DISCUSSION
Demographic profile of adolescent girls of EXPT and ONG group revealed that majority of the girls of both groups belonged to families of low income group with higher proportion of girls of ONG group belonging to the category of below poverty line. The geographical locale of EXPT group was the periphery of Panchkula city, a satellite town of Chandigarh, where the girls were more exposed to urbanization, modern amenities and advanced technology. The girls of ONG group belonged to Sirsa District, which is a remote and backward area from the point of view of social and economic development. Majority of the families in both groups were Hindus and their proportion was higher in ONG group. The educational background of their parents revealed that majority of them were illiterate, the literacy level of fathers being slightly higher than that of mothers but the proportion of illiterate parents was higher in ONG group. The occupational grades of fathers of majority of girls were low like unskilled workers, truck drivers, and sweepers etc in EXPT group, who were engaged in service of varied people and at varied places whereas fathers of girls of ONG group were agricultural labourers and dairy farmers, being engaged in their own fields or farms. Majority of the mothers in both groups were housewives. However, a few (28%)were engaged in low occupational jobs as household maids in EXPT group so as to supplement their family income and were exposed to different cultures of different families. The ecological background of the girls revealed that larger proportion of the girls of EXPT group had pucca houses with separate kitchen, used gas/stove as fuel and electricity available to them as compared to girls of ONG group. A larger proportion of girls of EXPT group had separate toilets in their home or used public toilets whereas majority of the girls of ONG group used to defecate in the fields. Thus, the girls of ONG group exhibited poor household and environmental conditions. All adolescent girls of both the groups had the same low socio economic conditions but different cultural and environmental conditions. The girls of ONG group were more backward culturally as well as in respect of their access to modern amenities, advanced technologies and adequate medical facilities.
The results of the present study revealed that adolescent girls of EXPT and ONG group were shorter and lighter than those of NCHS standard (50th percentile) in all age groups at the beginning of the study (T1), there being no significant difference between the two groups. The deficit in height increased with increasing age (Table 4.16). The height percentile status also showed a declining trend with increasing age. The percentile status of girls of EXPT group was between 25th-50th percentile at 9 years, near 10th percentile at 10 years, near 5th percentile at 11 years and below 5th percentile in higher age groups i.e. 12-15 years (Fig 4.31 to 4.37). The adolescent girls of ONG group were below the 5th percentile in all age groups, except 12, 13 and 15 years age groups, in which they were between 5th and 10th percentile (Fig 4.32 to 4.37). Thus, the height percentile status of girls of EXPT group was higher than that of ONG group upto 11 years and thereafter, the girls of ONG group had better percentile status, except in the age group of 14 year, in which girls of both groups had same percentile status i.e. below 5th percentile. Though there was no significant difference between the height of girls of two groups in all age groups but the height of girls of ONG group was slightly less than that of EXPT group in younger girls i.e. upto 11 years but higher than that of EXPT group in older girls i.e. 12-15 years. Like deficit in height, the deficit in weight also increased with age in both groups (Table 4.20) along with deterioration in their percentile status with increasing age. The percentile status of weight of girls of EXPT group was between 10th - 25th percentile at 9 years, near 5th percentile at 10 years and below 5th percentile in other higher age groups i.e. 11-15 years (Fig 4.41 to 4.47). The weight of girls of ONG group was below 5th percentile in all age groups, except in the age group of 10 year, in which they were near 10th percentile (Fig 4.42 to 4.47).

The increasing deficits in height and weight of girls with increasing age could be due to the fact that older girls were exposed to nutritional deprivation for longer periods and hence larger deficits. Moreover, marked spurt in height and weight associated with adolescents growth spurt called for a need for increased...

The likely reasons for these girls lagging much behind in growth was that they were exposed to severe nutritional, social and environmental strains. The ecological environment of these girls revealed poor housing facilities, improper sewage disposal and unhygienic surroundings. Nutrition being an important contributor to the nutritional status, it was found that their diets were deficient to a great extent. The observed deficit in height and weight of adolescent girls of both groups at the beginning of the study (T1) was most likely due to deficit in intake of calories to the extent of 50% of RDA in the diet of younger adolescent girls i.e. 9 – 12 years and a slightly lesser deficit (39 - 44% of RDA) in the diet of older adolescent girls of 13 - 15 years. The calorie intake of older adolescent girls (13 - 15 years) of ONG group was significantly higher than those of EXPT group (Table 4.14 A). The probable reason for lesser deficit in calorie intake of older adolescent girls of ONG group could be their better access to food in the household due to their involvement in household activities related to cooking and feeding. Other important nutrient essential for physical growth and development i.e. protein was also deficient to the same extent (46-47% of RDA) in younger adolescent girls (9 -12 years) of both groups. The difference between the two groups was highly significant in the age group of 13 - 15 years, the deficit being 50% and 42% in girls of EXPT and ONG group respectively. The higher protein intake, though deficient as compared to RDA, by adolescent girls of ONG group was due to higher consumption of milk and milk products due to rearing of cattle at home resulting in better availability of milk and milk products. However, the consumption of pulses, though deficient as compared to RDA, was comparatively higher by adolescent girls of EXPT group. Though the older girls of ONG group had significantly higher intake of calories and protein as compared to girls of EXPT group but it revealed its impact only in terms of slightly better height of
older girls of ONG group, the difference between the two groups being insignificant.

The likely reasons for insignificant difference in height and weight of girls despite higher calorie and protein intake by older girls of ONG group could be prevalence of more morbidity among girls of this group, who were exposed to poor housing and unsanitary environmental conditions. The access to doctors/medical practitioners and medical facilities was also poor to girls of ONG group. Moreover, these girls were spending comparatively more number of hours in moderate activities resulting in slightly higher energy expenditure as compared to girls of EXPT group (Table 4.47 & 4.48).

Cereals and millets form the bulk of Indian dietaries and, on weight basis, contribute to about 75 - 80 % of total diet in poor communities but the analysis of dietary intake of adolescent girls of both groups revealed that the observed deficit in calorie and protein intake in the diet of adolescent girls of both groups was mainly due to a lesser intake of all energy giving food groups i.e. cereals, fat and sugar. In the diet of these girls, a low intake of even staple food i.e. cereals was deficient to the extent of 52 - 55% of RDA in 9-12 years age group and 46 - 48% of RDA in 13-15 years age group in both groups. The possible reason for low intake in these girls may be low purchasing power of their parents and consequently inadequate availability of food. Further, lack of knowledge possessed by mothers and adolescent girls themselves vis-a-vis nutrition and health and the requirements for different age groups could also be another contributing factor.

The main sources of energy are cereals, fat and sugar. Besides cereals, the concentrated source of energy i.e. visible fat was also deficient and accounted for calorie deficit in the diet of adolescent girls of both groups (Table 4.14 A). The probable reason for low intake of visible fat was its high cost. The invisible fat in the diet is estimated to contribute to about 6 % of energy and even a
A predominantly cereal based diet would provide 15 gm of invisible fat (ICMR, 1989), which together with visible fat would meet the fat requirement of individuals of poor communities. Since the intake of cereals and pulses was found to be highly deficient, the intake of invisible fat was also bound to be deficient. Other energy giving food i.e. sugar was also highly deficient to the extent of 60% in the diet of adolescent girls of both groups. Its low consumption could be due to preference for salty foods by adolescent girls as well as its high cost and so less availability. Even the intake of jaggery, which is relatively cheap and abundantly available in winters, was also negligible due to the low food status assigned to it and food fads and fallacies associated with it.

Besides cereals, intake of pulses was also found to be highly deficient in girls of both groups, the deficit being significantly higher i.e. 57 - 65% in 13-15 years as compared to 55 - 59% of RDA in 9-12 years adolescent girls. Pulses being a costly food, small amount of these must be purchased due to poor purchasing power. Furthermore, these were consumed once in a while, may be due to longer cooking time required, which the mothers may not have. Another consideration could be to economize on the cost of fuel.

Besides the inadequate quantity of protein, poor quality of dietary protein also accounted for growth retardation in adolescent girls. Dietary sources of protein in the diet of adolescent girls revealed that only 8% and 15% of total protein in the diet of adolescent girls of EXPT and ONG group respectively was derived from animal sources. Milk and milk products was the only source of animal protein in their dietaries. Remaining protein was derived from vegetable sources i.e. cereals and pulses. A proportion of 5:1 for cereals and pulses has been recommended for best utilization of protein in the diet (ICMR, 1989). But the dietaries of girls of both groups comprised of cereals and pulses in the proportion of 9-10:1, resulting in poor utilization of available mixed vegetable proteins having net protein utilization (NPU) of 65%. In the face of qualitative and
quantitative inadequacy of protein as well as calorie deficit, it was possible that protein was used for energy purposes, thus affecting growth of girls.

A deficit of varying extents in calorie and protein intake of rural adolescent girls had been reported in a number of studies. A calorie deficit ranging from 26 – 36% and protein deficit of 23 – 32% has been reported in the diet of adolescent girls of rural Rajasthan by Chaturvedi et al (1996). Other studies by Pushpamma et al (1982) also reported calorie deficit of 19% and protein deficit of 15% and Sarupriya and Mathew (1988) reported calorie deficit of 18% in the diets of rural adolescent girls. A study by NNMB (1996) reported a deficit of 10 – 22 % of RDA in the intake of cereals and millets in the states of Maharashtra, Tamil Nadu and Kerala. Sarupriya and Mathew (1988) have also reported inadequate consumption of pulses. The protein deficit is also due to deficient intake of staple foods i.e. cereals and pulses, which can be corrected by increasing the quantity of cereal-based diet so as to correct the energy deficit, as reported by Vijay Raghvan and Hanumantha Rao (1998).

Growth in adolescence occurs because of a rapid accretion of new tissues. Various other developmental changes during this phase are accompanied by increased nutritional requirements relative to the requirements during childhood. When these increased nutritional requirements during adolescence are not met, overall retardation in growth takes place. Height, a linear measurement, is relatively a fixed parameter. It is a measurement of skeletal growth and is relatively insensitive to short term nutritional deprivation. However, it is liable to change if nutritional deprivation is of long duration. The girls of present study revealed height deficit of great extent, which increased with increasing age (Table 4.16) because the energy demands for other metabolic processes of the body cannot be compromised. Stunting, known to be an index of nutritional status, reflects long term past under-nutrition. Stunting i.e. low-height-for-age was prevalent to the extent of 31 – 39% (Table 4.31), which was possibly an
outcome of long term calorie and protein deficit in the past childhood years, manifesting in terms of slowing of skeletal growth.

When the nutritional requirements of adolescence are not adequately met, height deficit is also accompanied by weight deficit, even to a greater extent (Table 4.20). Body weight is the most labile parameter and is subject to alterations with in a short period of nutritional manipulations whereas other growth parameters cannot be compromised. So, it is the earliest manifestation of the impact of nutritional manipulations among various anthropometric measurements. Index based on it i.e. weight for age is also most labile. Prevalence of low weight-for-age was to the extent of 64% - 68% (Table 4.32) in adolescent girls of both groups in this study. This was a sure manifestation of continuing past nutritional deprivation of childhood years being reflected in their current nutritional status.

High prevalence of stunting and even higher prevalence of under weight among girls of both groups suggest that their nutritional deprivation was of long duration, which might have initiated in their childhood years and was continuing during adolescence. Since the dietary intake of these girls during childhood years has not been studied, the magnitude of past nutritional deprivation could not be ascertained.

Correlation analysis between these body measurements and dietary intake of girls revealed highly significant positive correlations between calories and weight \(r=0.61\), calories and height \(r=0.57\), protein and weight \(r=0.53\) and protein and height \(r=0.49\), indicating that the current sizes of these body measurements were lower in girls with deficient calorie and protein intake. A number of studies have reported prevalence of stunting and wasting of varying extents among poor children. A high prevalence of stunting (48.8%) and wasting (49.6%) has been reported among poor children of Haryana by Kumar et al (1996). The National Nutrition Monitoring Bureau (NNMB) data collected in 10 states of country during 1974 – 80 showed that prevalence of stunting was of much higher magnitude i.e.

A stepwise multiple regression analysis conducted to find out the contribution of various factors to the height and weight of girls revealed that factors significantly contributing to height of girls of EXPT group were age, intake of protein, calories, iron, education of father, ordinal position, occupation of father and mother, vitamin A intake and religion. The height of girls of ONG group was significantly affected by intake of protein, calories, religion, age, ordinal position and occupation of mother. Intake of protein, calories, iron and vitamin A are known to have significant contribution towards height of girls by increasing the muscle mass and mineral skeletal whereas education and occupation of parents reflect the economic status and hence the dietary intake of girls. Religion also contributed significantly towards the height of girls in the present study.

Various factors significantly contributing towards the weight of girls of EXPT group included age, intake of calories, protein, religion, iron intake, ordinal position and intake of vitamin A & C whereas weight of girls of ONG group was significantly affected by intake of calories, protein, calcium, age, religion, occupation of father and mother and education of father. The contribution of calories, protein, calcium, iron, vitamin C and vitamin A are known to have a role in formation of adipose tissues, muscle mass, bone, blood and visceral organs and consequently weight of girls whereas religion, ordinal position, occupation and education of parents indirectly affect the dietary intake of girls.

Beside height and weight-deficit, nutritional inadequacy among adolescent girls manifested in terms of lower values of circumferential measurement i.e. mid upper arm circumference (MUAC) as compared to ICMR standard in both groups. These girls had lower values of MUAC as compared to ICMR standard in all age groups. MUAC is known to reflect changes in muscle tissues and calorie
stores in the form of subcutaneous fat. These muscle measurements are the reserves, which accumulate only when calorie and protein intakes are adequate. But in the face of high calorie and protein deficit as in this study, it was normal to expect lower values of circumferential measurements. This is known to increase very little with age, so a small change can be easily detected.

The other circumferential measurement, which is of great significance during adolescence, is chest circumference. The increase in chest circumference during adolescence occurs as a combined result of skeletal growth and fat deposition in connective tissues. The girls of present study had slightly higher values of chest circumference as compared to ICMR standard up to 12 years in both groups but lagged behind thereafter. This was indicative of continuing skeletal growth during adolescence but fat deposition would occur, only if calorie and protein intakes were adequate. The correlation between calorie intake and various circumferential measurements was significant indicating that a reduction in muscle size occurs as a compensation mechanism to provide amino acids for gluconeogenesis and protein synthesis in the liver.

The chest circumference and MUAC of girls of the present study are comparable to other studies reported by ICMR (1968), Tripathi et al (1974), Sylvia Subapriya and Premakumari (1993) and Chaturvedi et al (1994), who have reported low values of these circumferential measurements.

The pelvic girth measurements are also indicative of skeletal growth and its increase results mainly from changes in pelvic bones. Most, though not all, of the difference in shape arises during adolescence. There is a close relation between growth in height and reproductive organ development during adolescence. Since no reference standards for pelvic girth measurements are available, it was compared to the values reported in other studies. The results of pelvic girth measurements are also comparable to standards reported in studies by ICMR (1968).
The measurement of calf, at its maximum diameter, is a composite value of bone, muscle and subcutaneous tissue. Bone and muscle velocities are always positive while subcutaneous tissue increases in amount from birth to 9 months, then decreases (velocity being negative) until about 6 years and then increases steadily during adolescence. The girls of present study showed a steady increase in calf circumference after 11 years of age in both EXPT and ONG group. The bone and muscle mass of calf continued to grow during adolescence while subcutaneous tissue might be decreasing in the face of calorie deficit, as evident from significant correlation \( r=0.41 \) between the calorie intake and the calf circumference.

The bicondylar breadth of humerus and femur, which are again indicative of skeletal growth, increase until the long bone epiphyses fuse, which follow a definite sequence. The earliest epiphyses to fuse are those of elbow and are closed by 18 or 19 years. The epiphyses of knee close a year or two later than that of elbow. The bicondylar breadth of humerus and femur increased steadily in the girls of both groups. This increase occurred only as a result of skeletal growth and not due to fat deposition, as evident from poor positive correlation between calorie intake and bicondylar breadth of humerus \( r=0.32 \) and bicondylar breadth of femur \( r=0.33 \). Neither any reference standards are available for these measurements, nor many studies have been reported on it. The mean values of calf circumference and bicondylar breadth of humerus and femur at various ages were comparable to rural scheduled caste Punjabi girls in a study conducted on children aged 6-12 years by Gaur et al (1995).

The use of skinfold thickness in the assessment of nutritional status is based on the assumption that increased subcutaneous fat results from either high calorie intake or low energy expenditure; it reflects a general calorie reserve. Since energy intake was highly deficient in these girls, lower skinfold thicknesses was an expected outcome. Skinfold thicknesses of adolescent girls of EXPT group were comparable to those of lower socio economic groups in a study reported by
Gaur et al (1995). However, studies conducted on well-to-do children by Raghvan et al (1974), NFI, Delhi (1989), Bhasin et al (1990), Qamra et al (1990), Kapoor et al (1991), and Aggarwal et al (1992) revealed higher skinfold thicknesses in well-to-do adolescent girls. When decrease in thickness of subcutaneous tissues occurs during growth, it does not imply a decrease in cross-sectional area of fat. The fat is a ring around musculo-skeletal centre, which is increasing at all ages. If the cross-sectional area of fat remained constant over the years, during which muscle and bone core enlarged, then inevitably the fat ring would be stretched thinner. Also, as the fat width diminishes, the percentage of body weight due to fat decreases. While linear and circumferential measurements are increasing, subcutaneous fat is either shedding or remains unchanged. Fat deposition increases rapidly as soon as maximum physical dimensions are achieved. During growth, total energy was utilized for somatic growth and extra energy was required for fat deposition. Lower values of various skinfold thicknesses in girls revealed a significant correlation with calorie intake \((r=0.29-0.40)\), indicating that skinfold thicknesses exhibited a reduction in the face of acute calorie deficit. A highly significantly positive correlation has also been found between various skinfold thicknesses with weight \((r=0.53-0.77)\) and BMI \((r=0.58-0.73)\) but less significant with height \((r=0.31-0.55)\). These correlations are suggestive of the fact that only excess energy is stored in adipose tissues after all other requirements of body, including weight gain and increase in BMI are met with. However, height gain continues despite deficit in calorie intake. Similar correlations have also been observed in other studies. Kapoor et al (1991) have also found good positive correlation of tricep skinfold thickness with weight and BMI but no correlation with height. Sood and Kapil (1991) have also observed a high correlation coefficient of weight with tricep skinfold thickness, followed by subscapular skinfold thickness but was relatively independent of height.

The total energy expenditure of adolescent girls of both groups was found to be similar and their energy expenditure was higher than their energy intakes (Table
Their energy intakes were low (39 – 50%) as compared to RDA, as revealed from their nutrient intake at the beginning of the study (T1). The possible responses to inadequate energy intake include reduction in physical activity, retardation in growth in both weight and height, loss of fat, loss of muscle, decrease in mass of visceral organs and decrease in basal metabolic rate. The physical activity profile of adolescent girls of both groups revealed that they were engaged in light to moderate activities spending only a few hours in moderate activities. This energy saving mechanism perhaps occurs through reducing the tempo, decreasing the intensity or increasing the mechanical efficiency of activities. The next response to negative energy balance revealed its manifestation in terms of growth retardation in height and weight, as evident from low height-for-age (31-39%) and low weight-for-age (64-68%) in girls of both groups at T1. The lower values of circumferential measurements and skinfold thicknesses indicating low calorie reserve was perhaps another compensatory mechanism. The low values of BMR of girls of this study seemed to be an adaptive response to energy deficit. Comparison of correlation coefficients between BMR and anthropometric variables / indices i.e. height, weight and BMI revealed the strongest positive correlation with body weight (r=0.92) than with any other nutritional anthropometric variable and / or index. However, BMR revealed a weaker correlation with height (r=0.70) as compared to body weight but a stronger correlation with BMI (r=0.88). Shetty et al (1994) have also reported similar correlations between BMR and anthropometric variables / indices.

As a consequence of dietary and nutrient inadequacies, several nutritional deficiencies with clinical manifestations was encountered in these girls; namely iron deficiency anaemia, Protein Energy Malnutrition (PEM), vitamin deficiencies and iodine deficiency. Among these, anaemia was found to be most prevalent among adolescent girls of both groups. Clinical signs of nutritional deficiencies make their appearance, when deprivation has been too long or severe. It serves as a practical tool for the assessment of nutritional status of the population.
The results of the present study revealed a highly significant difference in prevalence of vitamin and mineral deficiencies and PEM between EXPT and ONG group, the incidence being higher among adolescent girls of EXPT group at the beginning of the intervention (T1) (Table 4.44). The lower incidence of vitamin and mineral deficiencies among girls of ONG group could be due to their higher consumption of milk and milk products and comparatively more number of girls consuming GLV's at the beginning of the study.

Among various deficiency diseases prevalent in adolescent girls of EXPT group, the highest prevalence (54.4%) was of iron deficiency anaemia, which revealed its manifestation in more than half of the girl's population whereas its incidence was significantly lower (33.3%) in girls of ONG group (Table 4.44). Pallor of conjunctiva was considered to indicate the deficiency of iron in the body. The diet survey of girls at T1 revealed that their diets were inadequate in all foods, especially iron rich foods. The only major source of iron in their diet was cereals. The cereal-based diet is high in phosphorus and phytate content, from which iron absorption is very low (3%). GLV's were consumed by only 2% of girls in EXPT group and 20-26% of girls in ONG group but those who consumed, were consuming these in adequate amounts. Highly inadequate intake of GLV's and other seasonal vegetables resulted in deficit consumption of micronutrients like vitamin A, B, C, and minerals such as iron and calcium, as compared to RDA. The promoter, which enhance iron absorption i.e. vitamin C, was also inadequate in their diets. Vitamin C was found to be highly deficient (78-81% of RDA) in the diet of girls of EXPT group and significantly lesser deficient (33-48% of RDA) in the diet of girls of ONG group. The only source of vitamin C in their diet was tubers, which were consumed in abundance by comparatively more number of girls due to its low cost, easy availability and relatively simpler cooking process. But it being a heat sensitive vitamin, 50% of vitamin C is lost during cooking process, resulting in poor iron absorption. The other essential component of haemoglobin i.e. protein was also qualitatively and quantitatively inadequate, the deficit being 47 – 50% and 42 – 46% in girls of EXPT and ONG group.
respectively. Thus, the low dietary intake of iron along with its poor absorption were together precipitating the symptoms of anaemia in girls of both groups. Deficient intake of GLV's and other vegetables resulting in micronutrient deficiencies have been reported in a number of studies. VijayaRaghvan and Hanumantha Rao (1998) have reported that the intake of GLV's was less than 25% of RDA in the states of Andhra Pradesh, Kerala, Maharashtra, Gujrat and Tamil Nadu. The consumption of other vegetables was less to the extent of 50% of RDA in Gujrat, Maharashtra and Orissa. Pushpamma et al (1982) have found the consumption of green leafy vegetables by adolescents of Andhra Pradesh to be almost negligible and the consumption of the roots and tubers to be comparatively better in all regions of Andhra Pradesh. Thus, intake of calcium was met to about 50 percent of RDA while that of vitamin A, vitamin C and iron was very low. Sarupriya and Mathew (1988) have also reported inadequate consumption of roots and tubers and other vegetables while the intake of GLV's was completely lacking leading to deficit consumption of calcium and iron and have reported the presence of one or more clinical signs of deficiency diseases in 88% of tribal adolescent girls of Rajasthan. Similar findings have been reported in adolescent girls of Rajasthan by Chaturvedi et al (1996).

The observed deficit in calories, protein, iron and vitamin C, as revealed from their nutrient intake at T1, interfered with synthesis of haemoglobin. The qualitative and quantitative inadequacy of protein along with deficient intake of iron interfered with formation of haemoglobin in girls. This resulted in low level of haemoglobin in adolescent girls of both age groups. A comparison between dietary intake of anaemic adolescent girls (Haemoglobin < 12 gm / dl) and non anaemic adolescent girls (Haemoglobin >= 12 gm / dl) of both groups revealed that the dietary intake of calories, protein, iron and vitamin C of non-anaemic adolescent girls was higher as compared to anaemic adolescent girls in both age groups (Table 4.35).
The significantly lower incidence of anaemia (54.4% vs 33.3%) and PEM (19.3% vs 1.67%) among adolescent girls of ONG group was due to the fact that the adolescent girls of ONG group had significantly higher intake of calories, protein, iron and vitamin C as compared to those of EXPT group at the beginning of study i.e. T1.

Stepwise multiple regression analysis conducted to see the contribution of various factors to haemoglobin level of girls showed that factors significantly contributing in girls of EXPT group were age, intake of iron, calcium and vitamin A, occupation of mother, education of father and religion. The factors contributing to haemoglobin level of girls of ONG group included intake of iron, calcium, number of children, education and occupation of father and vitamin C intake of girls. Intake of iron along with vitamin C and vitamin A have an established role in haemopoises whereas occupation and education of parents indirectly affect the dietary and hence the nutrient intake of girls.

The girls of both EXPT and ONG groups of present study had low haemoglobin level, below the normal value (12gm/dl) in all age groups, which was indicative of anaemia (Table 4.34). The distribution of girls into various grades of anaemia also depicted that majority of the girls were in Grade I and II of anaemia (Table 4.37 & 4.38, Fig 4.59 & 4.60). The diet of girls of both groups in the present study contained 14-18mg of iron in the home diet (Table 4.14 C), which was in the range of 72 – 76% of RDA in younger girls (9 – 12 years) and 51 – 63% of RDA in older girls (13 - 15 years age group). However, the intake was significantly higher in older girls of ONG group. Iron is absorbed at the rate of 5% from mixed cereal diet under optimum conditions. The diet of girls of present study, which was rich in phosphorous and phytate content, poor in vitamin C content and having low biological value and consequently low net protein utilization of protein, absorption of iron was bound to be very poor resulting in poor bio availability of dietary non-haeme iron, thus precipitating anaemia in them. Moreover, the older girls, who had entered menarche at a median age of 11.53 years in EXPT group
and 12.59 years in ONG group, had marked losses of iron during mensuration, resulting in higher deficit of iron in older girls. Thus, with poor quality and inadequate quantity of diet consumed coupled with accelerated growth rate stage and the onset of menarche, iron balance of girls became negative. This deficit was made good by iron mobilized from tissue stores for haemoglobin synthesis. When the tissue stores were also exhausted, the supply of iron to the marrow for haemoglobin synthesis became inadequate and hypochromic anaemia developed. In such situations, the red cell count is reduced to a lesser degree than the haemoglobin level and the count may be near normal even when the Haemoglobin level is reduced to 8-9gm/dl. This was evident from the PCV and RBC level of adolescent girls of EXPT and ONG group, which were found to be within the normal range at T1 (Table 4.39 & 4.40). However, the indices derived from haemoglobin, PCV and RBC i.e. MCV, MCH and MCHC were reduced, the degree of reduction depending upon the severity of anaemia. A subnormal MCV (< approx. 80 fl), MCH (< approx. 27 pg) and MCHC (< approx. 30 %) observed in adolescent girls of both groups was indicative of hypochromic microcytic anaemia. Defect in red cell formation can be due to various reasons; one of them could be a condition, in which haemoglobin synthesis is impaired to a greater extent, the reason being inadequate iron available for the formation of haeme component of haemoglobin. Hence, subnormal MCV and MCH were indicators of early iron deficient haematopoiesis.

A large number of studies indicating the prevalence of anaemia among adolescent girls have been reported in the literature. Malhotra and Rao (1984) observed that about one third of school children of Wardha District of Maharashtra were having normal level of Haemoglobin (>= 12gm/dl) while the remaining two third suffered from varying degrees of anaemia. Kapoor and Aneja (1992) reported 47% of high socio-economic girls and 56% of low middle socio-economic girls to be suffering from anaemia. Vasanthi et al (1994) observed overall anaemia to be present in 25% of girls, irrespective of their urban-rural residence. But overall iron deficiency was of much higher order in rural girls.
irrespective of the menarcheal status. A study on the nutritional status of adolescent girls in the age group of 13-15 years revealed their Haemoglobin level to be in the range of 8.5-12.5 gm/dl, with a mean value of 10.73 ± 0.07 and only 23% of girls had the acceptable Haemoglobin level (Nagi et al, 1995). Anand et al (1999) observed overall prevalence of anaemia in rural North Indian girls (12 – 18 years) to be 48%, thus recommending school based mid day meal programme and iron supplementation for rural adolescent girls.

The indicators of iron status among adolescent girls of both groups revealed a low level of serum iron, closer to lower limit of normal range; a high level of TIBC, closer to the upper limit of normal range and low value of transferrin saturation, closer to cut off value of 16%, confirming iron deficiency anaemia in adolescent girls of both groups (Table 4.42). The reasons were inadequate intake of iron due to poor diet, diminished bio-availability or impaired absorption and also due to recurrent menstrual loss leading to iron deficiency anaemia in adolescent girls. In the development of iron deficiency anaemia, the gradual iron depletion occurs in a sequential manner. In initial stages of iron deficiency anaemia, the bone marrow stores are utilized to meet the demands of erythropoiesis. During this state of pre-latent iron deficiency, the normal level of storage iron concentration (80 mg%) falls to the level of 29 mg%, the normal TIBC level (290 mg%) rises upto the level of 335 – 345 mg%, but there are no significant changes in Haemoglobin level, serum iron and transferrin saturation level. With further depletion of iron stores, there is inadequate delivery of serum iron to bone marrow for erythropoiesis, TIBC continues to rise, while other indicators remain unaffected. This state is known as state of latent iron deficiency. When most of the storage iron is consumed, as encountered in iron deficiency anaemia, TIBC rises upto the level of 380 mg% but there is no overt anaemia. If the iron intake continues to be inadequate, serum iron and transferrin saturation decrease to critical levels. At this level, the formation of Haemoglobin will be retarded as a result of inefficient erythropoiesis and iron deficiency anaemia or overt anaemia ensues (Weinfeld, 1964). Similar findings have also been reported in other
studies. Dodd et al (1992) assessed iron status of Indian women of low socio-economic group and found that 57% of them were anaemic. All indicators of iron status i.e. Haemoglobin, serum iron, transferrin saturation and serum ferritin were significantly lower in anaemic subjects as compared to non-anaemic ones. Tater et al (1992) reported lower value of serum iron and transferrin saturation and increased level of TIBC in anaemic subjects as compared to their healthy counterparts. Donovan and Gibson (1995) found a significant correlation between intakes of iron and ascorbic acid with serum iron and TIBC. Sub-optimal iron status was attributed to low intake of poorly available iron by young US women (14-19), consuming vegetarian and omnivorous diets. Jackson (1996) examined the biochemical indices of iron nutritional status among adolescent girls of western Bangladesh and found 22% of the girls to be anaemic (Haemoglobin <120gm /l), 15% had subnormal serum iron (< 7.16 μol/l) and about 25% had low transferrin saturation level (<15%). Anaemic girls were found to have significantly lower PCV, MCHC, serum iron, transferrin saturation and higher TIBC as compared to those with normal Haemoglobin levels.

The indicators of protein status i.e. serum protein and albumin were low, closer to lower limit of normal range in adolescent girls of all age groups in both groups (Table 4.43). This may be an outcome of highly deficient protein intake and that too of low biological value by adolescent girls of both groups. Furthermore, protein was used as a source of energy in the face of very high calorie deficit, thereby adversely affecting the indicators of protein status. Significantly positive correlations between dietary iron and haemoglobin level (r=0.84), serum protein (r=0.15), serum albumin (r=0.40), serum iron(r=0.67) and TIBC (r=0.65) suggest the role of dietary iron in haematological profile of girls. While investigating the correlation between biochemical parameters and dietary intake of adolescent girls in the Midwest of United States, McCleary et al (1995) found that one – third of the girls had serum albumin level below the normal range and were of marginal health status.
Other nutritional deficiency disease in the descending order of prevalence was protein energy malnutrition (PEM). The incidence of PEM was significantly higher among adolescent girls of EXPT group (19.3%) as compared to those of ONG group (1.67%) (Table 4.44). This was due to qualitative and quantitative inadequacy of good quality protein i.e. milk and milk products along with a deficit in staple food resulting in energy and protein deficit, as revealed from their food intake at T1. The energy deficit resulted in wasteful utilization of protein for energy purposes, thus affecting their nutritional status. PEM among adolescent girls of EXPT group revealed its manifestations in terms of various clinical signs in varying degree of prevalence. The most prevalent signs were dis-pigmentation and lack of luster of hair followed by sparseness and easy pluckability of hair. A negligible number of girls suffered from muscle wasting and oedema. The sequential appearance of these signs was suggestive of early stages of PEM, which might have precipitated, if the deficiency continued.

The prevalence of vitamin deficiencies was also found to be higher among adolescent girls of EXPT group as compared to that of ONG group (Table 4.44). The significantly higher prevalence of vitamin C deficiency (15.2%) in girls of EXPT group manifested itself in terms of spongy bleeding gums (12%), recession (10%) followed by petechiae (3%). These were the early signs of vitamin C deficiency manifesting the low intake of vitamin C in their diets. The only source of vitamin C in their diet was tubers. Being a heat sensitive vitamin, 50% of it was lost during cooking, resulting in poor availability of vitamin C to the body.

The deficiency of vitamin B was also found to be significantly higher (13.5%) in girls of EXPT group as compared to those of ONG group (Table 4.44). The most commonly found signs of vitamin B deficiency were atrophic papillae, scarlet / raw tongue followed by chelosis and angular stomatitis. These were the early signs suggestive of riboflavin and niacin deficiency. Dietary intake of girls of both groups also showed deficient intake of riboflavin and niacin in their diets. The intake of riboflavin was 42% of RDA in girls of both groups in 9 -12 years age
group and 50% and 58% of RDA in 13 - 15 years girls of EXPT and ONG group respectively, the difference between the two groups being highly significant (Table 4.14 B). This could be due to higher consumption of milk and milk products, though deficient as compared to RDA, by girls of ONG group. However, riboflavin was highly deficient in the diets of girls of both EXPT and ONG groups due to inadequate intake of milk and milk products, green leafy vegetables and pulses in predominantly cereal-based diets. Intake on niacin was also deficient i.e. 48-51% of RDA and 46-51% of RDA in girls of both age groups of EXPT and ONG group respectively. This could be due to deficient intake of whole cereals, pulses and nuts. Milk and milk products, rich in tryptophan, a precursor of niacin, were also deficient in girls of both groups. Intake of thiamin was adequate and ranged between 80-110% of RDA, hence no signs and symptoms of thiamin deficiency were detected. Besides deficient intake of B-vitamins, inadequate calorie intake was sure to precipitate the situation because these vitamins serve as co-enzymes for the metabolism and utilization of calories in the body. In the face of acute calorie deficit, if the deficiency of this vitamin continues, consequences would be serious. Chaturvedi et al (1994) reported the prevalence of B-complex deficiency to the extent of 40% among adolescent girls of Rajasthan.

The prevalence of vitamin D deficiency was significantly higher (7.6%) in adolescent girls of EXPT group as compared to ONG group, which had no incidence of vitamin D deficiency (Table 4.44). The deficiency of vitamin D manifested its presence in the form of knock-knees and bowlegs. Its presence suggested that along with vitamin D availability, low intake of calcium (42-44% of RDA) with its reduced availability due to factors such as phytic acid in cereal based diets might be responsible for its occurrence in adolescent girls of EXPT group.

Iron deficiency anaemia and Protein-energy-malnutrition were found to be the major nutritional problems in girls of present study. One of the functional
consequences of anaemia and under-nutrition is believed to be an impairment of work capacity because of reduced oxygen uptake capacity of haemoglobin to carry oxygen to the different tissues of the body at maximum exertion. The maximum oxygen uptake (an aerobic capacity) is probably the best measure of a person’s physical fitness, provided the definition of physical fitness is restricted to the capacity of the individual for prolonged heavy work.

The physical fitness index (PFI) scores of adolescent girls of both groups were ‘poor’ in all age groups at T1. This might be attributed to high prevalence of under weight and anaemia among adolescent girls of both groups, the reasons being around 50% deficit in the intake of calories and protein and 28.4% and 48.9% deficit in intake of iron in the diet of 9–12 years and 13–15 years adolescent girls respectively at T1. No significant correlation was found between physical work capacity and anthropometric variables/indices of adolescent girls of EXPT and ONG group, who were engaged in light to moderate activities. However, a strong positive correlation ($r = 0.81$) has been found between physical work capacity and Haemoglobin level of adolescent girls of both groups, which indicated the deleterious functional consequences of iron deficiency on physical work capacity. The adverse effect of under weight and anaemia among adolescent girls of EXPT group at T1 also manifested in terms of higher recovery (1-1.5 min post-exercise) heart rate by anaemic girls, as evident from significant correlation ($r=0.43$) between Haemoglobin level of adolescent girls and their recovery heart rate, though initial heart rate was same for all. The higher heart rate of anaemic girls was because of the fact that for a given body size, the oxygen carrying capacity of blood was lower in low Haemoglobin group, necessitating a higher heart rate, showing that the anaemic girls had to strain more for performing the same exercise. Also, the anaemic girls could continue the exercise for lesser time as compared to non-anaemic girls (Table 4.49). A significant positive correlation ($r=0.83$) has been found between Haemoglobin level and exercise time of adolescent girls.
The adolescent girls of ONG group were also categorized as 'poor' on the basis of PFI scores in all age groups, except in the age groups of 10 and 13 years, in which their score were 'average'. They also exhibited higher recovery heart rate and lesser exercise time in case of anaemic v/s non-anaemic girls, the reason being under weight and anaemia prevalent in adolescent girls of ONG group at T1. Similar results have been reported by Satyanarayana et al (1977), Banerjee and Chatterjee (1983), Desai et al (1984) and Bhatia and Sheshadri (1984). The functional consequence of anaemia on impairment of physical work capacity has been reported by Gardener et al (1977), Basta et al (1979), Vijaylakshmi and Jayanthi (1986), Vijaylakshmi et al (1987), Murthy et al (1989) and Nelson et al (1993).

The meal pattern of adolescent girls of both EXPT and ONG group revealed that majority of the girls followed three meals pattern daily. Around 62 percent school going adolescent girls of EXPT group skipped eating their breakfast at home and carried the same and ate it as packed lunch in schools. The adolescent girls of ONG group were school dropouts, so stayed at home and had three meals pattern at home. Among adolescent girls of EXPT group, 82 % of the girls were vegetarian and the remaining 18 % took egg or meat occasionally. All the girls of ONG group were vegetarian.

An analysis of the food intake pattern of girls at the beginning of the study i.e. T1 showed that there was no significant difference in the intake of various foods by adolescent girls of EXPT and ONG group, except milk and milk products, pulses and tubers (Table 4.12). Intake of milk and milk products was significantly higher (P< 0.01) by adolescent girls of ONG group, though inadequate as compared to RDA. The significantly higher consumption of milk and milk products by girls of ONG group was due to rearing of cattle at home resulting in better availability of milk and milk products. This was highly deficient in the diets of adolescent girls of EXPT group, in which it was consumed only in tea and sometimes as curd or lassi. Intake of pulses and tubers was significantly higher by older girls of this
group because the tubers are cheap, abundantly available and also due to the simpler cooking process involved in it as some of the mothers in this group were engaged in household jobs as maids to supplement their family income.

The intake of cereals, mainly in the form of wheat consumed as chapattis and rice, was found to be deficient in the diet of girls of both groups to the extent of 50 % of RDA. The likely reasons for low intake of cereals might possibly be reduced hunger of girls due to continued low intake of food or loss of appetite due to iron deficiency anaemia in these girls, as also reported by Levin et al (1993). Lack of knowledge possessed by mothers and girls themselves regarding the requirements of this age group could be another factor.

Pulses, mainly Green gram, Black gram, Red gram and Lentil, were consumed as boiled whole or washed dals. Beans were consumed rarely. Intake of pulses was also deficient to the extent of 55 % among adolescent girls of EXPT group and up to 60 – 65 % among adolescent girls of ONG group, the mean daily intake being 20-22gms and 17-18gms in girls of EXPT and ONG group respectively. The reason for low intake of pulses could be its high cost, thus leading to less availability due to low purchasing power. Further, these require longer cooking time, which most of the working mothers may not have. To economize the cost of fuel may be another factor for its deficient intake.

Green leafy vegetables were consumed by a negligible number (2%) of adolescent girls of EXPT group as compared to 20 – 26 % of adolescent girls of ONG group (Table 4.12). Girls consuming green leafy vegetables were consuming these in more than adequate amount as per RDA. The reasons for consumption of GLV’s by small proportion of adolescent girls was its inadequate intake due to its time consuming and cumbersome cooking process, for which mothers working as household help did not have time and inclination. Also, liking for GLV’s was not developed by adolescent girls as it was not consumed by them since their childhood. Moreover, lack of knowledge possessed by themselves
and their mothers regarding the importance of GLV’s in their diet could be the likely contributing factor.

Seasonal vegetables like pumpkin, gourd, brinjal, cauliflower etc. were consumed by only 60 – 70 % of adolescent girls of both groups (Table 4.12). Seasonal vegetables were consumed by more number of girls due to its abundant availability and low cost in season and also due to its taste.

Tubers were consumed by 20 – 49 % of adolescent girls of ONG group as compared to only 23 – 26 % of adolescent girls of EXPT group (Table 4.12) and the girls consuming the same were found to be taking them in abundance. Tubers, mainly in the form of potatoes, were consumed by comparatively more number of girls probably due to its low cost, easy availability and relatively simpler cooking process.

Among the energy giving foods, sugar was also found to be deficient to the extent of 60 % of RDA in both groups. Its low consumption could be due to preference for salty foods by adolescent girls as well as its high cost and so less availability. Even the intake of jaggery, which is relatively cheap and abundantly available in winters, was also negligible due to the low food status assigned to it and food fads and fallacies associated with it.

Visible fat, in the form of mustard and cottonseed oil, was low in the diet of girls of both groups due to its high cost. The invisible fat present in cereal-based diet was also deficient due to high deficit in intake of cereals and pulses in the diet of girls of both groups.

Seasonal fruits were consumed by only small proportion of girls (11 - 26%) of EXPT group, though intake was found to be adequate. The adolescent girls of ONG group were not consuming seasonal fruits at all (Table 4.12). The reason for low intake of fruits by girls of both groups was its high cost. Though relatively
cheap in season, thrust lies on intake of foods satisfying hunger. Moreover, ignorance about the importance of seasonal fruits and vegetables in the diet could be another contributing factor.

Consequent upon low intake of various foods in the diet of girls of both EXPT and ONG groups, a deficit of varying extents in the intake of various nutrients was observed. Calories were deficient to the extent of 50% of RDA in younger girls (9 -12 years age group) but slightly less deficient (39 – 44% of RDA) in older girls (13 - 15 years age group), the deficit being significantly lesser in girls of ONG group. This could be due to higher intake of cereals, milk and milk products and fat by older girls of ONG group.

Protein was also deficient to the extent of 46 – 47% of RDA in younger girls (9 -12 years age group) of both groups. However, the deficit was significantly higher (50% of RDA) in girls of EXPT group as compared to girls of ONG group (42% of RDA) in older girls (13 - 15 years age group). The deficit in protein intake was due to low intake of pulses, it being a costly food as well as low intake of milk and milk products, its intake being significantly higher in ONG group, though deficient as compared to RDA.

Besides quantitative inadequacy, the quality of protein was also poor due to negligible contribution of animal protein to the total protein intake, it being only 8% and 15% in the diet of girls of EXPT and ONG group respectively. The remaining contribution of protein to the total protein intake was from vegetable sources i.e. cereals and pulses. Moreover, cereals and pulses were consumed in the ratio of 9 – 10 : 1, resulting in poor utilisation of available mixed vegetable protein.

Among water-soluble vitamins, intake of riboflavin was significantly higher by girls of ONG group, though highly deficient as compared to RDA, due to significantly higher consumption of milk and milk products and GLV’s by significantly higher
number of girls in ONG group. Intake of other water soluble vitamin i.e. vitamin C was also significantly higher by girls of ONG group (52 – 67% of RDA) as compared to 19 – 22 % of RDA by girls of EXPT group but deficient in both groups.

Among minerals, intake of calcium and phosphorous was significantly higher by girls of ONG group as compared to girls of EXPT group. Intake of calcium was 43-44% of RDA in EXPT group and 53-72% of RDA in ONG group whereas intake of phosphorous was more than adequate in both groups. This could be attributed to significantly higher consumption of milk and milk products and GLV’s by significantly more number of girls in ONG group.

Intake of iron was 72 – 76% of RDA in younger girls (9 -12 years age group) of both groups but was highly deficient (37 – 49% of RDA) in older girls (13 - 15 years age group), the deficit being higher in girls of EXPT group due to significantly lesser number of girls consuming GLV’s in EXPT group. Moreover, cereals, the main source of iron in their diets, were also deficient to the extent of 50% of RDA in both groups. Higher deficit in older girls was due to increased requirement of iron by these girls due to onset of menarche in this age group.

A review of the dietary pattern of girls of both groups revealed that their diets were deficient in all foods, especially energy giving and protein rich foods along with iron, which adversely affected their nutritional status and physical work capacity. Increasing the quality and quantity of food intake is the most commonly adopted strategy for improving their nutritional status. Vijayaraghavan and Hanumantha Rao (1998) have also reported that the primary bottle neck in the dietaries of our population is the energy deficit and protein deficit due to deficient intake of staple food i.e. cereals, which can be corrected by increasing the quantity of cereal based diet. Rao et al (1969) have also established a scientific basis for the supplementary programs in operation in our country, where primary
bottleneck in the dietaries of population depending mainly on cereals and millets, is energy deficit or protein deficit.

With this in view, a food supplement comprising of cereal-pulse combination (2:1) in the form of puffed rice, roasted Bengal gram / groundnut and gur was selected with a view to supplement the home diet to such an extent that deficit in total daily requirement was met partially through dietary supplementation providing one-fourth of the total daily calorie and protein requirements, as per the recommendations for dietary supplementation. The qualitative improvement was brought about through cereal-pulse combination, which provided good quality protein through mutual supplementary effect of the constituent amino acids, lysine and methionine, which were lacking in cereals and pulses respectively. Addition of gur further improved its caloric value, iron and calcium content to a great extent besides improving its taste and palatability. This combination was selected keeping in view of its local availability, high acceptability, easy to store, pack and distribute and ready to eat. Marginal increase in its cost as compared to NAGS sanctioned rates of Rs.1.15 per head per day in April, 1994, had to be made keeping in view the price hike of food items due to inflation, from the time it was sanctioned till date and above all due to its nutritional adequacy.

In order to analyse the impact of dietary supplementation, which was given to girls of EXPT group for 3 months during the first phase, the evaluation was done through growth parameters and haemoglobin profile of girls at the end of the 3 months of the intervention i.e. T2. Growth parameters, which were assessed at T2, were height and weight of girls, both of which showed significant improvement in all age groups at T2.

The EXPT group, in which dietary supplementation to adolescent girls was given for 3 months during the first phase i.e. T1 to T2, there was a highly significant gain in height of girls in all age groups (Table 4.16). Growth during adolescence occurs due to rapid accretion of new tissues in the body. Gain in height is a
natural biological process, which continues, though not to the optimum genetic potential, even in the face of dietary inadequacy, resulting in reduced lean body mass. Girls of the present study, diet of whom was deficient to the extent of 44-48% in calories and 47-50% in protein at the beginning of intervention i.e. T1, had height deficit of varying extent due to reduced lean body mass. Dietary supplementation increased the input of calories and protein by 23-24% and 15-18% of RDA respectively, resulting in highly significant gain in lean body mass and thereby height in all age groups. More than 20% of total growth in stature and upto 50% of adult bone mass are achieved during adolescence, resulting in 50% increase in calcium requirement and bringing it to 600mg per day. Intake of calcium was highly inadequate to the extent of 56-57% of RDA and was only 43-44% of RDA at T1. During T1 to T2, intake of calcium increased by 11.5% of RDA through dietary supplementation, which helped in bone growth and consequently height of girls. Thus, an increase in lean body mass and mineral skeleton resulted in highly significant gain in height of girls. This resulted in an improvement in their percentile status of height from anywhere between 25-50th percentile to > 50th percentile at 9 years, near 10th percentile to 25th percentile at 10 years, near 5th percentile to > 10th percentile at 11 years and < 5th percentile to > 5th percentile in higher age groups, except 13 year age group, in which there was an improvement but girls remained in the same percentile i.e. < 5th percentile (Fig 4.31 to 4.37).

Height velocity i.e. gain in height over a specified period of three months, was accelerated during this period in all age groups and was higher than NCHS standard (Fig 4.31 A to 4.37 A), thus resulting in highly significant height gain. This phenomenon was indicative of catch-up or compensatory growth as a result of dietary supplementation, which was provided to these girls. It was, further, observed that younger girls had higher growth velocities as compared to older girls. The reason for higher growth velocities in younger age groups as compared to older girls is that the adolescent growth spurt is characterized by a rapid gain in lean body mass and even greater increases in adipose tissue along with
increase in mineral skeleton. When the increased nutritional requirements associated with adolescent growth spurt are met, girls in younger age groups gain more height as compared to older ones. Moreover, younger girls were in the phase of growth spurt and their nutritional deficit was of shorter duration, hence larger catch-up in growth in contrast to older girls, who had crossed their growth spurt and had deficit in diet for longer duration, so their catch-up in growth was not up to the optimum level.

Another growth parameter i.e. weight of girls showed that there was highly significant gain in weight of girls in all age groups (Table 4.20). When the inadequacy in intake of calories was met through dietary supplementation, making it 81% of RDA, which is more or less adequate, height gain was accompanied by weight gain. Weight gain manifested itself in the form of an increase in adipose tissues, skeletal muscles, bone, blood and visceral organs. With significant gain in weight, percentile status of weight of girls, especially in younger age groups, improved from anywhere between 10-25th percentile to 25th percentile at 9 years, near 5th percentile to 10th percentile at 10 years and < 5th percentile to > 5th percentile at 11 years, whereas the older girls remained in the same percentile i.e. below 5th percentile (Fig. 4.41 to 4.47). The likely reason for younger girls improving in their percentile status was increased body mass, adipose tissues and skeleton muscles associated with growth spurt. When the growth spurt was over, as in older girls, weight gain, though significant, was to a lesser extent and was not adequate enough to improve their percentile status and these girls remained in same percentile i.e. below 5th percentile.

Highly accelerated weight velocity i.e. weight gain over a specified period of three months, resulted in significant weight gain and was higher than NCHS standards (Fig. 4.41 A to 4.47 A), which was again indicative of catch-up growth. Younger girls had higher growth velocities as compared to older girls because of their growth spurt, which enabled them to catch-up in growth but not up to the optimum level. Secondly, younger girls had higher deficit in calories, which was made up
through dietary supplementation given to these girls. It is a known fact that higher the deficit in food intake, greater the catch-up in growth. There is considerable evidence that significant compensatory or catch-up growth is possible when the growth limiting condition i.e. prolonged under-nutrition is remedied (Largo, 1993). For instance, children, who have spent their childhood in poverty and then adopted into affluent families, may show catch-up growth and early pubertal development, reaching a final height in normal range (Proos, 1991).

Another important observation was that the growth velocities in height were higher than those of weight in all age groups. It is the natural biological phenomenon of the body to continue gain in height, though not to the optimum level, despite deficit in food intake but gain in weight would occur, only when nutritional needs for somatic growth are met with. Thus, height gain is an earliest response to nutritional intervention followed by weight gain at a minimum genetic potential for height. Though dietary supplementation improved the nutrient intake of adolescent girls (Table 4.13) but the increased dietary intake resulted in more improvement in height in view of the alternating priorities of the body for height gain till peak height velocity by malnourished girls because priorities of the body for muscular and skeletal growth are alternating (Rao and Joshi, 1992). Higher growth velocities in height among under privileged girls helped them to narrow down but not completely bridge the initial height deficit. Most girls showed catch-up growth regarding height and to some extent regarding weight. The degree of catch-up regarding both height and weight was directly correlated to degree of under-nutrition. Linear growth and final height, besides genetic factors, is influenced by nutritional conditions and also by timing of pubertal development, which may be triggered earlier in malnourished girls undergoing metabolic activation during catch-up growth (Proos et al, 1991). Similar priorities of the body for height gain by malnourished children and weight gain by normal children have been reported by Rao and Joshi (1992). Studies on the effect of the sudden nutritional improvement showing catch-up growth have been reported by Marotell.
et al (1994). It indicated that catch-up growth brought about by an intervention would decrease obstetric risk in women due to small maternal size.

Besides these anthropometric measurements, another parameter on which the impact of dietary supplementation was assessed, was the haemoglobin level of girls. The haemoglobin profile of girls at T2 revealed that girls continued to be anaemic after first phase of dietary supplementation. Dietary supplementation contributed 6 mgm of iron to the total iron intake, which was 71.6% and 51.1% of RDA in 9 -12 years and 13 - 15 years age group respectively at T1. This increased it by 31.6 % and 21.4 % in 9-12 years and 13 –15 years adolescent girls respectively, thus making it adequate in younger girls but still deficient by 27.5% of RDA in older girls. This resulted in an insignificant increase in haemoglobin level of girls of all age groups (Table 4.34) and the majority of the girls still continued to be in Grade I and II of anaemia (Table 4.37). However, girls, who were severely anaemic, improved and shifted from Grade III and Grade II to normal and Grade I, whereas mildly and moderately anaemic girls did not improve much and continued in Grade I & II and some of the older girls deteriorated in their haemoglobin status (Fig 4.59) It is a known fact that higher the severity of anaemia, greater the improvement upon supplementation (de Gruchy, 1990). The likely reasons for insignificant improvement in haemoglobin level of adolescent girls as a result of 3 months of dietary supplementation could be low biological value (BV) and consequently net protein utilization (NPU) of vegetable protein, which may account for low level of serum protein for haemoglobin synthesis. Though the quality of protein was enhanced by adding more good quality protein in the form of cereal-pulse combination having mutual supplementary effect on component amino acids but it might have been used for energy purposes in the face of huge calorie deficit. Further more, the promoter of iron absorption i.e. vitamin C remained deficient as its status was not improved through dietary supplementation. The high phosphorous and phytate content of the cereal-based diet, which was being consumed, might have hindered the absorption of iron, leading to poor bioavailability of dietary non-haeme iron. Thus,
with poor quality and quantity of diet consumed, accelerated growth rate and onset of menarche, the girls continued to be anaemic, with only marginal increase in haemoglobin level in first phase of dietary supplementation.

After supplementing the girls for 3 months, the dietary supplementation was discontinued for 3 months to assess whether catch-up growth and other improvements observed during the supplementation period continued, when girls were on their usual home diets.

It was observed that during T2 to T3, a period of 3 months, when no supplementation was given to girls, height gain, though marginal and insignificant, continued (Table 4.16) despite deficit of 44-48% in calories, 47-50% in protein and 56-57% in calcium intake through home diet. This occurred perhaps due to the adaptive mechanism of the body to the continued low food intake by reduction in basal metabolic rate. Catch-up growth, which started during first 3 months of supplementation period, continued even during non-supplementation period, during which no increase in food intake occurred through home diet. Due to marginal height gain, there was no change in percentile status of height of girls, who remained in the same percentile as at T2 (Fig 4.31 to 4.37). During this period, height velocity deescalated in all age groups as compared to first phase of supplementation period and was below NCHS standard up to 13 years age group and higher in older girls i.e. 14 and 15 years age groups (Fig 4.31 A to 4.37 A). This phenomenon was perhaps indicative of slower and longer growth span in older girls, who had been undernourished for the long period as also reported by Cameron et al (1994).

Another important anthropometric parameter i.e. weight showed that during T2 to T3 (3 months of non-supplementation period), marginal weight gain, though not significant and to a lesser extent as compared to first phase of supplementation period (Table 4.20), occurred through an outcome of growth spurt and catch-up growth, which continued even during non-supplementation period as the
momentum of growth continued for some time, though tempo of growth slowed down as evidenced from growth velocity. As a result, percentile status of girls remained more or less the same in all age groups as at T2 (Fig 4.41 to 4.47). Weight velocity deescalated in all age groups due to slowing down of rate of weight gain and was below NCHS standard in all age groups (Fig 4.41 A to 4.47 A) during non-supplementation period due to inadequacy of calories and protein in the diet of girls.

Another method used to analyze the growth of girls was through review of incremental growth in height and weight and to compare it with that of healthy girls. Since the NCHS standards for height and weight are available at six monthly intervals, height and weight of girls of present study were compared to NCHS standards after six months from the beginning of intervention. During T1 to T3 (6 months from the beginning of intervention which included 3 months of dietary supplementation and 3 months of non-supplementation periods), the height increments of girls were observed to be significantly higher in comparison to NCHS standard (Table 4.19), which was indicative of catch-up growth in nutritionally deprived girls which continued even during non supplementation period, though the tempo of growth slowed down. Individual variations in increments as well as the impact of feeding depend upon the initial nutritional status of the participants (Kennedy and Knudsen, 1985). The poorer the nutritional status, the higher the increments in growth. However, the weight increments during this period were comparable to those of NCHS standard in all age groups (Table 4.23). At this stage, the distribution of girls into different height percentiles revealed an improvement (shift) to higher percentile in all age groups and a highly significant improvement was observed in younger girls (9 -11 years age group) (Table 4.17). Girls in the lowest percentile i.e. < 5th percentile moved to next higher percentiles indicating that the higher the deficit in height, greater was the improvement. Younger girls in the age group of 9 -11 years showed significant improvement in their percentile status due to increased body mass and mineral skeleton during growth spurt. Moreover, dietary supplementation
given to these girls coincided with the phase of their growth spurt, thus enabling these girls to catch-up and improve in their percentile status. The distribution of girls into different weight percentiles depicted a shift to higher percentiles, especially in younger girls but not significant in any age group (Table 4.21). Slight improvement, though not significant, to higher percentiles in younger girls in the phase of growth spurt, was due to increase in adipose tissues and muscle mass. Another possible reason could be input of dietary supplementation coinciding with the phase of growth spurt, enabling the younger girls to catch-up in growth to some extent and improve slightly, though not significantly, in their percentile status.

Indices based on height and weight i.e. height-for-age and weight-for-age are sensitive indicators of nutritional status. These respond most quickly to variations in nutritional manipulations. Analysis of these indicators revealed that the overall prevalence of low height-for-age was reduced significantly from 31% at T1 to 20% at T3 (Table 4.31) and low weight-for-age was reduced from 64% at T1 to 60% at T3 (Table 4.32). Improvement in nutritional status using height-for-age index was highly significant in younger girls (9-12 years age group) as compared to older girls (13-15 years age group), in which it was not significant. It was also observed that girls, who were severely stunted, improved the most (Table 4.31). This was perhaps due to marked increase in lean body mass and mineral skeleton associated with adolescent growth spurt. Catch-up growth, which started during first 3 months of supplementation period, continued even during non-supplementation period, during which marginal increase in food items like milk and milk products and visible fat occurred, which perhaps was a result of Nutrition, Health, Hygiene and Child Care Education, which continued during the period of non-supplementation. The reduction in prevalence of stunting by 11% and under weight by 4% suggests that calorie and protein input of dietary supplement could promote gain in height to some extent, especially in younger girls, who were severely stunted but was not adequate enough to promote weight gain. Another possible reason could be priority of the body for height gain by
undernourished girls. The small reduction in the prevalence of stunting over such a short period was an expected outcome. Since linear growth is a slow process and even under favourable conditions, takes a relatively long time to show improvements, as also supported by a report of WHO working group (1986). There is good evidence that catch-up growth can restore stature of stunted children to normal, when nutritional conditions become favourable (Waterlow, 1988). Gaur and Singh (1994) have also reported a decrease in prevalence of stunting by restoring to normal growth in stature with increasing age through increased hormonal levels of adolescence, showing catch-up growth. Some cross-sectional studies have also shown that children living in adverse circumstances may experience some catch-up in growth during adolescence without specific intervention (Kulin et al, 1982). Cameron et al (1994) have demonstrated that rural children living in impoverished conditions have some capacity to compensate for these circumstances through increased hormonal levels of adolescence combined with increased sensitivity at target sites, which allow a more complete expression of the genes dictating adult stature, inspite of no major environmental changes.

The biochemical profile of adolescent girls during T2 to T3 i.e. 3 months of non-supplementation period revealed that there was no improvement/change in the haemoglobin level of adolescent girls of EXPT group in all age groups (Table 4.34). At T3, the distribution of adolescent girls into difference grades of anaemia continued to be more or less same, as at T2 (Table 4.37, Fig 4.59). The diet analysis of girls revealed that the home diet of girls continued to be more or less the same and there was no intervention during this period. Thus, there was neither any improvement nor any change in haemoglobin status of girls, which continued to be same as at T2.

Most of the girls continued to be anaemic despite dietary supplementation given to adolescent girls for 3 months in the first phase. This could improve the physical growth status of adolescent girls to some extent and reduce the deficits
in height and weight through catch-up growth. However, iron deficiency anaemia continued in majority of the girls, who continued to be in Grade I and II of anaemia, as at T1. In small scale pilot studies in India, 60 mg of elemental iron per day for 120 days in a year, given for 60 days in each school term, produced a significant improvement in haemoglobin level of adolescent girls and reduced the prevalence of anaemia from about 90% to 40% (ACC / SCN, 1991). An improvement in physical growth and biochemical profile of adolescent girls as a result of iron fortified salt supplementation (6.65 gm / day containing 1 mg of elemental iron per gm) for 3 months has also been reported by Yegammai and Gandhimathy (1993). Similar recommendation for iron supplementation has been made in a study by Vijayaraghavan (1995), who mentioned dietary inadequacy to be the primary cause of iron deficiency anaemia and recommended supplementation of specific micronutrient as one of the major intervention strategies for control of micronutrient malnutrition.

It was, therefore, planned to give iron and folic acid supplementation along with dietary supplementation to all adolescent girls to treat anaemia prevalent in these girls and so as to promote physical growth and also to improve their physical work performance. It is recommended under National Anaemia Prophylaxis Programme of Government of India that iron and folic acid supplementation for minimum of 120 days should be given to treat anaemia in children, adolescents and pregnant women (Nutrition Society of India, 1968). The duration of dietary and nutrient supplementation was decided to be 4.5 months, which included 120 working days, during which nutrient supplementation was given along with dietary supplementation to all adolescent girls of EXPT group.

During the phase three i.e. T3 to T4, when nutrient supplementation was given along with dietary supplementation to adolescent girls, there was a highly significant gain in height of adolescent girls in all age groups (Table 4.16). This significant gain in height resulted from an increase in calorie intake to the extent of 81% of RDA, protein intake to the extent of 70-77% of RDA and calcium intake
to the level of 66% RDA through dietary supplementation as well as through home diet, which was increased as a result of NHHCC education. Besides these nutrients, iron, the deficiency of which is known to be a limiting factor for growth during adolescence, might have helped in accelerated growth in height, as also reported by Chwang et al (1988). Dietary and nutrient supplementation given to girls for 4.5 months contributed 6 mg of iron through dietary supplementation and 20 mg of elemental iron through nutrient supplementation, in addition to 10-11% increase in iron intake through home diet as a result of NHHCC education, making it more than adequate i.e. 218% and 155% of RDA in 9 – 12 years and 13 – 15 years girls respectively (Table 4.14 C). This resulted in highly significant gain in height of girls in all age groups. This resulted in improved percentile status of height in all age groups, especially in younger girls i.e. until the age of 11 years (Fig 4.31 to 4.37). It is a known fact that the catch-up growth is more in younger girls as compared to older ones because accretion of new tissues and mineral skeleton is more in younger girls, enabling these girls to catch-up in height. Linear growth gets triggered in malnourished girls undergoing metabolic activation during catch-up growth. This is, further, evidenced from height velocity, which accelerated in the years of growth spurt i.e. up to 13 years age groups, formed a plateau in the age group of 14 year and deescalated in the age group of 15 year (Fig. 4.31 A to 4.37 A). Accelerated growth velocity in the years of growth spurt as a result of dietary and nutrient supplementation, was an attempt to reach the normal curve but to a lesser extent than first phase of dietary supplementation was indicative of the fact that catch-up velocity was large to start with and decreased progressively as the target curve was approached, as if velocity was regulated by a signal of mismatch between ideal or target curve and the actual situation.

The distribution of girls into different height percentile also depicted slight improvement, though insignificant, towards higher percentiles in all age groups (Table 4.17). Younger girls in the age groups of 9 -11 years, who were between 10th - 50th percentile at T2 and older girls in the age groups of 13 - 15 years, who
were below 10th percentile at T2, improved towards higher percentiles at T3 but
the improvement during this period was not significant. Height velocity during this
phase of dietary and nutrient supplementation was less than 1st phase of only
dietary supplementation but was higher than NCHS standard in all age groups
(Fig 4.31 A to 4.37 A). This was indicative of progressively diminishing effect of
dietary supplementation with improvement in nutritional status of girls. Walker et
al (1991) have also observed an overall growth response as a result of dietary
supplementation in the first six months of the study but no significant effect of
dietary supplementation in the second six months of study, possibly due to
decreased use of supplement and also due to diminishing effect of
supplementation with increasing age.

During this phase of dietary and nutrient supplementation, there was highly
significant increase in weight of girls in all age groups (Table 4.20). Dietary
supplementation increased the intake of calories, protein, calcium and iron to a
level, which was more or less adequate, resulting in an increase in adipose
tissues, muscle mass, bones, blood and visceral organs and consequently
weight of girls. This resulted in an improvement in percentile status of girls,
especially in younger age groups (9 -11 years) in the phase of growth spurt, who
moved from anywhere between 10th – 25th percentile to 25th percentile at 9 years,
near 5th percentile to > 10th percentile at 10 years and < 5th percentile to > 5th
percentile at 11 years but the older girls (12-15 years age groups) continued to
remain below 5th percentile (Fig 4.41 to 4.47).

The distribution of girls into different weight percentiles depicted slight
improvement, though insignificant, only in younger girls i.e. 9 -12 years age
group, who were below 10th percentile at T3 and shifted to next higher percentile
at T4 (Table 4.21). This was indicative of the fact that younger girls derived more
benefit from dietary and nutrient supplementation due to more nutritional
depprivation, especially of calories and larger weight deficit and also due to their
growth spurt. Weight velocity accelerated but the acceleration was less as
compared to first phase of three months of dietary supplementation period and was also less than NCHS standard in all age groups (Fig 4.41 A to 4.47 A), indicating diminishing effect of dietary and nutrient supplementation with an improvement in nutritional status.

Consequent upon significant improvement in height and weight as well as the percentile status of girls, the prevalence of low height-for-age (20%) at T3, was further reduced by 3% at T4. While the prevalence of low weight-for-age (60%) at T3, remained unchanged at T4 (Table 4.31 and 4.32). Insignificant reduction in over all prevalence of stunting indicated progressively diminishing effect of supplementation with improvement in nutritional status. Another possible reason for insignificant improvement during this period of 4.5 months of dietary and nutrient supplementation could be slow process of linear growth. No reduction in the prevalence of under weight in all age groups, except 10-year age group, showed the priority of the body for height gain by mal-nourished girls. Highly significant positive correlations were found between height of girls with protein intake ($r =0.67$) and calorie intake ($r =0.40$) as well as between weight of girls with calorie intake ($r =0.53$) but poor correlation between protein intake and weight ($r =0.17$) of girls. These correlations were indicative of the fact that increased calorie and protein intake as a result of dietary supplementation resulted in a significant increase in height of girls and consequently reduction in prevalence of stunting. However, for an improvement in weight-for-age of girls, more calorie input through dietary supplementation for a longer period and also at a higher quantum was required, as evident from these findings.

One of the reasons for variable response during various phases of intervention was the initial nutritional status of adolescent girls. Impact of supplementary feeding on height gain revealed that malnourished girls showed significant gain in height. Gain in height was more during first phase of supplementation as compared to second phase of supplementation showing catch-up growth during the period of nutritional supplementation. Moreover, the effects of
supplementation were not cumulative. The effect of supplementation was greater during nutritional deprivation and is expected to diminish, as the nutritional status of the adolescent girls improved. It has also been reported by Tanner (1990) that catch-up mechanism is based on the fact that catch-up velocity is large to start with and decreases progressively as the target curve is approached. It seems as if the velocity is regulated by a signal of mismatch between the ideal or target curve and the actual situation. Adolescents recover more or less completely by virtue of their regulatory power, provided the adverse condition are not too long or too severe. In complete catch-up with delay, growth continues for longer period, but in the end, complete catch-up for growth retardation is achieved.

A review of the pattern of incremental growth in height and weight are important for describing and analyzing the characteristics of adolescent growth spurt. Aligning the pattern of height velocity and weight velocity relative to its peak i.e. peak height velocity and peak weight velocity allows evaluation of the patterns, rate and timing of adolescent growth spurt. These are important for timely intervention for adolescents, who are at risk. Incremental growth of height of girls of present study revealed that peak height velocity was attained between 11-12 years, which corresponded to the age of peak height velocity, as per NCHS standards. However, the increments in the height of girls of present study were found to be higher as compared to those of NCHS standard in all age groups (Table 4.19). This may be attributed to the input of supplementary nutrition given to girls, which enabled these girls to catch-up in height due to increased muscle mass and mineral skeletal as a result of increased calories, protein and calcium in their diet. Incremental growth in weight of girls revealed its peak between 12 - 13 years, corresponding to the age of peak weight velocity, as per NCHS standards. However, the increments in weight were found to be comparable to those of NCHS standard in all age groups (Table 4.23). The median age of menarche was 11.53 years for these girls, which was preceded by peak height velocity and followed by peak weight velocity. It was, further, observed that growth velocity in height deescalates sharply after the onset of menarche, as
evidenced from incremental growth of NCHS standards (Hamill et al, 1979) but girls of present study revealed that undernourished rural girls showed significant height gain at later ages and continued to gain height, though at a slower rate, even after the onset of menarche. The long term under-nutrition prevalent among girls from poor communities and the beneficial effect of dietary supplementation during the period of growth spurt, thus, seemed to be responsible for slow and gradual de-escalation in height velocity leading to considerable post-menarcheal growth. The process of compensation appeared to occur through consistently higher post –peak height velocities that maintained growth increments above those of NCHS standard into early adult years. Rao et al (1998) have also reported significantly higher height velocities for undernourished girls than the normal girls, especially after peak height velocity, resulting in a significant post-menarcheal growth (of over 10 cm) in height. Similar finding have also been reported in the 4th report on the World Nutrition Situation (2000), which highlighted that undernourished girls, who grow more slowly but for longer duration, as menarche is delayed. Ultimately, these two factors tend to balance out and total height achieved during adolescence may be similar for well-nourished and undernourished girls. However, the adult height finally attained may still differ as a result of pre-existing childhood stunting. Thus, under-nutrition revealed its impact not only in terms of lower attained adolescent growth but also showed evidence of post menarcheal stature growth among these adolescent girls. Thus, malnutrition only delays the growth spurt but neither the sequence of events nor the time between two consecutive events is changed. Kanani and Consul (1990) emphasized adolescence as a second opportunity to make up for the growth retardation for the past, when peak height velocity takes place i.e. normally 11 – 12 years in well-to-do girls and almost delayed by a year in malnourished girls. Rohde, (1989) has also proposed optimal nutrition specifically 18 – 24 months immediately preceding menarche for promoting catch-up growth.

Besides height and weight, circumferential and breadth measurements as well as skinfold measurements were taken at the end of the intervention i.e. T4. Since
these measurements do not show any significant change in short duration of 3 months, as in the interventions of present study, these measurements were not taken at T2 and T3 i.e. after 3 months of supplementation and 3 months of non-supplementation periods. The changes in these measurements from T1 to T4 were a composite effect of two phases of supplementation of 3 months and 4.5 months each with a non-supplementation phase of 3 months in between the two supplementation phases.

Among circumferential measurements, chest circumference and pelvic girth revealed a significant increase in all age groups during T1 to T4 (i.e. during 10.5 months from the beginning of the study) (Tables 4.24 & 4.25). The chest circumference and pelvic girth are the composite structures of bone and flesh. A significant increase in these circumferences perhaps occurred due to growth in bone and flesh, which occurred as a result of increased amount of calories, protein, and calcium through dietary supplementation given in two phases to these girls during T1 to T4. Significantly positive correlations were found between calorie intake and chest circumference (r =0.48) and pelvic girth (r =0.52), indicating an increase in these circumferences with adequacy of calories in diet.

Out of the other circumferential measurements, MUAC and calf circumference revealed no significant change in all age groups during T1 to T4 (Table 4.26 & 4.27). MUAC and calf circumference are known to reflect changes in muscle tissues and calorie reserves in the form of subcutaneous fat and are very sensitive to adequacy of total nutriment. Only excess energy is stored in adipose tissues of these areas, after all other requirements of the body, including weight gain are met with. No significant change in these circumferences in girls of present study was indicative of the fact that increased intake of calories and protein as a result of dietary supplementation was used for somatic growth of these girls and was not adequate enough to be stored as calorie reserve in adipose tissues of these areas. Significant positive correlations between calorie intake with MUAC (r =0.50) and calf circumference (r 0.48) had been observed.
which suggested that an increase in MUAC and calf circumference would occur, only if calorie intake was adequate enough to meet all other requirements of the body.

The linear measurements i.e. bicondylar breadth of humerus and femur increased significantly in all age groups (Tables 4.28 & 4.29) indicating skeletal growth during adolescence, until the long bone epiphyses fuse, which are closed by 18 or 19 years of age. However, the bones, which grow by surface deposition of calcium, as in case of bicondylar breadth of humerus and femur, continue to grow and respond to stimulation even after the growth spurt, as found in the present study, whereby surface deposition of calcium on these bones occurred due to an increased intake of calcium through dietary supplementation as well as through home diet.

Skin fold thicknesses at four sites namely bicep, tricep, subscapular and suprailliac increased in all age groups in girls of EXPT group. This could be attributed to the fact that as a result of dietary supplementation and increase in home diet, the calorie intake of girls increased to the level of 81% of RDA in both age groups (Table 4.14 A), which was more or less adequate. This was evident from positive correlations between calorie intake and skinfold thickness at bicep (r =0.33), tricep (r =0.32), subscapular (r =0.46) and suprailliac (r =0.47), indicating an increase in various skinfold thicknesses with an increase in calorie intake. At this level of calorie intake, girls of EXPT group were found to have a positive energy balance, their energy expenditure being less than their energy intake (Table 4.48). Measurement of skinfold thicknesses provide a direct evidence of adequacy or otherwise of calories, independent of the phase of growth spurt. Significantly positive correlations between skin fold thicknesses and body weight (r=0.41-0.77), BMI (r=0.49-0.72) and less significant with height (r=0.18-0.59) suggested that adequacy of calories would increase skinfold thicknesses at various sites, after meeting the requirements of the body for weight gain and
increase in BMI. However, height gain would occur, though not to the optimum genetic potential, irrespective of the state of adequacy of calories.

Dietary and nutrient survey conducted at the end of the intervention i.e. at T4 revealed a significant increase in energy intake of adolescent girls of EXPT group (Table 4.14 A). A comparison between energy intake and energy expenditure revealed that energy balance of girls, which was negative at T1 improved after dietary supplementation, which resulted in positive energy balance at T4 (Table 4.48). The positive energy balance of girls revealed its manifestation in terms of various growth parameters i.e. significant increase in height and weight, increase in fat and muscle mass, though the level of physical activity remained the same for these school going adolescent girls.

The morbidity of girls, which manifested in the form of presence of iron deficiency anaemia, protein-energy-malnutrition, vitamin and mineral deficiencies at T1, was analyzed to assess the impact of dietary and nutrient supplementation at the end of intervention i.e. T4. The signs of these deficiencies were assessed haematologically and clinically. The most prevalent nutritional deficiency found in these girls continued to be iron deficiency anaemia.

The haematological profile of girls revealed that the haemoglobin level of girls increased significantly and reached very close to normal level in all age groups after dietary and nutrient supplementation for 4.5 months (Table 4.34). Dietary supplementation comprising of cereals, pulses and jaggery, increased the intake of calories by 23-24%, protein by 15-18% and iron by 21-31% of RDA in both age groups but had negligible impact on haematological profile of girls at T2 (i.e. after 3 months), whereby majority of the girls continued to be anaemic. In order to correct this situation and accrue maximum benefit of dietary supplementation, it was decided to give nutrient supplementation along with dietary supplementation to these girls for 4.5 months to treat anaemia. The objective of iron therapy was to restore the haemoglobin level to normal and to replenish the exhausted tissue.
stores of iron. Nutrient supplementation comprising of 20 mg of elemental iron and 0.1 mg of folic acid along with dietary supplementation increased the iron intake of girls. Even the home diet of girls at T4 revealed an increase in iron intake by 10-11% of RDA along with an increase in intake of vitamin C through home diet, which might have facilitated the absorption of iron from their diet. Thus, the total adequacy of iron through dietary and nutrient supplementation as well as through home diet reached to the level of 218% and 155% of RDA in 9 - 12 years and 13 - 15 years girls respectively. Moreover, administration of 0.1mg of folic acid along with iron, the deficiency of which leads to abnormal haemopoises, leading to megaloblastic anaemia, must have improved haemopoises in these girls. All these factors improved the absorption and utilization of iron, which was evident from significant increase in haemoglobin level of these girls. As a result, majority of girls improved in their haemoglobin status from anywhere between 9 –11gm/dl at T1 to near 12gm/dl at T4.

In order to assess the impact of improved iron intake on different grades of anaemia, from which these girls were suffering, the distribution of girls into different grades of anaemia depicted that majority of the girls shifted from Grade I and II of anaemia at T1 to normal and Grade I of anaemia at T4 (Table 4.37). Though there was an improvement in haemoglobin status of girls in all age groups but it was highly significant (P < 0.01) in younger age groups i.e. 9 – 12 years (Table 4.37). The likely reason for better response by these girls could be a dramatic increase in lean body mass containing a good deal of iron resulting from increased intake of calories, protein and iron and also an increase in blood volume and haemoglobin, which called for an increase in iron requirement, which was adequately met and so these girls showed marked improvement in haemoglobin. However, older girls, who had entered menarche at a median age of 11.53 years, had marked loss of iron during menstruation. Despite this, these girls improved in their haemoglobin level, depicting that their utilization of iron was good. Despite the availability of adequate amount of iron and other related factors, which enhance iron absorption, the improvement in haemoglobin, though
non-significant, was enough in the face of losses of iron due to mensuration in the older girls, who had entered menarche at a median age of 11.53 years. Even Benjamin Burton (1978) has reported that the degree of iron absorption depends to a large extent on the current iron balance of the body. This has also been reported by Kapoor and Aneja (1992) and Vasanths et al (1994), who have emphasized the need for iron supplementation to adolescent girls, long before they enter puberty.

It was, further, observed from the scattergram that girls, who were severely anaemic (haemoglobin level between 8.0-9.9) improved the most and shifted to higher grades of anaemia and majority of the girls from Grade I, II and III at T1 had shifted to normal grade at T4, showing an improvement in haemoglobin status of girls as a result of dietary and nutrient supplementation (Table 4.37, Fig. 4.59). It is a known fact that those, who are severely anaemic, improve the most and respond to treatment. The height of response to iron supplementation was inversely proportional to the haemoglobin level before treatment and may reach around 16% in severe anaemia. The rate of regeneration is also more marked in early stages and lessens, as haemoglobin value approaches normal (de Gruchy, 1990). Similar beneficial effects of iron supplementation have been reported in other studies. Kashyap and Gopaldas (1988) supplemented 8 – 15 years adolescent girls with 60 mg of elemental iron for 60 days twice in a year and found beneficial effects of supplementation on their haemoglobin level and physical work capacity.

Further more, multiple regression analysis was carried out to study the contribution of various factors to the haemoglobin level of girls. Factors found to be significantly contributing to haemoglobin level of girls included vitamin A, iron, education of father, intake of protein, vitamin C, calories, calcium as well as occupation of father, as obtained in step wise multiple regression analysis. A number of studies by Vijayalakshmi and Devadas (1987), Meija and Chew(1988) and Chawla and Puri (1995) have shown the role of vitamin A in haemopoises
but the mechanism underneath has not been established yet. The role of protein and vitamin C in absorption and utilization of iron is an established fact. Other factors contributing to haemoglobin level of girls i.e. education and occupation of father reflect the economic status of family and hence their purchasing power and their dietary intake.

Other indicators of haematological profile i.e. PCV, which refers to the proportion of red cells relative to the total volume of the blood and RBC count, both of which were low but within the normal range at T1, increased significantly in all age groups and were within the normal range all age groups at T4 (Table 4.39 & 4.40). Highly significant positive correlations have been found between total dietary intake of iron with haemoglobin (r=0.52), PCV (r=0.61) and RBC (r=0.67), indicating an increase in these haematological indicators with an increase in total iron intake.

The indices MCV, MCH and MCHC, derived from haemoglobin, PCV and RBC, also improved as a result of dietary and nutrient supplementation. MCV, a reliable index of the average size of the red cells, is of considerable importance to the nature of disorder underlying an abnormality in haemoglobin level. Its subnormal value is indicative of microcystosis. The MCV level of girls, which was found to be below the normal range in all age groups, except 9 and 15 years age groups at T1, increased and reached within the normal range in all age groups at T4 (Table 4.41). This improvement in MCV level was indicative of an increase in size of red cells as a result of increased haemoglobin level of girls, thus correcting the abnormality of microcystosis.

Another index i.e. MCH indicates mean amount of haemoglobin per red cell. A subnormal MCH also occurs in microcystosis, when it occurs in conjugation with a subnormal concentration of haemoglobin in the red cells, as in iron deficiency anaemia. The MCV level of girls, which was below the normal range in all age groups, except 15 year age group at T1, increased and reached within the
normal range in all age groups (Table 4.41), indicating an increase in amount of haemoglobin per red cell, thus correcting microcystosis.

The MCHC value of girls was within the normal range in all age groups at T1. It increased in all age groups during T1 to T4 and continued to be within the normal range at T4 (Table 4.41), indicating normal synthesis of haemoglobin in girls, as evident from the normal value of haemoglobin in these girls.

The indicators of iron status in the body, which are serum iron, TIBC and transferrin saturation, were found to undergo significant positive changes in girls in all age groups (Table 4.42) as a result of dietary and iron/folate supplementation. Serum iron, bound to a specific protein, transferrin, is kinetically the most active compartment of total iron in the body because it is normally replaced and recycled at least 10 times daily. Its value, which was very close to lower limit of the normal range at T1, increased significantly and was within the normal range at T4 (Table 4.42). With an increase in serum iron level, TIBC, which is the capacity of serum protein, transferrin to bind 2.5 to 4.0 mg of iron/litre, decreased significantly in all age groups and was within the normal range at T4 (Table 4.42), indicating better availability of iron for haemoglobin synthesis. With increased serum iron level as at T4, the formation of haemoglobin was improved as a result of efficient erythropoises and overt anaemia was corrected.

Clinical manifestation of iron deficiency anaemia is an outward manifestation of metabolism of iron in the body, as indicated by haematological indicators and indicators of iron and protein in the serum. Clinical examination of these girls at the end of the intervention (T4) revealed a highly significant reduction in the incidence of iron deficiency anaemia, as judged from the sign of pale conjuctiva, the prevalence of which was reduced from 54.4% at T1 to 17.5% at T4, thus registering 67.8% decline PerSe (Table 4.44). Dietary and nutrient supplementation as well as improved home diet as a result of NHHCC education.
increased the intake of iron from the level of 71.6% and 51.1% of RDA in 9-12 years and 13-15 years age group respectively at T1 to the level of 218% and 155% of RDA in these girls at T4. This resulted in a significant increase in serum iron level and a significant decrease in TIBC level, thus improving the synthesis of haemoglobin as a result of efficient erythropoises and overt anaemia was corrected. This correction of overt anaemia manifested itself by reduction in the prevalence of anaemia, whereby 34% of girls, having sign of pale conjuctiva at T1, healed and recovered at T4. Since all the girls had not improved, still there was a scope for improvement, which could be brought about, if dietary and nutrient supplementation was given again after sometime. Further, iron stores were also replenished leading to adequate delivery of iron to bone marrow for erythropoises. At this level of serum iron, TIBC continued to decrease further, indicating better utilization of available iron, thus correcting latent anaemia. The percentage of total iron binding protein, transferrin, to which iron is attached, is known as percent saturation of iron binding protein. Normally, transferrin is about 25-50% saturated and varies under different physiological and pathological conditions. The major role of transferrin is to transport iron from reticulo-endothelial system and the intestine to the bone marrow for haemoglobin synthesis in developing RBC's. With continued intake of enhanced iron and other related nutrients, the storage iron level also became normal, as the exhausted tissue stores of iron were replenished. This resulted in an increase in transferrin saturation level at T4 in all age groups from a value very close to the cut off value of 16% for diagnosing iron deficiency anaemia at T1 (Table 4.42), which was indicative of beneficial effect of iron supplementation on haematological status due to improved utilization of iron. A number of studies have reported the beneficial role of iron supplementation in haemopoises. Vijayalakshmi and Devadas (1987) have reported that supplementation of iron improves in some way the haemopoetic activity of anaemic mothers. Chwang et al (1988) also reported significant improvement in haematological status of anaemic children aged 8.5-13.5 years after giving them oral iron supplementation containing 10 mg of ferrous sulphate per kg per day for 12 weeks. Yegammai and Gandhimathy
(1993) found that iron fortified salt (6.65 gm per day containing 1 mg of elemental iron per gm of salt) supplementation resulted in an increase in haemoglobin level, serum iron, PCV and a decrease in TIBC of anaemic adolescent girls in the age group of 13-15 years. Li et al (1994) also observed an increase in mean haemoglobin and serum ferritin level of iron deficient female cotton mill workers after 12 weeks of iron supplementation. Chawla and Puri (1995) observed the beneficial effect of iron supplementation in improving haemoglobin, PCV and RBC count of pregnant mothers, indicating better availability and utilization of iron.

The indicators of protein status in the body i.e. serum protein, albumin and globulin levels, reflect changes in nutritional status, physical growth and immune system of an individual. Transferrin, a specific protein, which is synthesized in the liver, binds iron present in the serum and transports it from one storage site to another. The serum protein level of girls, which was close to the lower limit of normal range at T1, increased significantly in all age groups, except in the age group of 9 and 12 years, in which the increase was not significant and was within the normal range at T4 (Table 4.43). This increase in serum protein level might be attributed to an increase in intake of 10 gm of protein as a result of dietary supplementation, comprising of cereal – pulse mixture, which had mutual supplementary effect on the component amino acids, thus improving the quality of protein and its utilization by the body. This improved serum protein level could bind increased serum iron to be transported to the bone marrow for haemoglobin synthesis, as evident from improved haemoglobin level of the girls. Another major plasma protein i.e. albumin, is also synthesized in the liver from amino acid, which is absorbed from the ileum. Its level in the serum is least affected by changes in nutritional status and remains almost constant. The level of serum albumin was with in the normal range in these girls at T1 and remained more or less the same at T4 in all age groups, (Table 4.43). Another indicator of protein status i.e. the serum globulin level, which is obtained by subtracting serum albumin from serum protein, also increased along with an increase in serum
protein in all age groups, serum albumin level being almost unaffected (Table 4.43). There was no change in the ratio of albumin and globulin and it remained constant in all age groups because of no change in serum albumin level at T4 (Table 4.43).

Another nutritional deficiency disease i.e. protein - energy - malnutrition (PEM) prevalent among these girls to the extent of 19.3% at T1, was the manifestation of inadequacy of calories and protein to the extent of 50% in the diet of these girls at T1. The prevalence of PEM was reduced significantly to 12.87% at the end of the intervention i.e. at T4 (Table 4.44). Clinical signs of PEM also revealed that early signs of PEM i.e. easy pluckability of hair was reduced to one-half (4.68% at T1 to 2.34% at T4), dispigmentation and lack of luster of hair was reduced by one-third (10.53% at T1 to 6.43% at T4 and 11.11% at T1 to 7.02% at T4 respectively) and sparseness of hair by one-fourth (7.6% at T1 to 5.85% at T4) of its initial incidence at T1 (Table 4.45). The biochemical profile of girls also revealed a significant increase in serum protein level of these girls as a result of dietary supplementation, thus reducing the incidence of PEM at T4. The reason for reduction in the incidence of PEM was an increase in calorie intake by 23-24% of RDA and protein intake by 15-18% of RDA as a result of dietary supplementation, comprising of cereal-pulse combination along with gur, providing good quality protein as well as calories to make up for the food deficit. This increased calorie intake to the level of 81% of RDA, which was more or less adequate and protein intake was raised to the level of 70-77% of RDA, where by a deficit of 23-30% in protein requirement still existed at T4. Moreover, protein was being utilized for energy purposes in the face of inadequacy of calories, which manifested in terms of prevalence of PEM in 12.87% girls at the end of the intervention i.e. T4.

The incidence of vitamin C deficiency, which was prevalent to the extent of 15.2% in girls at T1, was reduced significantly to the level of 4.7% among these girls, registering maximum (69.2%) decline PerSe among all nutritional deficiency
diseases (Table 4.44). The early signs of vitamin C deficiency i.e. spongy bleeding gums present in 11.7% of girls at T1, were totally healed. The presence of other signs of vitamin C deficiency i.e. recession of gums in 9.9% of girls at T1, was reduced to one-half (4.7%) and petechiae, present in 3% of girls at T1, was reduced to one-fifth of its initial incidence (0.6%) at T4 (Table 4.45). Such a drastic reduction in incidence of vitamin C deficiency could be due to approximately 8-10 times increase in intake of vitamin C by girls of both age groups which increased from 19% to 228% of RDA in younger girls and 22% to 160% of RDA in older girls during T1 to T4. Though dietary supplementation didn’t contribute to vitamin C intake of girls, this increased consumption of vitamin C was due to intake of low cost, locally available, seasonal fruits like guavas, amlas, mango green etc and seasonal vegetables in increased amounts by significantly more number of adolescent girls as a result of NHHCC education. Further more, it could be due to improved cooking and feeding practices like sprouting, preserving foods rich in vitamin C in acid medium like pickles, chutneys and squashes and preventing cooking and storage losses through methods, which improved as a result of NHHCC education. Even after making allowances for cooking and storage losses, the increase in vitamin C was high enough to register 69.2% decline in incidence of vitamin C deficiency. It being the most labile vitamin and required on day-to-day basis, the improvement in intake of vitamin C is very easy with the input of educational intervention.

A highly significant decline (65.2%) has also been observed in the incidence of vitamin B deficiency among girls of EXPT group, which was prevalent to the extent of 13.5% at T1 and was reduced significantly to the level of 4.7% at T4 (Table 4.44). Prevalence of various signs and symptoms of vitamin B deficiency revealed that there were no signs of thiamin deficiency in these girls. Though the intake of calories was inadequate in these girls but the thiamin content of the diet was 80-90% of RDA at T1, which was more than adequate as per the calorie basis, thus manifesting no signs of thiamin deficiency. The early signs of riboflavin deficiency i.e. angular stomatitis and chelosis, present in a negligible
number of girls at T1, were totally healed as a result of significant increase of approximately 75ml in intake of milk and milk products, which increased from 30% of RDA at T1 to 60% of RDA at T4 and also in the intake of GLV's and pulses by girls of EXPT group. Signs of niacin deficiency i.e. atrophic papillae was reduced to one-fourth (9.4% at T1 to 2.3% at T4) and scarlet / raw tongue was reduced to one-half (4.7% at T1 to 2.9% at T4) of its initial incidence. This could be a consequence of increased intake of cereal-pulse combination through dietary supplement along with groundnuts, which are particularly very rich in niacin. Moreover, increased intake (75 ml) of milk and milk products, rich in tryptophan, a precursor of niacin, resulted in increased niacin content of their diet.

The incidence of vitamin D deficiency is very scarce in a tropical country like India and especially in this part of the country but it was found that 7.6% of girls had incidence of vitamin D deficiency in the beginning of intervention i.e. T1, which declined to 5.3% at T4, registering 30.8% decline PerSe. Sign suggestive of vitamin D deficiency i.e. knock-knees (7% at T1) was reduced to 5.3% at T4. This could be attributed to 11.5% increase in intake of calcium from dietary supplementation and 10-12% increase in calcium intake through home diet, in which intake of milk and milk products and GLV's increased significantly. An improvement in calcium intake is known to help in absorption and utilization of vitamin D in the body, thus reducing the incidence of vitamin D deficiency.

The functional consequences of anaemia and undernutrition, which manifest in an impairment of physical work capacity, were reversed with a reduction in incidence of iron deficiency anaemia and PEM at T4. This improvement in physical work capacity occurred due to an increase in haemoglobin level of girls, which improved the oxygen uptake capacity i.e. aerobic capacity of the haemoglobin to carry oxygen to different tissues of the body at maximum exertion, which resulted in an improvement in physical work capacity. This aerobic capacity refers to the person’s physical fitness, provided the definition of
physical fitness is restricted to the capacity of the individual for prolonged heavy work.

At the end of the intervention i.e. at T4, the physical fitness index (PFI) score of adolescent girls of EXPT group revealed a highly significant increase in all age groups (Table 4.49). The recovery heart rate (post-exercise), which is indicative of cardio-vascular stress continuing for 1 to 1.5 minutes after exercise, revealed a decrease (Table 4.49) because the heart had to stress less for the same physical activity. The exercise time, for which the girls could continue the exercise till exhaustion, increased (Table 4.49) for the same exercise at T4, indicating an improved capacity of adolescent girls for prolonged heavy activity.

The intervention comprising of dietary supplementation and iron/folate supplementation given to adolescent girls after giving them hematinics so as to accrue full benefit of the supplementation resulted in a significant increase in PFI scores of adolescent girls in all age groups, which were in the marginally average range (Table 4.49). The results indicate that dietary supplementation increased the iron intake of adolescent girls of EXPT group by 6 mg per day, thus contributing to 31.6% & 21.4% of RDA in 9 – 12 years and 13 – 15 years adolescent girls respectively. However, it was still deficient because of poor absorption and bio-availability of iron from mixed cereal diet and also due to increased growth needs and menstrual losses during adolescence. Thus, iron supplementation was required to replenish the exhausted iron stores of anaemic girls and restore their haemoglobin level to normal. The work output increased after dietary and nutrient supplementation, suggesting that adequacy of iron improved work output by increasing the aerobic capacity of the body. The improvement in the physical test scores could be attributed to an improvement in haemoglobin level of adolescent girls of EXPT group as a result of dietary and iron/folic acid supplementation. An improvement in physical work capacity correlated significantly with an increase in haemoglobin level (r=0.61), which suggested less cardio-vascular stress in girls with improved iron status. Li et al
(1994) have also reported a positive correlation between haemoglobin level and physical work capacity.

An improvement in nutritional status of these girls, as assessed through anthropometric, clinical, biochemical parameters and physical work capacity at the end of the intervention i.e. T4, was possible as a result of dietary and nutrient supplementation, which increased the total food intake and consequently nutrient intake of girls. Besides dietary and nutrient supplementation, another intervention i.e. NHHCC education given to these girls through an improved module of NHHCC education, resulted in an increase in quality and quantity of home diet of these girls.

An analysis of home diet of girls conducted at the end of the intervention i.e. T4 revealed an increase in quantity of certain foods and also more variety in their home diet. The educational intervention through improved module of NHHCC education had an imprint on the impressionable minds of the girls, for which they could convince their parents to purchase and provide those foods to them in increased amounts, thus increasing the intake of certain foods through their home diet.

A review of the home diet of these girls revealed certain changes in the quality and quantity of home diet, which could be attributed to an indirect impact of the educational intervention given to these girls for duration of one year.

GLV’s were consumed by only negligible number (2%) of girls at the beginning of intervention i.e. T1 and the girls consuming these, were consuming these in adequate amount as per RDA. A significant increase in number of girls (11% in younger girls and 20% in older girls) consuming GLV’s through home diet occurred at T4. Besides this, the quantity of GLV’s consumed by these girls also increased significantly, especially in older age group (Table 4.12). Moreover, the girls started consuming a variety of GLV’s like radish leaves, carrot leaves.
bathua, amaranth leaves, colocasia leaves, bengal gram leaves, coriander, mint etc. besides consuming cabbage, spinach, mustard and fenugreek leaves, which were mainly consumed at the beginning of the study. The girls started consuming these GLV's in the form of stuffed paranthas, chutneys or added to dal, curd or kadi etc. However, despite being cheap and easily available throughout the year, a large majority of girls were still not consuming GLV's at T4. This could be due to reasons like its time consuming and cumbersome cooking process. Another possible reason could be inability of these girls to convince their parents to purchase and provide these to them or to handle cooking activities independently. Above all, these girls had not developed taste for GLV's as they did not consume this right from their childhood.

Seasonal vegetables like pumpkin, brinjal, gourd, bittergourd, beans, cauliflower etc. were consumed adequately at T1 but the intake decreased significantly at T4, though still adequate as per RDA. This decrease in intake of seasonal vegetables might have occurred due to increased consumption of GLV's by significantly more number of girls, which occurred at the cost of seasonal vegetables because only one preparation was usually consumed in every meal by these girls, resulting in decreased consumption of seasonal vegetables.

Intake of milk and milk products was deficient to the extent of 70% of RDA in both age groups, their mean daily intake being only 70-75ml at T1. Intake of milk and milk products increased by about 75ml in girls of both age groups, the deficit being reduced to 40% of RDA in both age groups (Table 4.12, Fig 4.1). NHHCC education made these girls aware of the importance of the only animal protein (good quality protein) in their diet, thus motivating them to consume it in more amounts.

Visible fat, in the form of cottonseed and mustard oil, was highly deficient to the extent of 63% of RDA in younger girls at the beginning of the study i.e. T1. Its intake increased significantly by 5.4gm per day through home diet at T4, which
reduced the deficit to 38% of RDA (Fig 4.8). The invisible continued to be deficient due to deficient intake of cereals and pulses in the diet of girls of both age groups at T4.

The number of girls consuming fruits was very low i.e. only 11-26% of girls of both age groups at T1, the mean daily intake being 80-90gm. A significant increase in number of girls (97%) consuming seasonal fruits occurred at T4 as a result of NHHCC education, which made them aware of the importance of seasonal, low cost, locally available fruits like guavas, amlas, melons, mango green etc., for which they could convince their parents to purchase and provide them or procure from trees planted in school premises, nearby orchards, nurseries etc., though the mean daily intake decreased to 75-80gm at T4.

Consequent upon an increase in intake of various foods through home diet, intake of calories, increased significantly by 5.5% in 9-12 years and 2.2% in 13-15 years girls at T4 (Table 4.14 A), though it was still deficient by 42-43% of RDA. This increase in calorie intake was due to increased intake of milk and milk products and fat through home diet of girls, the increase being more in younger girls as compared to older girls.

Intake of protein increased significantly by 5-6% of RDA through home diet at T4, though a deficit of 41-45% of RDA continued (Table 4.14 A). Besides quantitative inadequacy, its quality was also poor at T1 due to negligible contribution (8%) of animal protein, milk and milk products being the only source of animal protein and the remaining contribution being from vegetable sources i.e. cereals and pulses. Qualitative and quantitative improvement in protein intake at T4 resulted from an increased intake of milk and milk products through home diet, the contribution of milk and milk products to total protein intake being increased to 14% and remaining protein being derived from vegetable sources i.e. cereals and pulses, the intake of which increased negligibly at T4.
Among water soluble vitamins, intake of B - vitamins especially riboflavin and niacin were deficient to the extent of 40-50% of RDA in girls of both age groups at T1. Intake of riboflavin increased by 8% of RDA in younger girls, though still deficient by 50% of RDA in both age groups at T4 (Table 4.14 B). An increase in intake of riboflavin occurred due to increase in intake of milk and milk products and GLV’s through home diet. Intake of niacin also increased by 4% and 2% of RDA in 9 -12 years and 13 - 15 years girls respectively, though still deficient by 47-48% of RDA at T4 (Table 4.14 B). An increase in niacin intake resulted from increased intake of milk and milk products, which are rich in tryptophan, a precursor of niacin. However, intake of thiamin was adequate (80-90% of RDA) at T1, despite inadequacy of calories in their diet. It increased by 10-20% of RDA in the diet of girls of both age groups at T4, making it adequate (100% of RDA).

Another water-soluble vitamin i.e. vitamin C was highly deficient (19-22% of RDA) in the diet of girls of both age groups at T1. A highly significant increase occurred in intake of vitamin C in the diet of girls, making it 228% and 160% of RDA in 9 -12 years and 13 - 15 years girls respectively (Table 4.14 B). Such a drastic increase resulted from significantly increased consumption of seasonal, low cost, locally available fruits like guavas, amlas, mango green etc and seasonal vegetables by significantly more number of girls at T4. Besides this, improved cooking practices like sprouting, preserving foods rich in vitamin C in acid medium like pickles, chutneys, squashes etc. prevented cooking and storage losses, thus increasing the availability of vitamin C to the body. Moreover, it being the most labile vitamin and required on day-to-day basis, its intake can be easily increased through home diet.

Among minerals, calcium, which was deficient to the extent of 56-57% of RDA in the diet of girls at T1, increased significantly by 10-12% of RDA through home diet but it was still deficient by 45-46% of RDA at T4 (Table 4.14 C). This increase in calcium intake resulted from an increased intake of milk and milk products (approx. 75ml per day) and GLV’s in the diet of these girls.
Another important mineral i.e. iron was also deficient in the diet of these girls at T1, the deficit being more in older girls (49% of RDA) as compared to younger girls (28% of RDA) (Table 4.14 C) because the older girls, who had entered menarche at the median age of 11.53 years, had increased losses of iron in menstrual blood loss. The educational intervention made these girls aware of the importance of iron rich foods in their diet for synthesis of haemoglobin, resulting in an improvement in the iron intake of girls by 9 –11% of RDA at T4, due to increased consumption of GLV’s and other seasonal vegetables by significantly more number of girls at T4.

Cereals, though comparatively cheap and abundantly available staple food, were not increased much in quantity through home diet due to the fact that body gets used to the continued low intake of food by reducing its hunger. Moreover, 50gm of cereals in the form of puffed rice, 25gm of roasted Bengal gram/groundnuts and 50gm of gur, given to these girls as a dietary supplement, increased the total food intake of girls by 125 gms, thus reducing the scope for an increase in intake of cereals and pulses through home diet.

The number of girls consuming GLV’s and seasonal fruits, which was negligible at the beginning of intervention i.e. T1, despite the low cost and abundant availability of these foods, increased significantly at the end of intervention i.e. T4. This could be due to the fact that more number of girls, who became aware of the importance of these foods in their diet as a source of vitamins and minerals required for synthesis of haemoglobin through improved module of NHHCC education, could convince their parents to purchase and provide these foods to them or could procure these foods from nearby orchards / nurseries or from trees planted in school premises. However, intake of seasonal vegetables and tubers decreased because an increase in intake of GLV’s occurred at the cost of seasonal vegetables and tubers.
Even the intake of costly foods like milk and milk products and visible fat increased significantly through home diet at the end of intervention i.e. T4. It could be inferred from this that though cost of food items was the main constraint due to limited purchasing power but it was not the only constraint. The other constraint for poor quality and inadequate quantity of diet consumed was ignorance of these girls as well as their parents regarding the nutritional requirements and balanced diet for them. The other intervention i.e. NHHCC education is a sinequanon for bringing about a permanent and favourable solution to the problem of under-nutrition and anaemia among these girls because nutrition related knowledge, attitudes and practices are also an important determinant of the nutritional status of these girls.

In the ONG group under National Adolescent Girls Scheme (NAGS) of Government of India, there was a provision of dietary supplementation to be given to adolescent girls in the form of alapahar / panjiri / biscuits for 6 days in a week and these girls were supposed to attend to the other activities of Anganwadi centre for only two days in a week. On observing the ongoing practice over a period of two weeks, it was found that these girls actually visited the Anganwadi centre only twice in a week and received the dietary supplement only for 2 days in a week on an average. The impact of dietary supplementation (@ 40 gm per day on an average) given to these adolescent girls was assessed through various parameters i.e. anthropometric, biochemical and clinical examination as well as through an improvement in physical work capacity at the end of the 6 months of intervention i.e. T3.

Among various anthropometric measurements, the most sensitive indicators of nutritional status i.e. height and weight of girls revealed that there was significant increase in height of girls in all age groups, except 13 year age group and weight of girls in all age groups, except 11 year age group, in which the increases were not significant (Table 4.16 & 4.20). Gain in height continued in these girls even in the face of dietary inadequacy, though it might not have reached the optimum
genetic potential. Girls of ONG Group, whose diet was deficient to the extent of 39 – 49% in calories and 42 – 46% in protein, had height and weight deficits of varying extent to begin with. Dietary supplementation contributed 10% increase in calories and 11-12% increase in protein, resulting in a significant increase in lean body mass of girls in all age groups. Furthermore, intake of calcium, which was highly deficient in both age groups (Table 4.14 C), increased by 35.5 mg as a result of dietary supplement, thus increasing it by 6% of RDA in both age groups. It helped in increasing the mineral skeleton and consequently height of girls. Though the height and weight of girls increased in all age groups as a result of increased lean body mass and mineral skeleton with increased intake of calories, protein and calcium through dietary supplementation, the increase did not improve their percentile status. As a result, majority of the girls continued to be in the same low percentile i.e. below 5th percentile as at the beginning of the study. With no change in percentile status of girls, the distribution of girls into different height and weight percentiles also depicted no significant improvement in all age groups (Table 4.18 & 4.22). This could be attributed to the fact that a deficit of 27-34% of RDA in calorie intake and 30% of RDA in protein intake continued even at the end of the intervention i.e. at T3.

Another method used to analyze the rate of increase in height and weight of girls was through their velocities. Height velocity revealed a maximum acceleration in the age group of 12-13 years, when peak height velocity was attained (Fig 4.32 A to 4.37 A) as compared to 11-12 years in normal girls, as per NCHS standard, which was indicative of delayed and longer growth span. During this period, weight velocity also accelerated with age, except in the age group of 11 years. The peak weight velocity was attained at a higher age i.e. 14-15 years (Fig 4.42 A to 4.47 A), which was delayed by almost 2 years, as compared to normal girls, as per NCHS standard. The median age of menarche was 12.59 years, which was preceded by peak height velocity and followed by peak weight velocity.
Incremental growth revealed that the increments in height were lower in comparison to NCHS standards upto 11 years i.e. before peak height velocity and higher thereafter. Similarly increments in weight were less than NCHS standards upto 13 years i.e. before peak weight velocity and exceeded thereafter. This might be attributed to an individuals attempt to acquire adult height and weight and to compensate for initial slow tempo of growth. Catch-up growth occurs in disadvantaged adolescent girls i.e. their height and weight increments are higher than their normal counterparts, which help them to narrow down but not completely bridge the total gap. The sporadic and marginal input of supplementary nutrition to adolescent girls of ONG group resulted in catch-up growth in severely nutritionally deprived girls, who revealed significant improvement in height and weight but not adequate enough to improve their percentile status.

Indices based on height and weight i.e. height- for- age and weight- for- age also revealed a reduction to some extent in the prevalence of stunting and underweight. The prevalence of stunting (Grade II and III) which was 39% at T1, was reduced by 9 % at T3 (Table 4.31). The prevalence of low weight-for-age, which was 68% at T1, was reduced only by 3% at T3 (Table 4.32). The reduction in prevalence of stunting and under weight was attributed to the priorities of malnourished girls to make up for height deficit as compared to weight deficit.

Highly significant positive correlations were found between height of girls with protein intake \((r = 0.57)\) and calorie intake \((r = 0.56)\) as well as between weight of girls with calorie intake \((r= 0.64)\) and protein intake \((r = 0.62)\), indicating that height and weight of girls were directly related to the intake of calories and protein in the diet.

Results of step wise multiple regression analysis revealed the contribution of age, protein and vitamin C intake, religion, ordinal position, per capita income, number of siblings, education of mother, calorie intake and occupation of father
towards height of girls whereas weight of girls was significantly affected by calorie intake, age, calcium intake, religion and per-capita income of girls. Intake of calories, protein, calcium and vitamin C increased the muscle mass, mineral skeletal and adipose tissues, thus affecting height and weight of girls whereas education and occupation of parents, per capita income, number of siblings, ordinal position and religion reflected the socio-economic status and hence affected the dietary intake of these girls.

Besides height and weight, some other anthropometric measurements i.e. circumferential measurements and breadth measurements were also taken at the end of the 6 months of intervention i.e. T3 to assess the impact of dietary supplementation.

Among circumferential measurements, chest circumference and pelvic girth were found to increase significantly in all age groups (Table 4.24 & 4.25). These circumferences, being a composite structure of bone and flesh, increase with age as a natural process, as in the case of height. However, some contribution from dietary supplement resulted in an increase in these circumferences with an increase in mineral skeleton and tissue mass resulting from increased intake of calories, protein, calcium and iron. Significantly positive correlations between calorie intake and chest circumference ($r = 0.48$) and pelvic girth ($r = 0.52$) indicated an increase in these circumferences with an increase in calorie intake, thus inferring that adequacy of calories was critical to bring the expression of full growth potential and its constraint would place a restraint thereon, as also reported by Qamra et al (1990). However, insignificant correlation between protein intake and chest circumference ($r=0.16$) but significantly positive correlation with pelvic girth ($r=0.52$) was indicative of the fact that dietary protein was being used to meet the basal energy rather than for growth in the face of inadequate calorie intake, as observed in the present study.
Other circumferential measurements, MUAC and calf circumference, revealed no significant change in all age groups, except in the age group of 15 year in case of MUAC, in which the increase was significant (Table 4.26 & 4.27). These circumferences are composite structures of muscle and fat and vary with intake of calories and protein in the diet. Only excess energy is stored in adipose tissues of these areas, after all other requirements of the body, including weight gain, are met with. No significant change in these circumferences in girls of this group was indicative of the fact that the increased intake of calories and protein as a result of dietary supplementation was used for somatic growth of these girls and was not adequate enough to be stored as calorie reserves in adipose tissues of these areas. However, significant increase in MUAC in the age group of 15 years could be due to the fact that the adequacy of calories in older girls reached to the level of 73% of RDA, which was more or less adequate. Moreover, these girls might have attained full height as per their genetic potential, thus sparing calories to be stored in adipose tissues of MUAC. Another possible reason could be their low activity level, thus enabling them to conserve energy to be stored and resulting in an increase in MUAC. Calorie intake revealed a significant positive correlation with MUAC ($r = 0.25$) and highly significantly positive correlation with calf circumference ($r = 0.52$) indicating that an increase in these circumferences would occur only in the face of adequacy of calories in the diet of these girls.

Besides circumferential measurements, bicondylar breadth of humerus and femur revealed significant increases in the age groups of 12, 14 and 15 years but insignificant increase in other age groups (Table 4.28 & 4.29). These increases in bicondylar breadth of humerus and femur are indicative of skeletal growth during adolescence, until the long bone epiphyses fuse. These bones also grow by surface deposition of calcium and increased intake of calcium (6% of RDA) through dietary supplementation resulted in an increase in the bicondylar breadth of these bones.
The energy intake of adolescent girls of ONG group also increased marginally as a result of dietary supplementation (Table 4.14 A) but the total energy intake at T3 was still less than the level of their energy expenditure (Table 4.48). Comparison between energy intake and energy expenditure at T3 revealed that the energy balance of girls continued to be negative, though to a lesser extent as compared to T1. The resultant negative energy balance, though marginal, might have been compromised by reduced level of BMR and insignificant change in fat and muscle mass among adolescent girls of ONG group, though their level of physical activity remained unchanged. Despite negative energy balance, these girls continued to grow, though not to the optimum genetic potential, due to adaptive response to energy deficit by reduction in their basal metabolic rate and other mechanisms of the body.

The morbidity of girls of ONG group was assessed haematologically and clinically at T1 and T3 to evaluate the impact of dietary supplementation. The picture of morbidity among girls of this group continued to be same (Table 4.44).

No significant change was observed in the haemoglobin level of girls in all age groups (Table 4.34). The haemoglobin level of majority of the girls, which was in the range of 10-12 gm/dl at T1, continued to be in the same range at T3. The distribution of girls into different grades of anaemia also continued to be same (Table 4.38) as there was no change in haemoglobin status of girls. However, severely anaemic girls in Grade II and III (haemoglobin level between 8.0-9.9gm/dl) at T1, shifted to higher grades i.e. normal and Grade I of anaemia (haemoglobin level between 11.0->12gm/dl) at T3 (Fig 4.60), thus showing that severely anaemic girls were benefited the most even on the input of small amount of dietary supplement. It is an established fact that the greater the severity of anaemia, the higher is the response to dietary supplementation and hence more improvement in haemoglobin level of girls. It has also been reported by de Gruchy (1990) that height of response to supplementation is inversely proportional to the severity of anaemia. Same findings have been observed in
this study. It was, further, observed that some (48%) of the older girls in normal and Grade I of anaemia deteriorated in their haemoglobin status, which may be attributed to an increased demand of iron during accelerated growth and the onset of menarche in older girls, who had entered menarche at a median age of 12.59 years, whereas other older girls (52%) maintained their haemoglobin level, despite menstrual losses, indicating improved utilization of iron. The reason for insignificant improvement in haemoglobin level of girls was that the dietary supplementation comprising of Alapahar / biscuits /panjiri increased the iron intake by only 2.2 mg, thus contributing 11.5% and 7.8% of RDA in 9-12 years and 13-15 years age groups respectively, thus raising the intake of iron from 75.8% to 87.4% in younger girls and 63.2% to 70.7% in older girls but it still continued to be deficient, when compared to RDA. It was further aggravated by poor bioavailability of iron from mixed diet with low absorption rate and the recurrent menstrual losses, which compounded the problem.

Other indicators of haematological profile i.e. PCV, referring to the proportion of red cells to the total volume of blood and RBC count, also revealed no significant changes and continued to be within the normal range at T3 (Table 4.39 & 4.40). However, the level of MCV, MCH & MCHC, which are the indices derived from haemoglobin, PCV and RBC, continued to be subnormal at T3, indicating the continuance of the prevalence of hypochromic microcytic anaemia in these girls (Table 4.41).

Multiple regression analysis conducted at the end of intervention i.e. T3 to see the contribution of various factors affecting the haemoglobin level of girls revealed that it was significantly affected by intake of iron, vitamin C, occupation of father and protein intake of girls, according to step wise multiple regression analysis. Intake of vitamin C and protein is known to have an important role in absorption and utilization of iron in the body whereas the occupation of father is indicative of economic status and hence the purchasing power of the family.
The indicators of iron status i.e. serum iron, TIBC and transferrin saturation also revealed insignificant changes in serum iron and TIBC and only a marginal increase in transferrin saturation in all age groups, except in the age group 10 years (Table 4.42). With a marginal increase in dietary iron through dietary supplementation and with poor bioavailability and absorption of iron from mixed cereal diet, the serum iron level of girls revealed no significant change in all age groups and continued to be near the lower limit of normal range at T3. TIBC, the capacity of serum protein, transferrin to bind 2.5-4.0 mg of iron per litre, also showed no significant decrease in all age groups, indicating poor availability and utilization of iron for haemopoietic activity. With insignificant changes in serum iron and TIBC level of girls, transferrin saturation i.e. the percentage of total iron binding protein, transferrin, to which iron is attached, increased marginally, though insignificantly, indicating poor utilization of available iron for correcting latent anaemia.

Clinical examination of girls of ONG group revealed a reduction in incidence of iron deficiency anaemia from 33.3% at T1 to 16.7% at T3, which was only to the extent of one-half from the beginning of the intervention to its end (Table 4.44). The clinical sign used to diagnose iron deficiency anaemia i.e. pale conjunctiva was also reduced to one-half from its initial incidence. The significant reduction observed in clinical signs of iron deficiency anaemia could be due to the fact that 58% of severely anaemic girls in Grade II & III of anaemia improved to normal and Grade I of anaemia, thus establishing the fact that severely anaemic girls improved in their haemoglobin status even on the input of small amount of dietary supplementation. Vasanthi et al (1994) and Kapoor and Aneja (1992) have emphasized the need for folifer supplementation to adolescent girls, long before they enter adolescence. Keeping in view the alarmingly high incidence of anaemia in girls of high and low socio-economic groups, Shrestha (1986) emphasized to provide nutrition education for adequate dietary intake of iron and hematinic supplement to the whole community, especially to the girls entering puberty.
The indicators of protein status i.e. serum protein, albumin, globulin and A:G ratio reflect changes in nutritional status, physical growth and immune system of the body. There was no significant change in the level of serum protein, albumin, globulin and A:G ratio in adolescent girls of ONG group at the end of the intervention (Table 4.43). Despite the fact that the dietary supplementation to adolescent girls of ONG group increased the protein intake by 6.8 gm, but a deficit of approx. 40% still existed, its qualitative and quantitative inadequacy and sporadic distribution were the limiting factors. Moreover, protein was being used for energy purposes in the face of calorie inadequacy, resulting in wasteful utilization of protein, thus affecting the nutritional status and growth of girls.

So far as the incidence of various vitamin deficiencies was concerned, the incidence of vitamin C deficiency revealed an increase at the end of the intervention i.e. T3 (Table 4.44). Since there was no contribution of dietary supplementation to vitamin C content of the diet, the unexpected increase in early signs of vitamin C deficiency i.e. spongy bleeding gums could be attributed to seasonal variations in the availability of seasonal vegetables from winter season at T1 to summer season at T3, thus affecting the intake of various foods at the end of 6 months of intervention. Moreover, vitamin C being the water soluble and most labile vitamin, its daily intake in the diet is essential to prevent the deficiency of vitamin C.

The physical fitness index (PFI) scores of girls of ONG group increased significantly in all age groups, except in the age group of 10 and 13 years, in which increase was not significant. The recovery heart rate was reduced and exercise time increased for the same exercise at the end of the intervention (Table 4.49) indicating less cardio-vascular stress and improved capacity of these girls for prolonged physical activity. The poorer response in PFI scores by girls of ONG group might be attributed to insignificant increase in the level of haemoglobin of adolescent girls of ONG group. The results of nutrient intake also
revealed no change in iron intake of adolescent girls through home diet. The dietary supplementation increased the iron intake of adolescent girls of ONG group by only 2.2 mg, thus contributing to 11.5% & 7.8% of RDA in 9 – 12 years and 13 – 15 years adolescent girls respectively. No hematinics were given to adolescent girls of ONG group, which could not accrue full benefit of dietary supplementation, resulting in no increase in their haemoglobin level and marginal increase in their physical work capacity. Another probable reason could be that girls, who were not initiated for this activity at the beginning of intervention due to inhibitions, became more confident, felt motivated and performed better at the end of intervention. Moreover, some of the severely anaemic girls, who had improved in their haemoglobin level, scored significantly higher in PFI scores at T3. At this stage, the PFI scores of girls were ‘average’ in the age group of 10 – 13 years and ‘poor’ in the age group of 14 & 15 years, which might be due to the fact that older girls had marked losses of iron during mensuration, though their haemoglobin level was maintained at in the range of 10-12 gm / dl through improved utilization of iron and hence the poor PFI scores of these girls. The beneficial effects of hematinics and dietary supplementation on physical work capacity of anaemics have been reported by Gardner et al (1977), Seshadiri and Malhotra (1984) and Diaz et al (1991).

The marginal improvement in nutritional status of girls of ONG group, as assessed through the various parameters and their physical work capacity at the end of 6 months of intervention i.e. T3 occurred as a result of dietary supplementation, which increased the total food intake and consequently nutrient intake of these girls. Besides dietary supplementation, another intervention i.e. NHHCC education given to these girls for 6 months through educational package of NAGS, resulted in an insignificant increase in intake of various foods through home diet. However, whether this marginal increase in home diet at the end of 6 months of intervention i.e. T3 was an indirect impact of the educational intervention or an impact of seasonal variations after 6 months was difficult to be separated out. A number of studies have reported seasonal variations in intake of
various foods. Puri et al (1984) have reported seasonal variations in intake of cereals, vegetables and fruits in all income groups. It also reported that nutrient intake of all income groups was satisfactory in winters, while their diets were deficient in β-carotene and vitamin C in summer due to consumption of milk, GLV's and other vitamin C rich foods in small amounts.

An analysis of home diet conducted at the end of 6 months of intervention i.e. T3 revealed no significant change in intake of various foods through home diet, except the intake of milk and milk products, fat and seasonal fruits, which increased significantly. An increase in number of girls consuming GLV's occurred, the amount consumed remained more or less the same, as others were eating at the beginning.

Intake of milk and milk products increased by 80-100ml per day, making it adequate as per RDA at T3 (Table 4.12). The educational intervention made these girls aware of the importance of only animal protein in their diet, motivating them to consume increased amount of food available at home in abundance due to rearing of cattle at home. Moreover, the availability of milk and milk products and its consumption in the form of curd, lassi etc. increased in summer season at the end of the study i.e. T3. With increased intake of milk and milk products, the intake of invisible fat also increased, which along with some increase in visible fat, resulted in an increase in total fat intake by 5.2gm and 3.2gm per day in younger and older girls respectively at T3.

Fruits were not consumed at all by girls of ONG group at the beginning of intervention i.e. T1. The input of educational intervention made these girls aware of the importance of seasonal, low cost, locally available fruits, for which they could convince their parents to purchase and provide them or procure these from nearby orchards/nurseries, thus significantly increasing the number of girls consuming fruits in adequate amount at T3. Moreover, the availability of fruits like melons, guavas, amlas, mango green etc. in abundance in summer season
made them consume these fruits in adequate amount at the end of the study i.e. T3.

GLV's, which are cheap and easily available throughout the year but consumed by only 20-26% of girls at T1, were consumed by significantly more number (36-43%) of girls at T3, the mean intake being more than adequate as per RDA. Though the number of girls consuming GLV's increased but the amount consumed remained more or less the same as at the beginning of the study due to limited availability of GLV's in summer season at T3. However, the variety of GLV's changed from mustard, spinach and fenugreek leaves to cabbage, colocasia and bengal gram leaves etc. being cooked as saag or vegetable / dal preparation.

Intake of seasonal vegetables and tubers decreased because increased intake of GLV's by more girls occurred at the cost of seasonal vegetables and tubers as only one preparation was consumed in every meal by these girls. Another likely reason could be seasonal variations from winter season at T1 to summer season at the end of the 6 months of study i.e. T3, when the availability of seasonal vegetables also decreased.

Consequent upon marginal increase in intake of various foods through home diet after 6 months of educational intervention, the intake of nutrients increased only marginally at the end of intervention i.e. T3.

Intake of calories and protein were highly deficient to begin with. Intake of calories increased by 2% and 5% and protein intake increased by 4% and 2% only in both age groups at T3. However, a deficit of 37-44% of RDA in calorie intake and 40-42% of RDA in protein intake continued even at T3. This marginal increase in calorie and protein intake was attributed to increased intake of milk and milk products and fat, resulting in an increase in calorie intake along with addition of good quality protein to the total protein intake.
Among water-soluble vitamins, intake of B-vitamins, especially riboflavin and niacin were deficient to the extent of 50% of RDA to begin with. Intake of these vitamins increased by 8% of RDA at T3 due to increased intake of milk and milk products and GLV’s by significantly more number of girls at the end of intervention i.e. T3.

Other water-soluble vitamin i.e. vitamin C, deficient by 33% and 48% of RDA in younger and older girls respectively, increased significantly to the level of 152% and 130% of RDA in these girls due to increased consumption of seasonal fruits and vegetables in increased amounts at T3. But it being the water soluble and the most labile vitamin, most of it being lost during cooking and storage, its daily intake in the diet is must to ensure the adequacy of vitamin C in the diet.

Among minerals, calcium was deficient by 28% and 47% of RDA in older and younger girls respectively. It increased by 5% and 7% of RDA in these girls but a deficit of 23% and 40% continued in older and younger girls respectively at T3. An increase in intake of calcium occurred due to increased intake of milk and milk products and GLV’s by significantly more number of girls at the end of intervention i.e. T3.

Thus, supplementary feeding is of paramount importance for promoting catch-up growth in undernourished adolescent girls, if given regularly in judicious combination and at a higher quantum for a longer duration. Moreover, supplementary feeding is of proven benefit for promoting optimum catch-up growth in adolescent girls, specifically in the period of growth spurt i.e. at least 18 – 24 months prior to menarche. Adolescent growth spurt offers an opportunity to adolescent girls to make for the growth retardation of the past. It can help to narrow down, though not completely bridge the initial growth retardation. But Government can not afford to supplement undernourished adolescent girls for very long durations in developing countries, where poverty resulting in deficient
intake as well as lack of knowledge, wrong attitudes and faulty practices vis-à-vis nutrition and health are contributory causes of under-nutrition. The other intervention i.e. NHHCC education is the sinequanon for bringing about a permanent and favourable solution to the problem of malnutrition in the population because nutrition related knowledge, attitudes and practices (KAP) are also an important determinant of nutritional status. Adolescent girls, at the brink of women-hood, are the future mothers. Knowledge of nutrition and dietary concepts held by them during adolescence are carried throughout life and are important for themselves and for feeding and rearing of their children. Thus, nutrition education is generally the accepted strategy for nutrition promotion.

The evaluation of the impact of educational intervention was done through a pre-test and post-test design whereby the knowledge, attitudes and practices (KAP) vis-à-vis Nutrition, health, hygiene and childcare (NHHCC) of adolescent girls of both EXPT and ONG groups were pre-tested before giving these girls NHHCC education i.e. at T1. The knowledge, attitudes and practices of girls was post-tested after giving them the educational intervention through an improved module of NHHCC for one year i.e. at T4 in EXPT group and after 6 months of educational intervention of National Adolescent Girls Scheme (NAGS) i.e. at T3 in ONG group.

The results of present study revealed a significant difference in initial pre-test scores of knowledge and practices between the two groups, the scores being significantly higher in adolescent girls of ONG group, the majority of the girls scoring between 40-80% in knowledge and practices as compared to girls of EXPT group, in which majority of the girls scored below 40% in knowledge and below 20% in practices (Table 4.53, Fig 4.90, 4.91 & 4.94, 4.95). There was no significant difference in initial pre-test scores of attitudes between the two groups, the majority of the girls scoring between 40-80% in both groups (Table 4.53, Fig 4.92, 4.93).
It was very intriguing to observe that the girls of ONG group scored significantly higher in overall scores of knowledge as compared to girls of EXPT group, whose scores were poor (Table 4.50). The reason for this difference might be due to difference in traditional beliefs and practices prevalent among populations of two culturally and environmentally different areas of Haryana. The geographical locale of this group was a remote and backward area, where there was poor access to modern amenities, advanced technologies and adequate medical facilities and/or practitioners. So they had to depend upon traditional folk wisdom, which might have proved useful in following the practices, especially those relating to therapeutic nutrition and hence the better scores. Moreover, the adolescent girls of this group were school dropouts and stayed at home, which might have resulted in more involvement of these girls in household activities relating to cooking and feeding. Furthermore, the lower per capita income of adolescent girls of this group perhaps made them utilize their available limited resources in a better economical way, thus resulting in better practices and consequently higher knowledge.

Analyzing the various components of knowledge, it was found that the adolescent girls of ONG group had average scores in therapeutic nutrition (55-59 %) in both age groups (Table 4.50). The likely reason for this might be higher morbidity among this group, due to unsanitary environmental conditions, as observed during their ecological survey (Table 4.10). Sickness was treated using folk wisdom and time tested traditional practices, which the girls had been observing and participating in with their parents. The younger adolescent girls (9 –12 years age group) had average scores in the area of ICDS / NAGS as compared to poor scores of knowledge in this area scored by older girls i.e. 13 – 15 years girls, who were school dropouts and were involved in household and child rearing activities, had no time left to go to anganwadi centers. Moreover, older girls might not be allowed to go to anganwadi centres due to conservative attitudes of their parents and consequently poor knowledge.
In EXPT group, both age groups of adolescent girls had average scores (in the range of 42-47%) in the area of Integrated Child Development Services Scheme (ICDS) / National Adolescent Girls Scheme (NAGS) and poor scores (in the range of 27-32%) in the area of maternal and child health care (MCHC) (Table 4.50). It is believed that knowledge possessed by a person is influenced by the factors, which are of interest or concern to him. Accordingly, areas of ICDS / NAGS were of much concern / interest to them because these girls attended the activities of anganwadi centre and used to get supplementary nutrition for themselves or their younger siblings, which served as an incentive to them and motivated them to participate in the activities of anganwadi centre. The slightly higher scores of older girls was perhaps due to longer association and so greater involvement of these girls in the activities of anganwadi centre. Knowledge possessed by the girls in the area of maternal and child health care (MCHC) was poor due to lack of interest in the area of least concern as these girls were going to school and were not engaged in child rearing activities at home. At this age, they were more engaged in play activities, less involved in household chores and had less sense of responsibility.

The common finding in both groups was that basic knowledge possessed by adolescent girls of both EXPT and ONG groups was poor (29-35% in EXPT group and 37-41% in ONG group in both age groups). This might be due to the fact that these girls had no exposure and no formal foods and nutrition education and the girls of ONG group had hardly any schooling or formal education. Whatever knowledge they possessed, was gained informally through media or was based on practices, which were carried on from generation to generation, tested over a period of time, happened to be correct as a result of trial and error and practised by them. People consume foods, which are available to them without knowing the importance of the same. Eating is instinctive and is normally governed by the cultural norms. What a food contains or why it is consumed is hardly questioned (Yarbrough, 1981). Similar findings have been reported in studies conducted by Kapil et al (1990,1991) on knowledge and attitudes...
amongst well-to-do adolescent schoolgirls. It revealed that majority of them lacked knowledge and had incorrect beliefs regarding nutritive value of foods, breast feeding and diet during diseases, pregnancy and lactation. Chandra et al (1992) also assessed the knowledge and attitude about nutritive value of food, diet during diseases, antenatal and postnatal period and various briefs regarding diets.

Significant differences between EXPT and ONG group were observed in the areas of therapeutic knowledge, MCHC and GOBI, the scores being significantly lower in girls of EXPT group. Poor scores of girls of EXPT group in therapeutic nutrition were due to their better access and dependence on doctors and medical practitioners in EXPT group, which is a periurban area of Panchkula city, a satellite town of Chandigarh, where the girls were more exposed to urbanization, modern amenities and advanced medical facilities. That's why these girls didn't bother to understand how diseases were being treated, which resulted in ignorance of folk wisdom because traditional beliefs had fallen apart. The difference in other areas of knowledge i.e. MCHC and GOBI between the two groups was due to the fact that girls of EXPT group were school going and hence less involved in activities of child rearing. Whereas the girls of ONG group were school dropouts, stayed at home and thus more involved in household and child rearing activities. Moreover, these girls felt motivated to learn about MCHC and GOBI as they were expecting to get married in a year or so and hence better scores.

Measurement of attitudes using two – point scale among adolescent girls of EXPT and ONG group revealed that overall attitude scores were average and there was no significant difference in scores obtained by girls of EXPT and ONG group (Table 4.51). Attitudes are learned, emotionally toned enduring predispositions to react in a consistent way, favourable or unfavourable, towards persons, objects, situations or ideas. An individual develops attitudes in coping with the various problems, one encounters in satisfying one's own needs. Hence,
favourable attitudes are developed towards objects that satisfy needs and unfavourable attitudes are developed towards those attitude objects that thwart or block individual need satisfaction (Rokeach, 1968).

The adolescent girls of both groups had strongly favourable attitudes regarding status of girls in the society. Though these girls belonged to families and society, which were traditional, illiterate and socio-economically poor but it was very heartening and impressive to note that these girls were aware of the fact that their status in the society was equal to that of boys. However, the society didn’t permit them to avail of most of the privileges, as enjoyed by the boys. The girls, it seems, acquired this knowledge through mass media, books, magazines, friends, teachers and social/health workers and hence possessed favourable attitudes.

The girls of both groups had average attitude scores with regard to adolescent health. These girls were not very much aware of their own nutritional and health needs due to poor basic knowledge possessed by them, the only source of inadequate and sometimes misleading information being mass media, magazines or friends. The concept of health was limited to these girls only to the extent of absence of disease and not beyond i.e. a state of complete physical, mental and social fitness.

Attitude scores in the area of MCHC were average by girls of EXPT group but significantly higher by older girls by ONG group. Attitudes belong to the domain of human motivation, the initial appearance of which depends on learning. The family is effective in shaping these in girls in proportion to the degree, to which other cultural influences operate in the same direction. Thus, the older girls in the ONG group, who were expecting to get married soon, felt motivated to learn healthy attitudes towards maternal and infant feeding.
The attitudes towards therapeutic nutrition revealed poor response by adolescent girls of EXPT group (37-39%) because of poor knowledge possessed by them in the area of therapeutic nutrition as compared to adolescent girls of ONG group, who revealed significantly higher scores (56-58%), though average, in therapeutic nutrition as compared to girls of EXPT group (Table 4.51). Since knowledge is a pre-requisite for attitude formation, which involves concept formation—a process that need not be conscious or deliberate. Thus, attitudes of girls towards therapeutic nutrition were formed on the basis of either direct experience or indirect experience gained by the girls. The girls of ONG group, who were more exposed to morbidity, had more direct/indirect experience of the traditional time tested practices based on folk wisdom, had higher attitude scores as compared to girls of EXPT group, who lacked both exposure and experience.

Overall observation was that older adolescent girls of 13-15 years of both EXPT and ONG group revealed higher scores in positive attitudes as compared to younger (9-12 years) adolescent girls because attitudes get well established, firm, enduring and less likely to change at a higher age. The group affiliation of these girls also played a vital role in formation of their attitudes. The primary group, to which these girls belonged was their family, which had a core of common attitudes that hold its members together and the other group was the peer group, with whom these girls shared their attitudes especially in the areas of inhibitions. These attitudes are developed during one's life and are more or less enduring, once they are formed.

So far as practices regarding NHHCC are concerned, the adolescent girls of EXPT group had very poor overall scores (below 20%) in all aspects of practices (Table 4.52). The likely reason for such poor scores was lack of basic knowledge (29-35%) possessed by them. Since knowledge possessed by a person and attitudes formed on the basis of direct or indirect experiences form the basis of practices/behavior to be followed, it is obvious that areas of sound knowledge and favourable attitudes predict good practices and vice versa, as is evident from
the correlation between scores of knowledge and practices \( r = 0.53 \) and knowledge and attitudes \( r = 0.31 \) in girls of this group. Practices are reflection of knowledge possessed by these girls, acquired either through formal education or through observation/experience gained in the family. Since these girls had neither formal education regarding basic, applied and therapeutic nutrition, nor were they aware of even the practices being practised in their homes, some of which might be correct out of trial and error as these girls were school going and not involved in household and child rearing activities. So, these girls lacked knowledge as well as experience regarding cooking and feeding practices, adolescent health, MCHC and therapeutic nutrition and consequently had very poor scores in all these areas.

The adolescent girls of ONG group had significantly higher scores in practices as compared to girls of EXPT group, the overall scores being average in girls of both age groups. These girls had good scores in practices related to therapeutic nutrition (75-87%), which could be attributed to the reasons, which have already been mentioned, while discussing reasons for better scores in knowledge in the area of therapeutic nutrition by girls of this group.

The scores of practices in the area of adolescent health and MCHC were average in both age groups. Practices, no doubt, are influenced by the knowledge but more influenced by the beliefs, which are accepted by a social group and followed blindly from generation to generation. The girls of ONG group, who were school dropouts and stayed at home, had been observing and participating in these traditional practices, which were carried on from generation to generation, so were aware of most of these practices and obtained average scores.

The scores of girls with regard to cooking and feeding practices were also in the range of average in both age groups. Some of the cooking practices like not removing bran from flour, making of missi roti, use of gur/jaggery etc. were the
healthy ones and being practised without knowing the scientific rationale underneath. However, feeding practices were governed by traditional beliefs and taboos, food fads and fallacies associated with feeding of infants, adolescents and pregnant mothers. Some of these traditional practices happened to be correct and others being incorrect, hence the average scores in this area.

The correlation between knowledge and practices of ONG group was found to be highly significant ($r = 0.69$) followed by correlation between knowledge and attitudes ($r = 0.46$), indicating that correct knowledge was a pre-requisite for good practices as correct knowledge helped in changing attitudes in right direction. With correct attitudes coupled with continued persuasion, practices also change; though take longer time to do so. A number of studies have reported similar findings showing lack of knowledge, unfavourable attitudes and poor practices among rural women and girls regarding nutrition and health. Assessment of nutrition KAP of mothers by Kumar et al (1989) revealed that majority of them lacked information regarding food values and therapeutic knowledge, 65% had unfavourable attitudes and 26% followed poor nutrition practices.

Assessment of knowledge, attitudes and practices of girls at the beginning of intervention through a pre-test at T1 was followed by input of an educational intervention, which was given to adolescent girls of EXPT group through an improved module of NHHCC education for a duration of one year. This educational package of improved module was improved in terms of its content, duration, continuity and its mode of delivery. Its impact was assessed through post-test at the end of intervention i.e. T3.

After giving the intervention of NHHCC education through the improved module of NHHCC education for one year using various teaching methods and aids, the post-test scores of adolescent girls of EXPT group revealed a significant increase in all aspects of KAP, the highest increase being in the area of knowledge (41-
47%), followed by practices (36-41%) and least in attitudes (26-31%) in both age groups (Table 4.55).

Review of the scattergrams showing the performance of girls into different scores of KAP, as a result of educational intervention depicted that all girls scoring below average at T1, improved to the level of average and above after the educational intervention for one year. Most of the girls scoring in the average range at T1, also improved to the level of above average at T4. However, girls scoring above average at T1, continued to score in the same range even after the input of educational intervention. Though the trend was same in all areas of KAP but the improvement in performance of girls was more evident in knowledge followed by practices and less evident in attitudes (Table 4.53, Fig 4.90, 4.92 & 4.94). It was observed that girls, who had below average and average scores at T1, improved the most because persuasive communication along with strong motivation enabled these girls to learn the maximum. No doubt, the girls with better scores also improved but not to the same extent because of lesser scope for learning as they already had good scores at T1.

A review of the overall knowledge scores revealed that a highly significant increase in knowledge scores (41-47%) was registered in both age groups of EXPT group, the quantum of improvement being 2.0-2.4 fold. This could be attributed to a number of factors, which were improved upon in the educational package delivered to girls of this group. Firstly, the content of improved module was enlarged to include basic fundamental concepts on food, nutrition and health. It was linked to the previous knowledge possessed by the girls. It is an established fact that the things to be learnt should be linked with their previous learning and be made a base for future learning so as to establish proper connection and association between the different aspects of learning. This improved module was prepared in a very simple regional language (Hindi), which was understandable to these girls to the level of their comprehension. Due care was taken to make it meaningful and relevant to their life situations. It is obvious
that learning is best fostered by capturing the learner's interest in the subject matter, which can be achieved by linking learning to life goals and making it relevant to them. Moreover, the written material in the form of cyclostyled notes was distributed to reinforce what was taught to them so that they could read them, refer in case of need and share with other family members. Thus, teaching was supplemented by written material in some form, as it helped in self-study and improved retention of the knowledge gained. This fact has also been reported by Rahman et al (1994). Singh et al (1993) evaluated the efficacy of health education pamphlets and found that pamphlets were able to improve the knowledge of mothers significantly regarding various aspects of childcare and it was retained on follow up after 2 weeks.

The duration and continuity of improved module was extended to 5 continuous days as initial orientation in the first month followed by one day of teaching in a month for 11 months continuously as continuing education, making it a total of 96 contact hours of teaching in 16 teaching days. The girls were engaged in educational activity for 6 hours each day through a variety of interactive and participatory teaching methods and audio-visual aids. They were provided dietary supplement in between and a break of 5-10 minutes after each session, which helped to refresh them, restore their energy and interest and recharge their enthusiasm. The extended duration and continuity of educational package increased the scope for more details, more rationale, more repetition and hence more retention of knowledge. The in-between recapitulation sessions helped to review the previous learning, bring continuity and momentum and fixed the messages in their minds. The relationship between practice and learning as scientifically explored by Ebbinghans (1885) states that the amount learned is a direct function of the time devoted to learning. It depends on the quantity of time that is actively spent in learning. It has also been reported by Vanka (1995) that learning is better, if it is spread over many days rather than crammed into a few. Also, a break of two to ten minutes after every 30-50 minutes of learning period helps to increase the efficiency.
The improved educational module of Nutrition, Health, Hygiene and Child Care education was imparted to adolescent girls by various experts from Food and Nutrition Board, Department of Women & Child Welfare, Health Department and Family Planning Association of India, who had expertise in their subjects and had adequate and varied experience of the field situations. Moreover, these experts from different fields knew the pedagogy of teaching skills, which made teaching sessions very effective, thus resulting in more learning. The sessions conducted by various experts helped to break the monotony and made the sessions interesting. Moreover, it resulted in better learning due to integration of efforts on a common platform.

This improved educational package was delivered to adolescent girls at their door steps i.e. Anganwadi center of their respective villages, which resulted in better learning through lesser distraction of mind towards unfamiliar situations. Rural women generally find it difficult to identify themselves with unfamiliar characters, situations and messages presented to them. Thus, an effective method for educating rural women should have the elements of interest, familiarity and indirectedness (Pathak and Shah, 1984).

Analyzing the various components of knowledge, a highly significant increase was observed in all aspects of knowledge. The highest increase (48-54%) was registered in the area of basic knowledge in both age groups. This could be attributed to enlargement of content of improved module of NHHCC education by including basic fundamental concepts of foods and nutrition. They were made aware of the facts about foods and nutrition by using actual foods they were eating, to make them understand about nutrients, their functions, sources, balanced diet, diet enrichment, enhancement and retention of nutrients. These concepts were taught to them through interactive and participatory methods like discussion, group songs, rhymes and riddles. These methods made nutrition education more meaningful because these imbibed more confidence, better
communication skills, improved thinking skills, increased motivation and commitment to improve nutrition behavior among learners. Similar findings have been reported by Abhusabha et al (1999) who have recommended facilitated group discussion to make nutrition education more meaningful. Furthermore, visual aids like slides and transparencies were used to sustain their interest, make them thoroughly understand and retain things better and longer. A number of researches indicate that 83% of learning takes place through sight. Moreover, it helps in capturing learner’s interest and make abstract things concrete. Thus, retention is always better. Learners perhaps cannot concentrate much on verbal media alone and learn better through visual media, which not only arouse interest but also enrich learning situations by sustaining interest, promoting better understanding and motivating thinking and action, as also reported by Shah and Gupta (1986).

The areas of Adolescent Health, MCHC and GOBI also improved significantly in both age groups because adequate emphasis was laid on these aspects in the improved educational package. As these areas pertained to their current and future needs, they felt interested and motivated to participate in discussions in these areas. It is well known that for effective learning to take place, girls should be made ready or motivated properly. Video films on various aspects of adolescent health, MCHC and GOBI were shown to enable these girls to gain maximum knowledge. Such films are of proven benefit because girls tend to identify themselves to the characters of the film and imitate them resulting in better learning. A study conducted by Bhangoo and Kaur (1995) on multi media approach in learning concluded that multi media approach was very effective in gaining maximum knowledge. However, it was more suited to new and difficult information rather than relatively simpler information. Secondly, the basis for combining methods should be such that each method related to a different sense, as the use of each sense contributed to gain knowledge. Finally, multi media approach provided economics of educational technology as well as physiological and psychological limits in learning.
The girls of both age groups improved by 2.1-2.2 fold in the area of therapeutic knowledge, the increase in scores being 40-41%. Various nutritional deficiencies and other diseases and their management were discussed and explained to them in the context of their own family situations using visual aids like slides and transparencies. Since this area of knowledge related to their own health and those of their siblings or other family members, they showed keen interest and felt motivated to learn, hence good scores by girls of both age groups in this area.

The increase in scores of adolescent girls of both age groups of EXPT group was 1.8 fold in the area of ICDS /NAGS because their knowledge in this area was average at T1. It was observed that the maximum increase in scores was in the areas of minimum scores at T1 & vice versa in both age groups. The likely reason might be the scope for more learning in the area of minimum knowledge at the initial stage of the study and vice versa. Every curve of learning shows a steep rise at the beginning, describing a period of rapid improvement from zero level. This period of rapid progress is followed by a period of little or no progress, as described by Jalota (1979). Ahmed et al (1991) also observed an increase of 60.2 % in the knowledge scores of illiterate mothers as result of 14 hours of nutrition and health education showing marked improvement from zero level.

As attitudes are affected by knowledge, an improvement in attitudes revealed that the adolescent girls of EXPT group registered highly significant increase (26-31%) in overall scores of attitudes. However, the quantum of improvement was only 1.5-1.6 fold due to average attitude scores at the beginning of the study. Attitudes are deep rooted in the minds of people. People continue to believe what they see being done in the family and the community, in which they live. In their daily life, they accept or reject certain foods on the basis of attitudes carried from generation to generation and is taken for granted that they are correct and
nobody dares to contradict them for the fear of conducting a disastrous experiment on their precious body.

Maximum increase in scores was in the area of therapeutic nutrition (45-48%) in both age groups. This increase in scores of attitudes to the extent of 2.2 fold was associated to a significant increase in knowledge related to therapeutic nutrition imparted to these girls. It was observed that awareness developed on scientific matters and knowledge gained through scientific literacy programs had an impact on the development of scientific attitudes, especially with regard to therapeutic nutrition by removing blind beliefs, superstitions and misconceptions. Beech et al (1999) reported that although knowledge and consumption level of adolescents with regard to fruits and vegetables were low, their attitudes towards learning about healthier eating practices were favourable. Thus, innovative school based nutrition and health education programmes, which were student friendly, culturally appropriate and used as a multi faceted approach were needed. A study conducted by Rao (1998) reported the impact of knowledge on attitude change and found a non-significant low correlation between pre-scientific awareness and attitudes of neo-literates but the post test analysis revealed a significant relationship between scientific awareness and attitude which indicated that awareness developed on scientific matters and knowledge around through scientific literacy programme had an impact over the development of scientific attitude by removing blind beliefs, superstitions and misconceptions.

Attitudes on adolescent health also improved significantly, the quantum of improvement being 1.5 – 1.7 fold. Change in attitude of these girls with regard to adolescent health occurred as a result of new information given to them, which had characteristics of high credibility, attractiveness, likability or perceived similarity to these girls. This change in attitudes was further strengthened through persuasive communication in a meaningful way. Attitude change theories also postulate that attitudes may be changed by opinions or beliefs, which in turn, can be changed by persuasive communication. Receivers are influenced through
channels, which carry selected messages. Some people undertake adoption before others and slowly innovation diffuses through the community.

Attitudes of girls with regard to status of girls in the society improved by only 1.3–1.5 fold due to good scores of the girls in this area at the beginning of the study. These girls were aware of their status in the society, the awareness being developed through mass media, magazines, peer group etc. These attitudes were strengthened through persuasive communication resulting in diffusion of messages through the community. Other aspects of adolescent attitude concern conformity and idealism. Society expects conformity of its members as a means of regulating stability and order. Lack of nutritional knowledge also prevents one from succumbing to increased social pressure. That’s why it is very difficult for adolescents to deny the acceptability of attitudes held by the peer group. Thus, it is concluded that scientific literacy is extremely essential for rural girls, not only to know their surroundings in right perspective but also to apply the knowledge to their lives and to assert their rights as knowledgeable people in communicating and decision making process in the world surrounding them.

Improvement in attitudes was minimum in the area of MCHC (20–22%), the quantum of improvement being 1.4 fold in both age groups. An attitude change typically focuses on the immediate effect that occurs after girls are presented with new information. As these girls were young and school going, not involved in the activities of maternal and child care, so did not get opportunity to reproduce and hence no reinforcements of attitudes.

It was, further, observed that the change in attitudes was more in 9–12 years adolescent girls as compared to 13–15 years adolescent girls in both groups. The likely reason might be more flexibility in attitudes and beliefs and also more receptibility of minds of younger girl.
With regard to an improvement in the scores of practices, it was observed that there was a highly significant improvement in overall scores of practices (36-41%) of adolescent girls of EXPT group, the quantum of improvement being 9.9 fold in younger girls and 4.3 fold in older girls. Such an impressive improvement in practices of these girls might be because of the very poor scores in practices at the beginning of the study. Moreover, increased knowledge as a result of educational intervention resulted in improved practices, as evidenced from significantly positive correlation between knowledge and practices ($r = 0.49$).

Maximum increase in scores of practices was in practices related to cooking (43-51%). The maximum increase in cooking practices was due to maximum increase in basic knowledge of these girls as a result of improved module whereby various basic concepts regarding food and nutrition were taught to them in a simple, understandable, meaningful way relevant to their life situations. For this knowledge to be practised, it was ensured that content was relevant and practical in their ecological context. The changes suggested were minimal, economical and durable in their local circumstances. Moreover, the distributed practice was more effective than massed practices. It didn't mean that with double the amount of practice would lead to twice of learning because the relationship between the two is not a simple linear one as stated by Ebbinghans (1885). For practices enhancing nutritive value of food, retention of nutrients, food hygiene and sanitation, participatory methods like demonstrations and nutrition games were used. These participatory methods facilitated changes in practices by enabling girls to feel more confident, practice various target behaviours and experience their reinforcing value, as advocated by Social learning theory of Bandura (1977). Rahman et al (1994) emphasized the importance of ‘Demonstration’ method over the other methods of education. Ramamohan (1990) studied the effectiveness of nutrition education programme through nutrition-games kit containing 16 games with the aim to create and improve the awareness of nutrition and found that the experimental group improved significantly in their knowledge related to nutrition and also on practical
situation tests. Udipi et al (1993) also studied the feasibility of group games as a medium for nutrition and health education of children. The dual benefit of such games was that children with relatively short attention span could imbibe the nutrition messages.

Feeding practices also improved by 42 – 47% as a result of educational intervention. These girls were made aware of the nutritional needs of various age groups through interactive methods using audio visual aids like video films. Since these nutritional needs pertained to them, their siblings and other members of the family, they felt motivated and interested to know and practice the same in their family settings, depending upon the degree of autonomy and facilities / infrastructure available to them.

The areas of adolescent health followed by MCHC also registered a significant increase in scores of practices. Since areas of AH related to their own self, knowledge instilled in their minds convinced them to change these practices, there being minimal inhibiting influences. Adolescent girls, being the future mothers, gained significantly in the area of MCHC and would carry the knowledge of MCHC on their impressionable minds and put into practice, when required. Pushpa and Sheela (1997) evaluated the impact of nutrition and health information through mass media and found that the media participation and knowledge gains were highly associated. Though the study involved the use of mass media but it was established that knowledge level and practices were highly correlated.

The least change in practices (25-29%) related to therapeutic nutrition could be attributed to the fact that knowledge gained and attitude changed were not always practiced due to certain limitations. Moreover, due to their easy access to doctors / practitioners and medical facilities in EXPT group, these girls did not bother to put into practice what they learnt.
The ONG group, in which NHHCC education was imparted for 3 continuous days as initial orientation in the first month followed by one day of teaching in the subsequent 5 months, making a total of 48 contact hours in 8 teaching days. This was conducted by the supervisors of ICDS scheme through a manual prepared by Department of women and child welfare, Govt. of India and provided to them for the purpose of teaching. These supervisors of ICDS scheme, who invariably were of matriculate or undergraduate level and sometimes promoted from lower jobs, had no formal orientation in this educational package and lacked teaching skills, as they had no training in pedagogy. Even, the knowledge possessed by supervisors vis-a-vis NHHCC may not be or may be there and not of current nature.

Results of post-test analysis at the end of 6 months of educational intervention i.e.T3 revealed that the gain in overall scores of knowledge (11-13%), though significant, was low in both age groups. However, there was no significant change in overall scores of attitudes and practices in both age groups (Table 4.55). The scores of girls of this group were in the average ranges in most of the areas of KAP at the beginning of the study and continued to be so even after the educational intervention. The quantum of improvement was negligible in most of the areas of KAP.

Looking at the performance of girls in various areas of KAP, as shown in scattergrams, it was found that most of the girls scoring below average at T1, improved to the level of average and above after the educational intervention. Those, who had average scores at T1, majority of them continued to be in the same average range and only a small proportion improved to better scores. Majority of the girls scoring above average at T1, continued to be in the same range, while a very small proportion deteriorated in their performance. Though the trend was same in all areas of KAP but the improvement was more evident in knowledge and not so in attitudes and practices (Table 4.53, Fig 4.91, 4.93 & 4.95).
Though there was a significant improvement (11-13%) in overall scores of knowledge, however it was not an impressive improvement, when reviewed in respect of effort and time devoted to this intervention. Among various components of knowledge, gain in scores (26%) was maximum in the area of therapeutic nutrition in both age groups because the educational package of NAGS laid more emphasis on this area. The quantum of improvement in the area of therapeutic knowledge was highest (1.4-1.5 fold) in both age groups. This might be because the adolescent girls could integrate the knowledge gained through formal education to the knowledge they already possessed and practised, as indicated by their scores at T1.

The area of adolescent health also improved significantly (11-15%) in both age groups. This area of adolescent health pertained to their own needs, so these girls felt motivated to know about their nutritional and health needs and thus improved significantly in this area.

Improvement in basic knowledge, though highly significant in older girls and less significant in younger ones, was to a lesser extent as compared to above two areas because of less emphasis on basic concepts of food and nutrition in the educational package of NAGS. Moreover, this package had limitations of its short duration, lack of important and relevant basic concepts, improper sequencing and inadequate allocation of time. It utilized the services of only Supervisors for teaching the package. The knowledge of Supervisors may not be adequate for the purpose for lack of any recent orientation in the subject. The method used for teaching was only lecture method, without making use of any audio-visual aids. Moreover, no written material was given to these girls, which could help them to reinforce the content taught. The only written material available even to Supervisors was the manual prepared by Department of women and child development, Govt. of India and given to them as a reference material. Moreover, their training in pedagogy i.e. method and mode of delivery of this
educational package was not at all there. Older girls might have learnt more in the area of basic knowledge because they could integrate their longer life experiences to the formally taught foods, nutrition and health education whereas younger girls had comparatively lesser life experiences. Similar lacunae in the various educational programmes have been reported in number of studies. Gopalan (1989) assessed the current status and relevance of community nutrition and health programmes through the health care system and reported that these had either inadequate training of staff or suffered from lack of proper aids in imparting knowledge properly. Pankajam and Shakuntala (1990) evaluated the mobile training teams in TamilNadu for structural and functional adequacies and found that the mobile training teams had untrained and ill-equipped people having inadequate audio-visual materials and books and were found to be less mobile.

With the enrolment of these girls in the ongoing NAGS, these girls especially the older ones got an opportunity to go to anganwadi centres and took advantage of it. They started visiting the anganwadi centres of their villages sporadically i.e. once in a while. During their visit, they participated in the activities of anganwadi centre and benefited from its services and thus improved their knowledge significantly in the area of ICDS / NAGS. The area of GOBI improved significantly only in younger girls, but the improvement was to a lesser extent as compared to the areas of therapeutic nutrition and adolescent health. Since these girls stayed at home, were looking after their younger siblings and were involved in child rearing activities at home, the area of GOBI captured their interest, thus enabling these girls to gain significantly in this area. Moreover, these younger girls had less of negative learning from the environment to unlearn and then learn the new facts in this area.

The improvement in the area of MCHC was not significant in girls of both age groups. These girls had been observing and participating in the activities of maternal and childcare and thus had average scores in this area at the beginning.
of intervention i.e. T1. The educational package of NAGS did not lay much emphasis on this aspect, thus leaving the scope for small improvement.

Attitudes are the dispositions of a person to react in a certain manner towards a situation or an idea. These are formed on the basis of direct or indirect experiences, which a person gains while dealing with problems, one has to face in a particular situation. Hence, need satisfaction of persons forms the basis of positive attitudes and vice-versa. Since knowledge gained by a person helps in satisfying one’s needs, the areas of sound knowledge form the basis of positive attitudes and vice-versa. Results indicated that overall attitudes of girls improved only marginally in the range of 3-9% in girls of both age groups as a result of educational intervention, though the improvement was not significant.

Analyzing the various components of attitudes, it was observed that attitudes of younger girls of this group improved significantly in the area of MCHC. Though these younger girls were not very actively involved in the activities of maternal and childcare but were receptive to know the facts about maternal and infant feeding, breastfeeding and weaning etc. due to their lesser involvement in other household activities as compared to older girls. Whatever little knowledge they gained, though not significant, was coupled with the cultural influences of the family with regard to maternal and infant feeding, breastfeeding, weaning etc. operating in the same direction, thus enabling these girls to strengthen the positive attitudes in this area. Moreover, these younger girls were yet not aware of the food fads and fallacies associated with maternal and infant feeding, thus had less of negative learning from the environment.

Attitudes of girls of both age groups with regard to status of girls in the society and adolescent health improved slightly from the beginning of the intervention at T1, though the improvement was not significant. Being aware of their status in the society through varied sources like mass media, social and health workers etc., these attitudes got strengthened through persuasive communication,
resulting in formation of positive attitudes in respect of their equality with the counterparts. However, the conservative attitudes of parents and society due to socio-cultural backwardness worked as negative forces, limiting the scope for much improvement in this area.

Though the knowledge of girls improved significantly in the area of adolescent health but the improvement in attitudes was not significant. The likely reason for this could be continued domination of deep seated traditional cultural beliefs. These girls continued to believe, what they had been observing being done in their families for a long time. It was taken for granted that those attitudes were correct. They could not dare to contradict them for the fear of conducting disastrous experiment on their precious body.

Improve in attitudes in the area of therapeutic nutrition was least of all areas and not significant, especially in younger girls. Significant gain in therapeutic knowledge of these girls helped them to pick up the facts about it because knowledge in this area was need based and easy to put into practice. Knowledge gained through formal education and coupled with experience of traditional time tested practices based on folk wisdom helped these girls to form positive attitudes in the area of therapeutic nutrition. Significantly positive correlations between knowledge and attitudes (r=0.39) established the fact that sound knowledge formed the basis of positive attitudes, thus confirming the above finding. Chandramani (1988) found that nutrition education had a positive impact on the children of all ages in terms of the nutritional knowledge gained and attitudes. It recommended that nutrition education should be integrated with the school curriculum at all levels.

There was marginal improvement in overall scores of practices of girls in both age groups. Significantly positive correlations between knowledge and attitudes (r=0.39) and between knowledge and practices (r= 0.30) indicated that correct knowledge helped in changing attitudes in the right direction. With correct
attitudes, coupled with strong motivation, practices also changed, though marginally and not significantly because social, economical and cultural factors had an inhibitory effect in putting into practice, what these girls knew and believed to be correct. Practices, which were being practiced in their families from generation to generation, were very difficult to change. Though these girls were handling the household and child rearing activities but lacked autonomy and decision making to change the practices done in their families for a long time. Moreover, the unavailability of facilities and infrastructure required to bring about a change in practices was another limitation. Above all, acceptability and support of the parents and other family members were required to change the traditional practices. In such situations, parents also need to be educated vis-à-vis NHHCC so as to improve their knowledge, change attitudes and follow correct practices. These girls would perhaps make use of the improved knowledge and changed attitudes to be put into right practice, if they get an opportunity to handle these activities independently. A number of studies have reported the impact of educational intervention on knowledge, attitude and practices. Prasad and Costello (1995) evaluated the impact and sustainability of health education intervention at a District hospital in Bihar. It was found that training of doctors and midwives greatly improved the feeding practices of mothers. However, the impact of training fell off quickly and refresher training was needed to sustain the improvement. Miller et al (1995) observed marked improvement in knowledge and skills of mothers, whose babies had been delivered by trained traditional birth attendants as educators of mothers. Singh and Leelavathy (1997) recommended continuous efforts of imparting nutrition training and follow up programme to bring desirable changes in behavior of tribal women of Bihar, where it was reflected in the adoption of recommended nutrition practices.

The common finding of both groups i.e. EXPT and ONG group was the highly significant correlation between knowledge and practices followed by knowledge and attitudes and the non-significant correlation between the attitudes and
practices (Table 4.58). A highly significant positive correlation between knowledge and practices supports the assumption that higher knowledge results in better practices because sound knowledge forms the basis of sound practices and vice-versa. Correct knowledge is a pre-requisite in acquiring and changing beliefs in right direction. With correct beliefs coupled with continued persuasion, practices also change but take longer time to do so. One may not always be able to put into practice, what one knows and believes to be correct because a variety of social, environmental and cultural factors may hinder in putting knowledge into practice. Significant positive correlation between knowledge and attitudes suggests that knowledge inspires confidence and improves attitudes towards NHHCC, though attitudes are difficult to change. From an insignificant correlation between attitudes and practices, it may be concluded that attitudes are not always practiced because the girls may not have independent hold on household activities and also due to lack of resources / facilities available to them. If the practices prove useful and have fruitful outcome, they reinforce the sound and correct knowledge.

As a result of educational intervention regarding NHHCC, the coefficients of correlation revealed different trends in both groups. These coefficients of correlation improved or were maintained in girls of EXPT group, after the educational intervention but revealed a declining trend in girls of ONG group after the educational inputs.

The improvement in coefficient of correlation between knowledge and attitudes of girls of EXPT group highlighted the fact that significant improvement in knowledge of girls of this group as a result of educational intervention, significantly improved the attitudes of girls in positive direction. The correlation between knowledge and practices of girls was maintained, though did not improve because practices take longer time to change, despite increase in knowledge. From the slight improvement in correlation between attitudes and practices, it may be concluded that with positive improvement in attitudes,
practices also improved, but concomitant to the amount of increase in attitudes because practices take longer time to change and also due to other constraints in putting attitudes into practices.

In girls of ONG group, the coefficients of correlation between knowledge and attitudes and knowledge and practices revealed a declining trend after the educational intervention. Despite significant improvement in knowledge of girls of this group, there was marginal change in attitudes and negligible change in practices of girls, which were not significant. Though correct knowledge is a prerequisite for changing beliefs in right direction but it required to be coupled with strong motivation and continuous persuasion. These elements were lacking in girls of this group because educational package of NAGS given to these girls suffered from limitations of its inadequate content, short duration and improper mode of delivery i.e. lack of audio-visual aids, resource persons etc. This limited the scope for more details, more emphasis, more rationale and hence more retention of knowledge. Whatever knowledge was gained by these girls, could not be put into practice because of the limitations of lack of resources / infrastructure, autonomy / decision making as well as acceptability and support of the parents and other members of the family. Pathak and Shah (1984) also reported that lack of motivation or interest on the part of learners to be mainly responsible for widespread illiteracy among our rural women.

Similar correlations have been reported in large number of studies. Kumar et al (1989) have also reported a highly significant correlations between knowledge and practices followed by knowledge and attitudes but insignificant correlation between the attitudes and practices. Sreedevi (1990) studied the knowledge, attitudes and practices of nutrition among adult education programme instructors in Andhra Pradesh and found that knowledge, attitudes and practices were positively and significantly interrelated. Knowledge influenced practices, both directly and indirectly, as mediated by attitudes concurrently. Mitchell and Lerner (1991) studied the nutrition related KAP of pregnant middle class women in
Cleveland, Ohio and reported that there was no relationship between scores achieved on nutrition knowledge scale and scores on attitude test \((r = 0.12)\), the mean scores on nutrition knowledge and attitudes being 65% and 75% respectively. Neumark-Sztainer (1996) reported that nutrition knowledge / attitudes of mothers were positively associated with nutrition practices \((r = 0.42)\) and also mothers education was positively associated with nutrition knowledge / attitudes \((r = 0.32)\). Devgan (1997) found no significant relation between parents of different levels of education and practices adopted by them for breastfeeding but significant differences were observed regarding age of weaning between parents of low and high level of education.

An interesting finding that came to light from this study was that learning by adolescent girls of 9-12 years was better as compared to 13-15 years adolescent girls of both EXPT group and ONG group in all aspects of knowledge, attitudes and practices. Though learning is a continuing life long process but the likely reason for better learning response by younger adolescent girls was that they were more receptive because of their impressionable minds, had less negative learning from the environment, lesser distraction of the minds, enabling them to concentrate more and attend to learning activities, lesser responsibilities of siblings and more flexibility in their attitudes and beliefs. Moreover, the improved module having enlarged and simplified content, its longer duration and continuity, proper sequencing, use of participatory and interactive methods using various audio-visual aids by experts from various fields and delivered at the door steps of girls proved useful in significantly improving knowledge, changing attitudes and correcting practices of adolescent girls of EXPT group. The results of the study conducted by Budhani and Singh (1996) on communication support for training rural youth in ‘TRYSEM’ as a component of Integrated Rural Development Program (IRDP) also revealed that younger women gained more knowledge than older ones, when exposed to the messages through combination of media. It is, therefore, much easier to bring about a desirable change in knowledge, attitudes and practices of young adolescent girls, who can serve as a potential agent of
change for bringing about an improvement in the nutritional status of the community.

Since the two intervention i.e. dietary and nutrient supplementation and NHHCC education given to adolescent girls of EXPT and ONG groups were different owning to the improvements made in the interventions of ongoing NAGS, the two groups can not be compared as such. A critical analysis of ONG scheme revealed that it needed improvement and hence improved in terms of both the interventions. The salient features of the two groups are being discussed and shown in Table (5.1).

The two most sensitive indicators of the nutritional status i.e. height and weight measured after 6 months from the beginning of study revealed that though the height and weight of girls increased significantly in both groups but the percentile status of girls and the grades of height and weight percentiles improved only in girls of EXPT group, despite only 3 months of supplementation period during these 6 months. However, the girls of ONG group continued in the same low percentile i.e. below 5th percentile in height and weight. Height and weight velocities of girls accelerated in both groups and the acceleration was higher than NCHS standard in all age groups of EXPT group whereas the acceleration of height and weight in girls of ONG group was less than NCHS standard upto 11 years in case of height and 13 years in case of weight and was higher than NCHS standard thereafter. Six monthly increments in height and weight revealed that height increments were higher than NCHS standard and weight increments were comparable to NCHS standard in all age groups in girls of EXPT group whereas girls of ONG group revealed height increments less than NCHS standard upto 11 years and weight increments below NCHS standards upto13 years and higher thereafter i.e. after the attainment of peak height velocity and peak weight velocity in these girls.
### TABLE 5.1
SALIENT FEATURES OF EXPT AND ONG GROUP

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>EXPT GROUP</th>
<th>ONG GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropometric</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Height &amp; Weight</td>
<td>Increased Significantly</td>
<td>Increased Significantly</td>
</tr>
<tr>
<td>• Percentile Status of Height &amp; Weight</td>
<td>Improved to higher percentiles</td>
<td>Did not improved</td>
</tr>
<tr>
<td>• Height &amp; Weight Velocities</td>
<td>Accelerated &amp; acceleration higher than NCHS Standards in all age groups</td>
<td>Accelerated &amp; acceleration less than NCHS Standards up to 11 years in case of height and 13 years in case of weight and higher thereafter</td>
</tr>
<tr>
<td>• Six monthly increments in Height &amp; Weight</td>
<td>Height increments higher than NCHS Standards and weight increments comparable to NCHS Standards</td>
<td>Height increments less than NCHS Standards up to 11 years and Weight increments below NCHS Standards up to 13 years and higher thereafter</td>
</tr>
<tr>
<td>• Median age of menarche</td>
<td>11.53 years</td>
<td>12.59 years</td>
</tr>
<tr>
<td>• Peak height velocity</td>
<td>11 – 12 years</td>
<td>12 – 13 years</td>
</tr>
<tr>
<td>• Peak weight velocity</td>
<td>12 – 13 years</td>
<td>14 – 15 years</td>
</tr>
<tr>
<td>• Stunting</td>
<td>Reduced by 11%</td>
<td>Reduced by 9%</td>
</tr>
<tr>
<td>• Under weight</td>
<td>Reduced by 4%</td>
<td>Reduced by 3%</td>
</tr>
<tr>
<td>Biochemical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Haemoglobin</td>
<td>Insignificant increase</td>
<td>No change</td>
</tr>
<tr>
<td>• Grades of anaemia</td>
<td>Slight improvement</td>
<td>No change</td>
</tr>
<tr>
<td>• Indicators of iron status</td>
<td>Reached within the normal range</td>
<td>Continued to be below normal range</td>
</tr>
<tr>
<td>Clinical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Iron deficiency anaemia</td>
<td>Reduced from 54.4% to 17.3%; 67.8% decline PerSe</td>
<td>Reduced from 33.3% to 18.3%; 44.9% decline PerSe</td>
</tr>
<tr>
<td>• Other vitamin and mineral deficiencies</td>
<td>Decreased significantly</td>
<td>No change</td>
</tr>
<tr>
<td>Physical work capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PFI Scores</td>
<td>Increased significantly in all age groups from poor to average</td>
<td>Increased in all age groups except 10 &amp; 13 years, at the threshold of average</td>
</tr>
<tr>
<td>Increase in KAP Scores % (Range)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Knowledge</td>
<td>41 - 47</td>
<td>11 - 13</td>
</tr>
<tr>
<td>• Attitudes</td>
<td>39 - 45</td>
<td>3 - 9</td>
</tr>
<tr>
<td>• Practices</td>
<td>26 - 31</td>
<td>4 - 8</td>
</tr>
</tbody>
</table>
The median age of menarche was 11.53 years and 12.59 years in girls of EXPT and ONG groups respectively. It was preceded by peak height velocity and followed by peak weight velocity in girls of both groups, which were 11-12 years and 12-13 years in girls of EXPT group but delayed in girls of ONG group i.e. 12-13 years and 14-15 years respectively.

Indices based on height and weight i.e. height - for - age and weight - for - age revealed a significant reduction in prevalence of stunting by 11% and slight reduction (4%), though not significant in prevalence of under weight by girls of EXPT group. The girls of ONG group revealed a reduction of 9% in prevalence of stunting and 3% in prevalence of underweight during these 6 months.

The haematological profile of girls after 6 months from the beginning of the study (including 3 months of non-supplementation period) revealed an insignificant increase in haemoglobin level of girls of EXPT group. There was only slight improvement in grades of anaemia. Girls, who were severely anaemic, improved to better haemoglobin status but majority of the girls continued to be in Grade I and II of anaemia. However, there was no change in haemoglobin status of girls of ONG group in all age groups and majority of the girls continued to be in Grade I and II of anaemia.

After supplementing the girls of EXPT group for 3 months, dietary supplementation was discontinued for 3 months to evaluate whether catch-up growth observed during supplementation period continued, when the girls were on their usual home diets. It was observed that height and weight gain, though marginal, continued during this period but their velocities deescalated during this period as compared to supplementation period. However, there was no change in haemoglobin level of girls, who continued to be anaemic. Thus, iron and folic acid supplementation was given along with dietary supplementation to these girls for 4.5 months to treat anaemia, promote physical growth and improve physical work performance.
As a result of dietary and nutrient supplementation for longer duration, the haematological profile, indicators of iron and protein status showed a significant improvement in all age groups of girls of in EXPT group and reached within the normal range, indicating correction of hypochromic microcytic anaemia. There was no change in indicators of iron and protein status of girls of ONG group in all age groups, which continued to be below the normal range, indicating the continuance of hypochromic microcytic anaemia.

Clinical signs of iron deficiency anaemia were reduced from 54.4% to 17.3% in girls of EXPT group, registering 67.8% decline PerSe as a result of dietary and nutrient supplementation. The girls of ONG group revealed a reduction in prevalence of iron deficiency anaemia from 33.3% to 18.3%, registering 44.9% decline PerSe. This could be attributed to an improvement in haemoglobin status of severely anaemic girls, who improved even on the input of small amount of dietary supplementation.

Incidence of PEM and vitamin deficiencies decreased significantly in girls of EXPT group but revealed no change in girls of ONG group. Rather, the incidence of vitamin C deficiency increased in girls of ONG group, which could be due to its being water soluble and most labile and also seasonal variations at the end of 6 months of intervention from winter season at T1 to summer season at T3.

With a decline in incidence of iron deficiency anaemia, the girls of EXPT group improved in their physical work performance at the end of intervention. PFI scores increased significantly from poor to average, recovery heart rate decreased significantly and exercise time increased significantly in all age groups, indicating less cardio-vascular stress and improved capacity of girls for prolonged physical activity. However, the girls of ONG group improved only marginally in their PFI scores from poor to threshold of average. The marginal increase in PFI, decrease in recovery heart rate and increase in exercise time
could be attributed to improved haemoglobin status of severely anaemic girls, who responded to even small input of dietary supplementation. Another probable reason could be that girls, who were not initiated at the beginning of intervention, felt motivated and more confident at the end of intervention and performed better in this activity.

The impact of improved educational intervention and ongoing module was assessed in the form of an improvement in knowledge, attitudes and practices of girls vis-à-vis NHHCC. Its indirect impact resulted in changes in their dietary and nutrient intake at the end of intervention. The improved educational module was of one-year duration.

The improved module of NHHCC education resulted in a highly significant (P<0.01) improvement in knowledge, attitudes and practices of girls. The increase in scores of knowledge, attitudes and practices was 41-47%, 39-45% and 26-31% respectively in both age groups. However, the girls of ONG group improved significantly only in knowledge but not in attitudes and practices. The increase in scores of knowledge, attitudes and practices was 11-13%, 3-9% and 4-8% respectively in both age groups.

A further break up of the components of knowledge, attitudes and practices revealed that in girls of EXPT group, maximum improvement in knowledge was in the area of basic knowledge, therapeutic nutrition in case of attitudes and cooking and feeding practices among practices. On the other hand, the girls of ONG group revealed maximum improvement in therapeutic nutrition among various aspects of knowledge, MCHC in case of attitudes and no improvement in any area of practices. However, the increase in scores in most of the areas of knowledge, attitudes and practices was more in younger girls as compared to older ones in both groups.
Improvement in dietary and nutrient intake through home diet was an indirect impact of NHHCC education. An analysis of home diet at the end of intervention i.e. T4 revealed a significant increase in intake of various foods like milk and milk products and fat, besides an increase in number of girls consuming GLV's and fruits in improved variety. This resulted in marginal increase in intake of calories and protein but a significant increase in intake of vitamin B & C and mineral, calcium. The girls of ONG group revealed no significant change in intake of various foods, except in the quantity of milk and milk products and seasonal fruits, besides an increase in number of girls consuming GLV's, though the amount consumed and variety remained more or less the same. Though the intake of calories and protein increased only marginally and vitamin B & C and calcium increased significantly but the increase in nutrient intake of these girls was to lesser extent as compared to girls of EXPT group.

Looking at the picture of improvement in nutritional status and knowledge, attitudes and practices of girls vis-à-vis NHHCC, this was the outcome of the improvements made in the two interventions. The highly significant improvement in nutritional status of girls of EXPT group was due to input of dietary and nutrient supplementation given to these girls regularly in judicious combination of cereals and pulses in the proportion of 2:1. This combination of dietary supplementation was locally available, for which these girls were used to and consumed it happily. Intake of dietary supplementation raised the calorie intake of girls to the level of 81% of RDA, which was more or less adequate as per the recommendations of ICMR. Besides adequacy of calories, protein was improved in quantity as well as quality through mutual supplementary effect of the component amino acids in a cereal pulse combination, thus resulting in effective utilization of protein. Besides qualitative improvement in the dietary supplement given to girls, its quantity was also increased. An amount of 125gm of dietary supplement per head per day was given to girls, thus partially making up for the deficit in total food intake. Moreover, it was ensured that girls consume the whole amount of dietary supplement on the spot, thus avoiding the scope of sharing by the siblings. This
qualitatively and quantitatively improved input of dietary supplementation given regularly in two phases of 3 months and 4.5 months each, after giving them hematinics, resulted in greater impact of dietary supplementation on the nutritional status of girls as compared to the impact of 6 months of dietary supplementation given to girls of ONG group. The girls of this group attended the anganwadi centers only once in a while and collected the dietary supplement then and that too at a lower quantum i.e. on an average of 40gm per head per day twice a week in 6 months. This resulted in only marginal improvement in nutritional status of girls.

The in-depth analysis of the results of both groups indicated that girls who were severely undernourished and anaemic responded even to the input of small amount of dietary supplementation. From this, we can derive the conclusion that initial screening of girls is very important to identify the severely undernourished and anaemic girls, who are most vulnerable and should be selected for dietary and nutrient supplementation after giving them hematinics, so as to accrue full benefit of dietary and nutrient supplementation.

A highly significant improvement in knowledge, attitudes and practices of girls of EXPT group can be attributed to the improved package of NHHCC education. The original package was improved upon in terms of its content, duration and continuity of sessions. The content of improved module was enlarged to include basic fundamental concept on foods, nutrition and health. It was prepared in simple regional language (Hindi). It was understandable, meaningful and relevant to their life situations. The written material in the form of cyclostyled notes was given to them so as to reinforce, what was taught to them. The duration and continuity of educational package was extended to one year so as to increase the scope for more details, more rationale, more repetition and hence more retention of knowledge.
Use of various participatory and interactive teaching methods and use of audio visual aids made the sessions interesting, effective and left the long lasting imprint on the impressionable minds of the adolescent girls. Involvement of resource persons from various fields like Food and nutrition board, Department of health, women and child welfare and Family planning association of India, who had expertise in their subjects, varied experience of field situations and pedagogy in teaching skills, resulted in greater impact of improved module on knowledge, attitudes and practices of girls. Moreover, this module was delivered to girls at their doorsteps i.e. in the anganwadi centers of their respective village, which resulted in better learning through lesser distraction of their minds towards unfamiliar situations.

The educational package of NAGS was delivered to girls of ONG group through a module prepared for this purpose by the Department of Women and Child Welfare, Government of India and given to supervisors of ICDS scheme, who were not oriented formally regarding this package. Moreover, supervisors were invariably of matriculate or under graduate level, sometimes promoted from lower jobs, lacked knowledge of current nature. They had no degree in pedagogy and had poor teaching skills. Whatever knowledge and skills they possessed, was used to deliver the package through only lecture method without using any audiovisual aids. Further, girls of this group were taken to supervisors headquarter for this purpose, which was more of an outing for them. They had no seriousness for learning, as they were more interested in knowing what was going around. This resulted in lesser attention of their minds towards the content of educational package and hence lesser learning.

The proven benefits of both the interventions given to girls of EXPT group through improved module have established the beneficial effects of improved module over the ongoing intervention of NAGS being given to girls of ONG group. The improvements observed were such, which could be easily incorporated and executed.