversely affect the cognitive development, performance and behaviour.

According to observations of *Upadhyay* and *coworkers(1989)*, variation in the degree of chance in visual motor co-ordination of malnourished children depends upon the grade of malnutrition. They are also in consonance with the findings that malnourished children performed poorly in visual perception and motor co-ordination compared to normal children. Anthropometric measurements such as Somatic Quotient(SQ), Development Quotient(DQ), Motor Quotient(MoQ) and Mental Quotient(MeQ) in 136 children of 1 to 3 years with varying degrees of malnutrition were compared by *Sathi* and *co-workers(1991)*, with an equal number of comparable well-nourished children. There was a progressive reduction in SQ, DQ, MoQ and MeQ as the degree of malnutrition advanced. There was a direct linear correlation between height and DQ in 4^0 protein-energy malnutrition.

In a comparative study of temperament and intelligence by *Savitha (1990)* in groups of mentally retarded and normal children; it was found that mentally retarded children who also had excess of psychopathology in them, showed greater signs of difficult child temperament. Relationships between intelligence and emotionality varible of temperament was linear and positive in the mentally retarded children. This study generates the hypothesis that negative mood may be temperamental and correlated with mental retardation.

Morality et al (1966) observed that the young child's reactions to testing were typically determined by a capacity to handle new people, places and things and by the ability to use the examiner for support and reassurance. Thus for some children, formal and somewhat rigid testing procedures are always exceedingly disagreeable and uncomfortable. They reported that cognitive deficiency appeared to accompany discomfort to varying degrees and concluded that children's IQ as well as their qualitative handling of tests varied in relation to the extent to which they could "bind, defend against, or compensate for the anxiety they experienced.

Howell (1971) reported that anaemic, iron deficient 3 to 5 year olds displayed decreased attentiveness, narrow attention span and perceptual restriction.

An activity-attention scale was incorporated into the Pediatric examination of educational readiness by *Judith* and his associates *(1981)* to determine whether performance of age appropriate tasks would elicit or provoke attentional weakness or activity level modulation in a sample of kindergarten children. This study underscores the variability and complexity of attention and activity findings and confirms the need for direct observation as well as integration of information from all available sources.

Lozoff et al *(1982)* investigated the effect of iron deficiency and iron deficiency anaemia on the Bayley Scales of Infant Development Scores (motor and mental scales) in infants 6 to 34 months of age and found that anaemic infants showed deficit in both mental and motor development indices.

According to *NIN* reports *(1990)* in a pilot study undertaken on a sample of 123 rural preschool (3 to 5 years) children, the psychosocial developmental test battery which was standerdized was used for assessment of development. The well-nourished children attained higher scores than the under-nourished children irrespective of their participation in the various developmental programmes.

Physical work capacity can be defined as the potential of an individual to engage its activities involving muscle action . A reduction in haemoglobin concentration during anaemia decreases the oxygen carrying capacity of the blood which may reduce oxygen delivery to the tissues during exercise.

According to *Intenational Nutritional Anaemia Consultancy Group (1977)*, nutritional anaemia in view of its high prevalence in developing countries assumes great importance as a factor that may limit physical work capacity of individuals. *Nutritional Reviews (1983)* has reported that iron deficiency anaemia is a major concern in many developing countries, as severe anaemia is claimed to impair work capacity, learning ability and immune functions.

Ozorio (1984) noted that 230 million people in the third world suffer from nutritional anaemia and this mild or moderate anaemia impairs the well-being, reduce the maximal work capacity and the work performance. *Wheeler and Tan (1983)* have the view that the nutritional status of an individual has a direct and identifiable effect on his or her productivity at work.

Devadas et al *(1988)* has revealed that non-anaemics expended less energy than anaemics for the same activity. According to *Nair (1990)* iron deficiency anaemia, apart from its other metabolic effects, including those on immuno-competence, impairs physical stamina and working efficiency. *Ghosh (1987)* has stated that anaemia has a profound effect on health, it lowers resistance to fatigue and decreases and affects working capacity.

Bhatia (1987) found that anaemic children were to use higher heart rates than normal children for the same level of work and had poor endurance capacity. *Sheshadri (1984)* indicated that the aerobic capacity is reduced in anaemic children which would lead to early fatigue.

Vijayalekshmi and *Selvasundari (1983)* has stated that iron deficiency anaemia affects the physical work capacity by reducing the availability of oxygen to the tissues, which in turn affects the cardiac output. Studies conducted by *Gardner et al (1977)* indicated that subjects with lower haemoglobin concentration had a lower work capacity. *Edgerton et al (1981)* have reported that work tolerance is related to haemoglobin concentration irrespective of the adequacy of stored iron. *Dhira et al (1981)* have found that subjects with low haemoglobin and high serum iron, work longer than those with low haemoglobin and low iron.

Iron, 30 to 40 mg given daily for 60 days to under privileged children with initial haemoglobin 10.7 g/100 ml, significantly reduced concentration of lactate in blood and improved work capacity and in those with haemoglobin 11.5 g/100 ml, the improvement in work capacity was greater as studied by *Gopaldas (1985)*.

Recent evidences by *Seibel (1986)* suggest that children with iron deficiency and iron deficiency anaemia experience aberration in attention, cognitive function, activity level and ultimately diminished capacity to learn which may be permanent changes that occured in the brain because of nutritional restrictions that occured during the vulnerable period of brain growth.

METHODOLOGY

METHODOLOGY OF THE EXPERIMENT

An investigation on **"Iron deficiency and behaviour pattern in preschool children"** was carried out to assess the daily iron intake of preschool children and to ascertain the possible role of iron deficiency on the intellectual behaviour development in these children.

3.1. Selection Of Sample

An ICDS block of Thiruvananthapuram district was selected and Anganwadi units coming under this block, which is the nucleus at the grass root level for the implementation of preschool component of ICDS program was approached for selecting the samples needed for the study. Fifty preschool children from the low income strata were selected at random for the study.

3.2. Plan Of Action

The plan of action of the present study comprised of:

a. Assessing the biochemical/cellular evidence for iron deficiency in the blood profile of the fifty preschool children selected, through suitable laboratory techniques.

b. Based on the above findings, grouping the sample as, children with optimum (normal) serum iron profile and children with evidence of iron deficiency.

c. Determining the daily iron intake of children by analysing the iron content in the cooked food consumed by them through standard laboratory techniques.

d. Determining the behaviour development of the children with reference to "discrimination learning" and "short term memory" using Raven's intelligence scale for children.

e. Ascertaining the association between iron status and behavioural development in these children.

3.3. Selection Of Tools And Conduct Of The Study

Internationally accepted tools and techniques were selected to determine the socio-ecomomic and dietary pattern of the children and blood profile of the children and their behavioural development as detailed below:

3.3.1. Socio-economic and dietary profile of the children

A suitably structured pre-tested schedule was used through oral questionnaire method to elicit information on the socio-economic background and dietary pattern of the child with reference to the type of family, family size, number of children in the family, maternal health status during pregnancy, birth weight of the child and dietary habit and meal pattern (Appendix-I).

The mother of the child was interviewed to whom the investigator presented each item by means of specific questions and continued the dialogue until sufficient information is gathered to satisfy the research objectives as instructed in the techniques fabricated by *Charles* and *Kaln (1968)* and *Bass et al (1979).*

3.3.2. Anthropometric measurements

The anthropometric measurements including the present head circumference and chest circumference were also assessed by using a plastic tape.

The head circumference to chest circumference ratio is important as it helps to assess the extent of malnutrition prevailing in the child in early ages *(Hutchison, 1981).*

Measuring Head Circumference

Measuring Chest Circumference

3.3.3. Food intake by the children

After reviewing the methods recommended by *Mary (1985)*, dietary recording and recall interviews were selected for the present study to determine the quantity of foods consumed by the children by one day recall method. An equal share of cooked food was collected from the houses and the iron content of the food was determined by the Wong's method *(NIN, 1991)* (Appendix-II).

3.4. Blood Profile Of The Children

The blood profile of the children were determined by estimating Haemoglobin , Total Iron Binding Capacity (TIBC) and Corpuscular Volume . These parameters were chosen because they would help to confirm the extend of iron deficiency as reported by *Rajajee (1985)*.

Estimation of Iron Binding Capacity is also expected to give a clear picture of iron balance status of an individual as explained by *Mudaliar* and *Krishna Menon (1987)*. According to *Soof (1967)*, haemoglobin levels are satisfactory indices, for detecting iron deficiency. *Soof (1981)* further explains that estimation of total quantity of iron in serum after complete saturation of transferrin is useful in finding out iron deficiency status of an individual.

The Mean Corpuscular Volume (MCV) gives an estimate of the mean cell size *(Hutchison, 1984)*. In anaemia, the mean cell size is reduced and in iron deficiency the mean corpuscular haemoglobin content is reduced because the red cells are smaller than usual *(Chatterjee, 1984)*.

Blood Collection A

The haemoglobin content of blood was estimated by the cyanmethaemoglobin method among the 50 preschool children *(Dacie et al, 1975)* (Appendix-III).

The estimation of Total Iron Binding Capacity in serum was carried out by Magnesium Carbonate method (Appendix-V).

The Mean Corpuscular Volume is derived by relating the red cell count to the haemoglobin and packed cell volume *(NIN,1990)*.

$$\textit{Mean Corpuscular Volume} = \frac{\textit{Packed Cell Volume in } 1000\,ml}{\textit{Red Blood Cell count in } mm^3}$$

3.5. Behavioural Development Of The Child

The behavioural development with reference to discrimination learning and short term memory was assessed using the Raven's Scale for preschool children. This test was adopted since it was a standardised and internationally accepted one.

The test was conducted by exposing the child to various questions and figures, the answers to which were recorded. The respective scores for the responses were given. Iron deficiency reduced the attention span as evidenced by *Sulzer (1973)*. The scores were rated, the rating being as follows:

80 - 100% - normal children (good scores)
60 - 80% - Slightly anaemic (fair scores)
less than 60% - anaemic (poor scores)

Applying Intelligence Test A

3.6 Association Between Iron Status And Behavioural Development

The iron status of the child may have a forceful impact on his/her behavioural development. It has been reported by *Oswella (1971)* that anaemic, iron deficient 3 to 5 year old children displayed decreased attentiveness, narrow attention span and perceptual restrictions. *Sulzer* and his associates *(1973)* in a study of 4 to 5 year old children observed that anaemic subjects had lower scores on IQ tests, vocabulary lab and measures of latency and associative reactions.

Hence correlation between iron status and scores obtained for behaviour development was worked out.

The data collected were analysed and interpreted using suitable statistical techniques as explained by *Gupta (1985)*

3.7. Statistical Analysis

Analysis of variance was performed to study the effect of age, normal versus iron deficient group and the interaction of these two factors.

ANOVA TABLE

Source	Degree of freedom
Age group (A)	2
Normal vs Iron deficient (B)	1
A x B	2
TOTAL	49

Wherever the F value is found to be significant at 5 % and 1 % level of significance, * and ** is marked and 'ns' for insignificant

RESULTS AND DISCUSSION

The present study entitled , **"Iron deficiency and behaviour pattern in preschool children"** was conducted to assess the possible role of iron deficiency in the intellectual behaviour development in fifty (50) preschool children in an ICDS block of Thiruvananthapuram district. Among these, 25 children were normal and the remaining 25 were iron deficient. The results obtained are presented under the following sections.

4.1. Health Profile Of The Preschool Children

4.2. Dietary Profile Of The Preschool Children

4.3. Behaviour Profile Of The Preschool Children

4.4. Blood Profile Of The Preschool Children

4.5. Association Between Iron Consumption And Blood Profile

4.6. Association Among Different Blood Parameters

4.7. Association Between Iron Status And Behavioural Development In Preschool Children

4.1. Health Profile Of The Preschool Children

Health profile of the children are reported to be generally influenced by various factors like type of family, family size, maternal health status during pregnancy and birth weight of the child.

4.1.1. Social profile of the families

Social profile of the families in this study was assessed mainly related to its size, type and number of children.

Increased family size may adversely affect the nutritional status of every member of the household including preschool children. *Devadas et al (1980)*, had reported this variable to be an important factor influencing the development of children in all respects. Higher occurrence rate of school-dropouts and poor scholastic achievements among children were also reported from families of large size *(Rao et al, 1993)*.

TABLE 1. PERCENTAGE DISTRIBUTION OF FAMILIES ACCORDING TO FAMILY TYPE AND SIZE

Type Of Family	DISTRIBUTION BASED ON FAMILY SIZE			
	1 TO 3 Members	3 TO 5 Members	5 TO 7 Members	Total
Nuclear	9 (18)	20 (40)	---	29 (58)
Joint	---	---	21 (42)	21 (42)
				50 (100)

(Numbers in parenthesis indicate percentage)

With social changes more number of nuclear families have emerged which has affected the life style of families both in rural and urban sectors. In the present study, (Table-1) 58 per cent of the families were found to be of the nuclear type and 42 per cent were of the joint type. Among the nuclear families, about 18 per cent were small-sized with 2 to 3 members and 40 per cent of the families were medium-sized with (3 to 5) members. In the case of joint families, all the families were large-sized with 5 to 7 members.

Several studies conducted in Kerala revealed that the nuclear type families were more popular in the State and these families are considered to be generally better off than the joint type, for the healthy development of the child *(Saxena, 1986)*. However, *Yasoda (1990)* in her study among preschool children had observed that children from joint families were better off in nutritional status.

4.1.2. Maternal status and birth weight of children

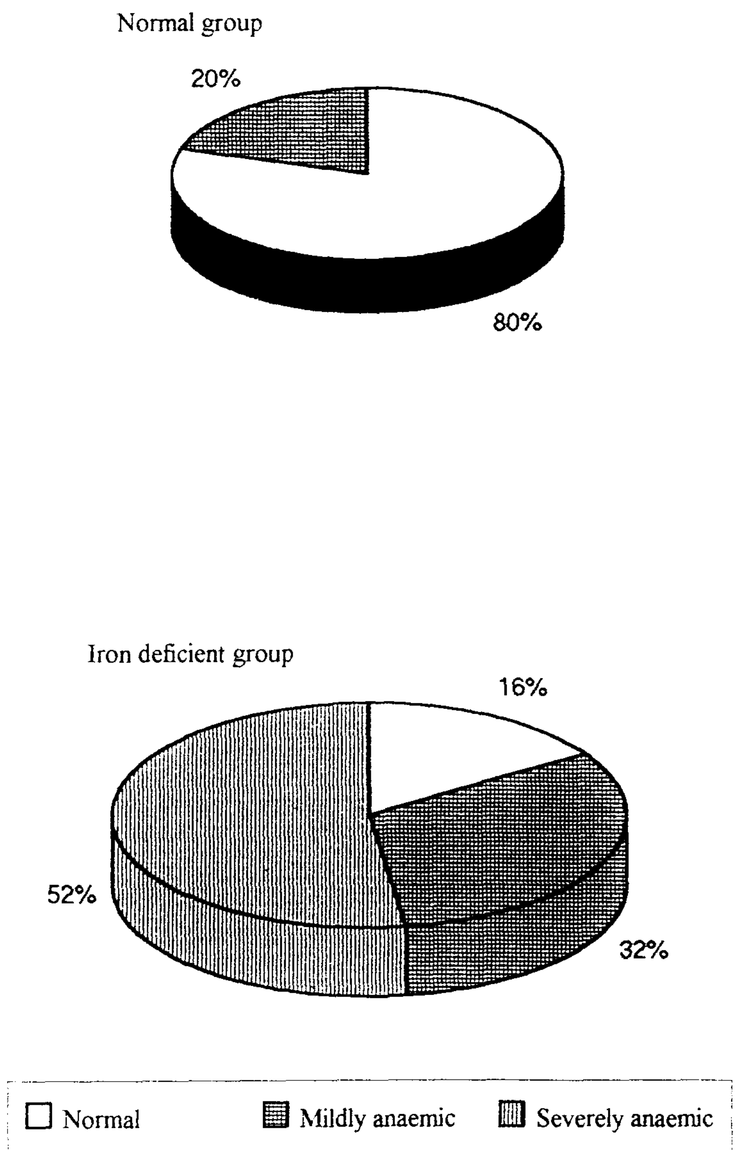
Earlier studies have revealed that the maternal status during pregnancy does affect the health status of the children *(Hutchison, 1984)*. A study conducted by *Kripke* and *Sanders* (1986) reveals that children born to anaemic mothers had possibilities of developing iron deficiency.

According to *Devadas (1984)*, the birth weight influences the health of the child in the future. Similar results were reported by *Sanders (1986)* who observed that children born to anaemic mothers had possibilities of being low birth weight babies.

Individual birth weights of the children are presented in Appendix - VI, and a comparison of the birth weight of the children with maternal status is presented in Table -2.

As depicted in the table, 48 per cent of the mothers were normal healthy women while there were an equal percentage of mildly anaemic (26 per cent) and highly anaemic mothers (26 per cent). In the normal group 80 per cent of the mothers were not anaemic during pregnancy while the remaining 20 per cent were mildly anaemic. However, in the iron deficient group, 52 per cent of the mothers were highly anaemic during pregnancy and 32 per cent were mildly anaemic. Only 16 per cent mothers were normal healthy women. The results further indicate that in the normal group, 48 per cent of the children born to non-anaemic mothers had birth wieghts, in the range of 3 to 3.8kg. While 32 per cent of the children had brith weight, in the

Fig. 1
MATERNAL STATUS DURING PREGNANCY



range of 2 to 2.9kg, 12 per cent of the children borne to mildly anaemic mothers had birth weights in the range of 3 to 3.8Kg and for 8 per cent in the same anaemic state it was in the range of 2 to 2.9kg.

TABLE 2. INFLUENCE OF MATERNAL STATUS ON THE BIRTH WEIGHT OF THE OFF-SPRING

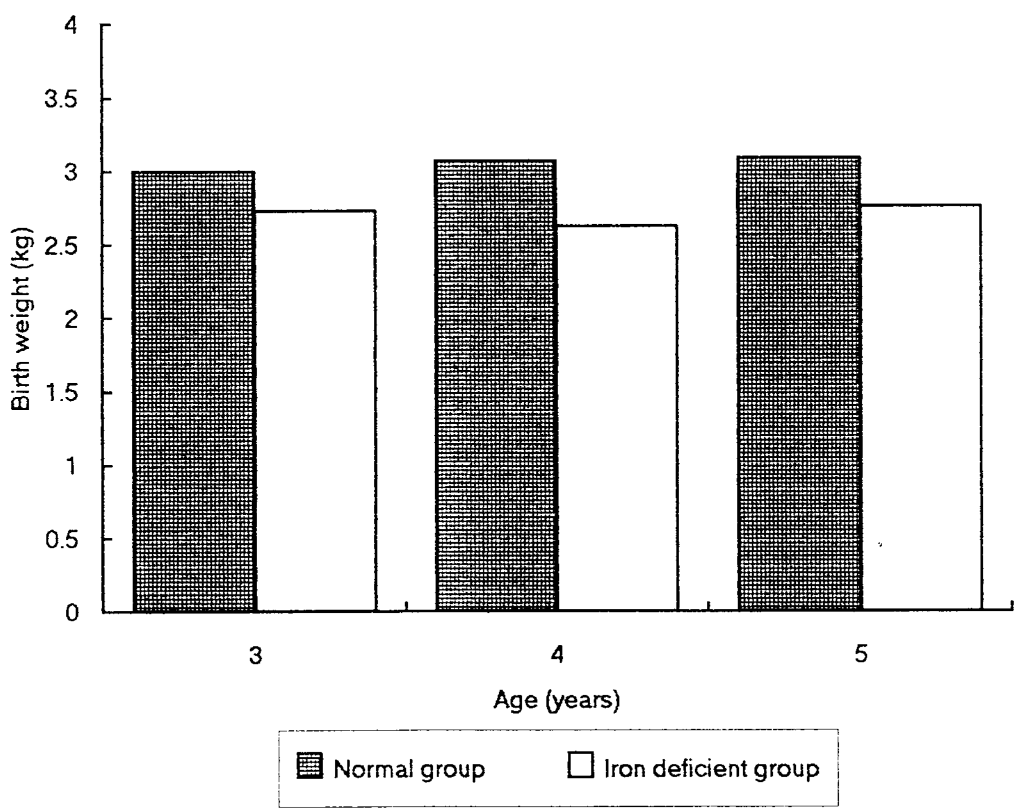
Maternal Status	Total Number	DISTRIBUTION OF THE FAMILIES					
		Normal group			Iron deficient group		
		2 TO 2.9 Kg	3 TO 3.8 Kg	TOTAL	2 TO 2.9 Kg	3 TO 3.8 Kg	TOTAL
Normal	24 (48)	8 (32)	12 (48)	20 (80)	1 (4)	3 (12)	4 (16)
Mildly anaemic	13 (26)	2 (8)	3 (12)	5 (20)	5 (20)	3 (12)	8 (32)
Severely anaemic	13 (26)	---	---	---	13 (52)	---	13 (52)

(Numbers in parenthesis indicate percentage)

In the case of iron deficient group all the children (52 per cent) born to highly anaemic mothers had birth weight in the range of 2 to 2.9Kg. Only 12 per cent of the children borne to mildly anaemic mothers had 3 to 3.8Kg while 20 per cent had it from 2 to 2.9Kg. In the case of the children born to normal healthy mothers, 12 per cent had birth weight between 3 to 3.8kg. while only a single child had 2 to 2.9Kg. This reinforces the fact that children with low birth weights were born to a majority of anaemic mothers.

Considering the various socio-economic variables in the case of birth weight there was no significant difference among different age groups of the children as revealed in Table - 3. Meanwhile the birth weight of the children belonging to normal group was significantly higher than their counter parts in the iron deficient group and the percentage difference accounted to

Fig. 2
MEAN BIRTH WEIGHT OF THE RESPONDENTS



about 12.75 per cent. This indicates that children born with lower birth weights had increased chances of getting iron deficiency anaemia.

TABLE 3. MEAN BIRTH WEIGHT OF THE CHILDREN.

Age	Normal group n=25	Iron deficient group n=25	Mean
3 Years	3.00	2.730	2.865
4 Years	3.07	2.625	2.848
5 Years	3.09	2.760	2.925
MEAN	3.05	2.705	

$$Percentage\ difference\ = \frac{3.05-2.705}{2.705} \times 100 = 12.75$$

4.1.3. Physical state of the children

Present physical state of the children was assessed with regard to selected anthropometric measurements such as head circumferance and chest circumference.

The head circumference measurement is believed to give an estimate of the brain size during the early ages *(Hutchison, 1982)*. According to *Nair (1990)*, iron deficiency anaemia during the early years affects the brain development which in turn may hinder their cognitive function and intellectual performance. Head circumference measurements of the children are presented in Appendix - VI and standard values are detailed. in Table - 4.

As revealed in the table, male children (44 per cent) in the normal group had higher values than the standard head circumference values, while 28 per cent had lower values. In the case of female, children 20 per cent had lower values than standard head circumference values and only 8 per cent had higher values. In the iron deficient group, among the male children

Table 4. DISTRIBUTION OF CHILDREN BASED ON THEIR HEAD CIRCUMFERENCE.

Groups	Sex	*Standard Head Circumference	Less Than Standard Values	Greater Than Standard Values	Total
Normal n=25	Male (18)	51.9	7 (28)	11 (44)	25 (100)
	Female (7)	52.4	5 (20)	2 (8)	
Iron-deficient n=25	Male (16)	51.5	10 (40)	6 (24)	25 (100)
	Female(9)	51.1	5 (20)	4 (16)	

(Numbers in parenthesis indicate percentage)

***Source - Swaminathan (1991)**

40 per cent had lower values than standard head circumference values and 24 per cent higher values than standard values. For the female children, 20 per cent had lower values and 16 per cent higher values.

Table-5. MEAN HEAD CIRCUMFERENCE OF THE CHILDREN.

Age	Normal group	Iron deficient group	Mean
3 Years	51.67	51.2	51.44
4 Years	52.1	51.25	51.68
5 Years	52.4	52	52.2
Mean	52.06	51.48	

$F(A) - 1.433^{ns}$

$F(B) - 2.658^{ns}$

Statistical analysis of the data revealed that there was no significant difference among the various age and sex groups and also between the normal and iron deficient groups (Table - 5).

The chest circumference measurements gives an estimate of the extent of wastage of muscles *(Nair 1990)*. Appendix VI gives details of the chest circumference measurements of children and standard values are presented in Table-6.

Table 6. DISTRIBUTION OF CHILDREN BASED ON CHEST CIRCUMFERENCE

Groups	Sex	*Standard	Less Than Standard Chest Circumference	Greater Than Standard Chest Circumference	Total
Normal group n=25	Male (18)	58.7	8 (32)	10 (40)	25 (100)
	Female (7)	60	3 (12)	4 (16)	
Iron deficient group n = 25	Male (16)	57.1	9 (36)	7 (28)	25 (100)
	Female (9)	55.2	5 (20)	4 (16)	

(Numbers in parenthesis indicate percentage)

***Source - Swaminathan (1991)**

In the normal group, 40 per cent of the male children had greater than standard chest circumference values. While 32 per cent had lower values when compared to standard values. In the female children, 16 per cent had chest circumference values above standard while 12 per cent had lower values. In the iron deficient group among the male children, 36 per cent had lower values than standard while 28 per cent were above the standard chest circumference values. For female, 16 per cent had higher chest circumference values than standard, while 20 per cent had lower values.

TABLE 7. MEAN CHEST CIRCUMFERENCE OF THE CHILDREN.

Age	Normal group	Iron deficient group	Mean
3 Years	61.1	58	59.55
4 Years	57.3	56.8	57.05
5 Years	56.71	55.75	56.23
Mean	58.37	56.85	

F(A) - 2.495^{ns}

F(B) - 7.16^{*}

F(AxB)- 0.599^{ns}

$$Percentage\ difference = \frac{58.37-56.85}{56.85} \times 100 = 2.68$$

Statistical analysis revealed that although there was no significant difference among the various age groups, however in between the experimental and control group there was a significant difference which accounted to be 2.68 per cent.

4.2. Dietary Profile Of The Children

4.2.1. Food intake of the respondents

The dietary intake of all the children were assessed by a 24 hour dietary recall method. This survey enables to analyse the quality and quantity of foods consumed by an individual and to locate their adequacy and inadequacy. Their diets were analysed for their constituent's and nutritional composition and compared with their Recommended Dietary Allowance (RDA) suggested by ICMR in 1991.

TABLE 8. AVERAGE QUANTITY OF FOOD STUFFS CONSUMED BY THE CHILDREN.

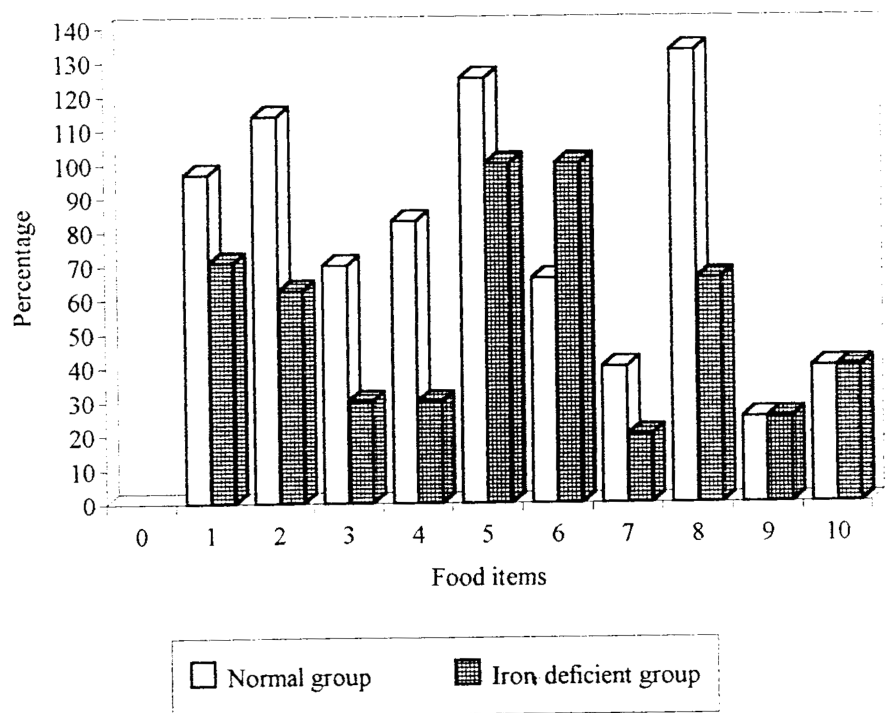
Food items	*R.D.A (g)	NORMAL GROUP		IRON DEFICIENT GROUP	
		Average quantity consumed (g)	Percentage of R.D.A. met	Average quantity consumed (g)	Percentage of R.D.A. met
Cereals	175	170	97	125	71
Pulses	35	40	114	25	62.5
Green Leafy Vegetables	50	35	70	15	30
Other Vegetables	30	25	83	10	30
Roots & Tubers	20	25	125	20	100
Fruits	60	40	66	60	100
Milk	250	100	40	50	20
Fish	30	40	133	20	66
Sugar And Jaggery	40	10	25	10	25
Fats And Oils	25	10	40	10	40

***Source - NIN (1991)**

Details pertaining to the actual quantity of foods consumed by the children, in comparision with the suggested Recommended Dietary Allowance are presented in Table-8. Details pertaining to the food intake of the 50 children are presented in Appendix-VII.

A comparison among the two groups revealed that food items like pulses, roots and tubers and fish, in the case of the normal group were met above the Recommended Dietary Allowances. However, for the children in the iron deficient group, the situation was different since pulses (62.5 per cent of RDA) and fish (66 per cent of RDA) were not fully met. In case of the children in the normal group, cereals (97 per cent of RDA), other vegetables (83 per cent of RDA), green leafy vegetables (70 per cent of RDA) and fruits (66 per cent of RDA) were inadequate to meet the norms suggested for a balanced diet. The diets of children in the iron

Fig. 3
AVERAGE FOOD INTAKE IN TERMS OF R D A



1. Cereals
2. Pulses
3. Green leafy vegetables
4. Other vegetables
5. Roots and Tubers
6. Fruits
7. Milk
8. Fish
9. Jaggery and Sugar
10. Fats and Oils

deficient group were more inadequate in the availibility of cereals (71 per cent of RDA), vegetables (30 per cent of RDA) and fruits (100 per cent of the RDA). Unlike these foods, milk consumption of these children were very poor since only 40 per cent of RDA was met for the children in the normal group while for children in the iron deficient group, 20 per cent of RDA was met for this food. For accessories like sugar, jaggery, fats and oils in diets of children in the two groups were very inadequate, meeting 25 per cent and 40 per cent of the RDA respectively.

4.2.2. Mean nutrient intake of the children

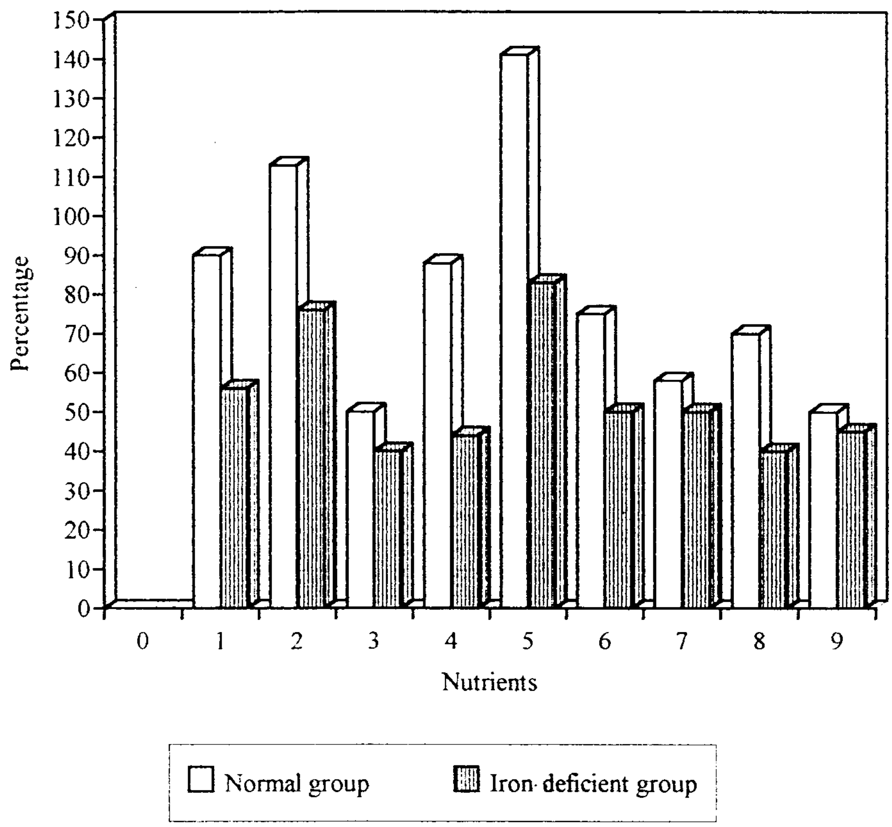
The nutrient intake of the children were computed from the actual quantity of foods consumed and are presented in Table-9 and the information pertaining to individual children are presented in Appendix-VIII.

TABLE 9. MEAN NUTRIENT INTAKE OF THE CHILDREN

Nutrients	*R.D.A	NORMAL GROUP		IRON DEFICIENT GROUP	
		Nutrient intake	Percentage of R.D.A. met	Nutrient intake	Percentage of R.D.A. met
Energy (K.cals)	1,600	1,430	90	906	56
Protein (g)	31	35	113	23.8	76
Fat (g)	20	10	50	8	40
Calcium (mg)	400	350	88	175	44
Iron (mg)	18	26.4	141	15	83
Thiamine (mg)	0.8	0.6	75	0.4	50
Retinol (mg)	400	230	58	200	50
Riboflavin (mg)	0.1	0.07	70	0.04	40
Vitamin C (mg)	40	20	50	18	45

***Source - NIN (1991)**

Fig. 4
MEAN NUTRIENT INTAKE IN TERMS OF R D A



1. Energy
2. Protein
3. Fats
4. Calcium
5. Iron
6. Thiamine
7. Retinol
8. Riboflavin
9. Vitamin C

A comparison between the normal and iron deficient groups revealed that, nutrients like protein and iron for the children in the normal group were adequately met, over and above the RDA where as, for the children in the iron deficient group, only 76 per cent and 83 per cent of RDA for proteins and iron respectively were found to be met. For the children in the normal group, diets were more or less adequate in 90 per cent of the energy requirement, 88 per cent of calcium, 75 per cent of thiamine and 70 per cent of riboflavin. But for children in the iron deficient group, their diets supplied only 56 per cent of energy requirement, 44 per cent of calcium, 50 per cent thiamine and 40 per cent of riboflavin. Children in the normal group obtained 50 per cent of fat needed were as, their counter parts, in iron deficient group, obtained only 40 per cent. Trend for other nutrients like retinol and vitamin C were similar meeting 58 per cent of the former and 50 per cent of the latter in the diets of children of normal group while retinol and vitamin C in the diets of children in the iron deficient group were sufficient to meet 50 and 45 per cent of their requirements respectively.

4.2.3. Food combinations observed in the diets of the children

For the availability of all the nutrients it is necessary to consume a mixed diet consisting of all the basic foods *(Antia, 1989)*. A diet inadequate in the basic foods can adversely affect the nutritional status of the children. *(Robinson, 1985)*.

Table 10 reveals the various food combinations observed in the diets of the children. As depicted in the table, 20 per cent of the children in the normal group had a well-balanced mixed diet consisting of cereals, pulses, fruits,vegetables, milk and animal foods. None of the children in the iron-dificient group was found to consume a mixed diet as such. In the normal group 48 per cent of the children and 32 per cent children in the iron deficient group had a diet consisting of cereals, pulses, vegetable, fruits and milk without animal food. A diet of cereals, pulses, vegetable and fruits was consumed by 24 per cent of the children in the normal group and 36 per cent of the children in the iron deficient group. Cereals and pulses alone were consumed by 8 per cent of children in the normal group and 24 per cent of children in the iron deficient group. A diet consisting of cereals alone was consumed by 8 per cent of the children in the iron deficient group.

TABLE 10. FOOD COMBINATIONS OBSERVED IN THE DIETS OF PRESCHOOLERS

Food Combinations	Normal group	Iron deficient group
Cereal + Pulse + Veg/Fruits + Milk + Other Animal foods	5 (20)	---
Cereal + Pulse + Veg/Fruits + Milk	12 (48)	8 (32)
Cereal + Pulse + Veg/Fruits	6 (24)	9 (36)
Cereal + Pulse	2 (8)	6 (24)
Cereals alone	----	2 (8)
Total	25 (100)	25 (100)

(Numbers in parenthesis indicate percentage)

4.2.4. Available iron in the cooked food given to the children

Cooked food samples from 50 families were collected and dietary iron available in the diets of the preschoolers were determined by Wong's method *(NIN, 1990)* and verified whether the same is in accordance with the Recommended Dietary Allowance of *ICMR (1991)*.

TABLE 11. DISTRIBUTION BASED ON IRON INTAKE OF PRESCHOOL CHILDREN

Food Iron In Ranges (mg)	DISTRIBUTION OF THE CHILDREN	
	Normal group n= 25	Iron deficient group n= 25
8.1 - 16	------	11 (44)
16.1 - 24	10 (40)	14 (56)
24.1 - 32	13 (52)	------
32.1 - 40	2 (8)	------
Total	25 (100)	25 (100)

(Numbers in parenthesis indicate percentage).
Recommended Dietary Allowance (RDA) - 18 mg/day. ***(ICMR - 1991)***

Table 11 depicts the average food iron intake by the preschoolers and the individual data is presented in the Appendix-VIII. In can be observed that, in the case of the normal group, many (52 per cent) children consumed about 24.1 to 32 mg. of iron through their daily diet which was hightly adequate in terms of R.D.A. Daily consumption of iron by 40 per cent of the children were in the range of 16.1 to 24 mg. and about 8 per cent of the preschoolers obtained 32.1 to 40 mg. dietary iron per day. All the children in the normal group were found to consume 16.1 to 40 mg. iron through their diets which was enough to meet their requirements. However, in the case of iron deficient group, about 44 per cent of the children received only 8.1 to 16 mg. of iron which is less than their RDA. About 56 per cent of the preschoolers in this group received 16.1 to 24 mg of iron. The unavailability of iron from the diet as in the case of the iron deficient group could possibly account for the severity of their iron deficiency. According to Agarwal (1991), iron deficiency anaemia is due to inadequate supply of nutrients like iron. The quantity and also quality of foods consumed affect the absorption of iron available through the diet. Dietary factors does play an important role in the development of iron deficiency anaemia in the Indian subjects. Although most habitual diets consumed in different regions of the country contain apparently adequate amounts of iron, the poor absorption of this dietary iron is a serious limiting factor in fulfilling iron requirements.

TABLE 12. AVAILABLE IRON IN THE DIET OF PRESCHOOLERS

Age	Normal group	Iron deficient group	Mean
3 Years	24.70	15.95	20.32
4 Years	24.90	15.63	20.26
5 Years	26.34	15.61	20.98
Mean	25.31	15.73	

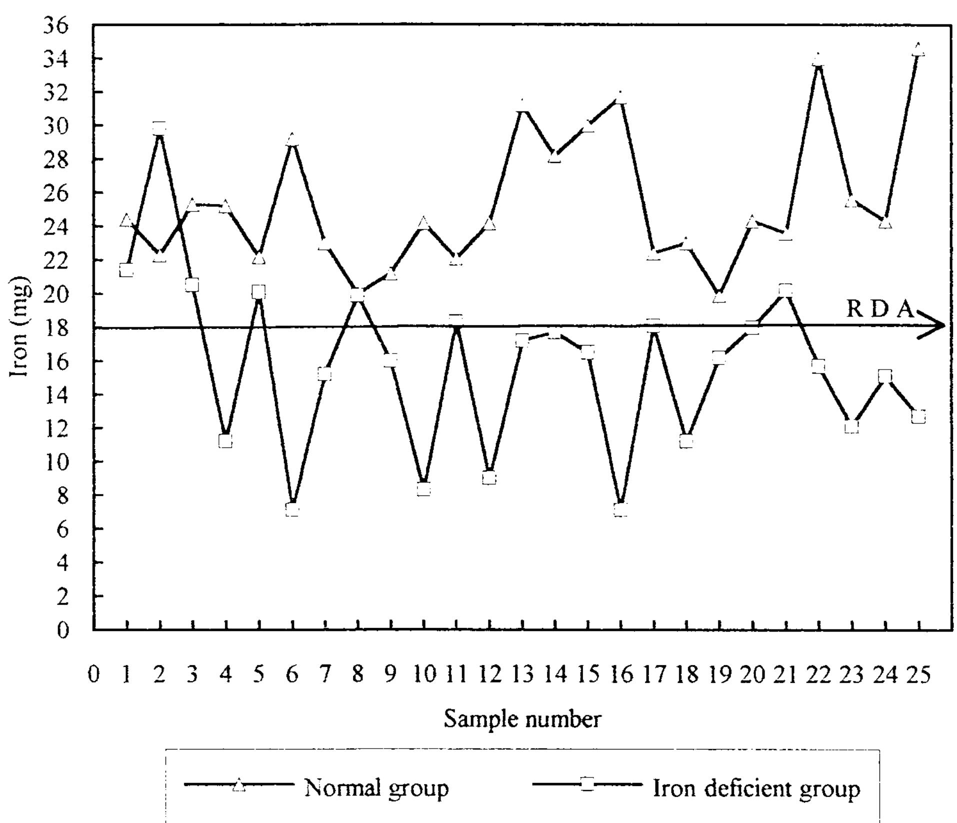
$$\mathbf{F(A) = 1.547^{ns}}$$

$$\mathbf{F(B) = 61.82^{xx}}$$

$$\textit{Percentage difference} = \frac{25.31-15.73}{15.73} \times 100 = 60.87$$

Statistical analysis of the data as depicted in Table-12 has revealed that, in the case of the available iron in the diet of the children surveyed, it was observed that there was no significant difference in the amount of iron available in the diet consumed by the children of three age groups. However there exists a highly significant difference in the iron availability for children in the two groups. The children in the iron deficient group consumed 60.87 per cent less iron when compared to the children in the normal group. This in turn is likely to influence the extent of iron deficiency, which does influence the mental development and performance ability of the children. Dietary profile of the children revealed the adequacy of the diets of the children in the normal group, when compared to the children in iron deficient group, with specific reference to

Fig. 5
IRON INTAKE OF THE PRESCHOOLERS



their balanced diet constituents, nutrients (especially food iron) contributed and various food combinations included in their daily diets.

4.3 Behaviour Profile Of The Children

The behavioural development of the children was assessed with respect to discrimination learning and short term memory. The children were exposed to the Raven's Intelligence scale and their responses were recorded and scored. Individual scores obtained are presented in Appendix IX.

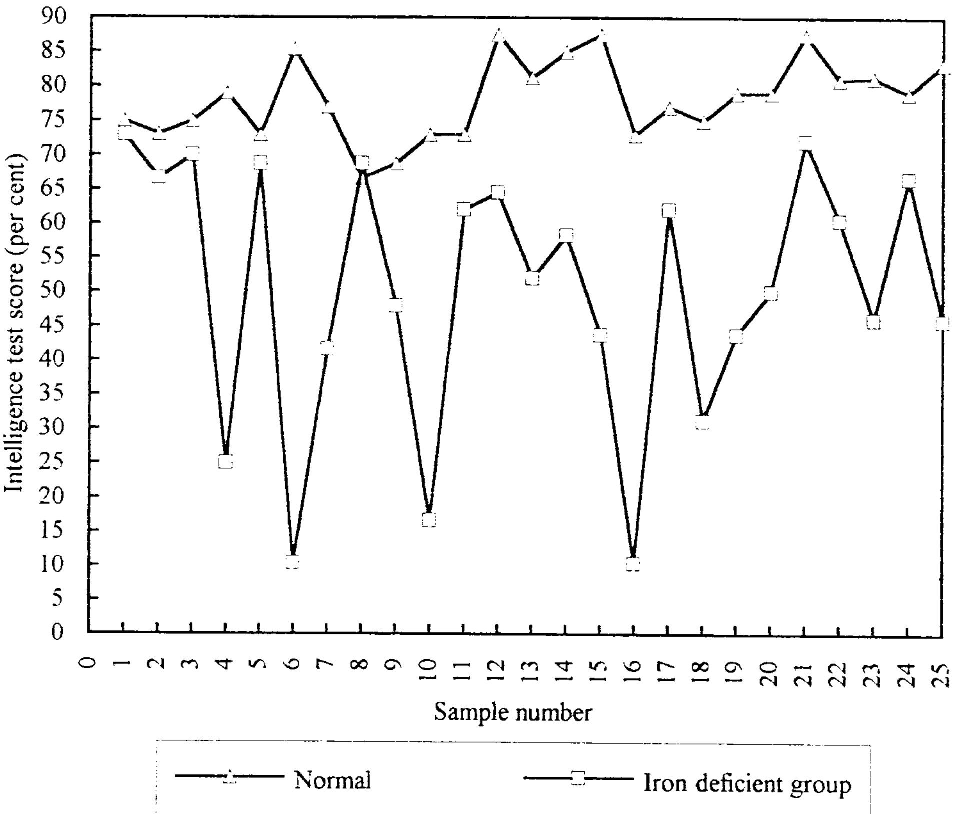
TABLE 13. DISTRIBUTION OF THE CHILDREN BASED ON THE INTELLIGENCE TEST SCORE

Test scores (per cent)	Normal group n=25	Mean	Iron deficient group n=25	Mean
Less than 20	----	----	3 (12)	12.4
20.1 -- 40	----	----	2 (18)	28.1
40.1 -- 60	----	----	91 (36)	47.6
60.1 -- 80	17 (68)	74.8	11 (44)	61.3
Above 80	8 (32)	84.8	----	----
Total	25 (100)		25 (100)	

(Numbers in parenthesis indicate percentage)

Table-13 depicts the mean and the range of intelligence test scores of the preschoolers. In the case of the children from the normal group the scores obtained ranged from 66.6per cent to 87.5per cent where as for the iron deficient group their scores ranged from 10.4 per cent to

Fig. 6
INTELLIGENCE SCORES OF THE PRESCHOOLERS



68.7per cent. The highest score obtained in the former group was 86.4 per cent and the lowest being 66.6per cent, while in the latter group the highest score was 62.6per cent and the lowest 10.4per cent.

As depicted in Table-13, in the normal group, higher per cent of children (68 per cent) were identified to obtain 60.1 to 80 per cent scores followed by 32 per cent scoring in the range above 80 per cent. Similarly, in the latter (iron deficient group) the scores obtained were in four ranges with 44 per cent of children attaining 60.1 to 80 per cent while 36 per cent obtained 40.1 to 60 per cent, 8 per cent obtained 20.1 to 40 per cent and 12 per cent scored only less than 20 per cent. The variation in intelligence test score could be influenced by other socio-economic factors, their living environment, exposure to better nutritional status as evidenced in earlier studies *(Rajajee, 1990)*.

TABLE 14. MEAN INTELLIGENCE TEST SCORES OF THE PRESCHOOLERS

Age	Normal group	Iron deficient group	Mean
3 Years	76.71	48.84	62.77
4 Years	76.54	48.01	62.27
5 Years	80.15	54.94	67.54
Mean	77.80	50.59	

F(A) = 2.21 ^{ns}

F(B) = 45.66^{XX}

$$Percentage\ diffrence = \frac{77.8-50.59}{50.59} \times 100 = 53.76$$

Statistical analysis of the data as interpreted in Table 14 revealed that there was no significant difference in the intelligence test scores of the children in between the age groups. However there was a highly significant difference in the test scores in between the normal group and iron deficient group. The test scores of the normal children were 53.76 per cent higher than that of the iron deficient children.

4.4. Blood Profile Of The Children

The iron status of the preschool children were estimated with specific reference to the biochemical indicators like haemoglobin, serum iron, Total Iron Binding Capacity (TIBC) and Mean Corpuscular volume (MCV). The individual blood profile of the children in the two groups are presented in Appendix X.

4.4.1. Haemoglobin

Details of haemoglobin level of the children belonging two the 2 groups are presented in Table 15. According to *WHO* reports *(1990)*, the haemoglobin level for characterisation of iron deficiency anaemia from 6 months to 6 year old is below 11 g/dl.

As revealed in Table-15, in the normal group 68 per cent of the preschoolers had haemoglobin values from 12.1 to 14 g/dl while 32 per cent of the children had hamoglobin level in the ranges from 14.1 to 16 g/dl. In the iron deficient group, 52 per cent children had haemoglobin values from 8.1 to 10 g/dl. Only 20 per cent of the children in that group had 6.1 to 8 g/dl of haemoglobin and 16 per cent of the children had very low hamoglobin value ranging from 4.1 to 6 g/dl. In this group, only 12 per cent of the children had haemoglobin values in the range 10.1 to 12 g/dl.

TABLE 15. DISTRIBUTION OF THE CHILDREN BASED ON HAEMOGLOBIN LEVELS

Haemoglobin Range (g/dl)	DISTRIBUTION OF THE CHILDREN			
	Normal group n=25	Mean	Iron deficient group n=25	Mean
4.1 -- 6	---	---	4 (16)	4.5
6.1 -- 8	---	---	5 (20)	6.9
8.1 -- 10	---	---	13 (52)	9.2
10.1 -- 12	---	---	3 (12)	10.8
12.1 -- 14	17 (68)	12.7	---	---
14.1 -- 16	8 (32)	14.6	---	---
Total	25 (100)		25 (100)	

(Numbers in parenthesis indicate percentage).

Normal haemoglobin level - 11- 12 g/dl *(WHO, 1991)*

Various studies conducted by *UNICEF (1989)* had revealed that as the haemoglobin values decreased there was an increase in the intensity of iron deficiency anaemia.

The significant difference worked out statistically revealed that for haemoglobin values as presented in Table-16, a significant difference was observed for the various age groups. Similarly a very high difference in haemoglobin values was also observed between the normal and iron deficient group. The haemoglobin values of the normal children were 62.3 per cent higher when compared to iron deficient group.

Fig. 7
HAEMOGLOBIN CONTENT OF THE PRESCHOOLERS

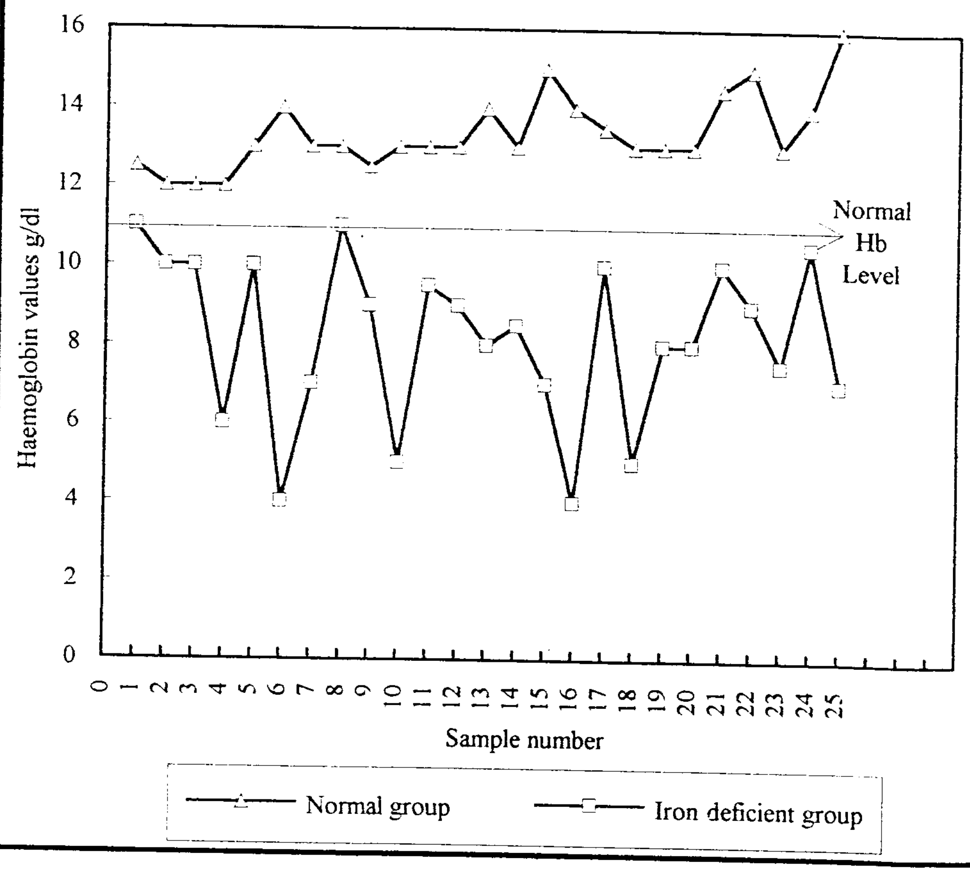


TABLE 16. MEAN HAEMOGLOBIN LEVELS OF THE CHILDREN

Age	Normal group	Iron deficient group	Mean
3 Years	12.58	8.32	10.44
4 Years	13.27	7.62	10.45
5 Years	13.90	8.57	11.23
Mean	13.25	8.16	

F(A) = 4.9958 ^{x}

F(B) = 124.08 ^{xx}

CD (Age, A)

A_1 Vs A_2, A_3 = 0.20

A_2 Vs A_3 = 1.14

$$\textit{Percentage difference} = \frac{13.25-8.16}{8.16} \times 100 = 62.3$$

4.4.2. Mean Corpuscular Volume (MCV)

The Mean Corpuscular Volume (MCV) gives an estimate of the mean cell size and is also a strong evidence of iron deficiency *(Opoenheimer, 1980). Kripke* and *Sanders (1984)* have observed that in iron deficiency anaemia the Mean Corpuscular Volume will be reduced.

From Table 17 it is evident that in the normal group, 64 per cent of preschoolers had MCV values ranging from 91 to 100 μ^3 which is far above the normal value (86 μ^3) while 24 per cent of the children had MCV levels from 71 to 90 μ^3 and few children (12 per cent) had MCV values above 101μ^3. In the iron deficient group many (44 per cent) children had MCV levels from 51 to 70 μ^3 while 28 per cent each had values ranging from 31 to 50 μ^3 and 71 to 90μ^3 respectively. In this group only 28 per cent of the children had MCV values in the normal range (71 to 90 μ^3) against the 64 per cent in the former group.

TABLE 17. DISTRIBUTION OF CHILDREN BASED ON THE MEAN CORPUSCULAR VOLUME.

MCV Ranges ($\mu 3$)	DISTRIBUTION OF THE CHILDREN			
	Normal group n = 25	Mean	Iron deficient group n = 25	Mean
31 -- 50	---	---	7 (28)	40.7
51 -- 70	---	---	11 (44)	58.9
71 -- 90	6 (24)	73	7 (28)	76.4
91 -- 100	16 (64)	95.8	---	---
Above	3 (12)	103	---	---
Total	25 (100)		25 (100)	

(Numbers in parenthesis indicate percentage)

Normal Mean Corpuscular Volume - 86μ^3

Statistical analysis worked out for Mean Corpuscular Volume values revealed in Table-18 reinforces that there was no significant difference in between the various age groups. While the difference between the normal and iron deficient group was very high and it accounted to about 59.3 per cent higher for the normal group.

Fig. 8
MEAN CORPUSCULAR VOLUME OF THE PRESCHOOLERS

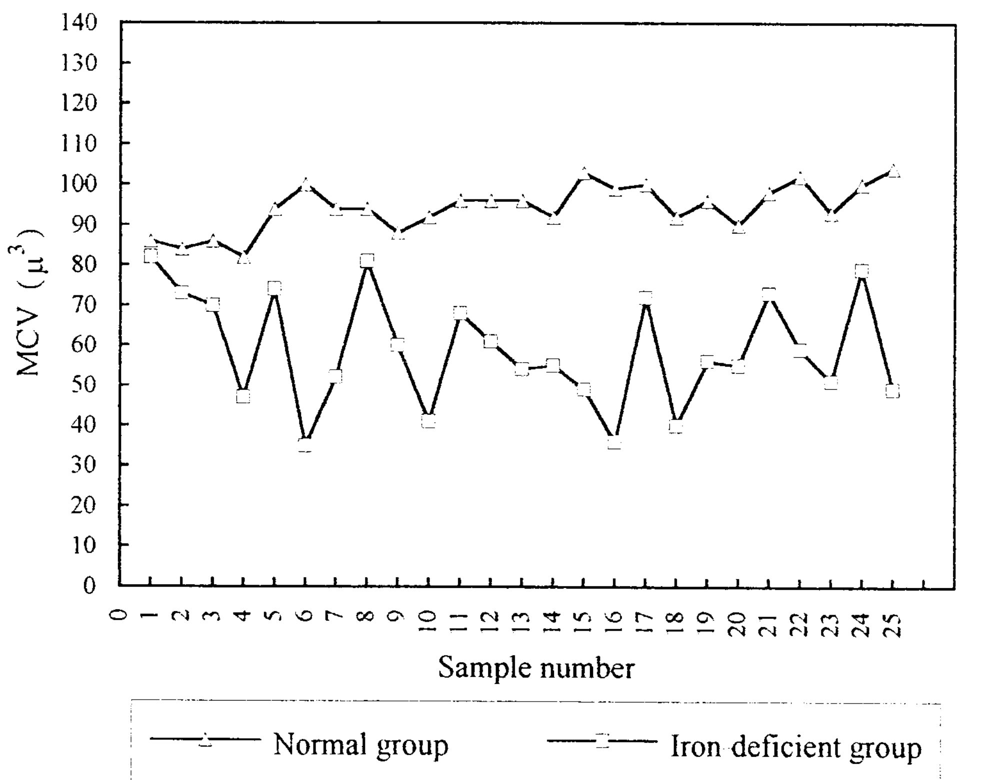


TABLE 18. MEAN CORPUSCULAR VOLUME OF THE PRESCHOOLERS

Age	Normal group	Iron deficient group	Mean
3 Years	88.66	61.50	75.08
4 Years	94.55	54.37	74.46
5 Years	97.40	60.28	78.84
Mean	93.54	58.72	

F(A) = 4.018 ^{ns}

F(B) = 136.9777^{xx}

$$Percentage\ difference = \frac{93.84-58.72}{58.72} \times 100 = 59.3$$

4.4.3. Serum iron

The direct measurement of iron in serum is extremely useful in detecting iron deficiency status.

Few investigators had enlightened about serum iron value in assessing the serum iron profile as a measure of latent iron deficiency *(Sanders, 1982)*. Estimation of serum iron is a useful investigation to confirm the extent of iron deficiency and this is used as a parameter to assess iron stores *(Reeves, 1989)*. Serum iron value is believed to be a satisfactory index for detecting iron deficiency anaemia *(Oski, 1978)*.

As revealed in Table-19, in the normal group 76 per cent of the preschoolers had serum iron levels ranging from 101 to 119 µg/dl which is in accordance with normal levels (80 to130 µg/dl). In the same group 16 per cent of the children had serum iron ranging from 81 to 99 µg/dl while 8 per cent had very high serum iron ranging from 121 to 139 µg/d1.

TABLE 19. DISTRIBUTION OF THE CHILDREN BASED ON SERUM IRON VALUES

Serum Iron Ranges (μg/dl)	DISTRIBUTION OF THE CHILDREN			
	Normal group n=25	Mean	Iron deficient group n = 25	Mean
20 -- 39	---	---	8 (32)	34
40 -- 59	---	---	9 (36)	53
60 -- 79	---	---	6 (24)	69
80 -- 99	4 (16)	95	2 (8)	83
100 -- 119	19 (76)	109	---	---
120 -- 139	2 (8)	126	---	---
Total	25 (100)		25 (100)	

(Numbers in parenthesis indicate percentage)

Normal Serum Iron Value - 80 - 99/μg/dl.

In the case of iron deficient group many (36 per cent) children had 41 to 59 μg/dl of serum iron levels while 32 per cent had very low serum iron values of 20 to 39 μg/dl. Among these children, 24 per cent had serum iron in the ranges of 60 to 79 μg/dl. Only 8 per cent of the children in this group had serum iron levels in normal ranges (80 to 99 μg/dl).

Statistical analysis of serum iron levels is also presented in the Table-20. There was a significant difference in between the various age groups and also in between the normal and iron deficient groups. Children in the normal group had 103.5 per cent higher serum iron values when compared to their counter parts in the iron deficient group.

Fig. 9
SERUM IRON CONTENT OF THE PRESCHOOLERS

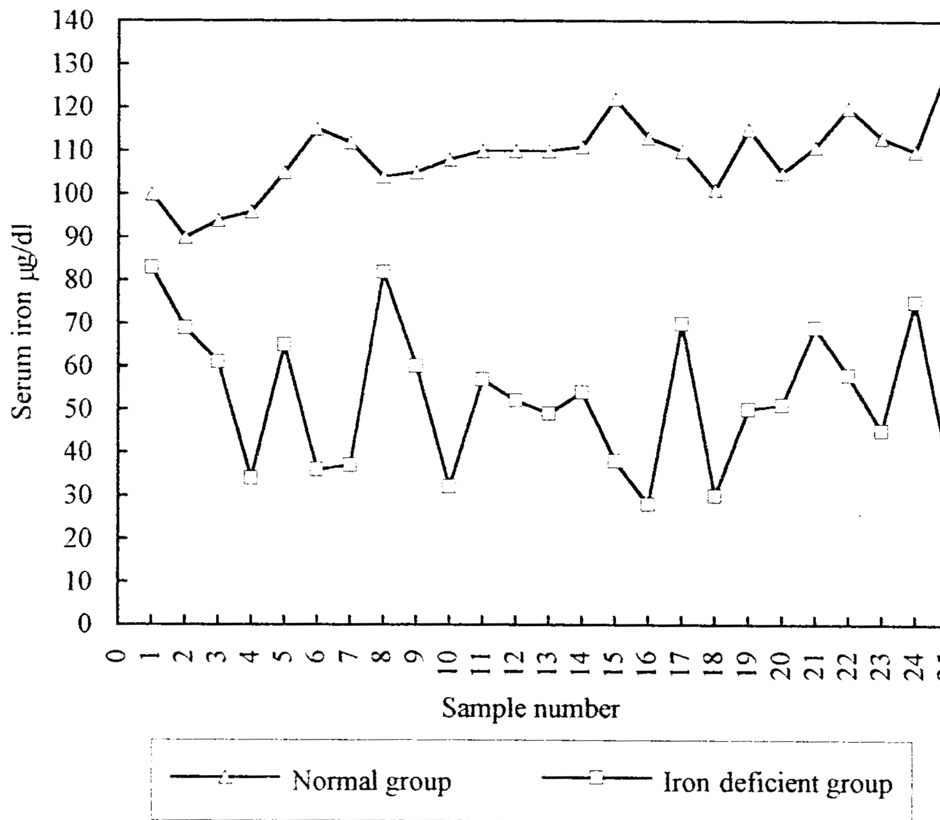


TABLE 20. MEAN SERUM IRON VALUES OF THE PRESCHOOLERS

Age	Normal group	Iron deficient group	Mean
3 Years	100.00	55.90	77.95
4 Years	109.11	47.25	78.18
5 Years	112.8	55.00	83.90
Mean	107.30	52.72	

F(A) = 6.878[X]
F(B) = 233.36[XX]

CD (Age, A)

A_1 Vs A_2 A_3 = 1.57
A_2 Vs A_3 = 8.90

$$Percentage\ difference = \frac{107.3-52.72}{52.72} \times 100 = 103.5$$

4.4.4. Total Iron Binding Capacity Values (TIBC)

The Total Iron Binding Capacity indicates the distinction of nutritionally deficient individuals from iron deficient one'sdue to infections, inflammatory or neoplastic diseases giving a clear picture of the iron balance status of an individual *(Monckeberg, 1989)*. Many studies conducted by *Rajajee (1990)* had revealed that in iron deficiency anaemia the TIBC values will be highly elevated.

As depicted in Table-21, many children (76 per cent) in the normal group had normal TIBC values in the range of 261 to 390 µg/dl, while 24 per cent of the children in this group had lower TIBC values ranging from 131 to 260 µg/dl. In the case of the iron deficient group, 68 per cent of the children had TIBC values ranging from 521 to 650 µg/dl, while few children (28 per cent) had TIBC ranging between 391 to 520 µg/dl. Only 4 per cent children had values above 651 µg/dl. Studies conducted by *Sulzer* and his associates *(1983)* have revealed that in iron deficiency anaemia, the TIBC values will be highly elevated.

TABLE 21. DISTRIBUTION OF THE CHILDREN BASED ON TOTAL IRON BINDING CAPACITY VALUES

TIBC ranges (μ/dl)	DISTRIBUTION OF THE CHILDREN			
	Normal group n = 25	Mean	Iron deficient group n = 25	Mean
131 -- 260	6 (24)	254	---	---
261 -- 390	19 (76)	301	---	---
391 -- 520	---	---	7 (28)	493
521 -- 650	---	---	17 (68)	545
Above 651	---	---	1 (4)	666
Total	25 (100)		25 (100)	

(Numbers in parenthesis indicate percentage)

Normal TIBC values - 260 - 390 μg/dl.

TABLE 22. MEAN TOTAL IRON BINDING CAPACITY VALUES

Age	Normal group	Iron deficient group	Mean
3 Years	333.83	538.40	439.12
4 Years	277.00	575.75	426.38
5 Years	272.10	544.42	408.26
Mean	296.31	552.85	

$F(A) = 11.475^{x}$

$F(B) = 373.64^{xx}$

CD (Age, A)

A_1 Vs A_2, A_3 = 5.87

A_2 Vs A_3 = 33.19

$$Percentage\ difference = \frac{552.85-296.31}{296.31} \times 100 = 86.6$$

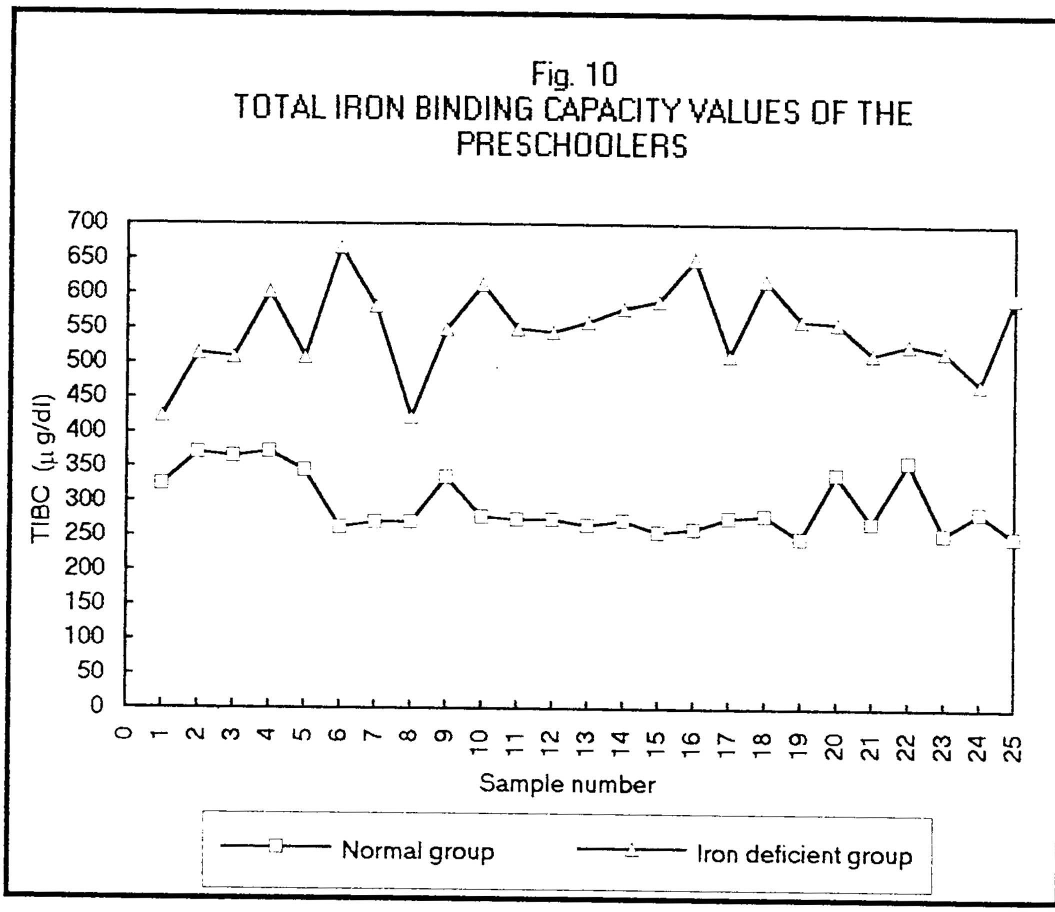


Fig. 10
TOTAL IRON BINDING CAPACITY VALUES OF THE PRESCHOOLERS
TIBC (µ g/dl)
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Sample number
Normal group
Iron deficient group

The above results were reinforced by statistical analysis, which revealed a highly significant difference in TIBC both in between the age groups as well as between the normal and iron deficient groups. Children in the iron deficient group had 86.6 per cent higher TIBC values than the children in the normal group.

4.5. Association Between Iron Intake And Blood Iron Profile

Iron intake or the amount of available iron in the diet is of importance since iron is an essential micronutrient for haemoglobin formation and also for other enzymatic processes. Deficiency of iron in the diet leads to iron deficiency anaemia which is characterised by reduced erythropoiesis and defective red cell formation *(De Maeyer, 1987)*. Among different blood parameters, haemoglobin, serum iron, Total Iron Binding Capacity and Mean Corpuscular Volume were considered. Association between food iron consumed and iron status in the blood was tested using suitable statistical measures.

4.5.1. Influence of iron consumption on haemoglobin levels

Reduced iron consumption is reported to affect proper haemoglobin formation *(Nair, 1990)*. *Basta et.al (1984)* and *Seshadri (1984)* have also observed a relationship between iron supplementation and haemoglobin levels. The positive influence of iron consumption on haemoglobin levels was evidenced in the present study also.

As depicted in Table 23, it is evident that in the normal group, all the children had adequate supply of iron from their diets and their haemoglobin levels were in the normal range of 12 g/dl to 16 g/dl as specified by *WHO (1990)*. The food iron intake of children in the iron deficient group was poorer than the normal group and this fact was well reflected in the haemoglobin levels of these children. In the normal group, 8 per cent of the children consuming

Table 23. Effect Of Iron Consumption On Haemoglobin Level Of Preschoolers.

Food Iron In Ranges (mg)	HAEMOGLOBIN RANGES (g/dl)															
	Normal group n=25								Iron deficient group n=25							
	4.1-6	6.1-8	8.1-10	10.1-12	12.1-14	14.1-16	Mean Hb	Total	4.1-6	6.1-8	8.1-10	10.1-12	12.1-14	14.1-16	Mean Hb	Total
8.1-16	--	--	--	--	--	--	--	--	4 (16)	3 (12)	3 (12)	1 (4)	--	--	6.7	11 (44)
16.1-24	--	--	--	--	8 (32)	2 (8)	13.8	10 (40)	--	2 (8)	10 (40)	2 (8)	--	--	9.9	14 (56)
24.1-32	--	--	--	--	9 (36)	4 (16)	14.2	13 (52)	--	--	--	--	--	--	--	--
32.1-40	--	--	--	--	--	2 (8)	15.5	2 (8)	--	--	--	--	--	--	--	--
Total	--	--	--	--	17 (68)	8 (32)	--	25 (100)	4 (16)	5 (20)	13 (52)	3 (12)	--	--	--	25 (100)

(Numbers in parenthesis indicate percentage).

r (normal) = 0.7085**

r (iron deficient) = 0.9669**

RDA for iron = 18 mg/day

Normal haemoglobin level = 11-12 g/dl

**** Significant at 1% level.**

32.1 to 40 mg of iron had haemoglobin values ranging from 14.1. to 16 g/dl. 36 per cent of the children who consumed 24.1 to 32 mg of iron daily had haemoglobin levels ranging from 12.1 to 14 g/dl while another 16 per cent consuming the same amount of food iron had higher haemoglobin values (14.1 to 16 g/dl). Similarly, 32 per cent with lower iron consumption of 16.1 to 24 mg also had haemoglobin values ranging from 12.1 to 14 g/dl and 8 per cent had 14.1 to 16 g/dl of haemoglobin .

In the iron deficient group, 8 per cent of the children having a supply of 16.1 to 24 mg iron daily through their diet, had haemoglobin levels from 6.1 to 8 g/dl. While 40 per cent consuming the same dietary iron had higher haemoglobin levels (8.1 to 10 g/dl) and 8 per cent had 10.1 to 12 g/dl of haemoglobin. However compared to the children in the normal group, who had similar iron intake, the haemoglobin values were lower for iron deficient group. A comparison of the mean haemoglobin levels of the two groups also reveals similar trends.

In the iron deficient group, for children with lower dietary iron consumption (8.1 to 16 mg) 4 per cent had 10.1 to 12 g/dl haemoglobin, while 24 per cent had haemoglobin levels ranging from 6.1 to 10 g/dl. However 16 per cent of the children with similar iron intake (8.1 to 16mg) had very low haemoglobin levels (4.1 to 6 g/dl). It could also be observed from Table 23 that with a decrease in the dietary iron available daily there was a corresponding decrease in the mean haemoglobin content in both groups. In this context, the salient finding is that with similar food iron consumption levels, the haemoglobin level, was varying between the children in the normal and iron deficient groups.

However, an observation of the mean haemoglobin levels of different categories based on food iron consumption, indicated that the haemoglobin increase was directly influenced by the iron intake.

The positive influence of iron consumption on the haemoglobin level was further reinforced by statistical treatment of the data which revealed a highly significant and positive correlation between the two parameters. The association between available iron and haemoglobin levels was higher for the iron deficient group ($r = 0.9669^{**}$)when compared to the normal group ($r = 0.7085^{**}$) . Higher the deficiency, more is the utilization of iron *(Autopak, 1994).*

4.5.2. Effect of iron consumption on Mean Corpuscular Volume (MCV)

The iron consumption does influence the haemoglobin formation and red cell count which in turn does have a direct effect on Mean Corpuscular Volume *(De.Maeyer, 1987).* The effect of dietary iron on the Mean Corpuscular Volume has been illustrated in Table 24.

As evident from the table, in the normal group, 40 per cent of the children who were consuming 16.1 to 24 mg of iron daily had a Mean Corpuscular Volume in the range of 91 to $100\mu^3$(32 per cent) and 71 to $90\mu^3$ (8 per cent). In 52 per cent of children with a higher iron intake of 24.1 to 32 mg, the MCV values were in the range of 71 to $90\mu^3$ (16 per cent) and 91 to $100\mu^3$ (32 per cent). Only one child (4 per cent) had higher MCV values above $101\mu^3$. With a further hike in the consumption of dietary iron (32.1 to 40 mg), 8 per cent of the children were observed to have MCV values above $101\mu^3$.

In the iron deficient group, 54 per cent children consuming 16.1 to 24 mg had varying MCV values between 71 to $90\mu^3$ (24 per cent), 51 to $70\mu^3$ (28 per cent) and 31 to $50\mu^3$ (4 per cent). In comparison with the normal group, with the iron intake of 16.1 t o 24 mg the MCV values were lower than the iron-deficient group. Comparison of the mean values between the normal and iron deficient group also revealed similar trends with a MCV value of $56.9\mu^3$ for the iron deficient group and $77.5\mu^3$ for the normal group. In the iron deficient group, 24 per cent of

Table 24. Effect Of Iron Consumption On Mean Corpuscular Volume In Preschoolers

Food Iron In Ranges (mg)	Mean Corpuscular Volume (μ^3)													
	Normal group n=25							Iron deficient group n=25						
	31-50	51-70	71-90	91-100	Above 101	Total	Mean MCV	31-50	51-70	71-90	91-100	Above 101	Mean MCV	Total
8.1-16	--	--	--	--	--	--	--	6 (24)	4 (16)	1 (4)	--	--	49.5	11 (44)
16.1-24	--	--	2 (8)	8 (32)	--	10 (40)	77.5	1 (4)	7 (28)	6 (24)	--	--	56.9	14 (56)
24.1-32	--	--	4 (16)	8 (32)	1 (4)	13 (52)	93.5	--	--	--	--	--	--	--
32.1-40	--	--	--	--	2 (8)	2 (8)	103	--	--	--	--	--	--	--
Total	--	--	6 (24)	16 (64)	3 (12)	25 (100)	--	7 (28)	11 (44)	7 (28)	--	--	--	25 (100)

(Numbers in parenthesis indicate percentage)

r(normal) = 0.4902**

r(iron deficient) = 0.9169**

RDA for iron - 18mg/day

Normal MCV value - 86 μ^3

**** Significant at 1% level**

children, had lower MCV values (31 to 50 μ^3), 16percent had still higher values (51 to 70 μ^3), while one child (4 per cent) had MCV between 71 to 90 μ^3, though they all had an intake ranging from 8.1 to 16 mg of iron daily.

It could be observed from the table that with a decrease in the quantity of dietary iron consumed there was a corresponding decrease in the MCV values observed in both groups. Decrease or increase in MCV in the two groups were not in proportion to iron intake especially in the iron deficient group. In onological disorders also, similar observations were reported *(Rajajee, 1990)*.

Statistical analysis of the data further revealed that a significant positive correlation does exist between iron intake and MCV in the two groups. However the association was highly pronounced in the iron deficient group ($r=0.9169^{**}$) at 1percent level in comparison with the normal group ($r= 0.4902^{*}$).

4.5.3. Effect of iron consumption on serum iron levels of preschoolers

Iron consumption does have an effect on serum iron level as reported by *Ohira et al (1979)*. *Hedgeston (1981)* has also reported that iron supplementation significantly enhanced serum iron levels. The correlation between iron consumption and serum iron levels has been observed in the present study also and the results are given in Table 25.

As revealed in the table, in the normal group, out of the 40 percent of children, consuming 16.1 to 24 mg of iron, there was fluctuation in serum iron as 100 to 119 µg/dl (36 per cent) and 80 to 99 µg/dl (4 per cent). Fifty two per cent of children consuming higher amount of iron also showed varied serum iron concentration with 12 per cent of the subjects having 80 to 99 µg/dl, 36percent with values between 100 to 119 µg/dl and 4 per cent with serum iron values

Table 25. Effect Of Iron Consumption On Serum Levels Of Preschoolers

Food Iron In Ranges (mg)	SERUM IRON (μg/dl)															
	Normal group n=25								Iron deficient group n=25							
	21-39	40-59	60-79	80-99	100-119	120-139	Total	Mean Serum Iron	21-39	40-59	60-79	80-99	100-119	120-139	Total	Mean Serum Iron
8.1-16	--	--	--	--	--	--	--	--	6 (24)	3 (12)	2 (8)	--	--	--	11 (44)	43.5
16.1-24	--	--	--	1 (4)	9 (36)	--	10 (40)	108.2	2 (8)	6 (24)	4 (16)	2 (8)	--	--	14 (56)	77.6
24.1-32	--	--	--	3 (12)	9 (36)	1 (4)	13 (52)	116.7	--	--	--	--	--	--	--	--
32.1-40	--	--	--	--	1 (4)	1 (4)	2 (8)	125	--	--	--	--	--	--	--	--
Total	--	--	--	4 (16)	19 (76)	2 (8)	25 (100)	--	8 (32)	9 (36)	8 (32)	2 (8)	--	--	25 (100)	--

(Numbers in parenthesis indicate percentage)

r (normal) = 0.5537*

r (iron deficient) = 0.8672**

RDA for iron - 18mg/day

Normal serum iron level - 80-99μg/dl

*** Significant at 5% level**

**** Significant at 1% level**

of 120 to 139 µg/dl. With still higher amount of dietary iron intake of 32.1 to 40 mg, one child each (4 per cent) had serum iron in the ranges of 100 to 119 µg/dl and 120 to 139 µg/dl. In case of serum iron status it was found that daily iron intake does influence serum iron values.

In the iron deficient group, children consuming 16 to 24 mg of iron (56 per cent) had serum iron values in 4 ranges; with 8 per cent in 80 to 99 µg/dl level, 16 per cent with 60 to 79µg/dl, 24 per cent with lower values of 40 to 59 µg/dl and 8 per cent with very low serum iron values of 21 to 39 µg/dl. With a lower iron intake of 8.1 to 16 mg , 8 per cent of the children had 60 to 79 µg/dl of serum iron while 12 per cent had lower values between 40 to 59 µg/dl and 24percent had very low serum iron values between 21 to 39 µg/dl.

When the mean serum iron values of both the groups were compared it could be concluded that level of iron content of the diet does have an effect on serum iron values since, as the dietary iron decreased there was a decrease for the mean serum iron values. For the same daily iron intake of 16.1 to 24 mg, children in the two groups showed variation in the serum iron values. In the iron deficient group only 8 per cent of the children possessd normal range of serum iron (80 to 99 µg/dl) while in the normal group all the children had serum iron levels within the normal range though there were variation in iron intake. This variation could be due to varied iron absorption in the iron deficient group probably because of frequent occurrence of infection common in such nutritional situation. This is well reflected in the mean values obtained for the children in the two groups, with the same iron intake. A comparison of the mean values of serum iron between the two groups, in general, indicated a positive influence of food iron on serum iron values.

Correlation was worked out between the available iron and serum iron and the results reinforced the fact that a positive and significant correlation does exist between the two parameters. However the association was stronger for the iron deficient group ($r=0.8672^{**}$)

significant at 1 per cent level where as for the normal group (r= 0. 5537*) there was significance only at 5 per cent level.

4.5.4. Effect of iron consumption on Total Iron Binding Capacity (TIBC)

Serum iron levels is reported to influence the Total Iron Binding Capacity *(Basta et al 1974)*. According to *Sheshadri (1988)*, with decreased iron stores there will be depleted serum iron levels and this in turn increases iron absorption which elevates the iron binding capacity.

Table 26 illustrates the effect of iron consumption on the TIBC values. In the normal group, children consuming 16.1 to 24 mg iron (40 per cent) had low TIBC values of 261 to 390 µg/dL (32 per cent) and 131 to 260 µg/dl (8 per cent) . However children (52 per cent) consuming higher amounts of iron ranging between 24.1 to 32 mg also has TIBC values in ranges like 261 to 390 µg/dl (36 per cent) and 131 to 260 µg/dl (16 per cent). Two children (8 per cent) consuming higher amounts of iron (32 to 40 mg) also had TIBC value in the range of 261 to 390 µg/dl. In the normal group, all the children had TIBC in the normal level.

In the iron deficient group, due to lower iron intake, children had higher TIBC values than normal group. Fifty six per cent of children who consumed 16.1 to 24 mg iron daily had TIBC values in 2 ranges with 44 per cent having 521 to 650 µg/dl and 12 per cent with lower values of 391 to 520 µg/dl. With less amounts of dietary iron available (8.1 to 16 mg) , 44 per cent of children exhibited wide variations in TIBC values as 16 per cent had values between 391 to 520 µg/dl, while for 24 per cent TIBC value ranged between 521 to 650 µg/dl and one child (4percent) had a very high TIBC value of above 651 µg/dl.

Comparing the mean TIBC values it was evident that with an increase of dietary iron available there was a reduction in TIBC values for the two groups. The fluctuation for TIBC

Table 26. Effect Of Iron Consumption On The TIBC Values Of preschoolers

Food Iron In Ranges (mg)	Total Iron Binding Capacity Values µg/dl													
	Normal group n=25							Iron deficient group n=25						
	131-260	261-390	391-520	521-650	Above 651	Mean TIBC	Total	131-260	261-390	391-520	521-650	Above 651	Mean TIBC	Total
8.1-16	--	--	--	--	--	--	--	--	--	4 (16)	6 (24)	1 (4)	586	11 (44)
16.1-24	2 (8)	8 (32)	--	--	--	297	10 (40)	--	--	3 (12)	11 (44)	--	532	14 (56)
24.1-32	4 (16)	9 (36)	--	--	--	306	13 (52)	--	--	--	--	--	--	--
32.1-40	--	2 (8)	--	--	--	380	2 (8)	--	--	--	--	--	--	--
Total	6 (24)	19 (76)	--	--	--	--	25 (100)	--	--	7 (28)	17 (58)	1 (4)	--	25 (100)

(Numbers in parenthesis indicate percentage)

r(normal) = - 0.4029**

r(iron deficient) = - 0.8726**

RDA for iron - 18mg/day

Normal TIBC value - 260µg/dl

**** Significant at 1% level.**

values observed could be due to other metabolic disorders, since with the same dietary iron consumption pattern (16 to 24.1 mg) TIBC values varied in between and within the two groups. For the normal group there was lower TIBC values while for the iron deficient group there was an increase in TIBC values which was characteristic of anaemia.

Correlations worked out further clarified the influence of iron consumption on TIBC values in both the groups . A significant but negative correlation was observed between the two parameters. The association was higher for iron deficient group ($r = -0.8726^{**}$) in comparison with the normal group ($r = -0.4209^{*}$) where the correlation was significant only at 5 per cent level.

Besides the iron intake, variation in blood parameters could be attributed to various socio-economic and non-nutritional factors which may impair iron utilisation and metabolic disorders in an individual like infection, neoplastic diseases and malignant tumours as observed by *Rao et al 1982*, and *Jerry De Reeves, 1984*. However, surplus availability of dietary iron may dampen the ill effects of these factors for a while.

4.6. Association Among The Various Blood Parameters

Association among the various blood parameters viz., haemoglobin, mean corpuscular volume (MCV), serum iron and Total Iron Binding Capacity (TIBC) was conducted and the results are presented in comparison with normal and iron deficient situation. Indicators such as Mean Corpuscular Volume, serum iron and Total Iron Binding Capacity are presented in comparison with haemoglobin.

4.6.1. Effect of haemoglobin levels on Mean Corpuscular Volume

The Mean Corpuscular Volume is dependant on haemoglobin concentration and red cell count *(Damsadaran, 1980)*. In studies conducted by *Patiroglu* and *Dogan (1989)* it has been reported that in iron deficiency anaemia, the MCV values will be reduced due to defective haemoglobin formation and defective red cell count. Similar observations were seen in the present study also.

In Table 27, the effect of haemoglobin on the Mean Corpuscular Volume is presented. In the normal group, 68 per cent of the children with haemoglobin levels ranging between 12.1 to 14 g/dl were observed to have varying MCV values, with 16 per cent having 71 to 90 μ^3, 44percent having 91 to 100μ^3 while 8 per cent showed values above 101μ^3 respectively. With higher haemoglobin levels of. 14.1 to 16 g/dl also, the remaining 32 per cent children were having fluctuating MCV values as 71 to 90 μ^3 (8 per cent), 91 to 100 μ^3 (20 per cent) and one child had above 101μ^3.

The variation in the MCV values could be attributed to either environmental factors or infections which were not detectable during the clinical examination conducted.

In the iron deficient group, 12 per cent of the children with 10.1 to 12 g/dl of haemoglobin had very low MCV values of 31 to 50μ^3 while with lower haemoglobin values of 8.1 to 10 g/dl, 28 per cent of the children were found to have 71 to 90μ^3 MCV and 24 per cent had 51 to 70μ^3 MCV respectively. With still lower haemoglobin values of 6.1 to 8 g/dl, 20 per cent also had MCV ranging from 51 to 70μ^3. As the haemoglobin levels further decreased to 4.1 to 6 g/dl in 16 per cent of the children the MCV values were found to reduce to 31 to 50μ^3.

A comparison of the mean values for the two groups also revealed that in the normal group, mean MCV was in the range of 92 to 102μ^3 while in the iron deficient group the range

Table 27. Effect Of Haemoglobin Levels On The Mean Corpuscular Volume Of Preschoolers

Haemoglobin In Ranges (g/dl)	Mean Corpuscular Volume (μ^3)													
	Normal group n= 25							Iron deficient group n=25						
	31-50	51-70	71-90	91-100	Above 101	Mean MCV	Total	31-50	51-70	71-90	91-100	Above 101	Mean MCV	Total
4.1-6	--	--	--	--	--	--	--	4 (16)	--	--	--	--	39.8	4 (16)
6.1-8	--	--	--	--	--	--	--	--	5 (20)	--	--	--	52.3	5 (20)
8.1-10	--	--	--	--	--	--	--	--	6 (24)	7 (28)	--	--	66.5	13 (52)
10.1-12	--	--	--	--	--	--	--	3 (12)	--	--	--	--	46.9	3 (12)
12.1-14	--	--	4 (16)	11 (44)	2 (8)	92.9	17 (68)	--	--	--	--	--	--	--
14.1-16	--	--	2 (8)	5 (20)	1 (4)	101.8	8 (32)	--	--	--	--	--	--	--
Total	--	--	6 (24)	16 (64)	3 (12)	--	25 (100)	7 (28)	11 (44)	7 (28)	--	--	--	25 (100)

(Numbers in parenthesis indicate percentage)

r(normal) = 0.8926**

r(iron deficient) = 0.9711**

Normal haemoglobin - 11-12g/dl

Normal MCV value - 86μ^3

**** Significant at 1% level.**

was found to be between 39 to 66μ^3. Unlike in the normal group, in the iron deficient group children were found to have no direct association between haemoglobin and MCV since children with lower haemoglobin values (eg., 6.1 to 8 g/dl and 8.1 to 10 g/dl) were found to have better MCV compared to the children having a haemoglobin level of 10.1 to 12 g/dl. However in the normal group, there was a direct association between haemoglobin concentration and mean MCV values. Fluctuation in the MCV values for respective haemoglobin concentration could also be contributed to non-nutritional defects or other metabolic disorders *(Jerry De Reeves, 1984)*

Statistically this fact was reinforced as correlation worked out between haemoglobin and MCV revealed a highly significant and positive correlation between the two parameters in both the groups. However, the association was higher for the iron deficient group ($r=0.9711^{**}$) in comparison with the normal group ($r=0.8926^{**}$).

4.6.2. Effect of haemoglobin level on serum iron status

Bothwell et al (1989) revealed that serum iron level 40 µg/dl is considered diagnostic of iron deficiency if the individual is free of infection or other disorders affecting iron metabolism. They had also reported that serum iron shows a consistent and progressive fall when negative iron balance occurs.

Association between haemoglobin levels and serum iron was ascertained and the results are presented in Table 28. In the normal group, 60 per cent of the children with haemoglobin levels between 12.1 to 14 g/dl had serum iron in the range of 100 to 119 µg/dl. Meanwhile, with the same haemoglobin level 8 per cent of the children had 80 to 99µg/dl of serum iron. With higher haemoglobin levels of 14.1 to 16 g/dl, serum iron levels were found to vary considerably

Table 28. Effect Of Haemoglobin Levels On Serum Iron Status

Haemoglobin levels in ranges (g/dl)	SERUM IRON (µg/dl)															
	Normal group n=25								Iron deficient group n=25							
	20-49	40-59	60-79	80-99	100-119	120-139	Mean serum iron	Total	20-49	40-59	60-79	80-99	100-119	120-139	Mean serum iron	Total
4.1-6	--	--	--	--	--	--	--	--	4 (16)	--	--	--	--	--	30.4	4 (16)
6.1-8	--	--	--	--	--	--	--	--	3 (12)	2 (8)	--	--	--	--	36.2	5 (20)
8.1-10	--	--	--	--	--	--	--	--	--	7 (28)	6 (24)	--	--	--	58.4	13 (52)
10.1-12	--	--	--	--	--	--	--	--	1 (4)	--	--	2 (8)	--	--	66.3	3 (12)
12.1-14	--	--	--	2 (8)	15 (60)	--	107.8	17 (68)	--	--	--	--	--	--	--	--
14.1-16	--	--	--	2 (8)	4 (16)	2 (8)	123.4	8 (32)	--	--	--	--	--	--	--	--
Total	--	--	--	4 (16)	19 (76)	2 (8)	--	25 (100)	8 (32)	9 (36)	6 (24)	2 (8)	--	--	--	25 (100)

(Numbers in parenthesis indicate percentage)

r (normal) = 0.8815**

r (iron deficient) = 0.9417**

Normal haemoglobin level - 11-12g\dl

Normal serum iron level - 80-99µg\d

**** Significant at 1% level.**

with 8 per cent having 80 to 90 μg/dl, 16 per cent having 100 to 119 μg/dl while 8 per cent had even higher serum iron values ranging between 120 to 139 μg/dl.

In the iron deficient group, with haemoglobin levels of 10.1 to 12 g/dl one child had very low serum iron level ranging between 20 to 49 μg/dl while 8 per cent of the subjects had normal serum iron values between 80 to 99 μg/dl With lower haemoglobin levels of 8.1 to 10 g/dl, 28 per cent of the children had 40 to 59 μg/dl of serum iron while it was 60 to 79 μg/dl for 24 per cent. Twelve per cent of the children with 6.1 to 8 g/dl of haemoglobin had 20 to 49 μg/dl of serum iron and with the same haemoglobin level 8 per cent had slightly higher serum iron values ranging between 40 to 59 μg/dl. However 16 per cent of the children had very low haemoglobin values. Haemoglobin levels could be influenced by other factors including the serum iron status. In cases of infection and infestation or other inflammatory diseases there will be a reduction in haemoglobin content *(De Maeyer,1991)*. This could be the reason for the fluctuation observed in serum iron values in the normal and iron deficient group for the same haemoglobin levels. However, as evident from the Table 28 with a reduction in the haemoglobin levels there was a corresponding decrease in the serum iron values also.

Statistical analysis worked out revealed similar results since correlation between haemoglobin and serum iron levels was highly significant and positive. However the association was higher for iron deficient group ($r=0.9417^{**}$) when compared to normal group ($r=0.8815^{**}$).

4.6.3. Effect of haemoglobin values on TIBC

In iron deficient conditions there is an increase in iron-absorption and TIBC is found to be highly elevated *(Bothwell, 1979)* and since there is a depletion in the iron stores there will be a deficit in haemoglobin formation *(Nair, 1990)*. Association between haemoglobin and TIBC was worked out and the results are presented in Table 29.

Table 29. Effect Of Haemoglobin Level On T~~able~~otal Iron Binding Capacity

Haemoglobin Level In Ranges (g/dl)	TIBC VALUES IN RANGES (μg/dl)											
	Normal group n=25						Iron deficient group n=25					
	131-260	261-390	391-520	521-650	Above 651	Total	131-260	261-390	391-520	521-560	Above 651	Total
4.1-6	--	--	--	--	--	--	--	--	4 (16)	--	--	4 (16)
6.1-8	--	--	--	--	--	--	--	--	2 (8)	3 (12)	--	5 (20)
8.1-10	--	--	--	--	--	--	--	--	1 (4)	12 (48)	--	13 (52)
10.1-12	--	--	--	--	--	--	--	--	--	2 (8)	1 (4)	3 (12)
12.1-14	2 (8)	15 (60)	--	--	--	17 (68)	--	--	--	--	--	--
14.1-16	4 (16)	4 (16)	--	--	--	8 (32)	--	--	--	--	--	--
Total	6 (24)	19 (76)	--	--	--	25 (100)	--	--	7 (28)	17 (68)	1 (4)	25 (100)

(Numbers in parenthesis indicate percentage)

r (normal group) = - 0.6782**

r (iron deficient) = - 0.9374**

Normal haemoglobin level - 11-12g/dl

Normal TIBC level - 260-390 (μg/dl)

**** Significant at 1% level.**

As revealed in the table, in the normal group, 60 per cent of the children with 12.1 to 14g/dl haemoglobin had their TIBC values ranging between 261 to 390 μg/dl which was within the normal range (normal value-260 to 390 μg/dl). With similar haemoglobin levels few children (8 per cent) had lower TIBC values between 131 to 260 μg/dl. For haemoglobin levels of 14.1 to 16 g/dl 16 per cent each had TIBC values ranging between 131 to 260 μg/dl and 261 to 390 μg/dl respectively.

However, in case of the iron deficient group an increase in TIBC values, characterisation of anaemia was observed as revealed in Table 29 . With normal haemoglobin levels of 10.1 to 12 g/dl (WHO, 1990), TIBC values were recorded between 521 to 650 μg/dl in 8 per cent of the subject and one child (4 per cent) had it above 651 μg/dl. However, with very low haemoglobin values of 4.1 to 6 g/dl , 16 per cent of the children had their TIBC values between 391 to 520 μg/dl . Eight per cent of the children having 6.1 to 8 g/dl of haemoglobin had TIBC in the ranges of 391 to 520μg/dl while 12 per cent had TIBC ranging between 521 to 650μg/dl. With haemoglobin values of 8.1 to 10 g/dl one child had 391 to 520 μg/dl while 48 per cent had 521 to 650 μg/dl. However on comparison of the mean values in both the groups, an increase in TIBC values for a decrease in haemoglobin levels was observed . The fluctuations observed in TIBC could also be attributed to metabolic disorders like malignant conditions and also infections where also the TIBC is normally elevated *(Autopak, 1994)*.

Statistical analysis of the data revealed a highly significant, negative correlation between the haemoglobin and TIBC and the association was more pronounced in case of iron deficient group($r= -0.9374^{**}$) in comparison with the normal group ($r=-0.6782^{**}$).

4.6.4. Effect of serum iron or Mean Corpuscular Volume

With a reduction in serum iron stores there will be defective haemoglobin formation and reduced cell count and these two factors in turn results in a decrease in the mean corpuscular volume *(Hutchison, 1984)*. Association between serum iron and MCV was verified in the present study.

Table 30 depicts the findings related to serum iron and Mean Corpuscular Volume (MCV). In the normal group, among 16 per cent of the children with 80 to 99 μg/dl of serum iron, 12 per cent had 71 to 90μ^3 of MCV while 4 per cent possessed above 101μ^3 MCV. With serum iron values ranging between 100 to 119 μg/dl in 76 per cent of the children, 3 ranges of MCV were observed viz., as 8 per cent with 71 to 90 μ^3, 64 per cent with 91 to 100μ^3 and one child with above 101$\mu^3$of MCV. Similarly, with a serum iron value of 120 to 139μg/dl one child each had 71 to 90μ^3 and above 101 $\mu^3$of MCV.

In the iron deficient group, 8 per cent of children with normal serum iron values between 80 to 99 μg/dl had MCV in normal ranges (71 to 90 μ^3). With lower serum iron range of 60 to 79 μg/dl , 20 per cent had 71 to 90μ^3 MCV while in case of 4 per cent only 51 to 70μ^3 MCV was observed. With a decrease in serum iron in the range of 40 to 59 μg/dl, 36 per cent of the children had 51 to 70μ^3 MCV and with still lower serum iron values of 20 to 39 μg/dl, 28 per cent had very low MCV values ranging between 31 to 50μ^3 while one child had 51 to 70 μ^3MCV. It could be observed from Table 30 that as the serum values decreased there was a corresponding decrease in the MCV value.

This fact was further reinforced by correlation estimated between serum iron and MCV which revealed a highly significant positive correlation. The correlation was highly significant for the iron deficient group ($r=0.9627^{**}$) as well as the normal group ($r= 0.8779^{**}$).

Table 30. Effect of Serum Iron On Mean Corpuscular Volume In Preschoolers

Serum Iron In Ranges (µg/dl)	Mean Corpuscular Volume (μ^3)													
	Normal group n=25							Iron deficient group n=25						
	31-50	51-70	71-90	91-100	Above 101	Mean MCV	Total	31-50	51-70	71-90	91-100	Above 101	Mean MCV	Total
20-39	--	--	--	--	--	--	--	7 (28)	1 (4)	--	--	--	44	8 (32)
40-59	--	--	--	--	--	--	--	--	9 (36)	--	--	--	56	9 (36)
60-79	--	--	--	--	--	--	--	--	1 (4)	5 (20)	--	--	73.5	6 (24)
80-99	--	--	3 (12)	--	1 (4)	83.5	4 (16)	--	--	2 (8)	--	--	80.2	2 (8)
100-119	--	--	2 (8)	16 (64)	1 (4)	95.5	19 (76)	--	--	--	--	--	--	--
120-139	--	--	1 (4)	--	1 (4)	103.5	2 (8)	--	--	--	--	--	--	--
Total	--	--	6 (24)	16 (64)	3 (12)	--	25 (100)	7 (28)	11 (44)	7 (28)	--	--	--	25 (100)

(Numbers in parenthesis indicate percentage)

r(normal) = 0.8779**

r(iron deficient) = 0.9627**

Normal serum iron level - 80-99µg/dl

Normal MCV value - 86μ^3

**** Significant at 1% level.**

4.6.5. Effect of serum iron on TIBC value

Bothwell (1979) reported that exhaustion of body iron reserves is associated with a decrease in serum iron, increase in iron absorption and iron binding capacity.

The effect of serum iron on TIBC is revealed in Table 31. In the normal group, 16 per cent of the children with a serum iron range of 80 to 99 µg/dl had TIBC ranging between 131 to 260 µg/dL. Majority of the children (76 per cent) having higher iron levels of 100 to 119 µg/dl had TIBC values of 261 to 390 µg/dl. While with still higher serum iron values of 120 to 139 µg/dl 8 per cent of the children had lower TIBC values ranging between 131 to 260 µg/dl.

In the iron deficient group, 8 per cent of the children with 80 to 99 µg/dl of serum iron had TIBC ranging between 521 to 650µg/dl. With lower serum iron values of 60 to 79 µg/dl, two ranges of TIBC were observed with 20 per cent having TIBC values of 521 to 650 µg/dl while one child had value above 651µg/dl. With a decrease in serum iron values of 40 to 59 µg/dl there was a rise in TIBC values ranging from 521 to 650 µg/dl as seen in 36 per cent of the children. With very low serum iron ranges of 20 to 39µg/dl, 28 per cent of the children had 391 to 520µg/dl of TIBC while one child had TIBC between 521 to 650 µg/dl.

Statistically the influence of serum iron on TIBC was proved since correlation worked out between these parameters revealed a highly significant negative correlation. The association was higher for the iron deficient group ($r = -0.9489^{**}$) in comparison with the normal group ($r = -0.7918^{**}$). However the significance was evident at 1 per cent.

Table 31. Effect Of Serum Iron On Total Iron Binding Capacity Of Preschoolers

Serum Iron Ranges (µg/dl)	TOTAL IRON BINDING CAPACITY VALUE (TIBC) IN RANGES (µg/dl)											
	Normal group n=25						Iron deficient group n=25					
	131-260	261-390	391-520	521-650	Above 651	Total	131-260	261-390	391-520	521-650	Above 651	Total
20-39	--	--	--	--	--	--	--	--	7 (28)	1 (4)	--	8 (32)
40-59	--	--	--	--	--	--	--	--	--	9 (36)	--	9 (36)
60-79	--	--	--	--	--	--	--	--	--	5 (20)	1 (4)	6 (24)
80-90	4 (16)	--	--	--	--	4 (16)	--	--	--	2 (8)	--	2 (8)
100-119	--	19 (76)	--	--	--	19 (76)	--	--	--	--	--	--
120-139	2 (8)	--	--	--	--	2 (8)	--	--	--	--	--	--
Total	6 (24)	19 (76)	--	--	--	25 (100)	--	--	7 (28)	17 (58)	1 (4)	25 (100)

(Numbers in parenthesis indicate percentage)

r(normal) = - 0.7918**

r(iron deficient) = - 0.9487**

Normal serum iron level = 80-99 µg/dl

Normal TIBC level =260-390 µg/dl

**** Significant at 1% level.**

4.6.6. Effect of TIBC on MCV values

The TIBC content of the serum is found to have an indirect influence on the MCV values as more iron is absorbed in iron deficient condition *(Autopak, 1994)* and lesser amounts being available for its other functions like haemoglobin formation.

The effect of TIBC on MCV is revealed in Table 32. As evident from the table, in the normal group 24 per cent of the children having TIBC values between 131 to 260 µg/dl had MCV values between 71 to 90μ^3. With slightly high TIBC values of 261 to 390 µg/dl, 64 per cent of the children had MCV ranging between 91 to 100μ^3 while 12 per cent had MCV above 101μ^3.

In the iron deficient group, 28 per cent of the children with 391 to 520 µg/dl of TIBC had MCV values between 31 to 50μ^3. With higher TIBC values ranging from 521 to 650 µg/dl, 44 per cent had only 51 to 70 μ^3 MCV while 24 per cent had MCV ranging between 71 to 90 μ^3. However, one child with TIBC value above 651µg/dl had MCV between 71 to 90 μ^3. This variation could be attributed to infections and metabolic disorders *(De Maeyer, 1984)*.

However correlation worked out revealed a highly significant negative correlation between TIBC and MCV and the association was higher for the iron deficient group ($r=-0.9609^{**}$) when compared to the normal group ($r= - 0.8149^{**}$).

Table 32. Effect Of Total Iron Binding Capacity (TIBC) On Mean Corpuscular Volume

TIBC Ranges μg\dl	MEAN CORPUSCULAR VOLUME (MCV) IN RANGES (μ^3)											
	Normal group n=25						Iron deficient group n=25					
	31-50	51-70	71-90	91-100	Above 101	Total	31-50	51-70	71-90	91-100	Above 101	Total
131-260	--	--	6 (24)	--	--	6 (24)	--	--	--	--	--	--
261-390	--	--	--	16 (64)	3 (12)	19 (76)	--	--	--	--	--	--
391-520	--	--	--	--	--	--	7 (28)	--	--	--	--	7 (28)
521-650	--	--	--	--	--	--	--	11 (44)	6 (24)	--	--	17 (68)
Above 651	--	--	--	--	--	--	--	--	1 (4)	--	--	1 (4)
Total	--	--	6 (24)	16 (64)	3 (12)	25 (100)	11 (44)	7 (28)	11 (44)	7 (28)	--	25 (100)

(Numbers in parenthesis indicate percentage)

r (normal) = - 0.8149**

r (iron deficient) = - 0.9609**

Normal TIBC value - 260-390 μg/dl

Normal MCV value - 86 μ^3

**** Significant at 1% level.**

4.7. Association Between Iron Status And Behavioural Development

The behavioural development of the children was assessed using the "Raven's Intelligence Scale" for preschoolers. *Howell (1977)* reported that anaemic iron deficient 3 to 5 year old children displayed decreased attentiveness, narrow attention span and perceptual restrictions. *Walter et al (1978)* showed that iron deficient children performed poor on verbal tasks. According to *Ronal (1978)* iron deficiency anaemia affects the children's ability to concentrate and thus their performance on achievement tasks. Studies conducted by *Sathi (1991)* revealed that malnutrition affects the growth of brain if it occurs during rapid brain growth period and the malnourished children may perform poorly in a variety of intelligence tests when compared to the normal children. Studies done by *Patiroglou* and *Dogan (1991)* on the effects of iron deficiency anaemia on human behaviour indicates that iron deficiency anaemia might adversely affect the cognitive development and intellectual performance and behaviour of an individual. In the present study also an attempt was made to find out the association between iron status and behavioural development and the salient findings are presented under the following headings.

4.7.1. Effect of dietary iron on intelligence test scores

According to *Reeves (1991)* iron deficiency anaemia, which is characterised by low haemoglobin levels is due to inadequate consumption of iron. This in turn would lower the serum iron stores at the sametime and increase Total Iron Binding Capacity which directly or indirectly does hinder the intellectual performance ability of an individual.

The influence of dietary iron on intelligence test scores has been illustrated in Table 33. As evident from the table, in the normal group. 40 per cent of the children consuming 16.1 to 24mg of iron daily obtained an intelligence score in the range of 60.1 to 80 per cent.

Table 33. Effect Of Dietary Iron On Intelligence Test Scores

Food Iron In Ranges (mg)	Intelligence Test Score (percentage)													
	Normal group n=25							Iron deficient group n=25						
	Less than 20	20.1-40	40.1-60	60.1-80	Above 80	Mean Score	Total	Less than 20	20.1-40	40.1-60	60.1-80	Above 80	Mean Score	Total
8.1-16	--	--	--	--	--	--	--	3 (12)	2 (8)	4 (16)	2 (8)	--	36.5	11 (44)
16.1-24	--	--	--	10 (40)	--	72.2	10 (40)	--	--	5 (20)	9 (36)	--	54.4	14 (56)
24.1-32	--	--	--	7 (28)	6 (24)	80.3	13 (52)	--	--	--	--	--	--	--
32.1-40	--	--	--	--	2 (8)	85.4	2 (8)	--	--	--	--	--	--	--
Total	--	--	--	17 (68)	8 (32)	--	25 (100)	3 (12)	2 (8)	9 (36)	11 (44)	--	--	25 (100)

(Numbers in parenthesis indicate percentage)

r(normal) = 0.8812**

r(iron deficient) = 0.9327**

RDA for Iron - 18mg/day

**** Significant at 1% level.**

consumption of 24.1 to 32 mg of iron daily, 28 per cent obtained 60.1 to 80 per cent scores while 24 per cent obtained scores in a higher range (Above 80 per cent). As the intake of iron increased (32.1 to 40mg) there was an increase in the test scores also. (above 80 per cent) for 8 per cent of the children. However, unlike normal group in the iron deficient group children performed poorly as they had lower scores. The highest score obtained in this group was in the range of 60.1 to 80 per cent. This was obtained for 36 per cent of children with daily iron intake of 16.1 to 24 mg and 8 per cent who consumed to 8.1 to 16 mg of iron. As the amount of iron consumed lowered, their test scores also reduced. Children with 8.1 to 16 mg daily intake of iron had test scores in the range of less than 20 per cent (12 per cent), 20.1 to 40 per cent (8 per cent) and 40.1 to 60 per cent (16 per cent). Children consuming higher amounts of iron (16.1 to 24 mg) had better scores in the range of 40.1 to 60 per cent (20 per cent).

It could be observed from the table that for the same amount of iron consumed daily (16.1 to 24 mg), the mean test scores varied for both normal and iron deficient groups. Intelligence performance of children is dependent on other socio-economic factors, their background and therefore the variation could be due to reasons other than iron consumption.

However, from the study a positive effect of iron consumption on test scores was observed. This fact was confirmed statistically by working out correlation between iron consumed and intellgence test scores. The analysis revealed a highly significant positive correlation between the two parameters in both the normal and iron deficient group. Although the correlation was significant at both levels for both the group the significance was higher for the iron deficient group ($r = 0.9327^{**}$) in comparison with the normal group ($r = 0.8812^{**}$).

4.7.2. Effect of haemoglobin levels on intelligence test score

According to *Charles (1984)*, at very low haemoglobin level which characterises iron deficiency anaemia, the intellectual performance of children will be very poor and as the extent of iron deficiency increased, more were the chances of mental impairments. In the present study also, the effect of haemoglobin levels on intelligence test scores was ascertained.

As depicted in table 34, in the normal group 64 per cent of the children with normal haemoglobin values (12.1 to 14 g/dl) were observed to perform above average (60 to 80 per cent). With the same haemoglobin levels, 20 per cent of the children obtained higher scores above 80 per cent. With higher haemoglobin values (14 to 16 g/dl), 12 per cent of the children obtained scores above 80 per cent score while one child (4 per cent) had a score of 60 to 80 per cent. This indicates that iron deficiency as indicated by lower haemoglobin values has a direct influence on intelligence test score.

Unlike in the normal group, performance of children were poor in the iron deficient group, since they had lower scores. The highest score obtained in this group was 60.1 to 80 per cent. This was obtained for children with haemoglobin level 10.1 to12 g/dl (12 per cent) and 8.1 to 10 g/dl (32 per cent). As the haemoglobin levels lowered it was found to reduce the performance of children. Twelve per cent children with haemoglobin levels of 4.1 to 6 g/dl had test scores in the range of less than 20 per cent and 4 per cent had scored between 20.1 to 40 per cent. As the haemoglobin level increased 6.1 to 8 g/dl the test scores were increased to a range of 40.1 to 60 per cent in 16 per cent of children but one child obtained a score in range of 20.1 to 40 per cent. For haemoglobin levels of 8.1 to 10 g/dl 20 per cent children obtained scores between 40.1 to 60 per cent scores while 32 per cent obtained still higher scores (60.1 to 80 per cent). This further reinforces the direct effect of haemoglobin on intelligence test scores. It could be further observed from the table that, as the haemoglobin values decreased there was a corresponding decrease in mean intelligence test scores.

Table 34. Effect Of Haemoglobin Levels On Intelligence Test Scores

Hameo-globin In Ranges (g/dl)	Intelligence Test Score (percentage)													
	Normal group n=25							Iron deficient group n=25						
	Less than 20	20.1-40	40.1-60	60.1-80	Above 80	Mean Score	Total	Less than 20	20.1-40	40.1-60	60.1-80	Above 80	Mean Score	Total
4.1-6	--	--	--	--	--	--	--	3 (12)	1 (4)	--	--	--	15.6	4 (16)
6.1-8	--	--	--	--	--	--	--	--	1 (4)	4 (16)	--	--	43.2	5 (20)
8.1-10	--	--	--	--	--	--	--	--	--	5 (20)	8 (32)	--	63.3	13 (52)
10.1-12	--	--	--	--	--	--	--	--	--	--	3 (12)	--	64.6	3 (12)
12.1-14	--	--	--	16 (64)	5 (20)	76.9	21 (84)	--	--	--	--	--	--	--
14.1-16	--	--	--	1 (4)	3 (12)	83.6	4 (16)	--	--	--	--	--	--	--
Total	--	--	--	17 (68)	8 (32)	--	25 (100)	3 (12)	2 (8)	9 (36)	11 (44)	--	--	25 (100)

(Numbers in parenthesis indicate percentage)

r(normal) = 0.6378**

r(iron deficient) = 0.9669**

Normal haemoglobin level - 11-12g/dl

**** Significant at 1% level.**

While comparing normal and iron deficient group, although a highly significant positive correlation was observed between haemoglobin levels and test scores for both the groups the significance was higher for the iron deficient group.(r= 0. 9669**). which stabilises the fact that the behavioural development will be impaired or affected as the extent of iron deficiency increased.

4.7.3. Effect of Mean Corpuscular Volume on intelligence test score

The Mean Corpuscular Volume is usually reduced in iron deficiency anaemia *(Hutchison, 1984)*. In iron deficiency anaemia, the mean cell size, its count and haemoglobin content will be reduced and this results in reduced oxygen carrying capacity of the blood. This deprives the brain of oxygen which when continued for longer period, results in mental impairment *(Chatterjee, 1991)*. *De Maeyer (1991)* has reported that Mean Corpuscular Volume does have an effect on intelligence performance which may be direct or indirect. In the present study, the positive effect of MCV on intelligence test scores has been studied.

Table 35 depicts the influence of Mean Corpuscular Volume on Intelligence test scores. As evident from the table, in the normal group, 24percent of children with MCV of 71 to $90\mu^3$ obtained test scores in the range of 60.1 to 80 per cent. With higher MCV values (91 to 100 μ^3) 44 per cent of the children obtained scores in the range of 60.1 to 80 per cent while 20 per cent obtained higher scores (above 80 per cent). As the MCV values increased (above 101 μ^3), 12 per cent of the children obtained above 80.1 per cent scores. This indicates that Mean Corpuscular Volume does have a direct effect on intelligence test scores.

In case of the iron deficient group, as the mean corpuscular volumes decreased there was a decrease in the intelligence test scores. With MCV values of 71 to $90\mu^3$,28 per cent of the children obtained the scores between 60.1 to 80 per cent. Similar scores were observed by 16 per cent of children with lower MCV values ranging between 51 to $70\mu^3$. However, with a lower

Table 35. Effect Of Mean Corpuscular Volume On Intelligence Test Scores

MCV In Ranges (μ^3)	Intelligence Test Score (percentage)													
	Normal group n=25							Iron deficient group n=25						
	Less than 20	20.1-40	40.1-60	60.1-80	Above 80	Mean Score	Total	Less than 20	20.1-40	40.1-60	60.1-80	Above 80	Mean Score	Total
31-50	--	--	--	--	--	--	--	3 (12)	2 (8)	2 (8)	--	--	26.2	7 (28)
51-70	--	--	--	--	--	--	--	--	--	7 (28)	4 (16)	--	48.6	11 (44)
71.90	--	--	--	6 (24)	--	71.8	6 (24)	--	--	--	7 (28)	--	66.3	7 (28)
91-100	--	--	--	11 (44)	5 (20)	77.2	16 (64)	--	--	--	--	--	--	--
Above 101	--	--	--	--	3 (12)	85.3	3 (12)	--	--	--	--	--	--	--
Total	--	--	--	17 (68)	8 (32)	--	25 (100)	3 (12)	2 (8)	9 (36)	11 (44)	--	--	25 (100)

(Numbers in parenthesis indicate percentage)

r(normal) = 0.4902*

r(iron deficient) = 0.9169**

Normal MCV level - 86μ^3

*** Significant at 5% level**

**** Significant at 1% level.**

MCV value between 51 to 70 μ^3, 28 per cent of the children obtained scores only in the range of 40.1 to 60 per cent. As the MCV values decreased the performance ability also decreased as indicated by lower scores. For MCV values in the range of 31 to 50 μ^3, test scores were observed in the range of 40.1 to 60 per cent for 8 per cent of children while, another 8 per cent of the children obtained 20.1 to 40 per cent scores and another 12 per cent performed very poorly and secured scores below 20 per cent. A comparison of the mean test score values revealed that, with a decrease in the MCV values there was a corresponding decrease for the mean test scores.

Correlation estimated between MCV and intelligence test scores revealed a significant and positive correlation for both the groups. However the correlation for the normal group was significant at 5 per cent level ($r= 0.4902^{*}$) when compared to the iron deficient group ($r=0.9169^{**}$).

4.7.4. Effect of serum iron values on intelligence test scores

The association between serum iron and intelligence test scores was worked. Serum iron is a sensitive indicator for detecting iron deficiency anaemia *(Nair, 1990)*. With a decrease in serum iron there will be reduced haemoglobin formation and it has an effect on the behavioural development *(Gupta, 1961)*.

Table 36 explains the influence of serum iron on the test scores of preschoolers. In the normal group, 16 per cent of the children with serum iron values in the range of 80 to 99µg/dl obtained test scores in the range of 60.1 to 80 per cent. With an increase in serum iron values the children were found to perform better in the achievement tests. As the serum iron values increased (90 to 119 µg/dl), 52 per cent of the children obtained 60.1 to 80 per cent while 24 per cent obtained higher scores above 80 per cent. With still higher serum iron values 120 to 139 µg/dl few children obtained scores above 80 per cent. The finding enlightens the positive effect

Table 36. Effect Of Serum Iron On Intelligence Test Scores

Serum Iron In Ranges (µg/dl)	Intelligence Test Score (percentage)													
	Normal group n= 25							Iron deficient group n=25						
	Less than 20	20.1-40	40.1-60	60.1-80	Above 80	Mean Score	Total	Less than 20	20.1-40	40.1-60	60.1-80	Above 80	Mean Score	Total
20-39	--	--	--	--	--	--	--	3 (12)	2 (8)	3 (12)	--	--	21.4	8 (32)
40-59	--	--	--	--	--	--	--	--	--	5 (20)	4 (16)	--	54.3	9 (36)
60-79	--	--	--	--	--	--	--	--	--	1 (4)	5 (20)	--	61.4	6 (24)
80-99	--	--	--	4 (16)	--	72.3	4 (16)	--	--	--	2 (8)	--	66.6	2 (8)
100-119	--	--	--	13 (52)	6 (24)	76.9	19 (76)	--	--	--	--	--	--	--
120-139	--	--	--	--	2 (8)	84.2	2 (8)	--	--	--	--	--	--	--
Total	--	--	--	17 (68)	8 (32)	--	25 (100)	3 (12)	2 (8)	9 (36)	11 (44)	--	--	25 (100)

(Numbers in parenthesis indicate percentage)

r(normal) = 0.5539*

r(iron deficient) = 0.8672**

Normal Serum iron level - 80-99µg/dl

*** Significant at 5% level.**

**** Significant at 1% level.**

of serum iron on intelligence test scores. In contrast to this, in the iron deficient group a decrease in the test scores were observed with lower serum iron values. The highest scores obtained by this group were in the range of 60.1 to 80 per cent. Eight per cent of children with serum iron level between 80 to 99 μg/dl and 20 per cent with 60 to 79 μg/dl of serum iron obtained scores in the above range itself. One child with 60 to 79μg/dl serum iron obtained lower scores between 40.1 to 60 per cent.

With lower serum iron value between 40 to 59μg/dl 16 per cent obtained 60.1 to 80 per cent scores while 20 per cent obtained lower scores between 40.1 to 60 per cent. This variation could be attributed to environmental factors or other non nutritional factors which may also affect intellectual performance of an individual. As the serum iron values decreased (21 to 39 μg/dl) very low performance (less than 20 per cent) was observed for 12 per cent of the children and few children (8 per cent) obtained 20.1 to 40 per cent scores. With the same serum iron values 12 per cent obtained 40.1 to 60 per cent. In the case of influence of serum iron on test scores also a fluctuation between the two groups for the same serum iron (80 to 99 μg/dl) values were observed . The mean test score (66.6 per cent) was less for the iron deficient group although the serum iron was in the normal range (80 to 99 μg/dl). However, a comparison of the mean values of test scores as observed from the table indicate that with a decrease in serum iron values there was a corresponding decrease in the mean test scores. This implies the direct influence of serum iron on intelligence test scores.

Statistically the association between serum iron and behavioural development was proved since correlation estimated revealed a significant and positive correlation between the two parameters. However the correlation was significant at 1 per cent level only for the iron deficient group ($r = 0.8672^{**}$) where as for the normal group the correlation was significant at only 5 per cent level ($r = 0.5539^{*}$).

4.7.5. Effect of Total Iron Binding Capacity on Intelligence test Scores

In iron deficient conditions, the iron absorption is increased , thereby elevating the TIBC which results in unavailability of the nutrient iron which is necessary for various functions in the body *(Bothwell, 1979)*. This in turn does affect the behavioural develolpment of children. The influence of TIBC on the intelligence test scores was worked out in the present study and the results are presented in Table 37.

As revealed in the table, in the normal group children with TIBC values in the range of 131 to 260 µg/dl has obtained test scores in the ranges 60.1 to 80 per cent (8 per cent) and above 80.1 per cent (16 per cent). With higher TIBC values (261 to 390 µg/dl), 60 per cent of the children obtained 60.1 to 80 per cent and 16 per cent obtained above 80.1 per cent. However, the TIBC values for the normal group was in the normal range. In the iron deficient group on the contrary with an elevation of TIBC, a corresponding decrease was observed for the intelligence test scores. With TIBC values in the range of 391 to 520 µg/dl, 28 per cent children obtained scores between 60.1 to 80 per cent which was the higher score. The same scores were obtained by 16 per cent of the children with higher TIBC values between 521 to 650 µg/dl. Eight per cent of the children scored less than 20 per cent, another 8 per cent scored in the range of 20.1 to 40percent while 36 per cent obtained in the range of 40.1 to 60 per cent. With very high TIBC values (Above 651 µg/dl) one child (4 per cent) obtained less than 20 per cent scores. On comparison of the mean values however, it was observed that with an increase in TIBC there was a corresponding decrease in the intelligence test scores. However, the variation in test scores for very high TIBC values could be due to other factors which may cause highly elevated TIBC levels, like maligant tumours *(Autopak 1994)*.

Statically TIBC and intelligence test scores revealed a significant negative correlation for both the normal and iron deficient group. However, the correlation was significant at 1 per cent for iron deficient group ($r = -0.8726^{**}$) in comparison to the normal group ($r = -0.4209^{*}$). The significance was higher for the iron deficient group.

Table 37. Effect Of Total Iron Binding Capacity On Intelligence Test Scores

TIBC In Ranges (µg/dl)	Intelligence Test Score (percentage)													
	Normal group n=25							Iron deficient group n=25						
	Less than 20	20.1-40	40.1-60	60.1-80	Above 80	Mean Score	Total	Less than 20	20.1-40	40.1-60	60.1-80	Above 80	Mean Score	Total
131-260	--	--	--	2 (8)	4 (16)	74.5	6 (24)	--	--	--	--	--	--	--
261-390	--	--	--	15 (60)	4 (16)	79.5	19 (76)	--	--	--	--	--	--	--
391-520	--	--	--	--	--	--	--	--	--	--	7 (28)	--	64.6	7 (28)
521-650	--	--	--	--	--	--	--	2 (8)	2 (8)	9 (36)	4 (16)	--	51.3	17 (68)
Above 651	--	--	--	--	--	--	--	1 (4)	--	--	--	--	18.7	1 (4)
Total	--	--	--	17 (68)	8 (32)	--	25 (100)	3 (12)	2 (8)	9 (36)	11 (44)	--	--	25 (100)

(Numbers in parenthesis indicate percentage)

r(normal) = - 0.4209*

r(iron deficient) = - 0.8726**

Normal TIBC level - 260-390µg/dl

*** Significant at 5% level.**

**** Significant at 1% level.**

4.8 Direct and Indirect influence of the independent variables on the intellectual behaviour development in preschool children

The direct and indirect influence of the independent variables like haemoglobin, Mean Corpuscular Volume, serum iron, Total Iron Binding Capacity and available iron in food on the intelligence test scores of the normal as well as the iron deficient children were studied

NORMAL GROUP

The correlation between X_1 (haemoglobin) and Y (intelligence test score) was 0.6378 which was significant and positive but the direct effect of X_1 was negative and less. So this correlation was mainly attributed to the positive indirect influence of X_1 (haemoglobin) via X_5 (available iron in food) (0.6764). The indirect influence of X_1 via X_2 (mean corpuscular volume) and X_5 were also positive while through X_3 (serum iron) it was negative. Similarly the correlation of X_2 (MCV) with X_5 (available food iron) was also the result of indirect influence of X_2 via X_5, though the direct influence of X_2 (MCV) on Y (intelligence test score) was positive. The direct effects of X_3 (serum iron) on Y (test score) was negative while its correlation with Y (test score) was positive, the reason for this correlation being mainly its indirect effect via X_5 (available iron in food). Both the correlation and direct effect of X_4 (TIBC) on Y (test score) was negative (-0.2163). The indirect influence of X_4 (TIBC) via X_5 (available iron) has resulted in the enhanced correlation. The correlation of X_5 (available iron) with Y (test score) was mainly attributed to its direct effect itself (0.9546). The available iron in food is found to influence the intelligence score directly and indirectly in normal children. 56 percent of the variation in intelligence score may be explained in terms of the 5 independent variables studied. Forty four could be accounted only by factors / variables yet to be identified.

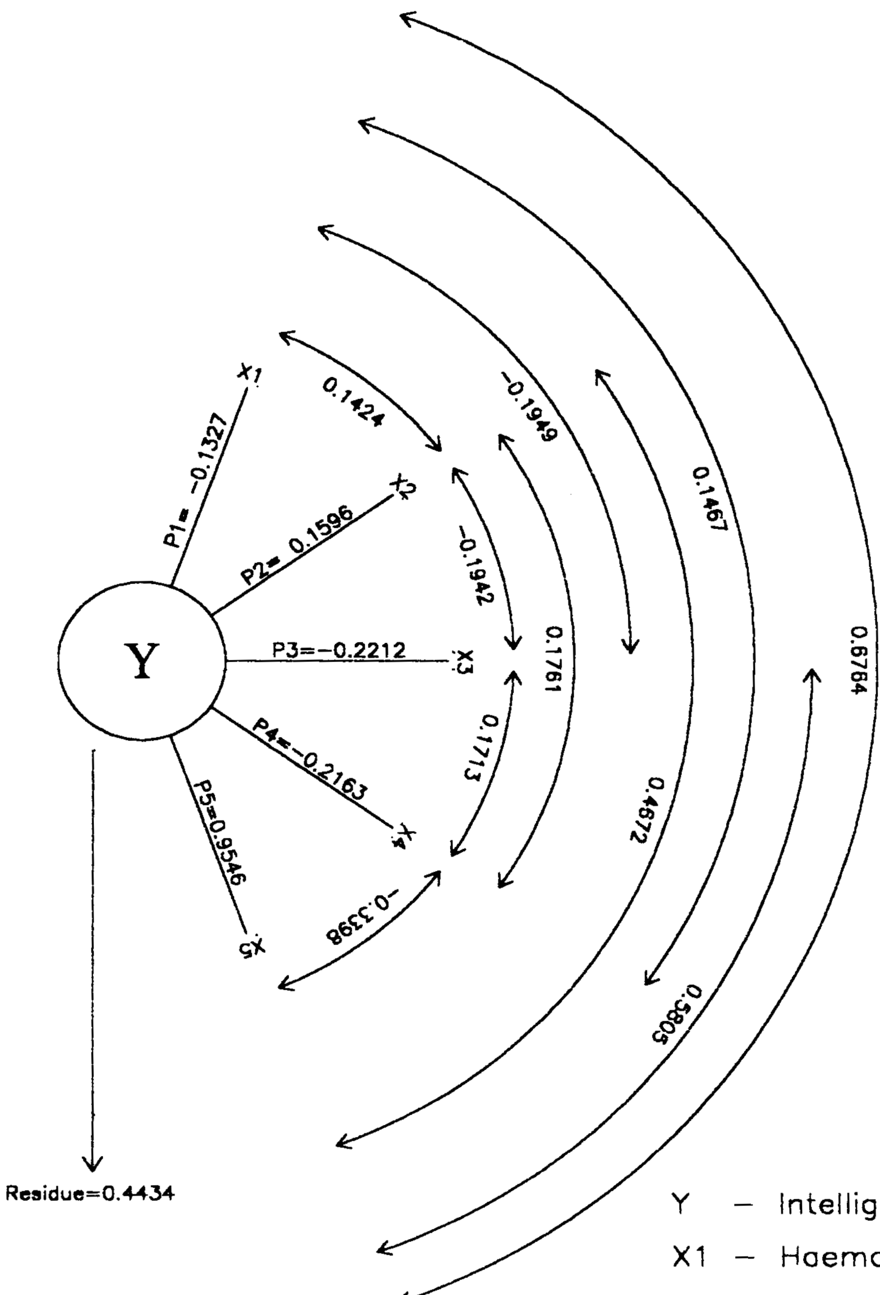
IRON DEFICIENT GROUP

Both the correlation and direct effect of X_1 (haemoglobin) was positive and high leading to infer that this factor itself was mainly responsible for this correlation. In this case of X_2 (MCV), the correlation was positive and high while the direct effect was negative and negligible. The influence of X_2 (MCV) via X_2 (MCV) yielded this correlation. Similar is the case with other factors also. The direct influence of X_1 (haemoglobin) and the indirect influence of other factors via X_1 resulted in this correlation. The Total Iron Binding Capacity negatively influenced indirectly via X_1 (haemoglobin) on intelligence test score whose correlation was also negative while in the other factors indirect influence was positive. From the results it can be inferred that the haemoglobin content in the blood is the main factor influencing the intelligence of iron deficient children. Eighty per cent of the variation in intelligence test scores may be attributed to these five factors.

Fig. 11

PATH DIAGRAM

NORMAL GROUP



Y – Intelligence test score

X1 – Haemoglobin

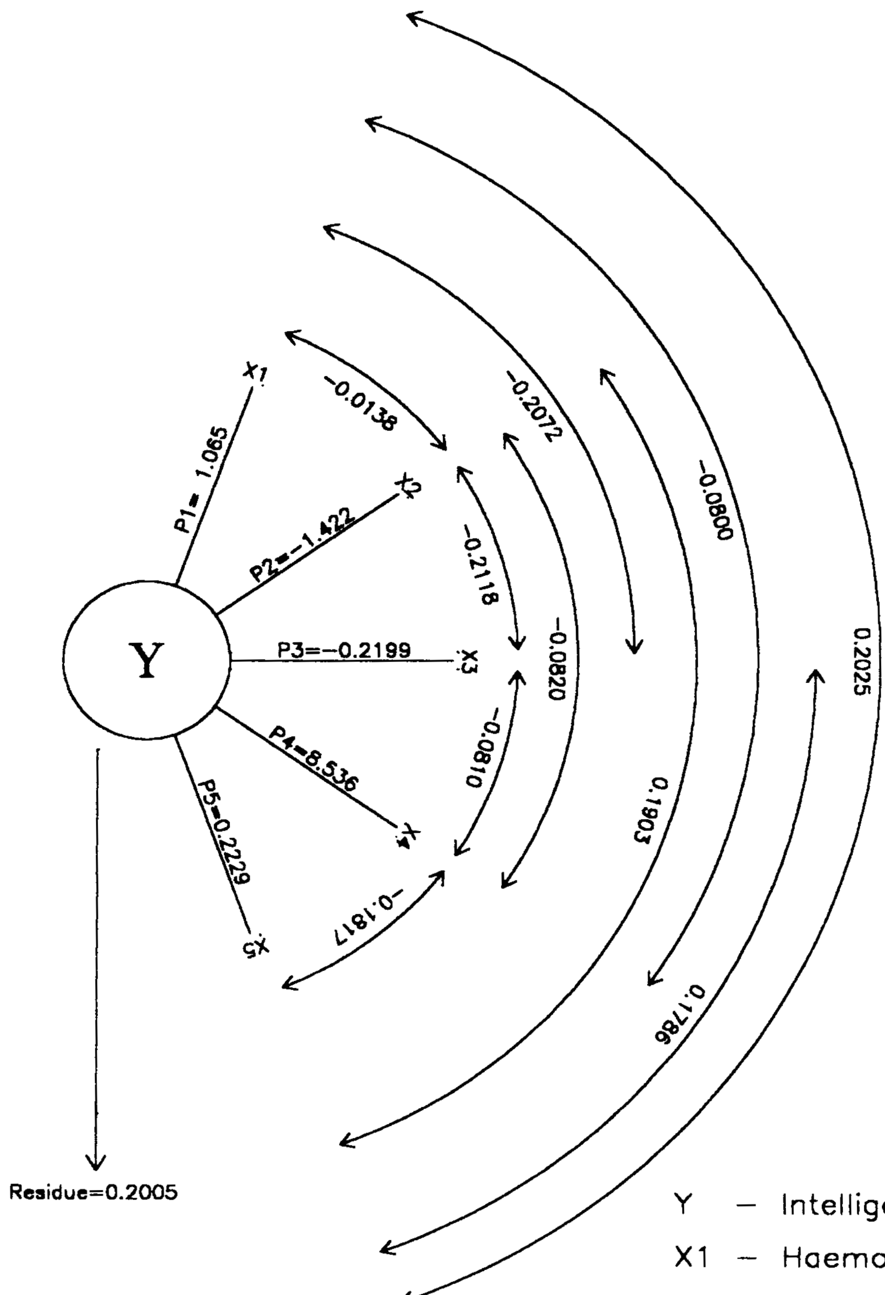
X2 – Mean Corpuscular Volume

X3 – Serum Iron

X4 – Total Iron Binding Capacity

X5 – Food Iron

IRON DEFICIENT GROUP



Y – Intelligence test score

X1 – Haemoglobin

X2 – Mean Corpuscular Volume

X3 – Serum Iron

X4 – Total Iron Binding Capacity

X5 – Food Iron

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

In the present study entitled "Iron deficiency and behaviour pattern in preschool children", the possible role of iron deficiency on the intellectual behaviour development in 50 preschool children (25 children normal and 25 children iron deficient) from an ICDS block of Thiruvananthapuram district was ascertained.

Dietary iron intake and bio-availability of iron is important for the proper formation and functions of blood. Deficiency of iron in the diet could lead to variations in the blood parameters which in turn could lead to iron deficiency anaemia. The present study carried out gives a comprehensive information on social health, dietary and blood profile with specific reference to iron status. The influence of the iron status on the behaviour profile of the children are also ascertained.

Information regarding the social background of the families indicated that among the families surveyed, many families were of nuclear type (40 per cent) and medium-sized with 3 to 5 members. Among the joint families, all the families were large-sized with 5 to 7 members.

Health profile assessment of the respondents revealed that normally healthy children were borne to non-anaemic mothers (92 per cent). While among the iron deficient preschoolers 52 per cent were borne to highly anaemic mothers and 32 per cent were borne to mildly anaemic mothers. Among the normal children, 48 per cent borne to mildly anaemic mothers.

In the iron deficient group, all the children borne to highly anaemic mothers had low birth weights (2 to 2.9 Kg). However, children in this group, borne to normal healthy mothers had normal birth weights.

Considering the physical state of the children, it was observed that in the normal group, 44 per cent of the male children and 8 per cent of the female children had head circumference higher than the standard values. Where as in the iron deficient group, 40 per cent of the males and 20 per cent of the females had lower values than the standard head circumference. While 40 per cent of the male children and 16 per cent of the female children in the normal group had chest circumference values higher than the standard values. In the case of iron deficient group, 36 per cent males and 20 per cent female had lower than standard chest circumference values. Statistical analysis revealed that there was a significant difference in the physical state and health status of the children between the normal and iron deficient group.

A comparison of the dietary profile of the children in the normal and iron deficient group revealed that the average diet is not balanced. Foods like pulses, roots and tubers and fish were met above the Recommended Dietary Allowances (R D A). Where as intake of fruits and milk were inadequate to meet the norms suggested for a balanced diet. In the iron deficient group, pulses, fish, cereals, fruit and milk were found inadequate. The average diet of the normal group, were adequate in proteins, iron, energy, thiamine and riboflavin. The diets of the iron deficient group were found to supply energy, calcium, thiamine, riboflavin, protein and iron inadequately. Food combinations of an average diet of normal group revealed that 20 per cent had a well-balanced mixed diet while similar situations were not observed in the iron deficient group. Available iron determined in the cooked food revealed that in the normal group, majority of the children had available dietary iron highly adequate where as in the iron deficient group none of the children received this required amount of dietary iron. The unavailability of iron from the diet as in the case of iron deficient group may possibly account for the severity of their iron deficiency. The quantity and also the quality of food consumed by this group must have affected the bio-availability of iron.

Statistical analysis of the data revealed significant difference in the iron availability for the children between the 2 groups. Dietary profile of the children revealed the inadequacy of the diets of the children in the normal group, when compared to the iron deficient group, with specific reference to their balanced diets, constituents and nutrients contributed and various food combinations included in their daily diets.

The behavioural development of the children assessed, through screening methods, revealed that children from the normal group obtained scores in the range of 66.6 per cent to 87.5 per cent where as in the iron deficient group, their scores ranged form 10.4 per cent to 68.7 per cent. The highest score obtained in the normal group was 86.4 per cent and the lowest score was 66.6 per cent. In the iron deficient group, the highest score was 62.6 per cent and the lowest 10.4 per cent. In the normal group, higher per cent of the children (68 per cent) obtained 60.1 to 80 per cent score. The children in the iron deficient group attained various scores with majority (66 per cent) obtaining scores below 60 per cent. The variation in intelligence test scores could be influenced by other socio-economic factors like their living environment, undiversified local food production and low family income. It could also be due to traditional factors, which predisposed to iron deficiency anaemia.

Clinical examination of the respondents of the two groups were conducted and the iron status of the preschool children were estimated with specific reference to biochemical indicators like haemoglobin, serum iron, Total Iron Binding Capacity and Mean Corpuscular Volume. In the normal group, majority of the children had normal values for these biochemical indicators. However in the iron deficient group the values for these indicators were far below normal indicating poor iron status. The variations in the values observed in the normal and iron deficient groups could be attributed to non-nutritional factors or other clinical conditions. The investigations carried out showed that majority of the children in the iron deficient group were having a negative iron balance and this could be the reason for the extent of the iron deficiency.

In the present study association between iron consumption and blood profile worked out revealed that iron consumption was positively and highly correlated with haemoglobin, Mean Corpuscular Volume and serum iron for both the normal and iron deficient groups. However the association was higher for the iron deficient group. Iron status was highly but negatively correlated to Total Iron Binding Capacity. It was evident that the amount of iron available through diet daily does have an effect on the blood profile of the preschoolers and this fact was further confirmed by the path analysis. Association among the various blood parameters worked out revealed that haemoglobin has a positive correlation which was highly significant with Mean Corpuscular Volume. Similarly serum iron levels were also positively correlated with Mean Corpuscular Volume. However Total Iron Binding Capacity was highly but negatively correlated with haemoglobin, serum iron and Mean Corpuscular Volume. In the case of serum iron and haemoglobin also a positive correlation existed. However the correlations were more significant for iron deficient group. In this experiment, the conclusion that change in one blood parameter does have a direct and indirect influence on the other was reinforced by the path analysis.

The effect or influence of iron status on behavioural development was proved by correlation. The intelligence test scores were significantly and positively correlated with haemoglobin, Mean Corpuscular Volume and serum iron. The significance was higher for iron deficient group compared to normal group. However intelligence score was negatively correlated with Total Iron Binding Capacity. The higher significance for the iron deficient group could be attributed to the fact that the effect of the iron status on behavioural development becomes more evident or pronounced in extreme cases of deficiency. As the extent of iron deficiency increases the negative balance for iron status becomes more pronounced. As the extent of iron deficiency increases more positive will be the effect on behavioural development. Here arises the necessity to keep in mind the impact of prolonged deficiency which could eventually lead to irreversible mental impairment.

REFERENCES

REFERENCES

Agarwal, D.K., Agarwal,K.N and Upadhyay, S.K. (1989). Effect of mid-day meal programme on physical growth and mental function. Indian Journal of Medical Research. 90: 163-174.

Agarwal, K.N. (1991). Functional consequences of Nutritional Anaemia. Proceedings of Nutritional Society of India. 37: 127.

Antia, F.P. (1989). Clinical Dietetics and Nutrition, 3rd edition. Oxford University Press, Bombay. pp: 438.

Badowal, J., Caldera, R. (1982). Iron deficiency anaemia. The Paediatricians point of view. Annales de Pediatric. 29 (4): 235-241.

Basta, S.S., Karyadi, D and Churchill (1974). Iron deficiency anaemia and the productivity of adult males in Indonesia World Bank. Staff Working paper No.175: 54.

Bhatia, D and Seshadri, S. (1987). Indian Pediatrics. 24: 133.

Bothwell, T.H., Charlton, R.W., Cook, J.D., Finch, C.A. (1979). Iron Metabolism in Man. Oxford. Blackwell: 235.

Calvo, B., Gnazzo, N.(1990). Prevalence of iron deficiency in children aged 9 to 24 months from a large urban area of Argentina. American Journal of Clinical Nutrition. 52: 534-540.

Carol, E.A., M.D, Jerry. Z. Finkleslein and Eleizer, N. (1984). Association of anaemia and early onset of pulmonary emphyrema in 3 siblings. Journal of Pediatrics, Vol. 105, No.2: 247-251.

Charles, W.R., M.D, Mary, J.O.C., Marvin, A., William, B., M.D and Arthur, H.P, Jr., M.D. (1984). Somatic growth and developmental functioning in children receiving prolonged home TPN. Journal of Pediatrics. 105: 842-843.

Chatterjee, P.K. (1991). Relation between diet and work capacity. Nutrition and work efficiency, F.F.H.C. Basic study. (5): 13.

Chavez, N.M., Bono, B.F. (1979). Early Nutrition and the development of intelligence in children. UNICEF NEWS.101: 31.

Cook, J.D. and Skikne, B. (1982). American Journal of Clinical Nutrition. 35: 1184.

Dacie, J.V., Lewis, S.M and Canon, D.S. (1975). Practical Hematology, Churchill Livington pub. 3rd edition: 31.

Damsdaran, M., Naidu, A.N., Sharma, K.U.R. (1979). Anaemia and morbidity in rural pre school children. Indian Journal of Medical Research. 69: 448-456.

David, A., Driggers, M.D., Jerry, D., M.D. (1981). Iron deficiency in 1 year old infants. Journal of Pediatrics. Vol. 98, No. 5: 753-758.

De Maeyer, E and Adiels - Tegman, M.C. (1985). The Prevalence of anaemia in the world. World Health Statistics quarterly, 38: 302-316.

Devadas, R.P., Sakthivelmani. A and Kaveri, R. (1980). Indian Journal of Nutrition and Dietetics. 16: 435.

Devadas, R.P. (1988). Nutrition and physical performance of selected categories of people involved in certain activities. Proceedings of Nutritional Society of India. 34: 35-42.

Dhira, N., Sitha lekshimi, S and Anuradha, V. (1984). Malnutrition and mental development - a critical view. Indian Journal of Nutrition and Dietetics 8: 149.

Dorice, M., Czajka-Narcns, Ph.D., Theresa, B., Haddy, M.D., and David, J., Ph.D. (1978). Nutrition and social correlates in iron deficiency anaemia. American Journal of Clinical Nutrition 31: 955-960.

Edgerton, V.R., Gardner, G.W., Ohira, A.J., Gunawardana, K.A and Senewirtane, B. (1979). British Journal of Medicine. 2: 1546.

Eiser, C. (1986). Effect of chronic illness on the child's intellectual development. Journal of Royal Society of Medicine. 79: 2-3.

Fall, M., Sow, D., Diakhate, L., Senghor, G. (1982). Nutritional anaemias in Senegalese children. Economic and cultural factors. Annales de Pediatric. 29(4): 283-288.

Gardner, G.W., Edgerton, V.R., Senewiratne, B., Barnard, R.J and Ohira, Y. (1977). American Journal of Clinical Nutrition. 30: 910.

Geetha, G., Devadas, R.P. (1986). Prevalence of malnutrition, morbidity pattern and nutritional status of 0 to 6 years old children in Coimbatore. Journal of Nutrition and Dietetics. 23: 148-157.

Ghosh, S., Zaidi, A., Ananda lakshmy, Choudhary and Sharuva, A. (1979). Growth and development of children in different ecological settings. Indian Journal of Nutrition and Dietetics. 16: 155.

Ghosh, S. (1987). Women's role in health and developmental health for the millions. xiii (1 and 2): 2-7.

Gopaldas, T., Raghavan, R and Kanani, S. (1983). Nutritional Research. 3: 831.

Gopaldas, T and Kale, M. (1985). Prophylatic iron supplementation for underprivileged boys. Impact on submaximal work capacity. Indian Pediatrics. 22(10): 731-736.

Gupta, M.N. (1968). Proceedings of the Seminar on "Women in Industry". ICMR, New Delhi.

Hancock and Harrison (1982). Journal of Clinical Nutrition. Pathol. 35: 1204.

Hedgeston, L and Scrimshaw, N.S., ed. (1981). Iron deficiency and work performance. Washington, DC. International Nutritional Anaemia Consultative Group.

Heresi, G. (1987). Unpublished Observations. American Journal of Clinical Nutrition. 46: 335-340.

Hogan , G.R., Jones, B. (1970). The relationship of Koilonychia and iron deficiency in infants. Journal of Pediatrics. 77: 1054.

Howell, D. (1971). Significance of iron deficiencies: Consequences of mild deficiency in children: Extent and meaning of iron deficiency in the US in Summary. Proceedings of Workshop of Food and Nutrition Board. National Academy of Sciences.

Hutchison. (1984). Iron deficiency and the immune response. American Journal of Clinical Nutrition. 46:329-334.

ICMR (1985). Functional significance of early malnutrition. ICMR Annual Report: 121-124.

ICMR (1986). Immune response on anaemia. ICMR Annual Report: 69.

Indian Council of Medical Research (ICMR). (1991). Recommended Dietary Intakes for Indians, NIN, Hyderabad: 46.

International Conference of Nutritional. Hidden hunger, preventing micronutrient deficiencies, Nutritional Global Challenge. Dec. 1992.

International Nutritional Anaemia Consultative Group. Guidelines for the eradication of iron deficiency anaemia. Washington, DC. INACG, 1977.

Judisch, J.M., Naiman, J.L., Oski, F.A. (1966). The fallacy of the fat iron deficient child. Pediatrics 37: 987-993.

Judith, S.P., M.D, Melvin, D., Levini, M.D and Caryl, A, M.S. Ed. (1981). An analysis of observed attention and activity patterns in preschoolers. Journal of Pediatrics. Vol.98, No.6: 1006-1011.

Klein, R.E., Freeman, H.E., Kagan, J., Youbrough, C and Bicht, J.P. (1972). "The relation of growth to cognition". Journal of Health and Social behaviour. 17(1): 219-225.

Kripke, S.S and Sanders, E. (1970). Prevalence of iron deficiency anaemia among infants and young children seen at rural ambulatory clinics. American Journal of Clinical Nutrition. 23: 716-724.

Lars, H.V and Ragnor, O. (1984). Iron in the preterm infant. The Journal of Pediatrics. Vol.105, No.1: 151-157.

Leibel, R., Greenfield, D and Pollitt, E. (1989). Biochemical and behavioural aspects of sideropenia. British Journal of Hematology. 41: 145-150.

Levi, S., Heisko, C., Grossowicg, N., Rachmileitz, M and Izak, G. (1970). Prevalence and causes of anaemia in children in Israel. American Journal of Clinical Nutrition: 1364-1369.

Looker, C.A., PhD, RD., Christopher, T.S., PhD, Clifford, J., MSPH and Elizabeth, A.Y. (1987). American Journal of Clinical Nutrition, 46: 655-672.

Lozoff, B., Brittenham, G.M., Viteri, F.E., Wolf, A.W and Urrutia, J. (1982). The effects of short term oral iron therapy on developmental deficits in iron deficient infants. Journal of Pediatrics. 100: 351-357.

Maeyer,E. and Adiels - Tegman, M. (1985). The Prevalence of anaemia in the world. World Health Statistics, Quart. 38: 302.

Malhotra, S. (1990). Temperament characteristics of mentally retarded children. Journal of Paediatrics. 57: 213-218.

Mauer, A.M. (1969). Pediatric Hematology. NewYork, Mc Graw-Hill Book.

Monckeberg, F. (1972). Malnutrition and mental capacity nutrition, the nervous system and behaviour. Pan American Organization. 251: 48-53.

Moriarity, A.E. (1966). Constancy and IQ change. Springfield. III. 25: 125.

Nair, K.S and Poehlman, E.T. (1991). Contribution of Protein Turnover to Energy Expenditure in Humans. Proceedings of Nutritional Society of India. 37: 199.

National Institute of Nutrition. (1989). Annual Report of Indian Council of Medical Research. Hyderabad, India. pp-18.

Nuruga,r.c.b. (1977). Effect of kwashiorkor on development among children. American Journal of Clinical Nutrition. 30: 1423-1430.

Nutritional anaemia. (1985). Nutirion Reviews. NIN. Hyderabad. Vol.24 (2): 32.

Nutrition Reviews (1983). Use of iron fortified salt to combat anaemia. The Indian experience 41, 10.pp 302-303. Indian Journal of Nutrition. (1987). 24: 253.

Ohira, Y., Edgerton, G.W., Gardner, G.W., Senewiralne, B., Barnard, R.J and Simpson, D.R. (1979). British Journal of Hematology. 41: 365.

Opoenheimer, S.J. (1980). Anaemia of infancy and bacterial infections in Papua, New Guinea. Annual Tropical Medical Parasitol. 74: 69-72.

Oski, F.A and Honig, A.S. (1978). The effects of therapy on the developmental scores of iron deficient children. Journal of Pediatrics. Vol. 92: 21-24.

Ozorio, P. (1984). 230 million women in third world suffer from nutritional anaemia-Prevalence highest in those pregnant. IFDA dossier, 39: 69-72.

Patiroglu, T and Dogan, P. (1991). Iron deficiency anaemia and catecholamine metabolism. Indian Pediatrics. Vol: 28: 51-56.

Peter, R.D, M.D, George, D.B., M.P.H, PhD, Constance, M.A, M.P.H, M.D and Henry, R. (1978). Haemoglobin concentration in white, black and Oriental children; Is there a need for separate criteria in screening for anaemia?. American Journal of Clinical Nutrition. 31: 377-380.

Pollitt, E and Leibel, R.L., ed. (1982). Iron deficiency: Brain biochemistry and behaviour. NewYork, Raven Press: 251-256.

Pollitt, E. (1983). Iron deficiency and cognitive test performence in preschool children. Nutrition and behaviour. 1: 137-146.

Pollitt, E. (1985). Cognitive effects of iron deficiency anaemia. Lancet. 1: 158.

Pollitt,E., Pollitt, C.S., Rudolph, L and Fernando, E.V. (1986). Iron deficiency and behavioural development in infants and preschool children. American Journal of Clinical Nutrition. 43: 555-565.

Rajajee, S. (1989). Nutritional Anaemias in Childhood. Proceedings of Nutritional Society of India. Hyderabad. Vol. No. 35: 122.

Raman, L. (1991). Ferritin status of preschool children; Nutrition News, NIN, Hyderabad, Vol. 12, No. 1: 25.

Rao, P.N., Shastry, G.J and Singh, A.K. (1993). Changes in the diet and nutrition profile in ten states in India. Nutrition News. 7: 2.

Reeves, D.J., M.D, David, A.D., Edward, Y.T., M.S and Peter, R.D., M.D. (1981). Screening for iron deficiency in 1 year old infants. The Journal of Pediatrics. Vol: 98, No: 6: 894-898.

Reeves, J.D., M.D., Lt Col USAFMC, Ray, Y.P., M.D, Vincent, A.K., M.D and Peter, R.D., M.D. (1984). Iron deficiency in infants. Journal of Pediatrices. Vol. 105: 874-879.

Robinson, C.H., Lawler, M.R., Chemoweth, W.L and Garwick, A.E. (1986). Anaemia and iron deficiency. Normal and Therapeutic Nutrition. The British Medical Bulletin. Vol. 37(1): 25-30.

Ronald, G.S., M.D. (1978). Iron deficiency, infections and immune function: A reassessment. American Journal of Clinical Nutrition 31: 660-666.

Sathy, N., Elizabeth, K.E., Nair, M.K.C and Sugura, N.S. (1991). Growth faltering and development in children with protein-energy malnutrition. Indian Pediatrics Vol. 28, No. 3: 255-258.

Saxena, K.J. (1986). The joint and nuclear family. A personal experience. The Indian Journal of Social work. XL VII: 32-36.

Seshadri, S and Malhotra, S. (1984). Indian Pediatrics. 21: 529.

Sheshadri, S. (1988). Effect of Anaemia on Physical performance of children and the impact of iron supplements, Proceedings of the Nutrition Society of India, NIN, Hyderabad.

Seshadri, S and Gopaldas, T. (1989). Impact of iron supplementation on cognitive functions in preschool and school age children, the Indian experience. American Journal of Clinical Nutrition. 50: 675-685.

Sigman,M, PhD., Neumann, C, M.D., Baksh, M and Mc Donald, M, Ph.D. (1989). Relationship between nutrition and development in Kenyan toddlers. Journal of Pediatrics Vol. 115: 357-364.

Sulzer, J.L., Wesley, M.H and Leonig, F. (1973). Nutrition and behaviour in head start children: Results from the Tulane Study, ed. Nutrition, Development and social behaviour, Publication 73-78. Department of Health, Education and Welfare.

Swaminathan, M. (1986). Principles of Nutrition and Dietetics. The Banglore Printing and Publishing Company Ltd:334.

Uberol, I.S., DeSweemer, C and Taylor, C.E. (1972). A study of anaemia among rural Punjabi children. Indian Journal of Medical Research 60(5): 793-799.

United Nation's Children's Fund (1990). The Nature of the nutritional problem strategy for improved nutrition of children and women in developing countries. UNICEF News pp.19.

Upadhyay, S.K., Agarwal, K.N and Agarwal, D.K.(1989). Influence of malnutrition in social maturity, visual co-ordination and memory in rural children. Indian Journal of Medical Research. 90: 320-327

Vazquez-Seoune, P., Windom, R and Pearson, H.A. (1985). Disappearence of iron deficiency anaemia in a high risk infant population given supplemental iron. Journal of Nutrition. 13: 129.

Vijaya lekshmi, P and Selvasundari, S. (1983). Relationship between iron deficiency anaemia and energy expenditure. The Indian Journal of Nutrition and Dietetics. 20(4): 113.

Walter, T., Kovalskeys, J and Stekel, A. (1983). Effect of mild iron deficiency on infant mental developmental scores. Journal of Pediatrics. 102:519.

Waterlow, J.C., Cravioto, J and Stephen, J.M.L. (1960). Protein malnutrition in man: Clinical and Social aspects. Adverse Protein Chemistry. 15: 138.

Wheeler, E.F and Tan, S.P. (1983). "From concept to practice food behaviour of Chinese imigrants in London". Ecology of Food and Nutrition. 13: 51-57.

WHO Technical Report Series, No 580, 1990. Control of nutritional anaemia with special reference to iron deficiency: report of an IAEA/USAID/WHO Joint Meeting.

WHO (1980). Assessment, prevalence and consequence of iron deficiency of anaemia. Proceedings of National Conference on iron deficiency anaemia: 8-10.

Wong, P., Riguera, I and Valencia, M.E. (1985). Relation between family income, expenditure and food intake in marginal urban areas of Sonora, Mexico. Nutrition Abstracts and Reviews (Series A). 55(7): 505.

Yatkin, U.S., McLaren, D.S., Kanawati, A.A and Sabbagh, S. (1971). Effect of undernutrition in early life on subsequent behavioural development. Proceedings of International Congress of Pediatrics. 2:71.

Yona, A. (1986). Life News letter, Vol. 18, N0.6: 25.

APPENDICES

APPENDIX - I

SOCIO - ECONOMIC STATUS RECORD

1. Name of the respondent: Age: Sex:
2. Address:
3. Type of family: Nuclear Joint
4. Family size: Adults Children
5. Materials status during pregnancy:
6. Birth weight of the respondent:
7. Head circumfrence of the respondent:
8. Chest circumference of the respondent:

FOOD CONSUMPTION PATTERN OF RESPONDENT - 24 HR RECALL METHOD

Name of the meal	Menu	Weight of total ingredients used	Weight of the total cooked ingredients	Weight of the cooked food used by respondents	Type of food preparation

APPENDIX - II

ESTIMATION OF AVAILABLE IRON IN FOOD (WONG'S METHOD)

PRINCIPLE

Iron is determined colorimetrically making use of the fact that ferric iron gives a blood red colour with potassium thiocyanate.

REAGENTS

1. 30 % H_2SO_4

2. 7 % potassium persulphate solution: 7 g of potassium persulphate is dissolved in glass distilled water and the solution made up to 100ml.

3. 40% potassium thiocyanate solution: 40 g of KCNS in 90ml glass distilled water, 4ml acetone added and the volume is made upto 100ml.

4. Standard iron solution : 702.2 mg ferrous ammonium sulphate is dissolved in 100ml glass distilled water & after addition of 5 ml of 1:1HCl, the solution is made upto 1litre and mixed thoroughly (0.1 mg Fe/ml). The standard solution is prepared fresh once in 6 months.

   Working standard solution is prepared by diluting the above solution 10 fold.

PROCEDURE

I. PREPARATION OF ASH

About 5-10g of the sample is weighed accurately into a tared platinum (or porcelain) crucible (which has previously been heated to about 600°c & cooled). The crucible is placed on a clay pipe triangle and heated first over a low flame till all the material is completely charred, followed by heating in a muffle furnace for about 3-5 hr at about 600°c. It is then cooled in a dessicator and weighed. To ensure completion of ashing, the crucible is again heated in the muffle furnace for 1/2 hr. cooled and weighed. This is repeated till two consecutive weights are the same and the ash is almost white or greyish white in colour.

$$Ash\ content\ (g/100g\ sample) = \frac{weight\ of\ ash}{Weight\ of\ sample\ taken} \times 100$$

II. PROCESSING OF THE ASH SOLUTIONS

The ash is moistened with a small amount of glass distilled water (0.5-1.0ml) and 5 ml of distilled hydrochloric acid is added to it. The mixture is evaporated to dryness in a boiling water bath. Another 5 ml of hydrochloric acid is added again and the solution evaporated to dryness. As before 4 ml of hydrochloric acid and few ml of water then added and the solution warmed over a boiling water bath and filtered into a 100 ml volumetric flask using Whatman No. 40 filter paper. After cooling, the volume is made upto 100 ml and suitable aliquotes are used for the estimation of iron. To an aliquot (6.5 ml or less) of the mineral solution, enough water is added (if necessary) to make up to a volume of 6.5 ml followed by 1.0 ml of 30 percent H_2SO_4, 1.0 ml of potassium persulphate and 1.5 ml of 40 percent KCNS solution. The red colour that develop is measured within 20 min. at 540 nm.

APPENDIX - III

Estimation of Heamoglobin (Cyanmethaemoglobin method)

Principle

Haemoglobin is converted into cyanmethaemoglobin by the addition of KCN and ferricyanide. The colour of cyanmethaemoglobin is read in a photoelectric colorimeter at 540nm against a standard solution Since cyanide has the maximum affinity for haemoglobin, this method estimates the total haemoglobin.

Reagent

Drabkin's solution : Dissolve 0.05 g of KCN, 0.02 g of pottasium ferricyanide and 1.00 g of sodium bicarbonate in 1 litre of distilled water.

Procedure

20 ml of blood is transferred with the help of a haemoglobin pipette and delivered on to a Whatman No.1 filter paper disc. The filter paper is air dried, labelled and can be stored upto one week. The portion of filter paper containing the blood is cut and dipped in 5 ml of Drabkin's solution taken in a test tube. Wait for 30 minutes and mix the contents in the tubes, take the readings in a photoelectric colorimeter. The reagent blank (Drabkin's diluent) is adjusted to zero.

Construction of standard curve

If the blood drawn from the subject contains haemoglobin 15g/dl after estimation then prepare three reference standards as follows.

1. Reference standard A.

 4 ml of blood in 1000 ml Drabkin's reagent contains haemoglobin 15 g/dl

2. Reference standard B.

 300 ml of reference standard A + 200 ml Drabkin's reagent contains haemoglobin concentration of 10 g/dl.

3. Reference standard C

 200 ml reference standard A and 300 ml Drabkin's reagent contains a haemoglobin concentration of 7.5 g/dl.

Thus we have three reference standards at three levels of haemoglobin concentration. Use 5 ml from each standard whenever haemoglobin estmations are done.

APPENDIX - IV

ESTIMATION OF SERUM IRON

PRINCIPLE

Iron is released from its carrier protein transferrin in a acetate buffer at pH 4.8 and reduced from the ferric to the ferrous state by ascorbic acid.

Ferrous ions chelate then with Ferene-S* forming a stable blue complex. The reaction is read at 578 nm (570-610 nm). *3- (2-pyridyl)-5, 6-bis [5-furylsulphonic acid)]-1,2,4- triazine.

SAMPLE COLLECTION

Serum or heparinised plasma may be used for analysis. Avoid the use of hemolysed samples.

REAGENTS

1. BUFFER
1A. ASCORBIC ACID
2. FERENE-S

STANDARD : Iron 100 ug/dL. Ready for use.

PREPARATION OF WORKING SOLUTIONS

Allow the reagents to attain room temperature.

SOLUTION 1: Add one measuring spoon (provided inthe kit approx.35 mg) of Reagent 1A to 20Ml of Reagent 1. Mix until completely dissolved.

SOLUTION 2: Dissolve the contents of vial 2 with 10mL of distilled water.

SOLUTION 3: Mix 0.5 volumes of SOLUTION 2 with 10 volumes of SOLUTION 1.

PROCEDURE

All solutions standard and samples should be brought to room temperature before use.

Prepare one standard and one reagent blank for each essay. It is recommended that a sample blank be prepared for each sample in the assay.

	Reagent Blank	Standard	Sample Blank	Sample
Standard	--	200 uL	--	--
Sample	--	--	200 uL	200 uL
Solution 1	--	--	1.0 mL	--
Solution 3	1.0 mL	1.0 mL	--	1.0 mL

Mix and keep at room temperature for 5 minutes. Read absorbance of reagent blank, sample and sample against distilled water at 578nm (570-610 nm).

CALCULATION

RB = Absorbance of reagent blank against distilled water

ASB = Absorbance of sample blank against distilled water

Ast = Absorbance of the standard - Absorbance of reagent blank (RB)

AS = Absorbance of the sample - Absorbance of reagent blank (RB)

$$\frac{AS-ASB}{Ast} * 100 = ug\ iron/dL$$

APPENDIX - V

ESTIMATION OF TOTAL IRON BINDING CAPACITY

PRINCIPLE

The iron carrying protein transferrin is fully saturated by the additon of an excess of ferric ions to the sample. The unbound iron is subsequently removed by absorbtion on basic magnesium carbonate powder. After centrifugation, the bound iron remaining in the supernatant (which represents the TIBC), is determined by the Ferene-S method (AUTOPAK Iron kit Code No.6685).

SAMPLE COLLECTION

Serum or heparinised plasma may be used for analysis. Avoid the use of hemolysed samples.

REAGENTS

1. FERRIC CHLORIDE
2. MAGNESIUM CARBONATE HYDROXIDE (POWDER)

All reagents are ready to use.

STORAGE AND STABILITY OF THE REAGENTS

All reagents are stable till expiry date indicated on the lables when stored at 2^0 C to 8^0 C.

PROCEDURE

The samples and the reagents should be brought to room temperature prior to use.

Pipette into a centrifuge tube:

Sample	0.50mL
Reagent 1	1.00mL

Mix and keep at room temperature for at least 5 minutes.

Reagent 2 One measuring spoon (provided in the kit).
(approx.80mg).

Mix well by inversion. Keep at room temperature of 10-20 minutes, shaking 3 or 4 times during this interval.

Certifuge at 3000 rpm for 10 minutes.

Take 200 uL supernatant and determine the iron concentration with AUTOPARK Iron kit. Code 6685.

CALCULATION

TIBC: ug of iron/dl = Serum iron determined in supernatant 3 (dilution factor).

LIBC (Latent Iron-Binding Capacity) = TIBC-Serum iron value.

APPENDIX - VI

Anthropometric Measurement Of The Preschoolers

Serial No:	Normal Group			Iron deficient Group		
	Birth weight (Kg)	Head Cirucmference (cms)	Chest Circumference (cms)	Birth weight (Kg)	Head Cirucmference (cms)	Chest Circumference (cms)
1	2.7	52	60	2.7	51	62
2	2.8	51	55	3.1	50	53
3	2.8	54	64	3.2	53	63
4	3.7	52	56	2.3	52	54
5	3.2	49	52	2.9	51	56
6	2.8	52	57	2.2	50	52
7	2.8	50	53	2.6	51	53
8	2.7	53	59	3.2	51	61
9	3.4	52	56	2.8	52	60
10	2.7	54	62	2.3	51	54
11	3.5	52	58	2.6	50	53
12	3.2	51	56	2.6	51	57
13	3	51	63	2.7	53	58
14	3	54	60	2.8	54	60
15	3.3	51	55	2.5	53	58
16	3.2	51	64	2.4	50	52
17	3	52	59	3	51	58
18	3.1	53	58	2.4	48	50
19	3.2	54	64	2.8	55	57
20	3.1	52	58	2.6	50	56
21	3.6	52	60	3	52	56
22	2.9	51	61	2.9	52	54
23	2.5	52	60	2.6	53	58
24	3.4	54	60	3	51	58
25	2.9	53	67	2.4	51	54

APPENDIX - VII

Quantity Of Foods Cnsumed By The Preschoolers Ascertained Through One Day Weighment

Serial No:	Normal Group							
	Cereals (g)	Pulses (g)	Other Vegetables (g)	Leafy Vegetables (g)	Roots and Tubers (g)	Frutis (g)	Milk (ml)	Animal Foods (g)
1	180	50	20	35	35	10	100	50
2	165	25	20	40	20	20	100	35
3	170	30	35	45	10	25	150	40
4	175	35	40	50	15	30	100	35
5	180	55	20	55	20	50	150	20
6	150	35	50	40	25	50	150	45
7	175	45	20	45	15	40	100	40
8	180	25	25	50	10	60	100	30
9	125	50	15	50	30	70	50	45
10	150	35	30	40	20	50	50	50
11	165	50	35	55	15	55	100	30
12	170	50	20	40	20	40	100	20
13	200	40	25	45	25	50	100	25
14	170	45	40	50	30	55	100	15
15	200	40	35	55	15	60	50	20
16	200	35	35	50	10	20	50	30
17	150	50	30	40	5	10	100	35
18	170	40	40	35	10	10	100	30
19	180	40	30	20	25	5	100	45
20	135	50	20	25	30	10	100	50
21	165	45	20	40	20	15	100	40
22	190	30	20	20	30	20	100	30
23	150	40	40	25	25	25	100	15
24	125	35	35	30	25	50	50	35
25	160	40	25	25	15	40	100	40

Serial No:	Iron deficient Group							
	Cereals (g)	Pulses (g)	Other Vegetables (g)	Leafy Vegetables (g)	Roots and Tubers (g)	Frutis (g)	Milk (ml)	Animal Foods (g)
1	170	30	20	–	10	50	50	20
2	160	20	30	50	20	60	75	35
3	150	25	25	20	–	65	60	20
4	75	20	30	–	25	50	70	30
5	100	25	25	25	35	–	65	35
6	50	30	30	30	30	–	70	–
7	75	35	25	40	50	70	75	20
8	170	20	20	50	20	15	50	–
9	150	25	15	55	40	–	50	–
10	50	20	30	–	–	–	50	25
11	150	20	10	–	60	20	–	20
12	160	–	15	–	75	30	–	20
13	140	25	20	10	20	40	50	25
14	130	20	30	15	30	45	55	30
15	150	25	–	25	35	60	–	35
16	160	30	–	–	40	–	–	–
17	55	25	35	–	–	–	–	–
18	170	35	20	35	–	60	50	20
19	100	–	–	–	25	50	50	20
20	100	25	15	50	30	40	50	25
21	150	35	10	40	15	–	50	40
22	160	45	–	55	10	–	50	–
23	170	20	–	–	25	–	50	25
24	175	25	–	–	35	25	–	40
25	155	30	5	–	40	20	–	30

APPENDIX - VIII

Mean Nutrients Intake By The Preschoolers

Serial No:	Normal Group								
	Energy (Kcals)	Protein (g)	Fat (g)	Calcium (mg)	Iron (mg)	Thiamine (mg)	Retinol (mg)	Riboflavin (mg)	Vitamin C (mg)
1	1,300	40	10	400	24.4	1.1	300	0.1	40
2	2,200	45	10	500	22.3	1.8	380	0.08	20
3	1,350	35	5	400	25.3	2	400	0.07	25
4	1,400	30	20	500	25.2	0.5	425	0.05	30
5	1,500	50	10	400	29.2	0.2	300	0.02	25
6	1,300	70	10	300	19.9	0.4	300	0.05	20
7	1,200	65	15	600	23	0.4	250	0.1	25
8	1,600	40	5	500	20	0.5	350	0.08	30
9	1,200	35	20	400	21.2	0.5	300	0.09	55
10	1,500	20	10	350	24.2	1	225	0.09	30
11	1,400	50	5	420	22.1	1.2	350	0.08	35
12	1,450	35	10	500	24.2	0.8	300	0.05	20
13	1,500	40	10	320	31.2	0.5	200	0.02	25
14	1,700	55	15	350	28.2	0.6	150	0.09	30
15	1,900	70	10	375	30	0.7	200	0.06	35
16	1,650	45	5	400	31.7	0.8	250	0.08	40
17	1,825	30	10	320	22.4	0.1	100	0.07	40
18	1,730	35	5	225	23	0.9	150	0.04	40
19	1,615	50	5	250	19.9	1.1	100	0.05	45
20	1,680	55	5	375	24.3	1.2	200	0.03	20
21	1,515	55	10	400	23.6	1	250	0.08	25
22	1,620	60	10	400	34	1.5	300	0.07	40
23	1,800	50	10	400	25.6	0.6	325	0.07	45
24	1,600	50	5	300	24.3	0.7	350	0.06	30
25	1,777	60	5	200	34.6	0.8	200	0.09	35

Serial No:	Iron deficient Group								
	Energy (Kcals)	Protein (gm)	Fat (gm)	Calcium (mg)	Iron (mg)	Thiamine (mg)	Riboflavin (mg)	Retinol (mg)	Vitamin C (mg)
1	1,500	31	10	200	21.4	0.7	0.03	200	25
2	1,200	28	10	100	19.8	0.9	0.02	296	30
3	1,000	16	5	80	20.5	0.6	0.05	130	40
4	800	15	5	160	11.2	0.2	0.04	420	45
5	600	25	10	400	20.1	0.4	0.06	150	50
6	500	25	10	300	7.1	0.3	0.05	370	10
7	400	30	15	125	15.2	0.6	0.05	325	20
8	1,000	35	5	135	29.9	0.5	0.04	360	25
9	1,200	20	5	100	16	0.2	0.01	278	8
10	1,150	25	10	125	8.3	0.09	0.03	150	10
11	1,000	20	–	200	18.3	0.3	0.06	156	8
12	500	18	10	225	19	0.7	0.07	138	10
13	700	20	10	100	17.7	0.8	0.01	190	15
14	300	25	10	150	16.5	0.9	0.1	200	20
15	375	40	10	125	7.1	1.1	0.03	150	10
16	575	15	10	165	18.1	0.6	0.02	178	15
17	800	20	10	170	11.2	0.4	0.05	200	10
18	950	25	–	75	16.2	0.3	0.08	400	7
19	1,000	30	5	60	18	0.09	0.01	325	20
20	1,200	35	10	100	20.2	0.2	0.02	520	25
21	1,300	38	15	150	15.7	0.1	0.06	320	10
22	1,400	20	10	20	12.1	0.01	0.07	200	5
23	500	36	–	50	15.1	0.07	0.04	150	15
24	900	10	10	75	12	0.7	0.03	275	10
25	1,300	25	10	120	17.2	0.2	0.02	100	5

APPENDIX - IX

Intelligence Test Scores Obtained by the Preschoolers

Serial No.	Intelligence Test Scores (per cent)	
	Normal group	Iron deficient group
1	75	72.9
2	73	66.6
3	75	70
4	79	25
5	72.9	68.7
6	85.4	10.4
7	77	41.6
8	66.6	68.7
9	68.7	47.9
10	72.9	16.6
11	72.9	64.5
12	87.5	52
13	81.3	58.5
14	85	43.7
15	87.5	10.7
16	72.9	62
17	77	31.2
18	75	43.7
19	79	50
20	79	72
21	87.5	60.5
22	81	46
23	81.3	66.6
24	79	62
25	83.3	45.8

APPENDIX - X

Blood Parameters Of The Preschoolers

Serial No.	Normal Group				Iron deficient group			
	Haemoglobin (g/dl)	Mean Corpuscular Volume (μ^3)	Serum Iron (µg/dl)	Total Iron Binding Capacity (µg/dl)	Haemoglobin (g/dl)	Mean Corpuscular Volume (μ^3)	Serum Iron (µg/dl)	Total Iron Binding Capacity (µg/dl)
1	12.5	86	100	325	11	82	83	424
2	12	84	90	370	10	73	69	514
3	12	86	94	365	10	70	61	509
4	12	82	96	372	6	47	34	602
5	13	94	105	345	10	74	65	509
6	14	100	115	262	4	35	36	666
7	13	94	112	270	7	52	37	582
8	13	94	104	270	11	81	82	422
9	12.5	88	105	335	9	60	60	549
10	13	92	108	278	5	41	32	613
11	13	96	110	274	9.5	68	57	550
12	13	96	110	274	9	61	52	545
13	14	96	110	265	8	54	49	560
14	13	92	111	272	8.5	55	54	579
15	15	103	122	255	7	49	38	590
16	14	99	113	260	4	36	28	650
17	13.5	100	110	276	10	72	70	512
18	13	92	101	280	5	40	30	620
19	13	96	115	247	8	56	50	562
20	13	90	105	340	8	55	51	558
21	14.5	98	111	270	10	73	69	514
22	15	102	120	354	9	59	58	528
23	13	93	113	254	7.5	51	45	518
24	14	100	110	285	10.5	79	75	472
25	16	104	130	250	7	49	37	597

IRON DEFICIENCY AND BEHAVIOUR PATTERN IN PRESCHOOL CHILDREN

BY

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ABSTRACT OF THE THESIS

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ABSTRACT

A study on "Iron deficiency and behaviour pattern in preschool children" was taken forth to evaluate the possible role of iron deficiency on the behaviour development of preschool children. Of the 50 preschool children surveyed, 25 children were normal and the remaining 25 were iron deficient. The socio-economic pattern, health profile, dietary profile and behaviour profile were evaluated.

Of the families surveyed, majority were of nuclear type, comprising of about 3 to 5 members. The health profile evaluated indicated that in the normal group most of the children were born to non-anaemic mothers while in the case of the iron deficient group, a larger portion of the children were born to highly anaemic mothers. Considering the birth weights of the normal group, majority had normal birth weights, while in the iron deficient group the major cases were low birth weight babies.

Considering the physical state, standard head and chest circumference measures were observed for children of normal group while the iron deficient children had lower values. Statistically this fact was reinforced since a significant

difference was observed for both the groups for both physical state and health status. Dietary profile with reference to the food consumption pattern of iron deficient children were inadequate when compared with normal children. Similar inadequacies were observed in cases of food intake and nutrient intake. For the iron deficient children most of the foods and nutrient were inadequate in terms of Recommended Dietary Allowance especially their iron intake was low which could be the reason for their deficiency.

The behavioural development of the children assessed revealed that in comparison with the normal group, the children of iron deficient group performed poorly in the intelligence tests. Also as the extent of deficiency increased their concentration and attention span decreased resulting in poor performance. However the variations observed could be due to other environmental or socio-economic factors.

The respondents with low iron status as in case of iron deficient group, reflected in their low haemoglobin, Mean Corpuscular Volume and serum iron levels and higher Total Iron Binding Capacity values. In the present study, a positive correlation was observed between intelligence test scores and haemoglobin, serum iron and Mean Corpuscular Volume, while with Total Iron Binding Capacity there was a negative correlation for both the groups. The significance was higher for the iron deficient group which establishes the fact that the variation in the blood parameters and intelligence test scores were more prominent when the extent of the deficiency increased. As the intensity of deficiency increases, more will be the chances for irreversible impairment. Here arises the necessity for iron therapy.