NUTRITIONAL STATUS OF ADOLESCENT GIRLS (12-19 years) AND IMPACT OF INTERVENTION PROGRAMMES

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by

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DECLARATION

I hereby declare that the dissertation entitled **"NUTRITIONAL STATUS OF ADOLESCENT GIRLS (12-19 years) AND IMPACT OF INTERVENTION PROGRAMMES"** submitted to Mahatma Gandhi University, Kottayam in fulfilment of the requirement for the award of the **Degree of Doctor of Philosophy in Home Science (Food and Nutrition)** is a record of original research work done by me under the supervision and guidance of **Dr.(Mrs.) Anooja Thomas**, Associate Professor, CMS College, Kottayam and it has not formed the basis for any Degree/Diploma/Associateship/Fellowship or similar title to any candidate of any other University.

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CERTIFICATE

This is to certify that the dissertation entitled **"NUTRITIONAL STATUS OF ADOLESCENT GIRLS (12-19 years) AND IMPACT OF INTERVENTION PROGRAMMES"** submitted to Mahatma Gandhi University, Kottayam, in fulfilment of the requirement for the award of the **Degree of Doctor of Philosophy in Home Science (Food and Nutrition)** is a record of original research work done by **Ramya. R** during the period of her study in the Centre for Research in Home Science, St.Teresa's College, Ernakulam, under my supervision and guidance. This dissertation has not formed the basis for the award of any Degree/Diploma/ Associateship/Fellowship or similar title to any candidate of any other University and it represents entirely an independent work on the part of the candidate.

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I. INTRODUCTION

Adolescence is a modern – and even postmodern – concept that acknowledges the unique space between childhood and full adulthood (Christenbury *et al*., 2009). According to World Health Organisation (WHO, 2011[a]), "Adolescence, a period of transition from childhood to adulthood, is crucial in the life of human beings. Adolescence is a particularly unique period in life because it is a time of intense physical, psychological and cognitive development". Adolescents constitute about 22.8 per cent of the population in India (Dasgupta *et al*., 2010). The word *adolescence* has been in usage since the 15th century, which was coined from *adolescere*, a Latin word to mean "grow up" or "to grow into maturity" (Lerner and Steinberg, 2004).

World Health Organization identifies adolescents by age – "young people between the ages of 10 and 19 years" (WHO, 2015[a]). Sacks (2003) also corroborate the WHO that adolescent period is roughly between 10-19 years of age. The Canadian Paediatric Society states, "Adolescence begins with the onset of physiologically normal puberty and ends when an adult identity and behaviour are accepted".

Malnutrition is posting a great threat to adolescents, especially in developing countries like India (WHO, 2011[b]). India occupies the 127th place among the 192 countries in the world in the Human Development Index (HDI) – mainly attributed to malnutrition (The Hindu, 2004). Nutrition of adolescent girls is particularly important, but undernutrition in adolescents, frequently goes unnoticed by the parents or the adolescents themselves. The most serious aspect of this negligence is that the negative effects of undernutrition developed during the adolescent stage are carried throughout a women's productive life (Zaimin *et al*., 2003).

About one-tenth of the population is adolescents and the nation's growth and wellbeing greatly dependent on the nutritional status of these adolescents. Malnutrition affects the adolescents the most, since during these periods, their requirement for nutrients is more. This requirement further increases during pregnancy (Choudhary *et al*., 2010).

Attention to nutritional status is important during the adolescent stage, especially for girls, as they are undergoing the complex process of growth and development. Adolescent period provides nutritionally deficient children a second opportunity to catch-up growth. During adolescence, the need for all nutrients increases. The remarkable development that happens in adolescence, second just to that in the first year of life, initiates increased demands for energy and nutrients (Stang and Story, 2009). At the peak of the adolescent growth spurt, the nutritional requirements may be twice compared to the remaining period of adolescence (Forbes, 1992). Shivaramakrishna *et al*., (2011), in their study found a high predominance of undernutrition among rural adolescent girls.

Adolescent period is however: the most perplexing and the most poorly understood stage. In this stage, physical attributes of adulthood are acquired but less emotionally developed as a grown person (Omotoso, 2007). Nearly 20 per cent of growth in height and roughly 50 per cent of body weight are reached. About 45 per cent of bone mass increases, bone remodelling takes place and soft tissues, organs, and even red blood cell mass also boost in size (Giuseppina, 2000). The requirement for micro and macronutrients are more during the adolescent period (Lopez and Matros, 2004). Acute energy insufficiency in adolescent girls leads to short stature and lean body mass and muscular strength and working capacity also decreases, which also increases the risk of adverse reproductive outcomes (Dey *et al*., 2011).

Nutritional status during adolescence is a crucial indicator of health outcome (Dey *et al*., 2011). Nutritional deficiencies lead to giving birth to undernourished babies transferring the undernutrition to the next generation too (Singh *et al*., 2012). This nutritional deficiency becomes more complicated to adolescents during infections and to those who are sexually active (Mulugeta *et al*., 2009), in addition leads to lower physical output and unfavourable reproductive results (Haboubi and Rizwana, 2009).

Anaemia is defined as a low level of haemoglobin in the blood and it is one of the world's most widespread nutritional problems (Galloway, 2003). According to World Health Organization, the anaemic level is where the haemoglobin level to be less than 12.0 g/dl for both adolescent girls and non-pregnant women (WHO, 2001[a]). A survey by Indian Council of Medical Research (ICMR, 2000) in different parts of India revealed that 87 per cent of pregnant women suffer from anaemia and about 10 per cent have severe anaemia (Hb<80 g/l). In another study by Toteja *et al*., (2006) exposed that the average prevalence of anaemia was 83 per cent (Hb<70 g/l) among pregnant women in 16 districts. According to a survey by Indian Institute of Health and Family Welfare (2002), only 19 per cent of adolescent rural girls, between 10 and 15 years of age in Hyderabad, had normal haemoglobin levels of 12g/dl or above.

Karaoglu *et al*., (2010) found an important relationship between the incidence of anaemia and the women's age, income, educational level and dietary behaviours. Women in the childbearing age, young children, particularly adolescent girls are affected by anaemia (Gautam *et al*., 2002). The growth spurt and menstrual status affect iron stores in adolescent girls with low iron intake (Ernst *et al*., 1998). Siddharam *et al*., (2011) found association with iron deficiency anaemia, weight loss and anaemia, pallor and anaemia among adolescent girls. In India, anaemia is the second most common cause of maternal deaths, accounting for 20 per cent of total maternal deaths (Goverment of India, 1995). Ahmad *et al*., (2010) found a high prevalence of anaemia (74.80%) among the observed rural pregnant women in India and most of the women were in the younger age group. Anaemia is associated with undesirable maternal outcome, such as puerperal sepsis, ante-partum haemorrhage, post-partum haemorrhage and maternal mortality (Roy and Chakravorty, 1992).

The most common nutritional disorder is iron deficiency, and is the major cause of anaemia, which affects about 20 per cent of the world population. About nine to forty per cent of adolescent girls were estimated to have affected by iron deficiency (Burner *et al*., 1996). Studies show that the incidence of anaemia varies from 33 to 100 per cent across India (Luwang *et al*., 1980 and Agarwal and Tejwani, 1999). Low haemoglobin level reduces the availability of oxygen to the tissues, and subsequently this oxygen deficiency affects the cardiac output (Beaton *et al*., 1989). Anaemic states are known to influence the hemodynamic and nervous system (Chang *et al*., 2009). A strong relationship was found between maternal anaemia and low birth weight babies (Malhotra *et al*., 2002). Studies have indicated that preterm delivery, low birth weight and inferior neonatal health were the possible results of iron deficiency anaemia among pregnant women (Tolentino and Friedman 2007). Maternal anaemia was also found to be a main risk factor for stillbirth (Ali and Adam, 2011). Lumley *et al.*, (2001) cited studies to show that about 70 per cent of birth defects, such as Neural Tube Defects could be prevented, if adequate folic acid is ensured before conception and during the early months of pregnancy. Folic acid deficiency if not addressed during the pre or periconceptual period, may cause irreversible fetal damage called Neural Tube Defects (NTD). About 3000 pregnancies are affected by NTD each year. NTD malformations include: spinabifida (open spine), meningomyeloceles, myeloceles, anencephaly (open skull), encephalocele (gap in the skull) and other anomalies (Bener *et al.*, 2006).

Popkin (2001) defined obesity as a condition of abnormal or excessive fat accumulation in adipose tissue to the extent that health may be impaired. According to World Health Organization, Body Mass Index (BMI) provides the most useful population level measure of obesity. As per World Health Organization, obesity is, "one of today's most neglected public health problems" and the extent of children and adolescents who are overweight and obese has additionally been increasing (WHO, 2004). Snacking of high-energy junk foods was one of the important influencing factors of obesity among children and adolescents (Bose *et al*., 2006). Thakkar *et al*., (2010) in his study cautions about the high prevalence of obesity (52%) especially by Indian guidelines among the female adolescents calls for the prevention and control of this problem. Study of Augustine and Poojara (2003) found high prevalence of overweight and obesity (24 and 10.5% respectively) among urban college-going girls in Ernakulam district. Takii *et al*., (1999) found links between unhealthy eating attitudes in female adolescents and pubertal changes in the body shape and weight. Risk of morbidity, bone and joint problems, sleep apnea and social and psychological problems such as stigmatization and poor self-esteem are found to have caused by obesity in adolescent girls (Daniels *et al*., 2005). Park (2005) found that childhood obesity increases the complications during the adulthood.

Disordered eating behaviours are common among adolescents (Eisenberg and Sztainer 2010). Sztainer *et al*., (2002) in their study found that more female adolescent respondents (92.4%) than male respondents (53.6%) reported engaging in weight control behaviours to lose weight or keep from gaining weight. Patel and Shah (2009) described that, 31 per cent respondents had anaemia due to poor diet, ongoing blood loss during menstruation and today's fashion trend of slimness; 53 per cent due to poor consumption of food and taking junk foods. The prevalence of disordered eating, 'crash' dieting, fasting and usage of slimming tablets, diuretics and laxatives by adolescent females was found among the study group by Grigg *et al*., (1996). Dieting and unhealthy weight-control practices foresee results identified with obesity and eating disorders after 5 years (Sztainer *et al*., 2006).

Malnutrition, as a risk factor for the educational future of children and adolescents is a major concern for health, nutrition and educational policies. Poor nutrition hampers pupils' learning process; a daily food intake reduces the negative effect of malnutrition. Food intake helps kids to keep concentrate, enhance pupils' attention span and then increase their daily learning time (Aubery, 2012). Anaemia reduces physical and cognitive capacity and the subsequent impact on reduced learning skill and academic performance among early adolescent school-going girls (Sen and Kanani, 2006). Maluccio *et al*., (2009) in their study found that higher intake of nutrients during early childhood and adolescent stage has a long-term impact on adult educational outcomes.

Surprisingly, information regarding the nutritional status of adolescents in Kottayam district of Kerala state is lacking. Information about absolute levels and trends with respect to adolescent girls' undernutrition are of relevance for designing, initiating or modifying intervention programmes (Mulugeta *et al.*, 2009). Adolescents, however, have been considered a low-risk group for poor health and nutrition and frequently get inadequate consideration. Due to these reasons, resources have traditionally been directed to children and mothers, especially pregnant women. The nutritional status and the impacts of interventions among adolescent girls of age group 12-19 years have been underexplored in Kottayam district. This information is essential for planning and implementing effective nutritional interventions including nutrition education programme for adolescent girls. With this background, this study, **"NUTRITIONAL STATUS OF ADOLESCENT GIRLS (12-19 years) AND IMPACT OF INTERVENTION PROGRAMMES"** therefore, is aimed at assessing the level of undernutrition, identifying the various factors contributing to girls' malnutrition and the impact of interventions to alleviate undernutrition among adolescents in Kottayam Taluk with the following specific objectives to:

SPECIFIC OBJECTIVES OF THE STUDY

1. Assess the nutritional status of selected adolescent girls, including their haemoglobin, iron, folic acid and vitamin B_{12} profile.
2. Examine the dietary pattern of adolescent girls.

3. Identify the factors affecting nutrient consumption among the adolescent girls.
4. Evaluate the nutritional knowledge among adolescent girls.
5. Develop a computer-aided teaching tool for giving education programme regarding nutritional deficiencies among adolescent girls.
6. Create awareness about iron, folic acid and vitamin B_{12} deficiency among adolescent girls using the developed computer-aided teaching tool.
7. Evaluate the effectiveness of computer-aided tool and distribute the developed tool to educational institutions and healthcare centres to assist in organizing awareness promotion programmes.
8. Evaluate the impact of three different intervention methods on haemoglobin, serum iron and serum folic acid profile of selected subjects.

II. REVIEW OF LITERATURE

The relevant literature reviewed for the present study entitled **"NUTRITIONAL STATUS OF ADOLESCENT GIRLS (12-19 years) AND IMPACT OF INTERVENTION PROGRAMMES"** is furnished under the following headings.

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2.1 Adolescence and the adolescents

2.1.1 Definition

According to United Nations International Children's Emergency Fund (UNICEF, 2011[a]) and United Nations (2008) "Adolescent" refers to individuals between the ages of 10-19 years; while adolescence is the period of physical, psychological and social maturing from childhood to adulthood. The word “adolescence” comes from a Latin word “*Adolescere”*, which means “to grow in maturity” (Kotecha *et al*., 2013).

According to Suriakanthi (2009), the stage of adolescence may be categorised into early adolescence and late adolescence. Early adolescence period extends from the time of puberty to the age of sixteen. The importance of this period is that physical changes of adolescence begin and get completed. The period of late adolescence extends from the age of sixteen to twenty. During this period the adolescent prepares himself to become an adult.

But Lewis (2013) asserts that “adolescence is described as being the teenage years from thirteen to eighteen years of age; however, puberty decides the onset of adolescence; therefore, adolescence occurs in some children as early as nine years of age”.

2.1.2 Demographic profile

According to an estimate by UNICEF (2011[a]), there are 1.2 billion adolescents in the world; nine out of ten of these young people live in developing countries. Millions are denied their basic rights to quality education, medical services, security and exposed to abuse and exploitation.

United Nations Population Fund (UNFPA, 2005) survey shows that almost 50 per cent of the world's population (almost 3 billion people) is less than 25 years old. More than 500 million youth live on not exactly $2 every day. About 238 million, or 22.5 per cent of the world's youth live in great destitution – on not exactly $1 dollar every day. More than 85 per cent of the world's youth live in developing countries. Asia alone is home to 70 per cent of the developing country's young people.

Adolescents constitute about 22.8 per cent of the population in India (Dasgupta *et al*., 2010). Highest incidence of iron-deficiency anaemia among women, including adolescents, is in India. In India, adolescent girls constitute a sizable portion of its population who structure a vulnerable group and are at a more serious danger of morbidity and mortality (Siddharam *et al*., 2011). Institute for Health Management, Pachod reports that between 60 and 70 per cent of Indian adolescent girls are anaemic (IHMP, 2011).

2.1.3 Physical and psychological changes during adolescence

Getting into puberty proclaims the physical changes of adolescence – a growth spurt and sexual maturation. It was found that even in schools where sex education is taught, numerous teenagers still feel not prepared for the progressions of puberty (Coleman and Hendry, 2011). Findings by Koff and Rierdan (1995) state that adolescent girls, who are not prepared for the physical and emotional changes of puberty, may experiences the most difficulty with menstruation.

Adolescent period is characterised by physical growth, personality adjustments and sexual development. They face ongoing clash and difficulty adapting to the sudden upsurge of sexual and aggressive drives. These changes are root causes of unrest and confusion in the adolescent's inner-selves and in the way they perceive the world (Lewis, 2013).

Elgar *et al*., (2005) studied the occurrence and stability of overweight and obesity in a cohort of adolescents. They found that inactive behaviour and physical activity in early adolescence both persuaded body mass in later stages of adolescence.

The enormous change in body composition of the adolescent girl happens in fat mass. In general, the body is made out of approximately 14 per cent fat in girls at six years of age, which increases to 25 per cent by 17 years of age (Naughton *et al*., 2000).

Adolescence is a period of unpredictable behaviour, lack of experience and the subsequent weak judgement ability. Adolescents frequently cannot appreciate the adverse outcome of their actions, at this stage they experience increase in sexual hormone other changes also takes place in their bodies, which they do not comprehend. They tend to investigate what they were being told by friends, read in different write-ups or watched (Olukunle, 2007).

According to Quint (2008) puberty and menstruation are troublesome issues for teens and for their family members. The effect of menstrual cycle on these teenagers, including cleanliness issues, menstrual irregularities because of specific clinical circumstances and treatment dilemmas are connected with the use of hormonal medication.

Mental and psychological growth is associated with physical growth and maturation during adolescent period (Sadhna and Achala, 2006). During adolescence, changes between childhood to adulthood, swift changes occur in physical, functional, sexual, emotional and psycho-social aspects, which need proper consideration and care. There is progress of human sexuality which comprises the knowledge, beliefs, attitudes, values and performance of individuals about sex (Roy *et al.*, 2007).

According to WHO (2001[b]) “adolescence, the second decade of life (10-19 years), is a period of rapid development. It is a time when growth is accelerated, major physical changes take place and differences between boys and girls are accentuated”.

Growth spurts of eight to twelve inches in a period of two or three years are some of the physical changes an adolescent experience. Puberty heralds acne, voice changes, body hair growth, growth of internal and external reproductive organs (ovaries, breasts, penis, and testes), production of oestrogen and mature egg release for females (Nevid and Rathus, 2005).

These sudden spurts connected with hormonal, intellectual and emotional changes. Growth in childhood is moderately uniform, which is abruptly altered in adolescence by an increment in speed of growth. Adolescence is a period of exceptional change in life of each individual (Spear, 2002).

National Institute of Mental Health (NIMH), using magnetic resonance imaging (MRI), supported that during teen years, brain is still under development and maturing. The biggest transformations occur in areas of the brain that affect self-control and decision making. During adolescence, the brain experiences a second wave of overproduction of gray matter in the frontal lobe (Giedd *et al*., 1999).

The accepted classification of an individual in regard to adolescent physical growth appeared as early, average, or late; in the case of girls, the classification was often pre-menarcheal or post-menarcheal. The physiologists found the early-developing boy and the late-developing girl tending to resemble the opposite sex in body build. On the other hand, the growth of the late-developing boy and the early-developing girl was found to terminate in shorter than average stature (Uhlin, 1962).

Remsberg *et al*., (2005) evaluated the impact of menarcheal age on changes in insulin, glucose, lipids and blood pressure during adolescence and found that girls with early menarche displayed lifted blood pressure and glucose intolerance compared with later maturing girls, independent of body composition.

A community-based, cross-sectional study, conducted in 1999 in a rural area of West Bengal, among 143 adolescent girls (10-19 years), revealed prevalence of acute and chronic morbidity as 30.8 per cent (Das and Biswas, 2005).

Emily and Smith (2012) studied the influencing role of neighbourhood disadvantage on the association between pubertal development and substance use among teenage girls. Results indicated that the relationships between pubertal development, neighbourhood disadvantage, and alcohol use were different for girls from different racial backgrounds. Though there was support for contextual amplification among black adolescent girls, low levels of neighbourhood disadvantage, during early adolescence, tended to be associated with higher levels of alcohol use.

The 2003 Survey Assessment of 7,584 Vietnamese Youth aged 14-25 years, resident in 42 of the countries and 61 provinces revealed that females tend to attempt suicide almost four times more likely than males. Past inebriation, ever having been a victim of premeditated injury of a family member or ever having had feelings of hopelessness were the other risk factors for suicide attempts (Le and Blum, 2011)

According to WHO (2015[b]) the biological determinants of adolescence are fairly universal; But, the duration and defining characteristics of this period varied across time, social, cultural and economic situations. Apart from these, physical and sexual maturation, these experiences include movement toward socio-economic independence, identity, and the achievement of skills needed to carry out adult relationships and roles, and the capacity for abstract reasoning.

Seiter and Nelson (2011) studied Indian young people aged 18 to 26 to observe (a) how they felt about their adulthood, (b) the criterion they consider necessary to become adults and (c) the degree to which they feel optimistic about their future. Four hundred and seventy eight college students in Coimbatore, Tamil Nadu, India and 100 nonstudents from rural villages surrounding Coimbatore were the participants. It was found that the mostly, 18-26 year olds felt that they had achieved adulthood. Participants exhibited attributes needed to perform family roles as the characteristic necessary for adulthood. Optimum levels differed between students and nonstudents.

Puberty includes physical changes in the body; development of secondary sex characteristics and reaching menarche. Body changes make them look beautiful and more attractive as a result they are on the lookout for people who could appreciate them and give them a compliment on the new look (Olukunle, 2007).

2.2 Adolescence-the period of storm and stress

2.2.1 Socio-economic problems

As per WHO (2014) “adolescence is not only a time of tremendous growth and potential, but also a time of considerable risk during which social contexts exert powerful influences. Adolescents depend on their families, communities, schools, health services and workplaces to learn a variety of important skills that would help them to cope with the pressures during the transition from childhood to adulthood”.

Research on the socio demographic associates of anxiety uncovers well-established associations with gender and financial status. Gender impacts on anxiety disorders and symptoms have been found in investigations of children and adolescents in English-speaking nations. Anxiety disorders and symptoms are more prevalent among girls (Weiss and Last, 2001).

Goodman *et al.,* (2005) found financial status to be both related and disconnected to anxiety. Association was found between social disadvantage and stress, whereas, mother’s employment was not found to have any negative influence on the social and emotional development of a child.

Richards and Duckett (1994) found evidence to show that the opposite may be true - children, particularly daughters, whose mothers are working, exhibit tendency to be more independent, higher self-esteem and higher educational and occupational aspirations and less stereotyped views of men and women, than compared to those whose mothers are not employed .

Armistead *et al.,* (1990) examined which coping methods teenagers used in response to parental divorce: active-cognitive, active-behavioural and avoidance. Results showed that the active-cognitive method was employed by the adolescents most often, followed by active-behavioural. Adolescent girls who reported more use of this method demonstrated more internalizing, externalizing and physical problems.

Amoke-P'Olak *et al.,* (2009) found relationship between family socio-economic position (SEP) and adolescents' emotional wellness. Using a cross-sectional design, the study examined the differential impacts of SEP on different mental health dimensions in preadolescents (n = 2230, baseline age 10-12). The study inferred that in early adolescence, the risk of psychological problems increases with diminishing SEP.

Gortmaker *et al*., (1990) established that socio-economic conditions were a significant factor that develops behaviour problems. Higher levels of depression/anxiety, peer conflict and social withdrawal were found among adolescents than among children. Other independent risks embrace the non-appearance of biologic parent, low versus high family income and low versus high maternal education.

National Nutrition Monitoring Bureau (NNMB, 1979) reports, the accessible information on adolescent development between 14 and 18 years demonstrated that young girls from poor families put on stature and weight at much lower rates than young girls in rich families. Among the poorest families of India the mean age at menarche was accounted for to be around 14.50 years, while among higher salary group it was just 13.20 years (Beegum, 2001).

The study by Cetin *et al*., (2010) studied 378 adolescents and found that adolescents from a low SES had essentially low scores on self-image scales compared with those from high and middle SES. Mexican American adolescents face aberrations in emotional well-being and scholastic achievement, which may be to some degree on account of discrimination experiences.

Study on low enrolment and dropouts of adolescent girls demonstrate that adolescent girls are lingering a long ways behind in comparison to adolescent boys. The cost of homely chores constitutes the major reason for the dropout of adolescent girls, followed by the perception of poor return on adolescent girl's education. Part of the reason is likewise discovered to be the apprehension of crimes likely to be committed against girls (Sinha, 2006).

The relationship between low income, on one hand, and lessened access to medical services and worse health, on the other, are the impacts of financial status on the life chances of adolescents (National Research Council, 1995).

Ellwood and Jencks (2002) discovered changes in the structure of families and the outcomes for the family salaries of young people have disintegrated the support that numerous adolescents get as they grow up. The outcomes demonstrated that in single parent families, particularly those in which the guardian is the mother, are significantly more likely than two-parent families to have low livelihoods.

McLoyd (1998) found association between household income and quality of life in the adolescents' households. A significant difference between low and high-poverty households was found on availing quality services. These characteristics, the study found, have harmful results for the cognitive functioning, socialization, physical health, emotional functioning and academic performance of adolescents.

Family income also found to have a significant impact on the educational opportunities of children and adolescents and their chances of educational achievement. This connected with constrained parental involvement in adolescents' education, found to have serious consequences (Ingersoll, 1999).

Ward and Ashley (2013), found an association between a child who is extremely beaten, sexually misused, who grows up witnessing intimate partner or family brutality; who attends a failing school or is not involved in structured after-school activities; or one who lives in a violent neighbourhood and risk of getting to be included in violent behaviour.

Hallal *et al.,* (2012) evaluated the relations between family financial trajectories from 0 to 11 years old and danger elements for non-transmittable disease at 15 years in Brazil. The results showed that adolescent's financial position is a huge determinant of risk factors for non-transferable diseases than socio-economic trajectories.

Amone *et al.*, (2009) assessed the extent of mediation of the association between family socio-economic position and mental health problems. They found a positive association between socio-economic condition and mental health and stress and these life stresses were also found to mediate this association.

Sridevi (2012) quotes that more than 50 per cent of the world's population belongs to adolescent age group and are facing serious health problems in the modern times. Apart from this, adolescent girls are liable to suffer sexual abuse, violence, rape, unwanted pregnancy, abortion and STDs from which they need protection.

In the realm of adolescence, antisocial behaviour is connected with contact with socially connecting to peers with negative behaviours (Schneider *et al*., 2012). Cortazar (2006) argues that adolescent criminal conduct is sometimes simply an issue of choice, poor decision making on the youth, and feels participating in a violent behaviour is not simply related to poverty or environment. It is a mix of all factors community, family and the youth's personal characteristics that help frame this choice of bad conduct.

Azagba and Asbridge (2013) found that school connectedness is defensive of smoking susceptibility, together with past research, gives additional confirmation that by enhancing school conditions that promote school connectedness, risky conduct of adolescents can be diminished.

According to Sabbah *et al*., (2009), "students who were not happy with their weight were more likely to be involved in risky behaviours such as bullying others at school, being bullied and smoking nargila, than adolescents who were more satisfied with their weight".

Wang *et al*., (2010) found that early adolescents who were male and who did not come from two-parent families had more risk behaviours than others.

2.2.2 Psychological problems

Aradhya (2013) studied psychosocial morbidities in school-going adolescent girls in a south Indian city. Depression was noted in 2 per cent of the girls; symptoms of anxiety were noted in 1 per cent; stuttering and poor concentration were observed in 1 per cent each; 0.4 per cent came from broken families; 1 per cent were suffering from anorexia nervosa, 0.6 per cent were suffering from bulimia nervosa and 2 per cent had psychosomatic symptoms and 1 per cent reported interpersonal violence among their hostel mates.

Costello *et al*., (2003) asserted that psychological disorders among school-going children and adolescents are not so uncommon. Essau *et al*., (2000) found negative association between anxiety and the adolescents' social, emotional and academic performance. Weeks *et al*., (2009) demonstrated association between coping skills and avoidance of social interactions/rejection, developing friendship, lower self-esteem and seeking loneliness. According to Hudson *et al*., (2009) avoidance of school by adolescents was negatively associated with abilities to solve problems and academic performance.

In India, the primary recorded reason for anxiety among school children and adolescents is parents' high educational prospect and pressure for scholarly accomplishment (Deb, 2001). National Crime Records Bureau (2000) also supported these findings and claimed that more than 2,320 adolescent children had committed suicide due to educational achievement related stress and anxiety.

Study conducted in Thiruvananthapuram indicated that the prevalence of depression was 2.6 per cent (Nair *et al*., 2004). Another study which was done on school going adolescent girls in Delhi found that the most common problem was anxiety/depression, which accounted for almost 10 per cent of all the problems which were faced by adolescents. Stuttering and poor concentration were seen in 1 per cent of the sample adolescent girls (Mishra and Sharma, 2001). In a similar study which was done in urban Delhi, the prevalence of stuttering and poor concentration was high i.e. 5.3 and 9.5 per cent respectively (Datta, 1979).

Samanta *et al*., (2012) compared the prevalence of protective factors, mental health issues and violence among the urban and rural adolescents. Higher proportion of urban students than rural (67.3% vs. 62.5%) reported that their guardians understood their problems. Mental health issues like loneliness (17.3% vs. 9.8%); Worry (17.3% vs. 10.7%) and suicidal thoughts (19.2% vs. 14.1%) were higher among urban students. Mental health and violence-related issues were found to be prevalent among urban adolescents than those among rural adolescent students, in spite of having more protective factors.

As per American Psychological Association (APA, 2001), adolescence is usually depicted as a negative phase of life – a time of storm and stress to be survived or endured. Survey by the General Public agenda revealed that “for 71 per cent of those polled, negative terms such as “rude”, “wild” and “irresponsible,” first came to mind when they were asked what they thought about American teenagers”.

Adolescents encounter an inclination to leave childhood, which always looks confusing as sometimes and they likewise need security and backing like a child. They realize that they are no more children and in the meantime not yet grown-ups; they have thoughts and kind of way of life they need to live which don't fit into any of the current ones. These normally push the young people out to where they can discover backing and it is for the most part from a wrong hand (Olukunle, 2007).

Psychological and behavioural risk factors in adolescent girls were studied by Stice *et al*., (2005). Results provided support for certain etiologic theories of obesity, including the affect regulation model. Self-reported dietary restriction, radical weight-control practices, depressive indications and perceived parental obesity – yet not high-fat food utilization, binge eating, or exercise recurrence anticipated obesity onset.

Dodge and Pettit (2003) presented a biopsychosocial model of the development of adolescent chronic conduct problems. This model places that biological dispositions and sociocultural contexts put certain children at danger in early life but that life experiences with parents, peers and social institutions augment and intervene this danger.

Repetti *et al*., (2002) observed that risky families are characterized by clash and aggression and by relationships that are cold, unsupportive and careless. They posit that these family characteristics make vulnerabilities and/or associate with hereditarily based vulnerabilities in teenagers that produce interruptions in psychosocial functioning (specifically emotion processing and social competence), disruptions in stress-responsive biological regulatory systems and poor health behaviours.

Smojver-Azic and Bezinovic (2011) analysed relations between protective/risk family interactions and depressive symptoms in adolescent boys and girls in the schools of Primorsko-goranska County, Croatia. Depressive manifestations were accounted for regularly and frequently by 19.1 per cent of girls and boys. Girls' assessment of the family relations was found to be significantly more positive than boys. Family attitudes and the father's love and consideration have a higher effect for female children than for male children, while dangerous parental conflict and the mother's hostility and antagonistic vibe are similarly discovered to be critical for both boys and girls.

Gomez *et al*., (2011) examined acculturative stress and perceived discrimination as statistical indicators of a suicide attempt history among an ethnically various sample of 969 emerging youth, ages 18–25 years. Asian individuals reported higher acculturative anxiety than all other racial/ethnic gatherings, while both Asian and Black members reported having experienced more separation in the prior year, appeared differently in relation to distinctive groups. Environmental acculturative anxiety was discovered to be connected with diminished chances of embracing a suicide endeavour history. Perceived discrimination was discovered to be connected with more than five times higher chances of a suicide attempt, overall, and particularly was connected with more than three times higher chances among Latino members and more than 10 times higher chances among White, US-born participants.

“Adolescents face turmoil due to different stages of development, different circumstances, different needs, and diverse problems” (Patil *et al*., 2009).

Patel (2013) found that “mental disorders, such as mood disorders, substance use disorders, and psychoses, are the leading cause of ill health in adolescents and young people. Moreover, it was found that a great number of suicide deaths were induced by mental disorders”.

A survey was conducted among adolescents in the 6^{th} through 10^{th} grades in the US. “Among them, 29.1 per cent experience headaches, 20.7 per cent report stomach aches, 23.6 per cent experience back pain, and 30.6 per cent report morning fatigue at the rate of more than once a week. Among girls who experienced headaches more than once a week, 3.2 million (53.3%) also reported stomach pain more than once a week and 4.1 million (74.3%) reported morning fatigue more than once a week” (Ghandour *et al*., 2004).

A study by Stattin *et al*., (2011) found that girls’ early pubertal timing has been connected in numerous studies to behavioural issues, for example, misconduct and substance utilization. Results demonstrated that early pubertal timing was most emphatically connected to wrong doing for young ladies who invested time in this connection and were intensely included with young men and companions. The study concluded that the coordinated peer-socialization/contextual-amplification model clarifies the connection between pubertal timing and external problem behaviour.

Examination of siblings drawn from the National Longitudinal Study of Adolescent Health uncovered critical ecological control of hereditary impacts on measures tapping genuine wrongdoing, savage misconduct, and individual exploitation. All in all, more noteworthy presentation to criminogenic danger components builds the impacts that hereditary variables have on these three introverted results (Beaver, 2011).

In a 50-country study undertaken between 2000 and 2004, Viner *et al.*, (2011) reported that mortality in people age 15-24 years was higher than that in children age 1-4 years. The report states that violence and suicide have become a major cause of death in this group: Suicide makes up a quarter to a third of mortality in exposed young men age 10-24 years.

Ata *et al.*, (2007) found that “adolescents were dissatisfied with their current bodies: males were concerned with increasing their upper body, whereas females wanted to decrease the overall size of their body. Low respect toward oneself and social bolster, weight-related teasing, and more noteworthy weights to get thinner were associated with young people's pessimistic body regard, body image, and eating state of mind”.

According to Wang *et al.*, (2010) although adolescents may be pressured into identifying with peers’ risk behaviours, adolescents who have good emotional regulation may deal with stress better and be less affected by peers’ risk behaviours.

A study by Morrison *et al.*, (1992) found that adolescents reporting sleep problems were more anxious, depressed and inattentive and conduct disorder behaviours than those who had no sleep problems. The study found that sleep problems were relative persisted over time from ages 13-15 years.

2.2.3 Dietary intake and disordered eating behaviour of adolescents

Grigg *et al.*, (1996) studied the disordered eating and unhealthy weight reduction practices among adolescent females. The study showed that a huge extent of adolescents is occupied with disarranged eating practices and horrible abstaining from food hones. These practices, the study found, alone or joined with a mutilated self-perception, or a powerful urge to achieve the flimsy "perfect" female body shape, may put these youngsters in significant danger. Thus, they may create dietary problems or different genuine nutrition related issues.

Eating disorders such as anorexia nervosa and bulimia nervosa are usually preceded by dieting (Polivy and Herman, 1985). Consequently, dieting is regarded as an important risk factor for the development of an eating disorder (Striegel *et al*., 1986). One study estimated that at 15 years of age, the relative risk of dieters becoming disordered eaters is eight times that of non-dieters (Patton *et al*., 1990). Anorexia nervosa has its highest incidence in girls at the beginning of adolescence and bulimia nervosa has its highest incidence at the end of adolescence (Striegel *et al*., 1986).

The effects of menarcheal status and opposite-sex socializing on dieting and disordered eating among early adolescent girls were examined by Cauffman and Steinberg (1996). The study found that girls who are more included in blended sex social exercises are more inclined to display confused eating propensities. Additionally adolescents who are dating and are all the more physically included with boys are more prone to report abstaining from food and cluttered eating than their companions.

Linville *et al.*, (2011) inspected linkages between depression systems (DEP) and positive adult support (PAS) in female adolescents and the mostly interceding impact of eating disorders. Results demonstrated that there was a critical, positive relationship in the middle of depression systems and positive adult support and that Eating Disturbances (ED) was found to mediate partially.

A study on dietary intake of adolescents by Pearson and Biddle (2011) indicated clear association with elements of a less healthy diet including lower fruit and vegetable consumption; higher consumption of energy-dense snacks, drinks and fast foods; and higher total energy intake.

Attie and Brooks-Gunn (1989) led a longitudinal study and inspected the rise of eating issues in juvenile adolescents as a capacity of pubertal development, self-perception, identity advancement and family connections. Results demonstrated that adolescents who right on time in immaturity felt most contrarily about their bodies were more prone to create eating issues.

Graber *et al.,* (1994) examined the eating issues in 116 adolescents drawn from an ordinary populace of understudies selected in non-public schools. Examination of the juvenile example of eating issues over youthful and mid-pre-adulthood demonstrated that example was connected with (1) prior pubertal development and higher muscle to fat quotients, (2) simultaneous mental aggravations, (3) consequent eating issues and (4) other long haul change results, for example, depressive impact in youthful adulthood.

Ata *et al*., (2007) found that females displayed more high risk eating behaviours—which were associated with more psychosocial risk factors—than males, whose high risk attitudes and behaviours were only associated with low parental support and greater pressure to be muscular.

Martin *et al*., (2011) in their study on adolescents observe that participants believed that fat children have weight problems because they consume too many calories, are lazy, have access to junk food, and lack self-control.

Johnson *et al*., (2002) in their study found that adolescents with eating disorders were at a substantially elevated risk for anxiety disorders, cardiovascular symptoms, chronic fatigue, chronic pain, depressive disorders, limitations in activities due to poor health, infectious diseases, insomnia, neurological symptoms and suicide attempts during early adulthood.

A study was conducted by Singh *et al*., (2006) among 510 students (279 boys and 231 girls) aged 12-18 years from classes 9-12 in an urban school of Delhi. The study showed that about one-third of the adolescents (34.4% boys and 29.4% girls) ate fast food more than three times a week. In addition, 31.5 per cent boys and 16.5 per cent girls committed having added extra salt to their food/salads. Only 39.4 per cent adolescents had fruits daily.

Sztainer *et al*., (2008) also observed high prevalence of disordered eating behaviours among adolescent girls and the protective role of family meals suggest a need for interventions aimed at promoting family meals.

Results of the study conducted by Rey-Lopez *et al*., (2011) among girls (*n*=699) and boys (*n*=637) aged 12.5–17.5 years of Europe indicated that boys reported more frequent consumption of beer and soft drinks whereas girls selected more fruit juice, water, herbal infusions and sweets (all $P \leq 0{\cdot}05$). Watching TV for >2 h/d was associated with the consumption of energy-dense foods and drinks. Girls whose mothers achieved the lowest education level had an adjusted OR of 3.22 (95

% CI 1·81, 5·72) for the consumption of energy-dense drinks during TV viewing *vs*. those whose mothers had the highest educational level.

Twenty-four-hour dietary recalls were applied in 525 male and female Brazilian adolescents aged 14–18 years by Junior *et al*., (2011). They found that for male and female adolescents, the prevalence of inadequate intake was: Mg, 89 per cent and 84 per cent; vitamin A, 78 per cent and 71 per cent; vitamin C, 79 per cent and 53 per cent; and vitamin B6, 21 per cent and 33 per cent, respectively. The study found a high prevalence of inadequate intake of nutrients that are recognised as being protective against chronic diseases. Adolescents in the lower income and lower parental educational level strata were less likely to have their nutrient intake requirements met.

Guest *et al*., (2010) studied 482 adolescent girls (14-17 years) from secondary schools in the northern Sydney and Central Coast regions of New South Wales, Australia. Participants who '*often'* used weight control methods had, on average, a healthy BMI of 22.5 (SD=3.7). However, assessment of blood derived markers between participants who *'never', 'occasionally'* or *'often'* used weight reduction techniques showed that, those who '*often*' used weight control methods had significantly lower haemoglobin, alkaline phosphatase, bilirubin, albumin, total protein and calcium but higher blood levels of creatinine and potassium.

The findings of Loud *et al*., (2005) found that approximately 2.7 per cent of the girls studied, had a history of stress fracture, 3 per cent engaged in disordered eating (using fasting, diet pills, laxatives, or vomiting to control weight), and 16 per cent participated in ≥16 hours per week of moderate to vigorous activity. Girls who participated in ≥16 hours per week of activity were also more likely than their peers to engage in disordered eating (4.6% vs. 2.8%); however, it was found that disordered eating did not have an independent association with stress fractures.

Wong *et al*., (2011) conducted a study and found that after the nutrition education the percentage of participants with a tendency toward eating disorders decreased from 10.4 per cent to 10.1 per cent in boys, and increased from 10.9 per cent to 12.3 per cent in girls.

Rampersaud *et al*., (2005) summarized the findings of 47 studies and found that breakfast skipping was exceptionally pervasive in the United States and Europe (10% to 30%), contingent upon age gathering, populace, and definition. In spite of the fact that the nature of breakfast was variable inside and between studies, youngsters who reported having breakfast regularly had a tendency to have unrivalled nutrition profiles than their breakfast-skipping counterparts.

Maliye *et al*., (2010) too reported that among the adolescent girls of Sewagram in the age group of 10-19 years, the average energy intake, which was 1239.6±176.4 kcal/day, was deficient of Recommended Dietary Allowance (RDA) by 39 per cent. The average protein intake was 39.5±7 gm/day. It was deficient by 36 per cent and the average iron intake, which was 13.2±2.5 mg/day, was deficient by 48 per cent.

Chiplonkar and Tupe (2010) attempted to identify a measure of micronutrient quality of diets of adolescent girls (10-16 years) of Pune city consuming a lacto-vegetarian diet. The average energy intake of the majority of the girls was found to be below the Indian recommended dietary intakes, whereas micronutrient intakes were 50 per cent to 70 per cent lower than recommended dietary intakes.

Alam *et al*., (2010) found the dietary intake of unmarried adolescent girls aged 13-18 years of rural Bangladesh were not satisfactory. Adolescents of the rich families ate fish/meat 2.1 (55%) days more and egg/milk two (91%) days more than the adolescents in the poor families. The general dietary knowledge was low. More than half did not know the names of energy and protein source foods, and 36 per cent were not mindful of the significance of taking additional supplements during the adolescent period for better growth.

Sharma *et al.*, (2005) investigated the calorie and protein consumption and its determinants among school-going adolescent girls. The study was conducted in Delhi. The outcomes demonstrated that the calorie and protein admission of the school-going adolescent girls was much lower among the lower financial group. Indeed, even in the relatively economically better groups, the consumption of calorie and protein was not adequate.

2.3. Nutrition-related health problems of adolescent girls

2.3.1 Anaemia

In a study carried out by Rao *et al*., (2011) 77 per cent of rural women of childbearing age (15-35 years) in three villages of Maharashtra had nutritional anaemia. Lower body weight and short maternal heights were also found. Rawat *et al*., (2001) found that majority (55.2%) of adolescent girls were having mild anaemia in the 24 sub-centre villages of Daurala block of Meerut.

Ramzi *et al*., (2011) investigated the prevalence of anaemia, iron deficiency anaemia and related risk factors in adolescent girls in Kavar urban area in Southern Iran. It was found that 8.5 per cent had iron deficiency and 1.7 per cent had iron deficiency anaemia. Most of the anaemic girls (85.7%) had mild anaemia.

Gupta *et al*., (2012) surveyed 1596 school girls of 10-19 age group schools in selected schools in Shimla district and he found prevalence of anaemia to be 21.4 per cent. Within this, 77.3 per cent were mild anaemic, 21.9 per cent of moderately anaemic and 0.5 per cent were severely anaemic.

Peter *et al*., (2012) in his study on non-pregnant, unmarried college-going girls aged 16-30 years found high prevalence of anaemia in both urban and rural girls in all BMI groups (Mean haemoglobin levels of urban and rural girls were 9.35±1.06 gm% and 9.40±.90 gm% respectively).

In a community-based cross-sectional study carried out in selected villages of Kolar district, among 230 adolescent girls of 10-19 age groups, Shivaramakrishna *et al*., (2011) found the prevalence of anaemia as 34.8 per cent and also reported that it was more among menstruating girls than non-menstruating girls. Another interesting finding was that anaemia prevalence was less among adolescent girls using footwear during defecation than girls who did not use footwear.

Toteja *et al*., (2006) studied the prevalence of anaemia among pregnant women and adolescent girls in 16 districts of India. The measurement of haemoglobin concentration indicated that the prevalence of anaemia among the 6,923 pregnant women from the 16 districts was 84.9 per cent. The overall prevalence of moderate and mild anaemia in pregnant women was 60.1 per cent and

11.8 per cent respectively. The highest prevalence of moderate anaemia was found in Nagaon district (82.7%) and the highest prevalence of mild anaemia (31.0%) in Mandi district.

IHMP, Pune carried out a study on 1,142 adolescent girls residing in 16 slums of Pune from 2000-03. Studies had demonstrated that weakness was fundamentally more probable among adolescents who eat less than two times in a day. It was likewise found that intercession has affected dietary conduct. Blood testing demonstrated that mean Hb levels expanded from 5.8 to 9.5 gm/dl for extremely severe anaemic adolescents and from 8.9 to 11.2 gm/dl for medium anaemic adolescents (International Centre for Research on Women, 2006).

Indian Institute of Health and Family Welfare (2002), Hyderabad surveyed the Prevention and control of Anaemia in Rural Adolescent Girls through educational system program in Andhra Pradesh. A blend of anthropometry, biochemical and meeting timetable strategies was utilized for evaluating the nutritious paleness status and consciousness of iron deficiency among study subjects. Signs and indications of weakness like paleness, exhaustion, windedness, poor hankering and absence of fixation in studies were accounted for. Mean Hb level at gauge study was 10.6 + 1.1 g/dl, which expanded to 11.6 + 1.0 g/dl amid mid-term study. It was discovered that haemoglobin levels enhanced in 45.6 every penny while they were static in 49.4 every penny and declined in just 5 every penny of subject. It was clear that IEC intercession brought about a noteworthy increment in Hb levels showing the achievability of this methodology.

Sharma *et al.,* (2011) led a study to acquire information on haemoglobin (Hb) levels of young girls from low-income families explored the relative viability of once "week by week" and "day by day" organization of iron-folate tablets concerning effect on Hb levels and to discover the impact of included ascorbic corrosive supplementation. Critical discoveries that rose up out of the study were, adolescents who were extremely malnourished demonstrated better retention; to fight anaemia by locally available GLVs (green leafy vegetables) could be utilized; and intake of iron and Vitamin C rich leafy foods needs to be upheld.

Chaudhary and Dhage (2008) conducted a study in Nagpur with an objective to estimate the prevalence of anaemia among adolescent females (10-19 years) and to study the socio-demographic factors associated with anaemia. The outcome showed a significant association of anaemia with socio-economic status and literacy status of parents.

Balci *et al*., (2012) did a study among 1120 children aged 12-16 years to evaluate the prevalence and risk factors of anaemia among adolescents in Denizli where Mediterranean cuisine is adopted. They found that overall prevalence of anaemia was 8.3 and 1.6 per cent for girls and boys respectively.

In Nepal, around 23 per cent of the population are of 10-19 years age group. Baral and Onta (2009) surveyed the prevalence of anaemia in Morang district. Among the 308 samples, the overall prevalence of iron deficiency anaemia was 65.6 per cent with the distribution of rural 62.4 per cent, urban 70.0 per cent, male 52.3 per cent and female 78.3 per cent.

Biradar *et al*., (2012) examined the prevalence of anaemia among 840 adolescent girls at villages which were under Vantamuri PHC, Belgaum. The prevalence of anaemia was 41.1 per cent and that of mild anaemia being 34.6 per cent. It was observed that the prevalence of anaemia was high in late adolescents (15-19 years) as compared to that in the early adolescents 10-14 years), also the prevalence was high among girls with low socio-economic status.

To estimate the prevalence of anaemia among adolescent girls and to study whether anaemia is associated with body mass index and the attainment of menarche, Gupta *et al*., (2012) made a cross-sectional survey in selected schools of Shimla District among 1596 school girls of 10-19 years. The prevalence of anaemia was found to be 21.4 per cent. Among these, 77.3 per cent had mild anaemia, 21.9 per cent had moderate anaemia and 0.5 per cent had severe anaemia.

Siddharam *et al.,* (2011) in his study reported that the prevalence of anaemia as 45.2 per cent. A statistically significant association was also found with iron deficiency anaemia, weight loss and anaemia, pallor and anaemia.

Patel and Shah (2009) studied the adolescent girls in Gujarat. The results revealed that only 22 per cent girls had normal Hb (12-14 gms) but 9 per cent girls had severe anaemia (< 8 gms Hb) and 22 per cent girls were nearer to anaemic level (8-10 gms Hb), whereas 47 per cent girls had normal Hb level (10-12 gms).

Imuetinyan *et al*., (2011) assessed the prevalence of sickle cell anaemia (SCA) among children of 1-16 years of age group. Prevalence of Microalbuminuria (MA) in the study subjects was 20.3 per cent; prevalence of MA was more in females (25.9%) than in males (16.7%).

Rawat *et al*., (2001) examined the prevalence of anaemia in 504 adolescent girls (10-18 years) from 24 sub centre villages of Daurala block of Meerut. The results showed 34.5 per cent prevalence. The prevalence of mild, moderate and severe anaemia among adolescent girls was found to be 19.0, 14.0 and 1.4 per cent respectively.

According to Allen and Ahluwalia (1997) inadequate absorption of dietary iron is the main explanation for the much higher prevalence of anaemia in the developing countries of Asia and other regions.

Osteoporosis – a rare cause of anaemia was researched by Saluja *et al*., (2009) by review of literature. The researchers concluded that Osteoporosis (OP) is a rare cause of anaemia due to effacement of haemopoitic tissue by fibrous tissue diagnosed during evaluation of anaemia.

Dias *et al.*, (2012) studied 613 female adolescent school dropouts, aged 15-19 years in two districts of Western Province of Sri Lanka. He found out that early dropout from school and being employed increases the risk of micronutrient deficiencies than non-working adolescents.

In a study by Verma *et al*., (2004) among 1295 school-going girls of 16-18 years age group from selected slums of the North Ahmedabad city, no significant relationship of anaemia was observed with socio-economic class, knowledge about anaemia, and parent's education, status of menstruation and daily consumption of lemon/sour fruits.

But on the contrary, Balasubramanian (2005), in a study on adolescent girls of 11-18 years of age group in the 13 villages of Kanchipuram District reported that the girls suffered the health consequences of their socio-economic status, poor personal hygiene and lack of nutrition. About 82 per cent of girls were reported to have had at least one reproductive health problem during the survey.

Singh (2008) undertook a cross-sectional sample survey of 556 adolescent girls of 10-18 years age group in an urban area of Meerut. Results showed a significant difference in prevalence of anaemia in adolescent girls in relation to caste, socio-economic status, father's occupation and mother's occupation. Reverse association was seen.

Jackson and Al-Mousa (2000) studied a cross-sectional sample of 1051 healthy adolescent school girls. Data indicated that environmental factors play a significant role in anaemia among healthy, well-to-do Kuwaiti adolescent girls.

Sharma *et al.*, (2012) studied the prevalence of anaemia among adolescent girl students in Assam. The study revealed that haemoglobin type E was the important determinant of anaemia among adolescent girl students.

Sachan *et al.*, (2012[a]) examined the effect of socio-demographic characteristics on the prevalence of anaemia among school going adolescent girls in Lucknow district. The study showed a significant association of anaemia with religion, caste, and socio-economic status.

“A major cause of anaemia is infection with malaria or other parasites. *Plasmodium falciparum* is the primary cause of severe malaria in regions of the world where malaria is endemic” – reports Menendez *et al*., (1994).

Karaoglu *et al*., (2010) found that having four or more living children being at the third trimester and having a low family income were determined as the independent predictors of anaemia. Anaemia was also found to be associated with soil eating (PICA).

Lokare *et al*., (2012) established the association between anaemia and adverse pregnancy outcome, higher incidence of preterm and low-birth weight deliveries in a study carried out at an urban health centre in Aurangabad. The study concluded that socio-economic class, illiteracy, Hindu religion were significantly associated with high prevalence of anaemia.

Jain and Sharma (2012) examined the various stages of iron deficiency and its ultimate manifestation as anaemia. The study points out that iron deficiency results from an inadequate intake of foods rich in iron and primary cause of anaemia is iron deficiency. Insufficient iron availability during growth phases or states of increased requirement results in iron deficiency (ID) and eventually iron-deficiency anaemia (IDA).

Reddy (2004) assessed the prevalence of iron deficiency and malnutrition in India. The findings showed that Assam had the highest prevalence of iron deficiency anaemia in the country (70%), followed by Bihar (63%) and Tripura (59%) and the lowest prevalence rate was in Kerala (23%), followed by Manipur (29%). The pattern of prevalence of anaemia among children (6-35 months old) was highest in the eastern region of the country, namely the states of Bihar, Orissa and West Bengal.

Anumudu *et al*., (2008) in their study attempted to estimate the prevalence of anaemia among pre-school and school-aged children. The results showed that most of the children were anaemic, 87.1 per cent, having PCV values below the 32 per cent cut-off and 95 per cent with haemoglobin levels lower than the 11 g/dl.

Agarwal (2010) reported that 77.2 per cent adolescent girls were found anaemic with severe (3.5%) moderate (28.2%) and mild (45.5%) only 22.8 per cent were observed non-anaemic with their haemoglobin levels 12 g/dl.

Kapur *et al*., (2002) discuss the nutritional anaemia and its control. They claim that prevalence of nutritional anaemia in India show that 65 per cent infant and toddlers, 60 per cent 1-6 years of age, 88 per cent adolescent girls (3.3 had haemoglobin < 7.0 g/dl; severe anaemia) and 85 per cent pregnant women (9.9% having severe anaemia) were anaemic. They argue that national programmes to control and prevent anaemia have not been successful.

2.3.2 Undernutrition

According to UNICEF (2012) survey nearly 50 per cent of adolescent girls of 15-19 age group in India are underweight with a body mass index (BMI) of less than 18.5.

Akhter and Sondhya (2013) evaluated the dietary pattern and also the extreme slimness status of a low-income family's adolescents furthermore their initial period of life in both urban and rural adolescents in Bangladesh. In light of the sustenance review and anthropometric results, the study presumed that hunger was basic in low-income family's adolescents and the extreme slimness rate was much higher in urban than in teenagers in rural locations.

Maliye *et al*., (2010) reported that among the adolescent girls of Sewagram in the age group of 10-19 years, 57 per cent were thin (BMI for age <5th percentile for CDC 2000 reference) and 43 per cent of the adolescents were reported normal.

Dapi *et al*., (2011) in a cross-sectional study of adolescent girls aged 12-16 years randomly selected from schools in low, middle and high SES (Socio-economic status) areas of Cameroon found that boys had a lower BMI and reported higher energy expenditures and physical activity levels (PAL) than girls.

In a study conducted by Banerjee *et al*., (2011) among adolescents of 10-19 age group in rural Goa reported that one-third of students who attended the health camps were underweight and 59.2 per cent of the 684 students reported experiencing hunger due to inadequate food consumption. The study also revealed that more boys were underweight than girls.

Alam *et al*., (2010) observed that the nutritional status of unmarried adolescent girls in rural Bangladesh, aged 13-18 years were not satisfactory. The study disclosed that 26 per cent of the girls were thin, 0.3 per cent was obese and 32 per cent were stunted.

In a study among 230 adolescent girls of 10-19 age group from selected villages of Kolar district by Shivaramakrishna *et al*., (2011) reported that the prevalence of wasting and stunting was 54.79 per cent and 31.17 per cent respectively and further showed that the trend of wasting and stunting declines with age. The prevalence of thinness was found to be 73.5 per cent as Indian standards.

Sachan *et al*., (2012[b]) studied the nutritional status of school going girls in Lucknow district in Uttar Pradesh. Overall prevalence of thinness was found to be 17.0 per cent and 11.4 per cent among urban and rural school-going adolescent girls respectively.

A cross-sectional study on the adolescent girls of age group 12-19 years, residing in hills of Garhwal was done by Saxena and Saxena (2011). The outcome showed that 34.61 per cent were stunted and 43.7 per cent were affected by thinness. However, the percentages were a little higher among the lower age group (12-15 years).

A report by NNMB (2000) on diet and nutritional status of adolescents revealed that most girls are still married during adolescence. Undernutrition among young girls improves up to the age of 12 years. When the adolescent period proceeds without any improvement in food consumption, it stagnates and brings about 40 per cent adolescents being hindered, demonstrating that the extent of hindering increased with increase in age.

Pathak *et al.,* (2003) examined the incidence of iron, vitamin A and iodine deficiencies amongst adolescent pregnant mothers in a rural block in Udham Singh Nagar District, Uttaranchal. The study showed the presence of three-micronutrient deficiencies. Anaemia, Vitamin A Deficiency (VAD) and Goitre were prevalent amongst 40 per cent, 15.9 per cent and 14.6 per cent of the respondents respectively.

Das and Biswas (2005) conducted a cross-sectional study in Amdanga block of North 24 Parganas district, West Bengal among 143 adolescent girls (10-19 years). The study failed to establish any significant association of thinness or stunting with per capita monthly family income and literacy status of parents. Common nutritional deficiency disorders found were anaemia (44.8%), dental caries (25.9%) and angular stomatitis (15.4%).

Kamath *et al*., (2012) assessed the nutritional status of school children in Mangalore city among 1630 students from 11 schools. The study reported that the nutritional status found in this study was found to be better than in other studies. Eighty two children (5.03%) were found to be undernourished; 2.3 per cent were overweight and 1.0 per cent was obese.

A study of obesity in Greece, with an objective to examine the relationship between breakfast habits and BMI in adolescents and breakfast skipping in relation to other health behaviours was done by Kapantais *et al*., (2011). It was found among both boys and girls, breakfast consumers had a lower BMI than breakfast skippers.

Haldar *et al*., (2004) showed that the prevalence of goitre among male and female adolescents to be 8.14 and 5.12 per cent respectively among school-going children in West Bengal.

Das *et al*., (2011) examined the prevalence of goitre among 2148 school children of 6 to 16 years age group in Chandigarh. Prevalence of goitre in the studied subjects was found to be 15.1 per cent. The study showed high prevalence of goitre despite iodine repletion and low thyroid autoimmunity. The concurrent iron deficiency correlated with the presence of goitre. However, the cause and effect relationship between iron deficiency state and goitre was not found.

2.3.3 Overweight and obesity

Mishra and Mukhopadhyay (2011) studied the weight concerns and eating behaviour changes among a group of adolescent girls in Sikkim. The results showed girls belonging to a higher economic status two times more dissatisfaction with their body weight than compared to adolescents from lower economic group.

According to Donohoue (2004), children with BMI equal to or exceeding the age-gender-specific 95th percentile were defined as obese. Those with BMI $\geq$ 85th but $\leq$ 95th percentiles were defined as overweight and were found at risk for obesity-related comorbidities.

Sachan *et al*., (2012[b]) studied the nutritional status of school-going adolescents in Lucknow district in Uttar Pradesh, which showed that the overall occurrence of overweight was found to be 5.4 per cent and 3.9 per cent among urban and rural school-going adolescent girls respectively.

In a study of Pan *et al*., (2013) on 3,470 US adolescents found that childhood obesity-related physical and psychological consequences are potentially associated with school absenteeism. They found that adolescents who were obese and overweight had 36 per cent and 37 per cent more sick days respectively than compared to adolescents of normal weight.

Babey *et al.*, (2013) examined 4,029 adolescents' leisure habits using the data from the California Health Interview Survey. They found a positive correlation between the time spent on watching television and obesity.

Goyel *et al*., (2010) investigated the prevalence of obesity and overweight and their association with socio-economic status and the risk factors. It was found that the prevalence of overweight among children was higher in middle socio-economic status as compared to high socio-economic status group in both boys and girls, whereas, the prevalence of obesity was higher in high SES group as compared to middle SES group.

Duncan *et al*., (2011) compared the weight perceptions, weight control behaviours and body fitness among adolescent girls from Europe, Pacific Island, East Asian, Maori and South Asian populations. It was found that the number of girls trying to lose weight exceeded those who perceived themselves as being overweight, with the magnitude of the difference dependent on ethnicity.

Kotian *et al*., (2010) carried out a cross sectional study among 900 adolescent of 12-15 age group. The study revealed the overall prevalence of overweight among adolescents was 9.9 per cent and obesity was 4.8 per cent. Within this 5.2 per cent girls and 4.3 per cent boys were found to be obese.

In a school-based cross sectional study among 2,785 affluent adolescents from six public schools in Meerut by Jain *et al*., (2010), prevalence of overweight and obesity was found to be 19.7 per cent and 5.3 per cent in girls and 18.36 per cent and 10.82 per cent in boys respectively. The study also found association between obesity and high intake of junk foods, binge eating, high calorie intake, lower physical activity and prolonged TV watching.

With an aim to examine associations between physical activity and obesity among black and white adolescent girls, White and Jago, (2012) conducted a study. A strong negative dose-response association between quartiles of accelerometer counts per day at age 12 years and obesity at age 14 years (using all 3 measurements of obesity) in white but not black girls were found. The study concluded that higher levels of physical activity are prospectively associated with lower levels of obesity in white adolescent girls but not in black adolescent girls.

Marwaha *et al*., (2006) studied the growth parameters and prevalence of overweight and obesity in school children from Delhi. The study found a significant inequality in anthropometric measurements among children belonging to the upper and lower socioe-conomic group. Incidence of overweight and obesity in children from as early as 5 years of age was found to be high.

Again, Kapil *et al*., (2002) also studied the prevalence of obesity amongst affluent school children in Delhi, which revealed that obesity was an emerging health problem in adolescent children belonging to affluent families. Highest number of obesity among affluent adolescents was reported to be in the age group of 10-12 years.

2.3.4 Consequences of nutritional inadequacy in adolescent girls

UNICEF (2012) report warns that anaemia, most commonly iron-deficiency anaemia, increases the maternal risk of haemorrhage and sepsis during childbirth. It causes cognitive and physical deficits in young children and reduces productivity in adults. The report also indicates that girls, 15-19 years old account for 11 per cent of all births and around 14 per cent of all maternal deaths, with some 50,000 girls dying from maternal causes annually.

Prakash *et al.,* (2011) found that women married at an early age had successive pregnancy, unplanned parenthood and premature births, which contrarily influenced their health status and youngsters destined to be mothers with poor regenerative health had lower opportunities of survival and a higher probability of anthropometric failure.

A study conducted by Rao *et al*., (2010) examined the confounding effect of early life undernutrition on adolescent pregnancy outcome in rural India. The findings indicated that pregnancy outcome was adversely affected by early conception and prolonged adolescent growth, which are the features of biological immaturity in undernourished population.

Sen and Kanani (2006) assessed detrimental functional impact of anaemia on 350 young adolescent school girls in Vadodara Municipal Primary schools. The findings of the study indicated that anaemia may well compromise physical work capacity and cognitive functions of girls within the pubertal phase of development. Further, even mild anaemic can have a deleterious impact on these characteristics. It turned out also found that this adverse impact gets especially aggravated, if both undernutrition and anaemia can be found. Cognition especially, seemed to be adversely afflicted with anaemia in, well-nourished and undernourished subjects.

Black *et al*., (2008) found that child and maternal undernutrition is responsible for approximately 3.5 million deaths in children below the age of 5 years and for 35 per cent of the disease burden in this age group. Stunting, low weight and low birth weight are found to be together responsible for 2.2 million deaths among children less than 5 years worldwide, it was reported.

Maluccio *et al*., (2009), using a longitudinal survey from rural Guatemala, found that higher intake of nutrients during early childhood has a long-term substantial impact on adult educational outcome. Glewwe and Miguel (2008) outlined theoretical and empirical evidences that points to how child health impacts educational attendance and performance. This paper examined the impact of childhood malnutrition, as measured by different anthropometric indicators, collected at three different stages of childhood, on the development of educational skills in Peru.

An assessment of brainpower and motivation was completed among children, aged 9-15 years, in severely and mildly iodine deficient communities in Uttar Pradesh, India by Tiwari *et al.*, (1996). The outcomes revealed that children through the severely iodine deficient villages learned more slowly and were less motivated to achieve. Iodine deficiency is a significant source of mental developmental problems in kids, including implications on reproductive functions and lowering of IQ levels in class-aged children (Kapil, 2007).

A meta-analysis by Bleichrodt and Born (1994) of 18 studies, over a total of 2,214 subjects, indicated that mean cognitive and psychomotor performance scores were 13.5 IQ points lacking in iodine deficient individuals. Also the condition of retarded neurological development is exacerbated through the many people within the affected child's social environment who'll also be dull, apathetic and unmotivated caused by iodine deficiency.

Delange (2001) reports that all levels of iodine deficiency (mild: iodine intake of 50-99 µg /day, moderate: 20-49 µg /day, and severe: less than 20 µg /day) affect thyroid function of the mother, neonate and mental growth of the child - the harm increases with the increase in iodine insufficiency, with overt endemic cretinism as the most severe consequence. Iodine insufficiency was found to be the cause of preventable damage to brain and mental growth.

2.4 Nutritional interventions for adolescence

2.4.1 Supplementation

Sen and Kanani (2012) studied the consequences of daily vs. intermittent iron folic acid (IFA) supplementation on haemoglobin levels and pubertal growth among primary school girls in early adolescence (9-13 years) in Vadodara. It was found that Hb levels significantly improved ($P < 0.01$) in all experimental schools (ES) compared to control schools (CS); BMI increment in ES vs. CS was significant in twice weekly IFA and daily IFA. The study concluded that twice-weekly IFA supplementation was comparable to daily IFA and once-weekly dose was inadequate to significantly improve growth.

Chakma *et al*., (2013) studied the impact of iron and folic acid supplementation among 274 tribal adolescent girls of Bajadandi block, Mandla district in Madhya Pradesh. IFA was given for 100 days. The impact study revealed that prevalence of anaemia was reduced from 94 per cent at baseline to 69 per cent after the intervention.

Ahmed *et al*., (2010) in his study on Bangladeshi Adolescent girls observed that twice-weekly multiple micronutrients (MMN) can improve micronutrient status effectively with no significant increase in Hb concentration compared with IFA supplements in non-anaemic adolescent girls. Receiving MMN supplement once-weekly was found to be less effective than MMN twice-weekly supplement in improving iron, vitamins A, riboflavin and folic acid status.

Randomized controlled trial was conducted in adolescent girls visiting "Urban Health and Training Centre" by Joshi and Gumashta (2013). The 120 anaemic adolescent girls were randomly divided into two groups – one received daily IFA supplementation and the other weekly. The mean rise in Haemoglobin after a lean period of one month in the respective groups was found almost equal.

Titaley and Dibley (2012) studied the relative contributions of antenatal iron/folic acid supplements and postnatal care in preventing neonatal mortality in Indonesia. It was found that the risk of early neonatal death was reduced by 51 per cent of mothers who took iron/folic acid supplements during pregnancy.

Deshmukh *et al.,* (2008) studied the potency of weekly supplementation of iron to manage anaemia among adolescent girls of Nashik, Maharashtra, India. The target ended up being to study the 'effectiveness' of a weekly iron-supplementation regimen among urban-slum, rural, and tribal girls of Nashik district, Maharashtra. The decline was statistically significant ($P < 0.001$) in tribal girls (48.6% from 68.9%) and among rural girls (51.6% from 62.8%). But the decline was not statistically significant among urban slum girls.

Indian Institute of Health and Family Welfare (2003) made a study in line with the study initiated earlier (2001-02) to examine the feasibility and acceptability of weekly IFA supplementation to adolescent girls, using school system as a vehicle for anaemia reduction at two randomly chosen *mandals* of Medak district, Andhra Pradesh. It was revealed that the mean haemoglobin level of paired samples at the baseline was 11.1 $\pm$ 1.1 g/dl, which increased to 12.1 $\pm$ 1.0 g/dl after 52 weeks of IFA supplementation and concomitant decrease of anaemia indicating the efficiency of weekly IFA supplementation.

Gupta and Kochar (2010) studied 54 anaemic girls of 15-18 age groups in three groups. One group was given *thandai* (a drink) along with Cofol-Z capsule (iron+folic acid); the second group received only Cofol-Z capsule and the third group was the control group. After six months, iron folic acid supplementation with *thandai* proved to be more efficacious in combating the problem of anaemia during adolescence.

Khosravi *et al*., (2010) also conducted a control-experimental study on 200 female high school girls in 14-19 age groups. One group was served 150 mg ferrous sulphate once in a week for 16 weeks and the other was the control group. The study showed that once-weekly supplementation of 150 mg ferrous sulphate significantly improved iron status.

Srinivasan and Prabhu (2004) studied the nutritional status of the social welfare hostels in Tirupati, Andhra Pradesh among school children of 5-15 age groups. The study suggested that improvement in diet, as well as treatment and prevention of infections along with iron and folic acid supplementation will definitely improve the nutritional status of the children and adolescents from under-privileged sections of the society.

Agarwal *et al*., (2003) analyzed the anaemia Prophylaxis in adolescent school girls by weekly or daily iron folate supplementation in four Government Senior Secondary Schools of North-East Delhi. The study results showed that regular weekly administration was effective and seems suitable for populations with mild to moderate anaemia.

Mathur *et al*., (2005) compared the impact of leaf concentrate and iron and folic acid supplementation on blood profile of anaemic adolescent girls. The results of the study were promising for leaf concentrate, which gave similar and comparable results on the iron status of the subjects. Both the supplements showed similar improvements.

Bhanushali *et al*., (2011) studied the iron deficiency anaemia and change in dietary behaviour among adolescent girls. Adolescents consumed iron-folate and calcium tablets on substitute days for 3 months. Results demonstrated there was an increase of 19.55 g/l haemoglobin in the gathering of adolescents who consumed IFA supplements, while haemoglobin diminished somewhat in adolescents in the control group. A considerable weight increase of 2.66 kg was additionally seen in the mediation group, though adolescents in the control group demonstrated less increase in weight.

Bilimale *et al*., (2010) explored improving adherence to oral iron supplementation during pregnancy by a controlled trial study with 140 pregnant women from a rural area of J.N. Medical College, Belgaum. Results showed that the mean rates of adherence and haemoglobin levels in observation group were higher than the control group. During the first visit, the mean haemoglobin value of study group was 7.97 gm per cent, and 7.9 gm per cent for the control group. During the 3rd visit, mean haemoglobin was 8.99 gm per cent and 8.42 gm per cent respectively. The difference in haemoglobin values during the 4th visit was statistically significant. The results demonstrated that compliance to oral iron tablet consumption was feasible by directly observing and monitoring the administration of oral iron supplementation.

Kotecha *et al*., (2009) studied the Adolescent Girls' Anaemia Control Programme by Gujarat. Programme strategy was to provide once weekly fixed day (Wednesday) supervised iron folic acid (IFA) supplements to all adolescent girls in Grade 8-12. Prevalence of anaemia was reduced by 21.5 per cent that is, from 74.7 per cent to 53.2 per cent ($P<0.05$). Further improvement in Hb was recorded among 80 per cent girls. Pre- and post-intervention also showed improvement in serum ferritin value, whereas dietary and nutritional knowledge and practices were not significantly changed among school girls.

Malagi *et al*., (2006) evaluated the National Nutritional Anaemia Control Programme in Dharwad (Karnataka). The outcome shows about 11 per cent of women in reproductive age were not registered with any of the health functionaries. The iron and folic acid tablets (IFA) were not distributed regularly by the Auxilary Nurse Midwives (ANMS) and 10 per cent subjects did not receive any tablets even once. Tablets were not regularly consumed because of side effects and blind beliefs.

Kotecha *et al*., (2004) evaluation the impact of adolescent girls' anaemia reduction programme in Vadodara District. The programme was more successful in rural locations than compared to tribal locations, but level of anaemia was controlled substantially among tribal adolescent girls.

In a study on the dangers of routine iron and folic corrosive supplementation for youthful youngsters Pasricha *et al*., (2009) endeavoured to present the link between iron-folic acid (IFA) and intestinal sickness. The study suggested routine iron and folic acid for all children under 6-60 months; (ii) in areas of India, where malaria transmission was phenomenal and access to essential medicinal services was better, routine IFA supplementation ought to proceed for all children; (iii) in zones of high intestinal sickness transmission, routine supplementation of IFA to children may be withheld, with accentuation on clinical case discovery and treatment of anaemic youngsters.

2.4.2 Fortification

Of all the strategies used to deliver additional iron to humans, food fortification has the greatest potential to improve the iron status of the largest number of people (Mannar, 2001).

Goyle and Prakash (2010) evaluated the effect of supplementation of micronutrient fortified biscuits on adolescent girls of 10-16 age groups studying in a government school in Jaipur. The intervention was with biscuits fortified with 30 mg iron, 100 µg folic acid, 600 µg Vitamin A, 40 mg Vitamin C and 150 µg Iodine. On supplementation, a three-fold increase in the percentage of adolescent girls in the 'normal' category of anaemia.

Goyle (2012) studied the effect anaemic reduction by supplying biscuits with and without nutrients. He found supplementation with biscuits resulted in significant weight gains of 1.85 kg and 2.00 kg in the control and experimental groups respectively.

Kumar *et al*., (2009) conducted a control and experimental group study among tribal children of 5-18 years age group. The study showed a significant improvement in all the biochemical measurements and memory tests in the experimental group when compared with the control group. It was found that the multiple micronutrients from the multiple micronutrient-fortified cooking salt were absorbed in the children and helped in combating micronutrient deficiencies.

Hyder *et al*., (2007) studied the effect of a multiple-micronutrient-fortified beverage on haemoglobin concentrations, micronutrient status and growth among adolescent girls in rural Bangladesh using control experiment method. The results confirmed that fortified beverage increased the Hb and serum ferritin and retinol concentrations at 6 ml ($P < 0.01$). Adolescent girls in the non-fortified beverage group were more likely to suffer from anaemia, iron deficiency and low serum retinol concentrations.

Assunção and Santos (2007) conducted a systematic review to identify studies assessing the effect of food fortification with iron on childhood anaemia. Out of 21 studies reviewed, only one failed to report a positive, favourable effect of iron fortification.

Seal *et al*., (2008) assessed changes in the iron and vitamin A status of the population of Nangweshi refugee camp associated with the introduction of maize meal fortification. The results showed that the introduction of fortified maize meal lead to a decrease in anaemia in children and a decrease in vitamin A deficiency in adolescents.

Bovell-Benjamin *et al.*, (2000) also learnt maize fortification. The radioisotope study showed that iron absorption by ferrous bisglycinate was six-fold more than absorption from ferric sulphate, when most of these iron compounds ended up added as fortificants to total maize porridge. Greater absorption of ferrous bisglycinate iron, as compared to iron from ferric sulphate of Feric ethylenediaminetetraacetic acid (FeEDTA) included with maize or white-coloured wheat flour has been reported by Layrisse *et al.*, (2000).

Walter *et al*., (1993) found that vitamin C is probably most effective for improving the absorption of fortificant iron added to foods. It was found that the addition of vitamin C to iron-fortified dry milk in Chile reduced anaemia in preschool children more than the milk fortified with iron alone.

In an experiment in Guatemala, Feric sodium ethylenediaminetetraacetic acid (NaFeEDTA) was added to sugar at a concentration of 1 g/kg. Average sugar consumption was 40 g/day. On an average, it was found that iron intake increased by more than 3 mg/day (Viteri *et al.*, 1995).

Hallberg *et al*., (1978) proved that the addition of meat or fish to a meal provides not only more absorbable iron, but also increases the absorption of non-haem iron including fortificant iron. The study found that when fish was added to a plant-based, South-East Asian food that had been invigorated with 5 mg press, the measure of iron assimilated from the fortification was multiplied.

Hurrell *et al*. (1989) found that ferrous furnarate, ferrous succinate and small particle size iron are suitable iron fortificants for infant cereals. Walter *et al*. (1993) tested with milk powder fortified to contain 15 mg/L ferrous sulphate when reconstituted. The prevalence of anaemia was found to fall from 27 to 10 per cent among children aged 3-15 months.

Child In Need Institute (CINI, 2005), directed a pilot venture gauge review in Howrah and in 24 North Parganas to battle iron deficiency and Vitamin A lack (VAD) in three diverse target aggregates specifically, pregnant and lactating ladies, preschool kids and juvenile young ladies. Invigorated confections were conveyed. There was no huge change in mean haemoglobin of pregnant and lactating women. The study suggested that the government can consider providing fortified candies to beneficiaries of ICDS programme and children covered under mid-day meal scheme as add on to the food distributed.

2.4.3 Nutrition education

Contento (2008) identified three essential components to nutrition education: (1) A motivational part, where the objective is to expand mindfulness and improve inspiration by tending to convictions, mentality through compelling communication systems. (2) An activity part, where the objective is to encourage individuals' capacity to make a move through objective setting and cognitive regulation toward oneself abilities. (3) An environmental component, where nutrition educators work with policymakers and others to promote environmental supports for action.

Fox *et al*., (2007) in their nutrition education research brief found positive association between intervention intensity and dietary behaviour change.

Contento *et al*., (2002) evaluated the measures used in nutrition education intervention. Physiologic parameters were used in about 33 per cent of behaviourally focused interventions with school-aged children and adults. Major implications found were that considerable preliminary work needs to be done before any intervention study to develop and test evaluation instruments.

Hindin *et al*., (2004) carried out a study to evaluate whether a media literacy nutrition education curriculum about the effects of television advertising on children's food choices influenced the behaviour, attitudes and knowledge of head start parents. Results suggested that a media literacy nutrition education curriculum can be easily conducted by dieticians. The media literacy nutrition education intervention curriculum had significant effects in terms of head start parents.

To survey the effect of a school-based nutrition education intervention aimed at increasing the fruits and vegetable consumption, Anderson *et al*., (2005) carried out an experimental and control group comparison. The results showed a significant increase in knowledge about fruits and vegetables and fruit intake for intervention group.

Warren *et al.,* (2003) assessed a pilot school programme aimed at the prevention of obesity in children in UK. The outcomes demonstrated enhancements in nutrition knowledge in all children post-intervention. Overall, fruit and vegetable intake increased significantly; no significant changes in rates of overweight and obesity.

Haldar *et al*., (2012) carried out a quasi-experimental intervention study in two primary schools of Burdwan District. The study proved that usual health-nutrition education by school teachers was ineffective unless it is actively imparted by reoriented, motivated teachers and periodically supported by health personnel.

In a study on the role of nutrition education in enhancing the nutritional knowledge among adolescent girls Gupta and Kochar (2009) surmised that there was noteworthy change in the nutritional awareness of the subjects after nutrition education.

Change in health-nutrition behaviour among primary school students by health-nutrition education was also revealed from other studies (Poh *et al*., 2009; Friel *et al*., 1999; Ruzita *et al*., 2007).

To establish the result of a school-based intervention to support healthful nutrition and physical activity on disordered weight-control behaviours, Austin (2007) conducted a study among adolescent girls and boys. The analysis indicated that disordered weight-control behaviours were lessened by two-thirds compared with adolescent girls in control schools. No intervention effect was observed in boys.

Kaur *et al*., (2011) evaluated the effect of nutrition education in lessening iron deficiency anaemia in 50 medical girl students of 17-19 years age group in Government Medical College, Amritsar. The study concluded that nutrition education is one of the appropriate, effective and sustainable approaches to combat iron deficiency anaemia.

Padhy *et al.,* (2013) assess the impact of planned teaching programme on family life education among 144 adolescent girls of a high school in Ankuli, Berhampur. It was found that average nutrition score increased from 39.24 per cent to 88.85 per cent before and after PTP (Planned teaching programme) respectively.

III. METHODOLOGY

The methodology of the study entitled **"NUTRITIONAL STATUS OF ADOLESCENT GIRLS (12-19 years) AND IMPACT OF INTERVENTION PROGRAMMES"** is detailed under the following headings.

3.1 Selection of area
3.2 Selection of subjects
3.3 Tools and techniques
- ***3.3.1 Interview schedule***
- ***3.3.2 Assessment of nutritional status***
  - *3.3.2.1. Anthropometric assessment*
    - (a) Height
    - (b) Body weight
    - (c) Body Mass Index (BMI)
    - (d) Waist hip ratio
  - *3.3.2.2 Biochemical assessment*
    - (a) Haemoglobin
    - (b) Serum iron
    - (c) Serum folic acid
    - (d) Vitamin B_{12}
  - *3.3.2.3 Assessment of dietary pattern*
    - (a) 24-hour recall
    - (b) Food frequency questionnaire
- ***3.3.3 Nutrition education programme***
- ***3.3.4 Assessment of nutritional knowledge and practices***
- ***3.3.5 Intervention methods***
  - (a) Supplementation
  - (b) Fortification
  - (c) Diet counselling

3.4 Impact of interventions on haematological parameters
3.5 Statistical analysis

3.1 Selection of area

The study was conducted in Kottayam district, known as the "Land of letters", is located in south-central Kerala and has a population of 357,533 according to the 2011 census. Also a pioneering centre of modern education in Kerala, Kottayam became India's first city to achieve 100 per cent literacy in 1989. It is the major centre of education in Kerala where the education of girls has much importance. So Kottayam Taluk area was selected for the study. Moreover scarcity of nutrition epidemiological data base for this area was also a major factor in the selection of the present study locale.

3.2 Selection of subjects

Adolescence is a period of marked changes, a period during which the individual rapidly undergoing a series of sequential physical and mental changes that transform a small child into a young adult (Story *et al.,* 2002). The nutritional status of adolescent girls, who are the future mothers, not only influences her health, but also determines the health of the future generations.

WHO identifies adolescence as the period in human growth and development that occurs after childhood and before adulthood, from ages 10-19 years; it is a time of intense physical, psychological and cognitive development (WHO, 2015[b]). Crider *et al.,* (1983) state that "adolescence is usually defined as the period that begins with the onset of puberty and ends somewhere around age eighteen or nineteen".

According to Agarwal and Agarwal (1992), the age of menarche in urban India was 12.6 years. There is also a general observation that age of menarche was 15-16 years in rural girls (Khadilkar, 2006). Based on these evidences, the criterion age group for selection of adolescent girls was determined as 12-19 years.

Sampling method

Multistage random sampling was the technique adopted for sample selection. Multistage sampling refers to sampling carried out in stages using smaller and smaller sampling units at each stage (Patterson, 2010). Schools and colleges of the Kottayam Taluk were selected as a first stage unit. As the age group of the study subjects ranged between 12 to 19 years, all Colleges, UP schools, High schools and Higher secondary schools in Kottayam Taluk were listed (Appendix I). Willingness of the institution authorities and the students to participate in the study was the criteria for the selection of participant institutions. Accordingly, informed consent was sought from the institution heads of all the educational institutions in the study area and the researcher was able to obtain the consent only from two schools and two colleges of Kottayam Taluk. Sample size was determined by the following formula (Gupta, 2003) using the proportion of problems, based on UNICEF (2011[b]) survey:

$$n > \frac{Z^2 \times pq}{d^2}$$

Where:

n = required sample size

Z = confidence coefficient = 1.96 (95% confidence)

p = proportion of selected problem in the total population 56 per cent or .56 (based on UNICEF, 2011[b] survey)

q = 1-*p* = 1 – .56 = .44 i.e. 44%

d = allowable difference between estimated and true value in the population = (4.5%)

$$n = \frac{1.96^2 \times 56 \times 44}{4.5^2} = 468$$

The calculated sample size, at 95 per cent confidence and 4.5 per cent tolerance and 56 per cent proportion, based on the UNICEF 2011 survey, was 468. Allowing lenience for withdrawal/discontinuance of respondents during the study, and to improve the accuracy, the sample size was determined as 500 adolescent girls between the ages 12 to 19 years, at the time of survey. These 500 adolescent girls were selected randomly by lottery method, from the aforesaid four educational institutions. Number of girls from each of the four institutions, for the first stage of selection was determined by the same ratio of required No. of respondents to the total number of adolescent girls in the four institutions:

$$Ratio = \frac{500}{3278} = 0.1525$$

Out of the 500 adolescent girls selected a sub-sample of 202 subjects, in the late adolescent age group (17-19 years), who were willing to participate and permitted by their parents to take blood sample, were taken for screening of anaemia. Blood samples were collected with the help of trained lab technicians. Late adolescence, being close to the reproductive phase of a woman's life, is very significant. Nutritional status during late adolescence thus requires immediate attention and appropriate interventions. In addition, 150 adolescent girls were selected for detailed dietary assessment, based on their willingness to participate in 24-hour recall and to respond to food frequency questionnaire.

Haemoglobin analysis revealed that 115 adolescent girls were anaemic. Those who had mild (10-11.9 g/dl) and moderate (7-9.9 g/dl) anaemia, and who were in the late adolescent age group, were purposively selected for "intervention" study. Consumption of nutritional supplements, anticonvulsant drugs and other medicines and gynaecological problems were the exclusion criteria considered for selecting subjects for interventions. Planning and execution of the interventions were done under the guidance and supervision of a qualified medical practitioner from the government sector.

“Supplementation”, “fortification”, “diet-counselling” were the intervention methods chosen for the study. Hence, 100 anaemic adolescent girls were divided into four groups, with 25 adolescent girls in each group: (i) Supplementation group, (ii) Fortification group, (iii) Counselling group and (iv) Control group. The group division was made by listing down the names of the 100 final sample girls, school-wise, and assigning serial numbers from 1 to 4 repeatedly. All those who were assigned No.1 formed the “supplementation” group; those who were assigned No.2 formed the “fortification” group; No.3 formed the “counselling” group and those who were assigned No.4 formed the “control” group.

3.3 Tools and techniques

Tools and techniques employ distinctive ways of describing and quantifying the data. “Each is particularly appropriate for certain sources of data, yielding information of the kind and in the form that can be most effectively used” (Best and Khan, 1999). The following tools and techniques were employed in this study:

3.3.1 Interview schedule

The interview schedule, as given by Thanulingam (2000) is a proforma containing a set of questions and is very useful in gathering information. The information received from an interview schedule was more reliable because the interviewer can clear up the doubts of informants and thus also accuracy of the statements could be checked by supplementary questions wherever necessary. Polit and Hungler (2001) state that interviews allow for a much greater richness of data compared to questionnaire. Direct interview method was adopted for the data collection. This method is reported to be a suitable way to proceed systematically and quickly to collect information (Kothari, 2001). In this method there is face-to-face interchange between interviewer and respondent before eliciting information (Kothari, 2003). The researcher explained each item of the schedule and the responses were recorded accordingly.

A semi-structured interview schedule was formulated with a view to collect data from the respondents on socio-economic background, anthropometric details, details regarding general health, practice of taking nutritional supplements, dietary pattern, intrinsic and extrinsic factors influencing nutrient intake and awareness about nutrition in adolescence. The same was pre tested among 20 adolescent girls, not involved in the study, which were later excluded from the actual study. After the pre test appropriate changes were made in the survey instrument (Appendix II.)

3.3.2 Assessment of nutritional status

Evaluation of nutritional status of a community is one of the initial phases of the plan of any public health strategy to battle malnutrition. The essential point of such an evaluation is to determine the type, magnitude and distribution of malnutrition in distinctive geographical areas, to identify the at-danger groups, monitor changes in the extent of malnutrition, select beneficiaries for intervention programmes and evaluate the impact of intervention (Rao and Vijayarakhavan, 1996). An understanding of nutrient gaps would help in planning nutritious diets to overcome nutrition-related morbidities and thus promote health of the people (Bamji *et al.*, 2010). Nutritional anthropometry, biochemical tests and dietary assessment were the methods employed in the present study to assess the nutritional status of adolescent girls.

3.3.2.1 Anthropometric assessment

"Anthropometry is measurement of body at various ages and levels of nutritional status. It is based on the concept that an appropriate measurement should reflect morphological variation occurring due to a significant functional physiological change" (Rao and Vijayaraghavan, 2003). Anthropometric survey was conducted among 500 adolescent girls between 12-19 years of age. In order to assess the nutritional status of subjects, their (a) Height, (b) Body weight (c) BMI and (d) Waist hip ratio were measured and recorded. And these data were compared with National Center for Health Statistics (NCHS) standards, National Health and Nutrition Examination Survey-I (NHANES-I) quoted by National Institute of Nutrition (NIN, 2005) and ICMR standards (1989) given in Appendix III, IV and V.

(a) Height

A vertical tape settled perpendicular to the ground on the wall was utilized as the scale to gauge the height of the respondents. This tape was non-stretchable. It was fixed carefully without any folds or tilting to any side. The subject was made to stand erect, looking straight on the platform with heels together and toes apart, without shoes. Height was read to the nearest of 0.5 cm. An average of three measurements was taken as the final measurement (Jelliffe and Jelliffe, 1991).

(b) Body weight

Weight of the subjects was measured using a bathroom balance. Checks on the scale were made routinely before recording the weight of each sample and the pointer was adjusted to zero using the screw provided. The respondents were asked to stand straight, bare-footed on the weighing balance, looking straight, while the measurement was read. The weight was recorded to the nearest 0.25 kg. Each subjects' weight was taken thrice and the average was taken as the final measurement.

(c) Body Mass Index (BMI)

Body Mass Index of the 500 adolescent girls of 12-19 years were calculated using the following equation:

$$BMI = \frac{Weight\ in\ Kg}{Height\ in\ m^2}$$

Each result was compared with BMI age/sex centiles given by NHANES I (NIN, 2005) (Appendix IV).

(d) Waist hip ratio

Waist hip ratio is used as a tool to assess obesity. The ratio above the cut-off value has been accepted as a method to identify abdominal fat accumulation (Vijayalakshmi *et al*., 2003). Waist and hip circumference of the adolescent girls were measured and the ratio was calculated using the formula given below:

$$Waist\ to\ hip\ ratio = \frac{Waist\ circumference\ (cm)}{Hip\ circumference\ (cm)}$$

3.3.2.2. Biochemical assessment

"In the development of any deficiency disease, biochemical changes can be expected to occur prior to clinical manifestations. Therefore, biochemical tests which can be conducted on easily accessible body fluids such as blood and urine can help to diagnose disease at the sub-clinical stage" (Davidson, 1990). Hence biochemical parameters were studied among a sub-sample of 202 subjects. The blood samples of the subjects were collected with the help of trained lab technicians. The biochemical parameters assessed were (a) Haemoglobin (Cyanmethymoglobin method), (b) Serum iron (Spectrophotometry) (c) Serum folic acid (Microbiological assay) and (d) Vitamin B_{12} (Microbiological assay).

(a) Haemoglobin

Haemoglobin evaluations are utilized generally to screen people for anaemia, to draw inferences about the iron status of populations, and to assess reactions to nutritional interventions (Morris *et al*., 1999). Haemoglobin levels of 202 subjects were analysed for assessing the prevalence of anaemia among the subjects. Cyanmethymoglobin method suggested by International Nutritional Anaemia Consultative Group (INACG, 1985) was chosen for the estimation (Appendix VI). Haemoglobin levels of the subjects were compared with anaemia classification given by WHO (1989).

(b) Serum iron

Iron (Fe) is a constituent of red blood cells and the muscles that assist in the transportation of oxygen all through the body. The World Health Organization considers iron deficiency, the number one nutritional disorder in the world. It has been expressed that two-third of children and women of childbearing age in developing countries suffer from iron deficiency and one-third suffering from severe deficiency and anaemia. The significant reason for anaemia is low dietary iron admission (Rao, 2001). Serum iron levels reflect the amount of iron in the blood. Serum iron estimation was done for a sub-sample of 115 adolescent girls with low haemoglobin values (Appendix VII).

(c) Serum folic acid

Folic acid is a B vitamin and is needed for the formation and growth of red blood cells. Serum folate is considered an indicator of recent folate intake. Low values of serum folate within an individual throughout the span of a month are indicative of low folate status or folate depletion (Gibson, 2005). Procedure of microbiological assay of folic acid is appended in Appendix VIII.

(d) Vitamin B_{12}

Vitamin B_{12} is vital for the formation of red blood cells, as well as for the proper functioning and health of nerve tissue. National Institute of Child Health and Human Development (NICHD, 2005) reports, Vitamin B_{12} deficiency is more prevalent in disadvantaged environments, which have adverse effects on children and adolescents. Vitamin B_{12} analysis was done by microbiological assay and the method followed is appended in Appendix IX.

3.3.2.3 Assessment of dietary pattern

Precise information on food consumption pattern of people, through application of appropriate methodology is often needed not only for assessing the nutritional status of people, but also for elucidating the relationship of nutrient intakes with deficiency as well as degenerative diseases (Khader *et al*., 2006). In order to assess the dietary pattern of adolescent girls, their meal pattern, dieting and meal skipping practices, individual and environmental factors influencing diet patterns and snacking pattern were recorded. Twenty-four-hour recall and food frequency questionnaire were administered among a sub-sample of 150 adolescent girls (17-19 years) to study the frequency of consumption of nutritious foods and actual nutrient consumption.

(a) 24-hour recall

Twenty-four-hour recall on a large group of participants is an efficient way to measure the average dietary intake of a group (Patterson and Pietinen, 2004; Willet *et al.*, 1999; Thimmayamma, 1987). According to Garrow (2000), in diet recall, the respondent is asked to recall the actual food and drink consumed on specific days, usually during the immediate past 24 hours (24-hour recall). The schedule used is given in Appendix X.

Twenty four hour dietary recall was done among a sub-sample of 150 adolescent girls (17-19 years). The subjects were asked to recall a day's food intake in terms of simple household measures. During the interview, food models and reference standard measuring cups and spoons were shown to the subjects, so that they could give the portion size accurately. Values of the household measures were converted to raw equivalents and the nutrient intake was calculated using the food composition table. The actual food and nutrient intake of the subjects were compared with ICMR (2004) RDA, which was prevailing during the study period.

(b) Food frequency questionnaire

Garrow (2000) stated that in food frequency questionnaire, the respondent is presented with a list of foods and is required to say how often each item is consumed, in broad terms as 'x' times per day/per week/per month etc. Foods listed are usually chosen for the specific purpose of a study and may not assess total diet. The food frequency questionnaire may be interviewer-administered or self completed.

"Diet history method is used for obtaining qualitative details of diet to study patterns of food consumption at household or industrial level. The procedure includes assessment of the frequency of consumption of different foods daily, or number of times in a week or fortnight or occasionally. This method has been used to study (i) meal pattern (ii) dietary habits (iii) people's preferences and avoidance during physio-pathological conditions like pregnancy, lactation, sickness etc." (Thimmayamma, 1987).

For this study, the food frequency questionnaire was administered to a sub-sample of 150 adolescent girls which included common nutritious foods, especially iron and folic acid rich items and is attached in Appendix XI. The subjects were asked to mark the frequency of consumption of each item on the six-grade scale of consumption.

3.3.3 Nutrition Education Programme

American Dietetic Association (ADA, 2011) defines nutrition education as instruction or training intended to lead to acquired nutrition-related knowledge and/or nutrition-related skills and be provided in individual. According to Gil (2010), nutrition education is a set of planned educational activities targeted at certain population groups and aimed at acquiring healthy nutrition behaviours. This could be possible through diverse channels, although, in general, this occurs within schools targeting young children, since food habits in early stages of life are said to determine practices and inclination in adulthood (Eat well, 2011).

As the influence of electronic media is increasing among adolescents, a tool for nutrition education was prepared using a power point presentation. Information on meaning, definition, classification and importance of adolescence, importance of nutrition in adolescence, balanced diet, nutrient rich sources, common deficiency diseases among adolescents, its causes, consequences and prevention and health tips for adolescents were collected and compiled to educate the 500 adolescent girls under study in different educational institutions with the help of computer aided teaching tool formulated (Appendix XII). A set of questions regarding basic nutrition was used to assess the nutritional knowledge of the adolescent girls, prior to the education programme (Appendix XIII). The results obtained showed that there were lacunae in general nutrition knowledge; therefore more emphasis was given to those low-scored topics. A discussion session was also conducted after the education programme and a leaflet was distributed among the subjects for future reference (Appendix XIV). The evaluation of the nutritional knowledge score before and after the nutrition education programme provided the effectiveness of the same among the subjects. Effectiveness of nutrition education is the degree with which it helps individuals to build food habits and practices that are consistent with the nutritional needs of the body and adapted to the cultural pattern and food resources of the region in which they live (Bosley, 2011). Computer aided teaching tool designed for nutrition education was distributed to educational institutions and health care centers for awareness promotion programmes.

3.3.4 Assessment of nutritional knowledge and practices

A well-structured questionnaire was developed which consisted of questions related to knowledge on nutrition and various dietary practices, which was administered to the subjects before and after one week of the education programme and scored (Appendix XV).

3.3.5 Intervention methods

"Nutrition intervention is a purposely planned set of actions designed with the intent of changing nutrition-related behaviour, risk factor, environmental conditions or aspect of health status for an individual or target group or population at large"(Lacey, 2003).

Accordingly, (a) Supplementation, (b) Fortification and (c) Diet counselling were the intervention methods chosen for the present study. Intervention programmes were implemented for a period of three months.

(a) Supplementation

A 'dietary supplement' can be defined as a product ingested orally that contains a 'dietary ingredient' intended to supplement the eating regimen. 'Dietary ingredients' may include vitamins, minerals, herbs or other botanicals, amino acids, and other substances (e.g., enzymes, organ tissues, glandular and metabolites), that are sold as either extracts or concentrates, in either tablet, capsules, soft gel, liquid, powder, or bar form (Kreider *et al*., 2010).

Supplementation was carried out among the sample subjects for a period of three months. Twenty five anaemic adolescent girls of supplementation group received the synthetic supplement (Livogen-Cap-tab), a micronutrient tablet containing ferrous fumerate-152 mg and folic acid-1500 mcg and they received one tablet per day. One Albendazole, the anti-worm drug, was also provided to the study subjects of supplementation group. Care was taken to see that the adolescent girls consumed the tablets regularly, even on holidays under the supervision of the investigator. The impact of supplementation was studied in terms of biochemical analysis. Those who could participate regularly alone were included as subjects in the final evaluation.

(b) Fortification

Food fortification is the process by which nutrient is added to commonly eaten foods to improve the quality of the diet. "Fortification is the addition of nutrients at levels higher than those found in original or in comparable foods" (Vaclavik and Christian, 2013). It has been regularly utilized as a strategy to control micronutrient deficiencies (Madukwe and Eme, 2012).

Anaemic adolescent girls (N=25) in the second intervention group received 100g per day of iron-folic acid rich food supplement in the form of biscuits weighing 20 grams each, for a period of three months. These biscuits formed a part of their daily diet and were advised to take in mid-morning and in the mid-evening. Care was taken to see that the adolescent girls consumed five of those Iron-Folic acid rich biscuits regularly, even on holidays under the supervision of the investigator.

In Kerala, Supplyco is providing wheat flour fortified with 0.45 mg of folic acid and 12.6 mg of iron per 300 gm flour which was used as a main ingredient for the recipe. Folic acid rich ingredients like gingelly seeds, egg and peanut butter were also added to the recipe and the method of preparation is given in Appendix XVI. To avoid monotony flavour of the biscuit was regularly changed to orange, vanilla and butter. As folic acid is a heat labile vitamin, actual content was tested after baking process to find out percentage of baking loss (Appendix XVII). The formulated biscuit provided 12.9 mg of iron and 50 µg of folic acid in their daily diet. The nutritive value of the formulated biscuit is presented in table 54. Its sensory evaluation and shelf-life was evaluated as follows.

Plate 1- Iron–folic acid rich biscuits

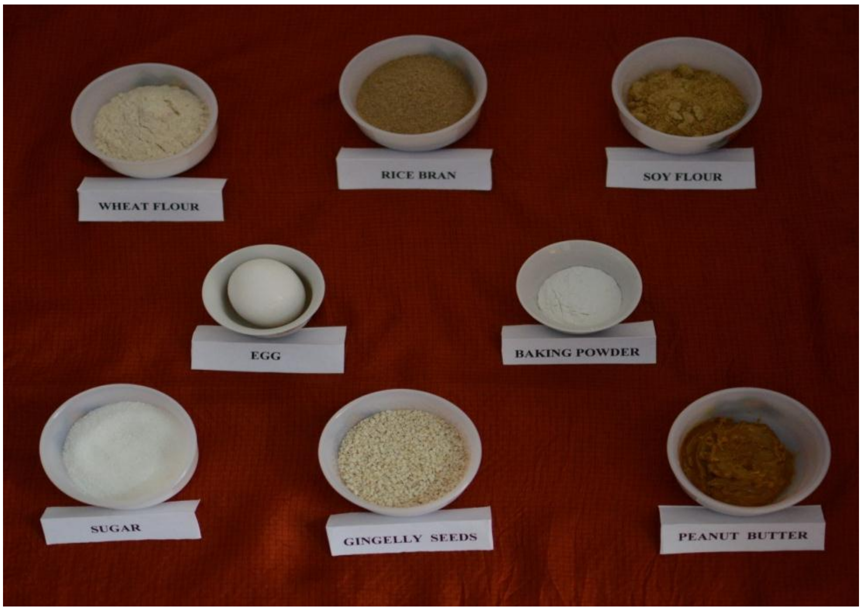


Plate 2- Ingredients of iron–folic acid rich biscuit

(i) Sensory evaluation

"When quality of a food product is assessed by means of human sensory organs, the evaluation is said to be sensory or subjective or organoleptic" (Srilakshmi, 2003). The acceptability on the basis of organoleptic parameters such as appearance, flavour, taste, colour, consistency was evaluated by selected panel members using the scoring procedure (Appendix XVIII).

(ii) Shelf-life quality

The shelf-life of a food can be defined as the time period within which the food is safe to consume and/or has an acceptable quality to consumers (Fu and Labuza, 1997). In order to assess the shelf-life quality of the formulated biscuits, Moisture (%), Total microbial count (cell/g at 37^0C), Reducing sugar (%**),** Peroxide value ($mEqO_2$/kg), Total ash (%) and Acid insoluble ash (%) tests were done. Procedures of these tests are given in Appendix XIX, XX, XXI, XXII, XXIII and XXIV respectively.

The effectiveness of the supplementation of Iron-folic acid rich biscuits among the anaemic adolescent girls were evaluated by the blood analysis.

(c) Diet counselling

Nutrition counselling is defined as a process by which a health professional with special training in nutrition helps people make healthy food choices and form healthy eating habits. North Carolina Board of Dietetics/Nutrition (NCBDN, 2010) defines nutrition counselling as the advice and assistance provided by licensed dieticians/nutritionists to individuals or groups on nutrition intake by integrating information from the nutrition assessment with information on food and other sources of nutrient and meal preparation, consistent with cultural background, socio-economic status and therapeutic needs.

The sub samples (N=25) selected for dietary counselling underwent a detailed individual diet counselling. Monthly follow up of the diet counselling were also given to the subjects during the three-month intervention period. A dietary counselling tool was developed to distribute as handouts for the subjects' easy reference and it is presented in Appendix XXV. By considering individual food preferences, meal timings and method or form of preparation preferred, food allergy etc., a diet chart was prepared. As the selected subjects were anaemic, emphasis was given to iron and folic acid rich foods in their daily diet.

3.4 Impact of interventions on haematological parameters

Haemoglobin, serum iron, serum folic acid and vitamin B_{12} analysis done prior to the interventions revealed that vitamin B_{12} deficiency was not existed among the subjects. This may be because of the adequate intake of non-vegetarian foods in daily diet. Therefore the study of impact of intervention methods on the haematological parameters was limited to the initial and final analysis of haemoglobin, serum iron and serum folic acid levels.

3.5 Statistical analysis

The model of data analysis was based on that of Huberman and Miles (1994) which has three main components. These are: (i) data reduction, (ii) data displays and (iii) drawing conclusions. The collected data were coded appropriately and were entered into a computer. Coding was the principal feature of the analytical methods, what Berg refers to as 'category development' (Berg, 1998), and Neuman calls 'concept formation' (Neuman, 2000). The statistical software SPSS version 17 was used for the data analysis. Consolidated tables, graphs and diagrams were prepared and presented in chapter IV. Appropriate statistical tools like frequency and percentage, Chi-square, *t*-test, Paired samples t-test, One-way analysis of variance and Pearson correlation were used to depict the results.

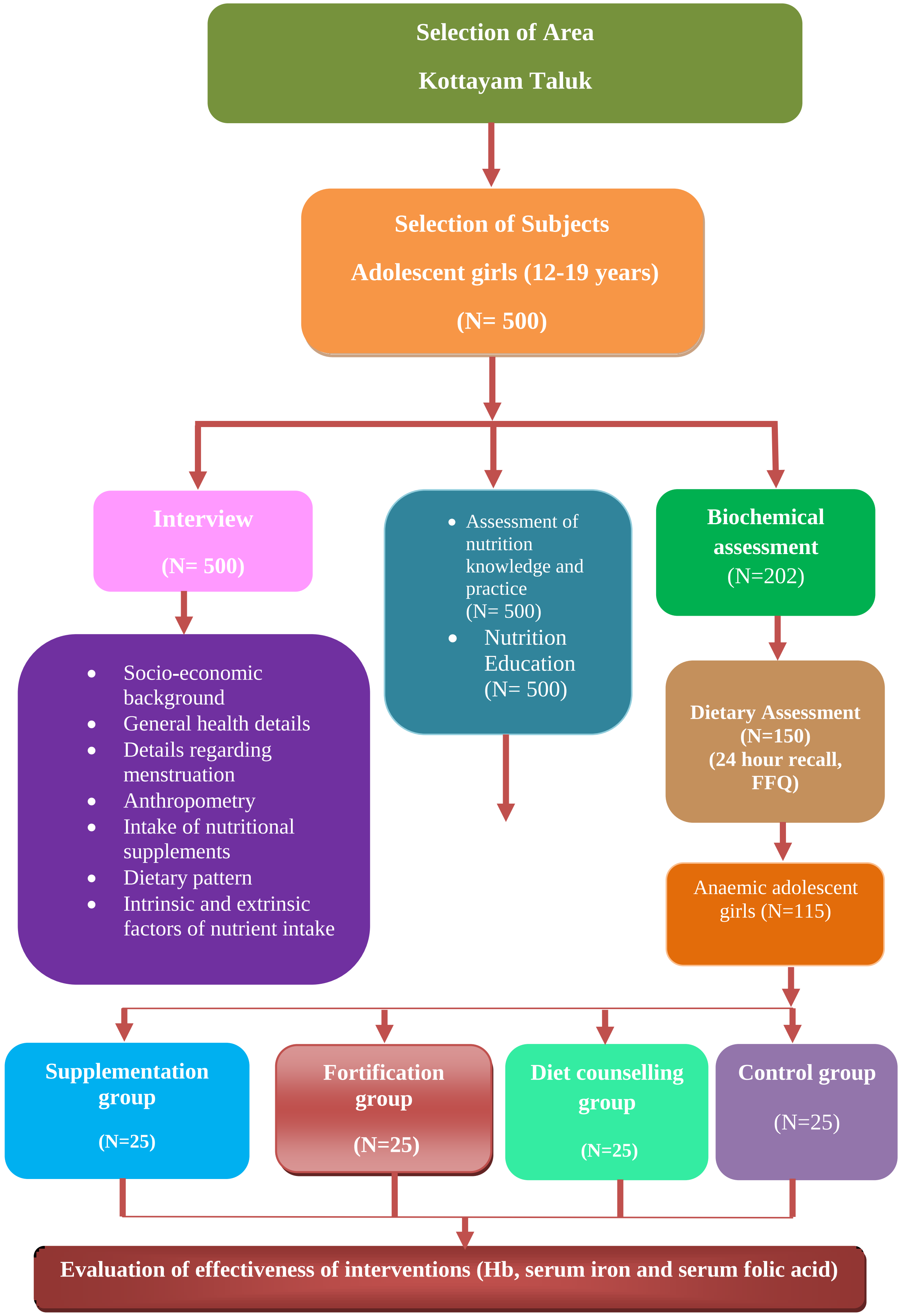


Figure 1- Research design

IV. RESULTS AND DISCUSSION

The results of the study entitled **"NUTRITIONAL STATUS OF ADOLESCENT GIRLS (12-19 years) AND IMPACT OF INTERVENTION PROGRAMMES"** are discussed under the following heads.

4.1 Socio-economic background of the subjects
4.2 General health details of adolescent girls
- **4.2.1 Intestinal problems**
- **4.2.2 Stress among adolescent girls**
- **4.2.3 Consumption of dietary supplements and medicines**

4.3 Details on menstruation
- **4.3.1 Menarcheal status of adolescent girls**
- **4.3.2 Commonly occurring signs and symptoms of menstruation**
- **4.3.3 Effect of menstrual problems on daily activities**

4.4 Anthropometric details of adolescent girls
- **4.4.1 Height, body weight and BMI of adolescent girls**
- **4.4.2 Comparison of mean height of adolescent girls with NCHS standards**
- **4.4.3 Comparison of mean body weight of adolescent girls with NCHS standards**
- **4.4.4 Comparison of mean height of adolescent girls with ICMR standards**
- **4.4.5 Comparison of mean body weight of adolescent girls with ICMR standards**
- **4.4.6 Classification of adolescent girls based on Body Mass Index (BMI)**
- **4.4.7 Waist hip ratio of adolescent girls**

4.5 Nutrition Education
- **4.5.1 Nutritional knowledge of adolescent girls**
- **4.5.2 Common misconceptions and beliefs among adolescent girls**
- **4.5.3 Content of the computer aided teaching tool**
- **4.5.4 Effectiveness of nutrition education programme**
- **4.5.5 Attributes of knowledge of adolescent girls before and after nutrition education programme**
- **4.5.6 Attributes of practices of adolescent girls before and after nutrition education programme**

4.6 Biochemical parameters
- **4.6.1 Categorization of subjects based on haemoglobin levels**
- **4.6.2 Symptoms of anaemia**
- **4.6.3 Haemoglobin, serum iron, serum folic acid and vitamin B_{12} levels of adolescent girls**

4.7 Dietary pattern of adolescent girls
- **4.7.1 Meal pattern**
- **4.7.2 Dieting and meal-skipping pattern of adolescent girls**

4.11.3.3 Effect of diet counselling on serum folic acid levels

4.12 Comparison of impact of different interventions on haematological parameters

4.12.1Comparison of impact of different interventions on haemoglobin levels

4.12.2 Comparison of impact of different interventions on serum iron levels

4.12.3 Comparison of impact of different interventions on serum folic acid levels

4.1 Socio-economic background of the subjects

The background information of the subjects pertaining to their age, type of family, ordinal position, family income, religion and mothers' educational qualification is discussed in Table.1.

Table 1

Socio-economic background of the subjects

(N=500)

Particulars	Number	Per cent
Age Category		
Early adolescence (≤16 years)	300	60
Late adolescence (17-19 years)	200	40
Type of family		
Joint family	108	21.6
Nuclear family	392	78.4
Birth order		
First	281	56.2
Second	180	36.0
Third and later-born	39	7.8
Family income*		
Economically weaker section (EWS) (< Rs.3,300)	98	19.6
Low income group (LIG) (Rs.3,301-7,300)	197	39.4
Middle income group (MIG) (Rs.7,301-14,500)	123	24.6
High income group (HIG) (> Rs.14,500)	82	16.4
Religion		
Hindu	259	51.8

Particulars	Number	Per cent
Christian	173	34.6
Muslim	68	13.6
Mother's education		
Up to 10th	30	6.0
10th Passed	169	33.8
12th Passed	209	41.8
Graduation and above	92	18.4

*Housing and Urban Development Corporation Ltd (HUDCO, 2007)

It was observed that among the 500 adolescent girls selected, majority (60%) belonged to early adolescent period; age ranged from 12 to 16 years. The percentage of girls in the late adolescence period was 40 in the age group of 17 to 19 years. Majority (78.4%) of them were from nuclear families. Only 21.6 per cent of adolescent girls were from joint families.

The distribution of ordinal statuses of the respondents showed that the highest percentage (56.2%) of adolescent girls was first-born. Next to this were second-born ones (36%). The least percentage (7.8%) was found in the case of third born girls and the ones born thereafter. According to HUDCO (2007), economic statuses of the subjects were grouped into four categories. Most of the subjects belonged to low income group (39.4%) and middle income group (24.6%). Economically weaker section constituted 19.6 per cent of the total respondents. Only 16.4 per cent were from high income families as they had a monthly income >Rs.14,500.

The religious distribution of respondents was that half (51.8%) of the subjects were Hindus, whereas Christians and Muslims constituted 34.6 per cent and 13.6 per cent respectively. It is remarkable that 94% of the mothers of adolescent girls had an appreciable educational status starting from matriculation to post graduation. Among them, a majority (41.8%) of the subjects had passed higher secondary levels and possessed professional qualifications too. Only 6 per cent of the mothers had educational status below matriculation.

4.2 General health details of adolescent girls

General details on the health of adolescent girls include intestinal problems, other health problems, and intake of dietary supplements and medicines.

4.2.1 Intestinal problems

Various intestinal problems experienced by the adolescent girls were depicted below.

Table 2

Intestinal problems

(N=500)

Health problems	Number	Per cent*
Intestinal problems		
History of worm infestation	236	47.2
Acidity and peptic ulcer	29	5.8
Food allergy	7	1.4
Gastritis	1	0.2
Appendicitis	5	1
Piles	2	0.4
ENT problems		
Allergy and asthma	26	5.2
Migraine and sinusitis	19	3.8
Tonsillitis/Fever/infection	6	1.2
Hypothyroidism and goiter	2	0.4
Heart problems	2	0.4
Others		
PCOD (Polycystic Ovarian Disease)	2	0.4

Health problems	Number	Per cent*
Urinary calculi	1	0.2
Skin diseases	1	0.2
Muscle pain	1	0.2

*Multiple response

From the above table it can be noted that the worm infestation was the major intestinal problem experienced by majority (47.2%) of the subjects followed by acidity and peptic ulcer (5.8%). Heartburn, nausea and other symptoms of peptic ulcer were also reported. Very few adolescent girls (1.4%) were allergic to different foods like pineapple, shell fishes, milk and milk products, etc. The health problems reported by the subjects showed that allergy and asthma (5.2%), migraine and sinusitis were the common problems (3.8%). Infections, PCOD, heart problems and piles were also reported by the adolescent girls.

The misery of parasites inflicts on humans remain a significant health problem worldwide. Anaemia, which can be mild to severe, acute or chronic, is typically associated with parasitic infestations. It is, regardless; emerge of the multitudes of complications connected with parasitic infestations. Oguntibeju (2003) reported prevalence rates of worm infestations like Ascaris lumbricoides (38%), Trichuristrichiura (16%), Necatoramericanus (22%), and Entamoebahistolytica (24%). The incidence rate was higher among the age groups 10-20 years and 21-30 years, and decreased progressively with age (less in 31-50 years and 51-65 years age groups).

Bigal *et al.*, (2007) conducted a study among 18,714 adolescents and reported that the migraine prevalence was higher in girls than in boys older than 12 years and in Whites than African Americans. Four hundred and sixty girls, in the age group of 15-18 years, from a residential college in Andhra Pradesh, South India were studied by Nidhi *et al.*, (2011) and reported 9.13 per cent prevalence of PCOD.

4.2.2 Stress among adolescent girls

Distribution of respondent adolescent girls based on the stress experienced is shown below.

Table 3

Stress among adolescent girls

(N=500)

Nature of stress	Number	Per cent*
Academic/exam stress	411	82.2
Social stress	5	1
Parental expectations	5	1

*Multiple response

Stress typically expresses a negative condition that can have an effect on one's mental and physical health. Stress is common during adolescence, but it is surprising to note that academic and exam stress were experienced by a considerable number (82.2%) of adolescent girls under study. They felt pressure to complete daily home works, problems with teachers, finish projects and study for exams. Teenagers frequently see themselves as being evaluated in terms of their scholastic performance and the pressure to excel is an important measure of their success (Ang and Huan, 2006). Academic stress adversely affects overall adjustment of students and one form of academic stress that merits attention is the one arising from expectations (Hussain *et al.*, 2008). Parental expectation was considered as a burden by one per cent adolescent girls under study.

Calaguas (2013) researched expectations as options for academic stress among college-freshmen. Statistical analyses revealed that the means of responses of the college freshmen to the items in the AESI (Academic Expectations Stress Inventory) ranged from 3.091 to 3.746 with 1as the minimum and 5 as the maximum response in every item. Likewise, male and female college freshers significantly varied in perceived parents/teachers' expectations, self-expectations, and scholastic expectations in general.

4.2.3 Consumption of dietary supplements and medicines

Consumption of dietary supplements and medicines by the adolescent girls were listed in the following table.

Table 4

Consumption of dietary supplements and medicines

(N=500)

Supplements/Medicines	Number	Per cent*
Health Drinks		
Horlicks	4	0.8
Bournvita	6	1.2
Annatone	1	0.2
Boost	5	1.0
Winsmart	1	0.2
Vitamin tablets		
Multivitamin tablets	7	1.4
Iron tablets	11	2.2
Vitamin A tablets	2	0.4
B Complex tablets	1	0.2
Iron folic acid tablets	1	0.2
Riboflavin tablets	2	0.4

Supplements/Medicines	Number	Per cent*
Ayurvedic supplements		
Chavanaprasha	10	2.0
Consumption of anti convulsant drugs		
Eptoin	1	0.2

*Multiple response

Practice of taking health drinks, dietary supplements, vitamin tablets and *Ayurvedic* supplements were observed among adolescent girls under study. Bournvita (1.2%), Boost (1%) and Horlicks (0.8%) were the health drinks regularly taken by majority of adolescent girls. Out of 500 subjects, 4.8 per cent were taking vitamin tablets, among them a majority, i.e. 2.2 per cent subjects consumed iron tablets. And multivitamin tablets were consumed by 1.4 per cent of subjects. It can be noted that 2 per cent of them used *Chavanaprasha*, an *Ayurvedic* formulation containing *amla* extract regularly. Eptoin, an anticonvulsant drug was consumed by an adolescent girl.

4.3 Details on menstruation

Menstruation is a real phase of pubescence in girls; it's one of the numerous physical signs that a girl is transforming into a woman. The menstrual status of the adolescent girls, symptoms of menstruation, influence of menstrual problems on daily routine and alteration in daily routine during menstruation are discussed below.

4.3.1 Menarcheal status of adolescent girls

The menarchical status and mean age of menarche of adolescent girls are presented in the following table.

Table 5

Menarcheal status of adolescent girls

(N=500)

Menstrual status	Number	Per cent
Pre-menarcheal stage	33	7
Post-menarcheal stage	467	93
Total	500	100
Mean age of menarche	12.5 years	

Menarche, the first indication of the completion of the physiological development, involves the physiological maturation of the brain, the endocrine glands and their hormones along with the general body growth. These individual developmental processes are in fact inseparable, essentially and primarily dependent upon the general metabolic and nutritional status of the whole organism. From both social and medical viewpoints, it is often considered the focal occasion of female puberty, as it flags the possibility of fertility (Celik, 2014).

Out of the 500 adolescent girls studied, majority 467 (93%) was in post-menarcheal stage, i.e. attained their menarche, whereas 7 per cent of them were in pre-menarcheal stage. The mean age of menarche of the respondent girls was 12.5 years. Girls experience menarche at different ages. The menarcheal age seems to be determined by the complex mixture of heredity, socio-economic factors and environmental factors.

In the opinion of Dahiya and Rathi (2010), age at menarche is firmly impacted by nutritional status in adolescence, outstandingly the level of stunting, which is in turn highly dependent on the level of stunting in early childhood. A ‘late’ menarche because of stunting may be detrimental for reproductive health in case of early childbearing because of the relationship between height and pelvic size.

In Western Europe, where information for about most recent 200 years is accessible, the time of menarche can be seen to have diminished from 17 years to 12.8 years. In urban India the time of menarche was indicated to be 12.6 years, which is similar to the age of menarche in the developed world (Yadav and Jain 2001; Agarwal and Agarwal, 1992).

4.3.2 Commonly occurring signs and symptoms of menstruation

Menstruation is a natural biological process; it may cause physical or psychological problems. Details on the self-reported symptoms and signs of menstruation experienced by the adolescent girls are depicted in table 6.

Table 6

Self- reported symptoms and signs associated with menstruation

(N=467)

Signs and symptoms	Number	Per cent
Symptoms of gynaecological problems		
Irregular cycle	147	31.4
Abnormal duration of menstruation	0	-
Amenorrhea (Missed cycle)	195	41.7
Dysmenorrhea complex		
Abdominal pain	298	63.8
Back ache	131	28.0
Gastrointestinal symptoms		
Abdominal blotting	43	9.2
Loss of appetite	158	33.8
Vomiting/Nausea/Constipation	10	2.1

Signs and symptoms	Number	Per cent
Psychological symptoms		
Irritability	236	50.5
Aggressiveness	171	36.6
Depression	114	24.4
Other physical symptoms		
Fatigue	193	41.3
Breast heaviness	16	3.4
Increased weight	6	1.2
Headache	95	20.3
Skin disorders	34	7.2

Out of 467 post-menarcheal girls, almost all the subjects experienced at least any one of the signs/symptoms of menstruation. Gynaecological symptoms, like irregular and missed cycles were experienced by 31.4 per cent and 41.7 per cent of the respondents. According to American Academy of Paediatrics (AAP, 2006), menstrual abnormalities can be brought on by aggravation of the central gonadotropin-releasing hormone pulse generator and also by critical weight reduction, strenuous activity, generous changes in sleeping or dietary patterns, and extreme stressors.

Dysmenorrhoea was a common problem experienced by 63.8 per cent of the adolescent girls. Back ache was another dysmenorrhoeal complex reported by 28 per cent of the subjects. Adolescent girls, quite often, noiselessly endure the pain by dysmenorrhoea and the discomfort connected with it due to lack of knowledge about reproductive health.

Similar findings were observed in a study conducted by Agarwal and Agarwal (2010), a high predominance of dysmenorrhoea, was reported (71.96%) among adolescent girls of Gwalior and it can be concluded that dysmenorrhoea is a very common problem among adolescent girls, and they encounter various physical and emotional symptoms connected with dysmenorrhoea.

Among the gastrointestinal problems, loss of appetite was a major symptom occurred in 33.8 per cent of respondents. Abdominal blotting was reported by 9.2 per cent of the subjects. Psychological disturbances were very common when compared to other symptoms. Irritability and aggressiveness prevailed among 50.5 per cent and 36.6 per cent of adolescent girls. Other physical symptoms were also reported by the subjects include: fatigue, breast heaviness, increased weight, headache and skin disorders. Fatigue was the complaint reported by 41.3 per cent of the subjects followed by headache (20.3%). Skin irritations like itching and burning were also found among 7.2 per cent of the subjects.

4.3.3 Effect of menstrual problems on daily activities

"Adolescence is truly a period of enormous physical and psychological change for adolescents. Serious gynaecological pathology is uncommon in this age group, however menstrual aggravations are not uncommon and may even include further interruption for this troublesome stage for teenagers" (Hickey and Balen, 2003). Daily routine of the study subjects was altered due to the problems caused by menstruation. And the details of the same are discussed below.

Table 7

Effect of menstrual problems on daily activities

(N=341)

Problems	Number	Per cent*
Prolonged rest	153	44.9
Missed work	75	22.0
Missed classes	108	31.7
Missed social activities	180	52.8
Sleep disturbances	147	43.1

*Multiple response

Out of the five hundred adolescent girls selected 93.4 per cent, i.e. 467 subjects attained menarche. Though menstruation is a normal phase of life, and a positive sign of good health, seventy three percentage post-menarcheal girls, in this study, complained of discomforts and difficulties during menstruation and thereby affecting their daily routine. Majority of the subjects (52.8%) could not participate in social activities and gatherings like marriages, outings, excursions, tours, etc. Prolonged rest was the second most common variation in daily routine reported by 44.9 per cent of subjects. Sleep disturbances and missing of classes were attributed by 43.1 per cent and 31.7 per cent respectively. Missed work was the least common variation that only observed among 22 per cent of the subjects. On the other hand 27 per cent of the subjects did not complain or did not experience any kind of difficulty or discomfort during those days.

Policy advocates for girls' education have proposed that there are substantial losses in schooling due to menstruation. The possible role of menstruation in constraining school participation has received critical consideration in popular media, about all of which contends that menstruation is likely to be a significant factor in schooling (Oster and Thornton, 2011).

4.4 Anthropometric details of adolescent girls

"Adolescence is a transitional stage in the middle of childhood and adulthood described by marked acceleration in growth. Growth monitoring by anthropometric measurement during this period, is an important health indicator as well as an indicator of various morbidity in the community, though the anthropometry is universally applicable, simple, inexpensive, and non-invasive technique, it is still an underused tool for guiding public health policy as well as individual clinical decision" (Sachan *et.al*., 2012[b]).

Height and weight were measured utilizing standard procedures. Body Mass Index (BMI) was processed from height and weight. Height-for-age and weight-for-age below 50th percentile values of NCHS reference was classified as stunting. BMI-for-age $\geq 5^{th}$ to $< 85^{th}$ percentile values of National Health and Nutrition Examination Survey (NHANES-I) recommended reference was classified as normal. Height and weight of the adolescent girls were also compared with the ICMR (1989) standards.

4.4.1 Height, body weight and BMI of adolescent girls

The mean height, weight and BMI of adolescent girls were presented in the following table.

Table 8

Mean height, body weight and BMI of adolescent girls

Age (years)	Height (cm)	Weight (kg)	BMI (Kg/m^2)
12	145.7	35.6	16.8
13	151.4	38.9	16.9
14	155.7	47.1	19.5
15	154.6	46.3	19.3
16	157.8	53.5	21.3
17	154.4	44.0	18.5
18	156.9	49.1	20.0
19	157.7	50.8	20.3

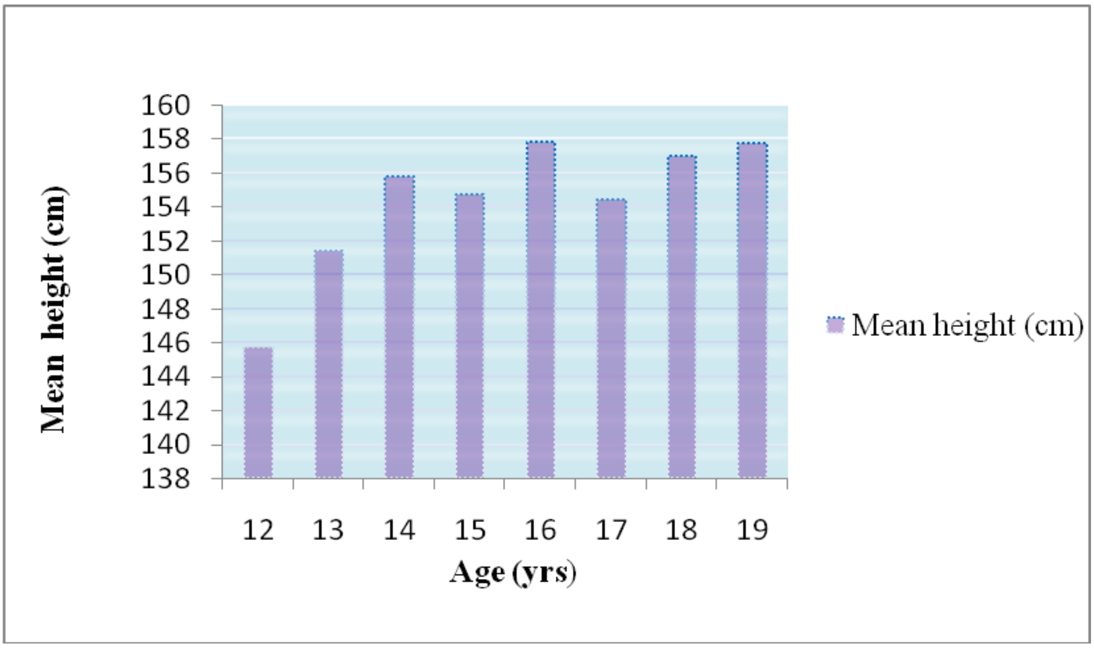


Figure 2 - Distribution of subjects by age and mean height

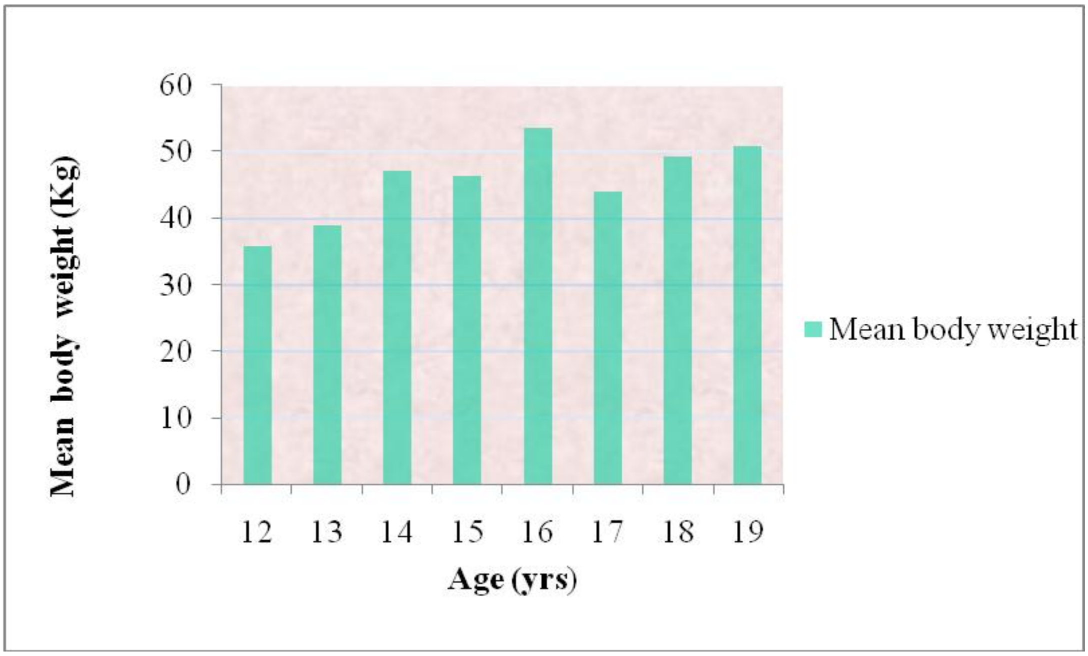


Figure 3 - Distribution of subjects by age and mean body weight

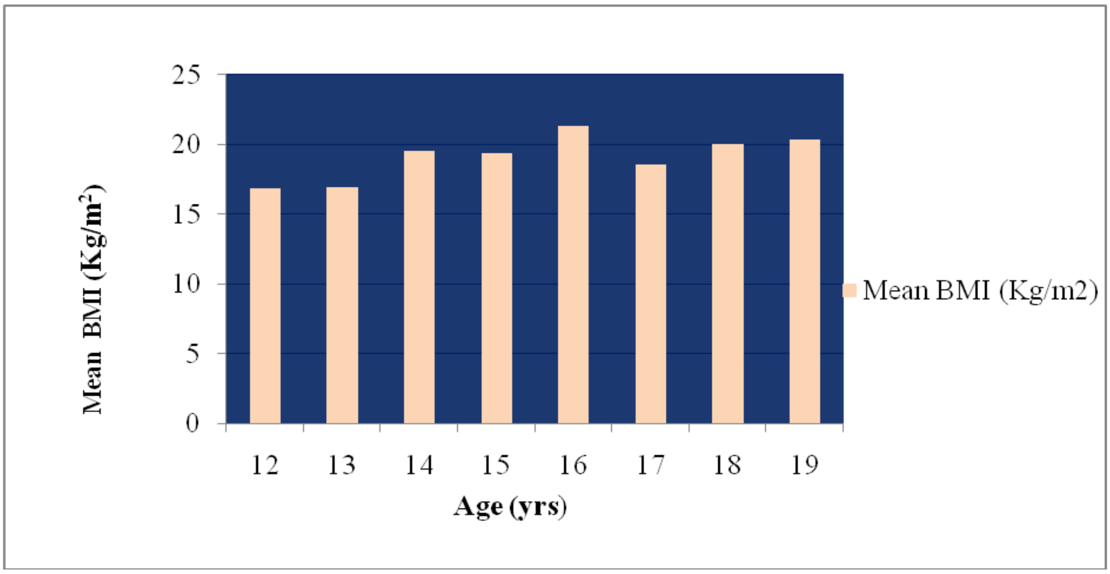


Figure 4 - Distribution of subjects by age and BMI

As seen in table 8, the mean weight of adolescent girls ranged from 35.6 kg to 53.5 Kg. The range of mean height of the adolescent girls started from 145.7 cm to 157.8 cm. Similarly BMI also ranged from 16.8 to 21.3 Kg/m^2. Except the other age groups, age 16 showed higher values in height, weight and BMI.

Sachan *et al.*, (2012[b]) reported that the mean height and weight of urban adolescent girls of Lucknow district ranged from 145.65 cm to 150.8 cm and 36.92 Kg to 44.83 Kg. BMI ranges of the adolescent girls of Lucknow district were only 17.32 to 19.71 Kg/m^2. Height, weight and BMI of the late-adolescent girls of study population were much higher compared to the above mentioned study.

4.4.2 Comparison of mean height of adolescent girls with NCHS standards

The below table and figure show age wise distribution of mean height of girls and their comparison with NCHS standard.

Table 9

Comparison of mean height of adolescent girls with NCHS standards

Age (years)	Height (cm)		*p*-value
	PS	NCHS Standard	
12	145.7± 7.618	154.6	0.000**
13	151.4± 5.215	159.0	0.000**
14	155.7± 6.137	161.2	0.000**
15	154.6± 5.701	162.1	0.000**
16	157.8± 4.262	162.7	0.019*
17	154.4± 4.729	163.4	0.000**
18	156.9± 5.230	163.3	0.000**
19	157.7± 5.457	163.3	0.000**

Ref: NIN (2005)
PS – Present study
**Significant at one per cent level
*Significant at five per cent level

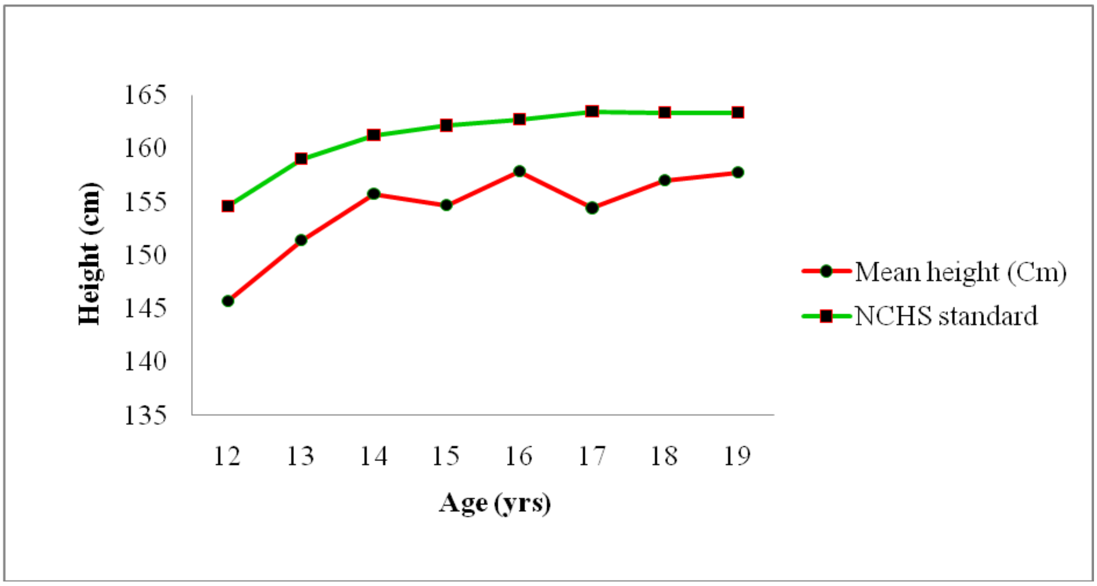


Figure 5 - Comparison of mean height of adolescent girls with NCHS standards

The above table shows a comparison between mean height of adolescent girls and the NCHS standards. Which reveals that there is a gradual increase in height up to the age of 12-14 years from 145.7 cm to 155.7 cm. Subjects falling in the age group of 15-17 years showed an irregular pattern in their mean heights. Thereafter by the age of 17 upwards there was a steady or gradual increase in height was observed, i.e. from 156.9 cm to 157.7 cm. *t*-test was performed to compare mean height of adolescent girls with NCHS standards. The results indicated that the respondent adolescent girls of all age groups did not achieve the mean height of NCHS standards with a *p*-values <0.01 and <0.05 for age 16. From the comparison between the study group and NCHS standard, it can be concluded that the mean height of adolescent girls residing in Kottayam Taluk was far below the NCHS standards.

4.4.3 Comparison of mean body weight of adolescent girls with NCHS standards

Body weight measures the total weight of an individual, including muscle, fat, water and bone. Changes in body weight are a basic marker of nourishing status, being underweight or overweight unfavourably affects mortality and morbidity. The mean body weights of adolescent girls were compared with NCHS standards and the results are presented in the following table.

Table 10

Comparison of mean body weight of adolescent girls with NCHS standards

Age (years)	Weight (kg)		*p*-value
	PS	NCHS Standard	
12	35.8±5.821	43.8	0.000**
13	38.9±5.738	48.3	0.000**
14	47.1±8.030	52.1	0.000**
15	46.3±7.782	55.0	0.000**
16	53.5±12.92	56.4	0.303NS
17	44.0±4.479	56.7	0.000**
18	49.1±7.963	59.9	0.000**
19	50.8±8.296	59.9	0.000**

Ref: NIN (2005)
PS – Present study
**Significant at one per cent level
NS- Not Significant

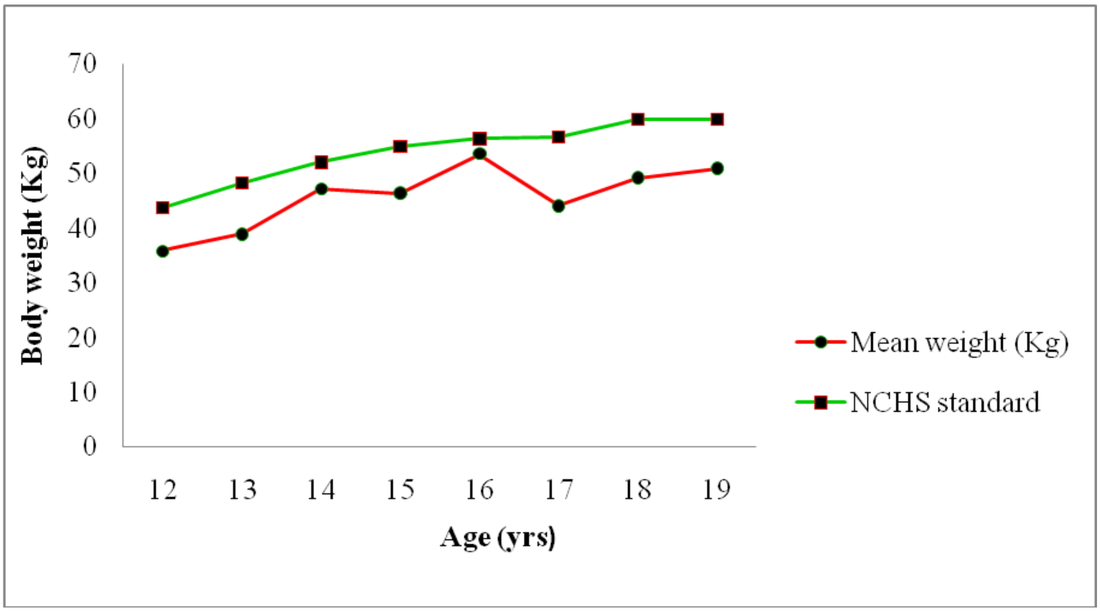


Figure 6 - Comparison of mean body weight of adolescent girls with NCHS standards

Table 10 shows the comparison between mean weight of adolescent girls and the NCHS standards which reveals that there is a gradual or a steady increase in body weight up to the age of 12-14 years from 35.8 kg to 47.1 kg. Subjects under the age group of 15-17 years showed an irregular pattern in their mean weights. Thereafter by the age of 17 onwards, a steady or gradual increase in weight was observed, i.e. from 44.06 kg to 50.84 kg. *t*-test was performed to compare mean weight of adolescent girls with NCHS standards which revealed that the mean weight of adolescent girls of all age groups under study except 16 years were not achieved NCHS standards with a *p*-value <0.01. However the mean body weight when compared with the NCHS standards shows that the weight was lower than the NCHS standards.

4.4.4 Comparison of mean height of adolescent girls with ICMR standards

The table shows age wise distribution of mean height of girls and their comparison with ICMR standard.

Table 11

Comparison of mean height of adolescent girls with ICMR standards

Age (years)	Height (cm)		*p*-value
	PS	ICMR Standard	
12	145.7 ±7.618	139.8	0.0013**
13	151.4 ± 5.215	144.5	0.000**
14	155.7 ± 6.137	148	0.000**
15	154.6 ± 5.701	150.2	0.000**
16	157.8± 4.262	151.3	0.0066**
17	154.4 ± 4.729	151.8	0.0215*
18	156.9 ± 5.230	152.2	0.000**
19	157.7 ± 5.457	152.1	0.000**

Ref: ICMR, 1989
PS – Present study

**Significant at one per cent level
*Significant at five per cent level

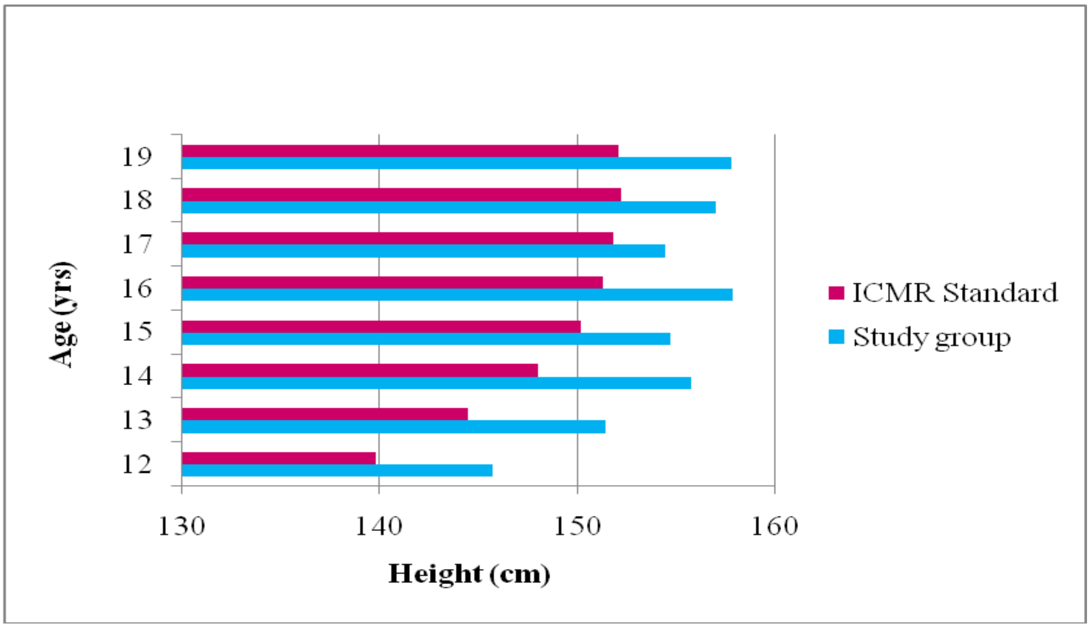


Figure 7 - Comparison of mean height of adolescent girls with ICMR standards

The table 11 and figure 7 shows a comparison between mean height of adolescent girls and ICMR standards. The mean heights of adolescent girls in all age groups were much better than ICMR standards. There was an increase in the height up to the age of 12-14 years (145.7 cm to 155.7 cm). Thereafter by the age of 17 upwards, there was a steady or gradual increase in height, i.e. from 156.9 cm to 157.7 cm. *t*-test was performed to compare mean height of adolescent girls with ICMR standards which revealed that the mean height of adolescent girls of all age groups under study were significantly higher than ICMR standards with a *p*-value <0.01 and *p*-value <0.05 for age 17. From the comparison between the study group and ICMR standard, it can be concluded that the mean height of adolescent girls residing in Kottayam Taluk achieved ICMR standards.

The findings of this study are in concomitant with the findings of Sachan *et al*., (2012[b]), who observed that the mean height of adolescent girls in all age groups in both urban and rural schools was superior to ICMR standards with the exception of age 19 years in urban schools. The mean height in all age groups in both urban and rural schools demonstrated huge contrast with the ICMR mean height for particular ages aside from in ages 15, 18, and 19 years in urban schools and in ages 16, 17, 18, and 19 years in rural schools.

4.4.5 Comparison of mean body weight of adolescent girls with ICMR standards

The mean body weight of adolescent girls was compared with ICMR standards and the results are presented in the following table.

Table 12

Comparison of mean body weight of adolescent girls with ICMR standards

Age (years)	Weight (kg)		*p*-value
	PS	ICMR Standard	
12	35.87 ± 5.821	30.5	0.000**
13	38.92 ± 5.738	34.3	0.000**
14	47.10 ± 8.030	37.7	0.000**
15	46.35 ± 7.782	40.1	0.000**
16	53.50 ± 12.92	41.9	0.0396*
17	44.06 ± 4.479	43.0	0.1789NS
18	49.15 ± 7.963	43.1	0.000**
19	50.84 ± 8.296	43.1	0.000**

Ref: ICMR, 1989
PS – Present study
**Significant at one per cent level
*Significant at one per cent level
NS – Not significant

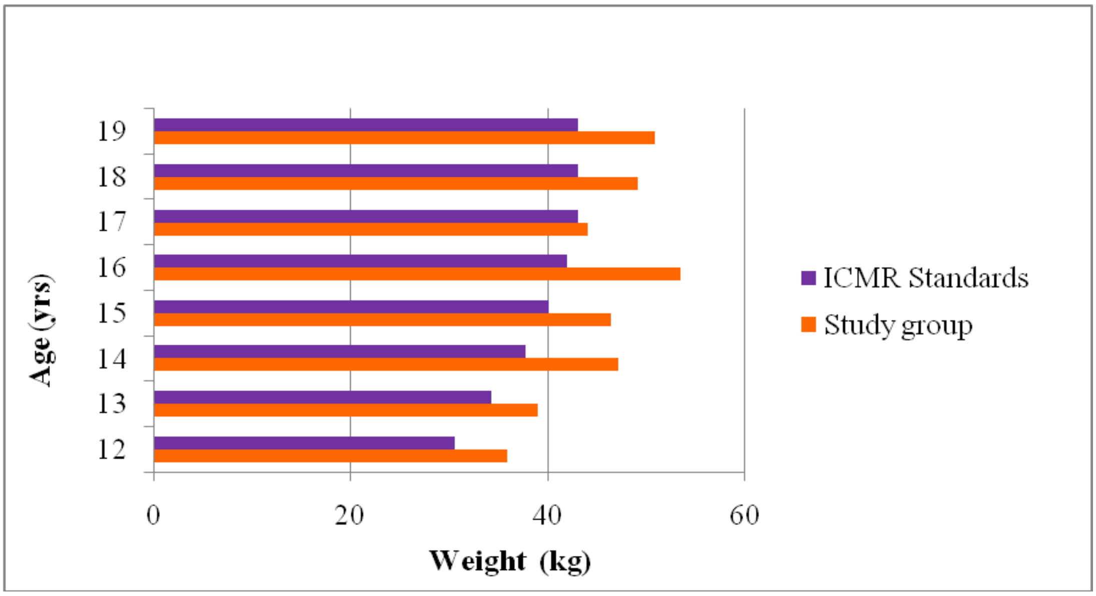


Figure 8 - Comparison of mean body weight of adolescent girls with ICMR standards

Table 12 shows a comparison between mean weight of adolescent girls and the ICMR standards, which revealed that there was a gradual or a steady increase in body weight up to the age of 12-14 years from 35.87 kg to 47.10 kg. Subjects falling in the age group of 15-17 years showed an irregular pattern in their mean weights. Thereafter by the age of 17 onwards there was a steady or a gradual increase in weight was observed i.e. from 44.06 kg to 50.84 kg. *t*-test was performed to compare mean weight of adolescent girls with ICMR standards which revealed that the mean weight of adolescent girls of all age groups under study except 17 years achieved ICMR standards with a *p*-value <0.01. However the mean body weight when compared with the ICMR standards shows that adolescent girls residing in Kottayam Taluk achieved ICMR standards.

Sachan *et al.*, (2012[b]) and Tripathi (2002) observed similar differences in mean weight from ICMR standard for corresponding ages, except in age 19 years, where it was below ICMR standard. There were also significant differences in ICMR mean weight at all ages except 13, 14, 18, and 19 years in urban girls.

4.4.6 Classification of adolescent girls based on Body Mass Index (BMI)

BMI is another method of analysing the prevalence of underweight /overweight issues because of food and nutritional inadequacies or mal-allocation. Distribution of adolescent girls on the basis of Body Mass Index (BMI) classification is presented in the following table.

Table 13

Classification of adolescent girls based on Body Mass Index (BMI)

(N=500)

Age (years)	Number	BMI classification			
		Under weight ($<5^{th}$ percentile) (%)	Normal ($\geq 5^{th}$-$<85^{th}$ percentile) (%)	Over weight ($\geq 85^{th}$-$<95^{th}$ percentile) (%)	Obese ($\geq 95^{th}$ percentile) (%)
12	20	15	80	5	-
13	49	24.5	75.5	-	-
14	97	9.3	79.4	8.2	3.1
15	128	7.8	87.5	4.7	-
16	6	-	83.3	16.7	-
17	16	18.8	81.3	-	-
18	104	14.4	81.7	2.9	1.0
19	80	11.3	81.3	7.5	-
***p*-value = 0.110^{NS}**			**df -21**		

NS –Not Significant
Ref: NHANES-I (NIN, 2005)

BMI is an effective parameter to assess nutritional status. The subjects were grouped into four categories, viz. underweight, normal, overweight and obese, based on their BMI. Detailed information on the BMI with respect to age is given in table 13. Between the age of 12 and 13, the percentage of underweight subjects (BMI for age $<5^{th}$ percentile) were 15 and 24.5 respectively. While 80 and 75.5 were the percentage of normal subjects (BMI for age $\geq 5^{th}$-$<85^{th}$ percentile), which is satisfactory. Only 5 per cent of subjects were overweight (BMI for age $\geq 85^{th}$-$<95^{th}$ percentile). There were no obese subjects at all in this group.

When considering the subjects in the age group of 14 and 15 respectively, 79.4 per cent and 87.5 per cent were the percentage of normal subjects (BMI for age

$\geq 5^{th}$-$<85^{th}$ percentile). Only 3.1 per cent obesity (BMI for age $\geq 95^{th}$percentile) was observed in age group of 14.

Majority of the subjects (above 80%) falling in the age group of 16 and 17 belonged to normal category. Only 16.7 per cent of the subjects in the age group of 16 were overweight (BMI for age $\geq 85^{th}$-$<95^{th}$ percentile). None of the subjects in this age group were underweight (BMI for age $<5^{th}$ percentile), whereas in the age group of 17, 18.8 per cent were underweight. There were no obese or overweight subjects in the same.

The age groups of 18 and 19 showed that above 80 per cent of the subjects had normal BMI. And above 10 per cent were underweight (BMI for age $<5^{th}$ percentile). While in the age group of 18, both overweight with BMI for age $\geq 85^{th}$-$<95^{th}$ percentile and obese with BMI for age $\geq 95^{th}$percentile subjects were present in the percentage of 2.9 per cent and 1 per cent respectively. In the age group of 19, only 7.5 per cent of subjects were found to be overweight.

From the above discussion a conclusion could be drawn that majority of the study population between the age group of 12-19 years were normal (75 to 87.5%). This shows a better status of nutrition among the study respondents, compared to other states of India.

4.4.7 Waist hip ratio of adolescent girls

Waist hip ratio or waist-to-hip ratio (WHR) is the ratio of the circumference of the waist to that of the hips. The WHR has been utilized as a pointer of excess fat in the abdominal region poses a greater health risk of developing serious health conditions. Furthermore, it is utilized as a measurement of obesity, which thus is a possible indicator of other more serious health conditions. According to NIN, (2005) waist to hip ratio ≥ 0.80 will be identified as obesity. The mean waist-hip ratio of adolescent girls is presented in the table shown below.

Table 14

Waist hip ratio of adolescent girls

(N=500)

Age (years)	Mean Waist hip ratio
12	0.75 ± 0.03
13	0.75 ± 0.03
14	0.75 ± 0.03
15	0.75 ± 0.03
16	0.7 5± 0.03
17	0.75 ± 0.03
18	0.75 ± 0.03
19	0.73 ± 0.02

Waist-to-hip ratio of the adolescent girls under the study ranged from 0.73 to 0.75. Subjects, 19 years of age possessed lowest waist-to-hip ratio of 0.73, which indicated that any of the girls under study were not having any risk of abdominal obesity with waist to hip ratio less than 0.80.

Mungreiphy *et al.*, (2012) observed that general body fat deposition, assessed by BMI, GMT (Grand Mean Thickness) and fat percentage, was discovered to be highest among Delhi females and males. Overweight/obesity was most prevalent among Delhi subjects and underweight among Kerala subjects. Nonetheless, central adiposity as evaluated from waist hip ratio (WHR), weight height ratio (WHtR), and conicity index (CI) was discovered to be altogether higher among the Manipur females signifying a relatively more androidal pattern of fat deposition, whereas male subjects from Delhi had higher central adiposity.

4.5 Nutrition Education

"Nutrition education is defined as 'any set of learning experiences designed to facilitate voluntary adoption of eating and other nutrition related behaviour conducive to health and well-being'. It is recognized as an important component in programs and interventions related to health promotion and disease prevention. For school-age children, nutrition education have not only been shown to improve knowledge and skills, but also eating and physical activity behaviours, as well as health status" (Shariff *et al.*, 2008).

Educational institutions are effective and efficient medium to impart nutrition education programmes as it reaches considerable number of adolescents at a time and provides an excellent learning atmosphere. In the present study nutrition education was given to all the selected adolescent girls with attractive and informative PowerPoint slides as a teaching tool. Nutritional knowledge of adolescent girls, common misconceptions and beliefs among adolescent girls, effectiveness of the nutrition education programme, knowledge attributes and practice attributes before and after one week of the education programme are discussed in the following headings.

4.5.1 Nutritional knowledge of adolescent girls

Knowledge on nutrition of the subjects was checked using a set of questions covering various aspects of the basic nutrition and presented in the table shown below.

Table 15

Age vs. nutritional knowledge

(N=500)

Age classification	Number	Mean score	Df	*p*-value
Early adolescence (≤16years)	300	4.97±1.416	498	0.000**
Late adolescence (>16years)	200	7.68±1.274		

**Significant at one per cent level

The overall dietary knowledge was found to be low. Majority could not name the main food sources of nutrients and were not aware of the importance of taking extra nutrients during adolescence for a growth spurt. It is concluded that early adolescent (≤16 years) scored a mean score of 4.97 while girls in the late adolescent stage scored much higher mean score of 7.68. Independent sample *t*-test was applied to evaluate the difference of scores obtained by early adolescent and late adolescent girls. This clearly showed that as age increased knowledge on nutrition also increased significantly at one per cent level with a *p*-value of 0.000.

As these adolescent girls are the future mothers, knowledge of nutrition and health plays a key role in their lives. The results obtained show that there was a lacunae in general nutrition knowledge among early adolescence. This could be corrected by incorporating various nutrition programmes at the school level itself, because nutrition awareness should be stressed as early as late-childhood. As indicated by Shariff *et al*., (2008), for children and adolescents to receive and keep up health-enhancing behaviours, they have to have satisfactory knowledge of the health concern, attain the right attitudes to deal with the concern and have the important aptitudes and be self-efficacious to expect the health-enhancing behaviour.

4.5.2 Common misconceptions and beliefs among adolescent girls

Common misconceptions and beliefs of adolescent girls regarding adolescent nutrition are expressed below.

Table 16

Common misconceptions and beliefs among adolescent girls

(N=500)

Misconceptions and beliefs	Opinion*	
	Yes	**No**
Dieting is good for all	361 (72.2%)	139 (27.8%)
Men need more nutrients in all the life stages than women	427 (85.4%)	73 (14.6%)
Knew about folic acid, its importance and sources	22 (4.4%)	478 (95.6%)
Knew about Neural Tube Defects	7 (1.4%)	493 (98.6%)
Early pregnancy leads to birth defects	81 (16.2%)	419 (83.8%)
Suffering gender discrimination in terms of food (N=302)	246 (81.4%)	56 (18.5%)
Discouraged by family to eat certain foods	274 (54.8%)	226(45.2%)
Washing vegetables before and after cutting is good	477 (95.4%)	23 (4.6%)
Discarding cooking water leads to nutrient loss	417 (83.4%)	83 (16.6%)
Cooking in open pan is good	299 (59.8%)	201 (40.2%)
Sprouting increases nutrient quality	494 (98.8%)	6 (1.2%)
Interested to learn nutrition	481 (96.2%)	19 (3.8%)
Would like to include nutrition in curriculum	478 (95.6%)	22 (4.4%)

*Number in parenthesis indicates percentage of subjects

The above table depicts the common misconceptions and beliefs of the adolescent girls under study. It is noted that 72.2 per cent of the subjects believed that dieting is good for all, which indicates lack of proper knowledge about dieting. Majority i.e. 85.4 per cent of the adolescent girls reported that men need more nutrients than women in all the stages of life. Almost 95 per cent of the subjects were not aware about folic acid and neural tube defects. It is surprising to note that 83.8 per cent of adolescent girls had an opinion that early pregnancy does not cause birth defects. Out of the 500 adolescent girls, 302 subjects had brothers at home and among them 81.4 per cent suffered from gender discrimination in terms of food. This can be considered as a sign of deep rooted male domination which still exists in this civilized world. About half of the adolescent girls (54.8%) were discouraged to eat certain foods like pickles, tamarind and other citrus foods by the family. The reason behind this was a misunderstanding that citrus foods cause abnormal vaginal discharge. Majority (95.4%) believed that washing vegetables before and after cutting and cooking in an open pan also is good which clearly indicates the insufficient knowledge regarding cooking practices. But the importance of sprouting was known to 98.8 per cent of the subjects. Around 95 per cent of the subjects were interested in Nutrition Science and willing to include the same in their curriculum.

4.5.3 Content of the computer aided teaching tool

The contents of the tool used for imparting nutrition education programme are presented in the following table.

Table 17

Concepts included in computer aided teaching tool

Concepts included in the tool
Importance of adolescence
Balanced diet
Nutrition in adolescence
Importance of iron, folic acid and vitamin B_{12}
Nutrition related problems among adolescence
Consequences of adolescent malnutrition
Dietary guidelines and tips

The computer aided teaching tool (power point slides) included topics like importance of adolescence, balanced diet, nutrition in adolescence, importance of iron, folic acid, and vitamin B_{12}, nutrition related problems among adolescence, consequences of adolescent malnutrition and dietary guidelines and tips.

Yusoff *et al.*, (2013) conducted a multimedia nutrition education program led at school setting and discovered practical and effective in enhancing awareness on iron deficiency among anemic adolescents. The topics covered were "Iron Deficiency Anaemia: An Introduction", "Iron Deficiency Anaemia: Symptoms and Risk Factors", "Iron Deficiency Anaemia: Prevention and Treatment" and "Prevent Iron Deficiency Anaemia Nutritionally".

4.5.4 Effectiveness of nutrition education programme

Adolescent girls are "mother to be"; this period of life is a golden time for nutritional knowledge promotion. The effect of nutritional education on knowledge of adolescent girls is depicted in the following table.

Table 18

Effectiveness of nutrition education programme

Score	Mean score	df value	*p*-value
BNE	6.05±1.90	499	0.000**
ANE	10±0.000		

BNE-Before nutrition education
ANE-After nutrition education
**Significant at one per cent level

It was observed that their knowledge in certain areas was limited. Mean score obtained before education programme was 6.05. It was significantly increased to 10.0, after the nutrition education programme. It can be found that the nutrition education programme was highly significant at one percentage level (P<0.01) with *p*-value of 0.000.

Similar findings were reported in a study conducted by Yazdani *et al*., (2010) among 315 adolescent girls in nine schools in different districts of Isfahan. Before the first step of education and ten days after the second step, information about knowledge and attitude were evaluated by a questionnaire. Education was performed as oral presentation, notes and pamphlet. After the education programme, knowledge score was significantly higher among case group (P < 0.0001).

Knowledge education, with appropriate efficiency is accounted as an important factor for nutritional knowledge promotion. This study showed that nutritional knowledge can be improved by educational programmes.

4.5.5 Attributes of knowledge of adolescent girls before and after nutrition education programme

As the preliminary evaluation of nutrition knowledge was not satisfactory, a detailed analysis of nutritional knowledge with five different sets of knowledge attributes were tested before and after one week of nutrition education programme and the results are shown below.

Table 19

Score of knowledge attributes before and after nutrition education programme

Knowledge attributes	Phase				Df	*p*-value
	BNE	ANE	SD	Difference		
K1	1.77	4.98	0.68	-3.20	499	0.000**
K2	2.70	4.95	0.58	-2.25	499	0.000**
K3	0.52	4.95	0.53	-4.42	499	0.000**

Knowledge attributes	Phase				Df	*p*-value
	BNE	ANE	SD	Difference		
K4	0.54	4.90	0.60	-4.36	499	0.000**
K5	1.51	4.91	1.16	-3.39	499	0.000**

BNE-Before nutrition education
ANE-After nutrition education
**Significant at one per cent level

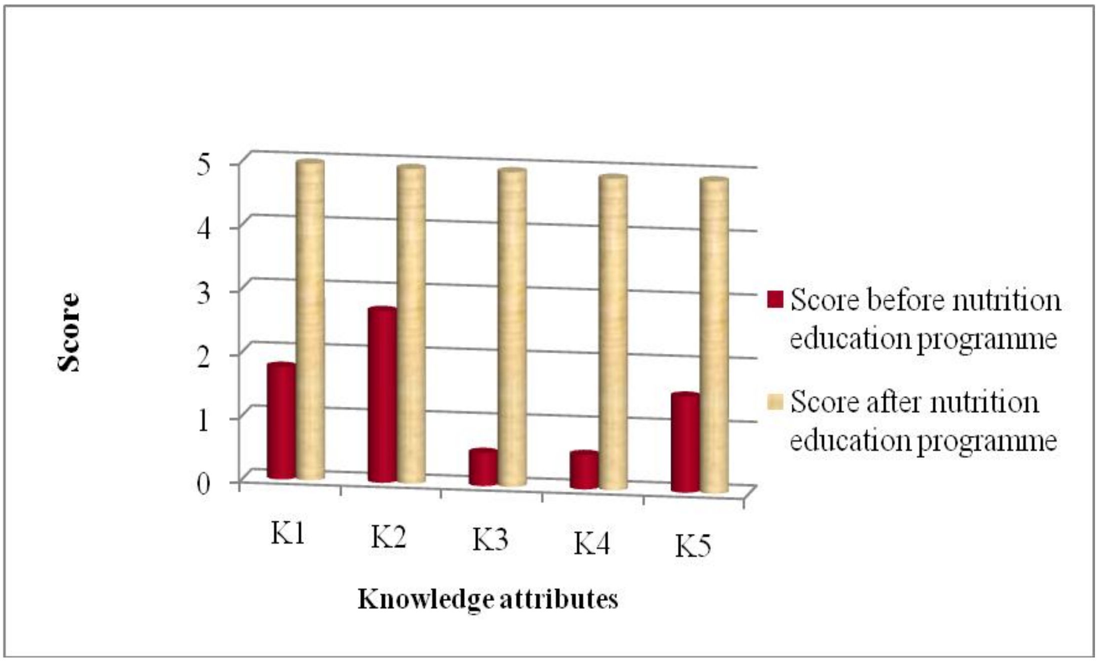


Figure 9 - Attributes of knowledge before and after nutrition education programme

The knowledge attributes were divided into five categories viz. K1, K2, K3, K4 and K5. In each category, five questions from specific areas were included. Paired *t*-test was performed to understand the change in knowledge attributes after imparting nutrition education programme. The category K1 included questions regarding nutrients and their sources. Initially the score was 1.77. A marked increase in score was observed, i.e. 4.98 with a difference of -3.20. When compared to other knowledge attributes, K2 ranked the highest score of 2.70 before nutrition education programme, as it included topics like balanced diet and general health which were very familiar to the study population. Because of previous knowledge the difference of the scores -2.25 was least when compared to other attributes and the final score was 4.95. K3 and K4 had a very low score of 0.5. After the education programme in both K3 and K4 knowledge levels increased to >4.5. Both categories had a difference of around -4. The areas covered in K3 and K4 were anaemia and other deficiencies and importance of nutrition in adolescence respectively. K5 category included questions regarding interventions and Government aids for adolescent girls. The scores before and after the programme were 1.51 and 4.91 respectively. There was a significant variation of -3.39.

From the above table it is clear that education programme had a significant impact on their nutritional knowledge. Paired *t*-test showed that all the five groups of knowledge attributes were significantly improved after nutrition education. Changes in all the five knowledge attributes were highly significant at one per cent level ($P<0.01$) with *p*-value of 0.000.

4.5.6 Attributes of practices of adolescent girls before and after nutrition education programme

A detailed analysis of nutrition related practices with five different sets of practice attributes was tested before and after one week of nutrition education programme and results are given in the table below:

Table 20

Score of practice attributes before and after nutrition education programme

Practice attributes	Phase		SD	Difference	Df	*p*-value
	BNE	ANE				
P1	1.48	4.96	0.54	-3.48	499	0.000**
P2	2.40	4.92	0.76	-2.52	499	0.000**
P3	2.23	4.93	0.98	-2.70	499	0.000**
P4	1.74	4.91	1.05	-3.17	499	0.000**
P5	1.78	4.97	1.07	-3.18	499	0.000**

BNE-Before nutrition education
ANE-After nutrition education
**Significant at one per cent level

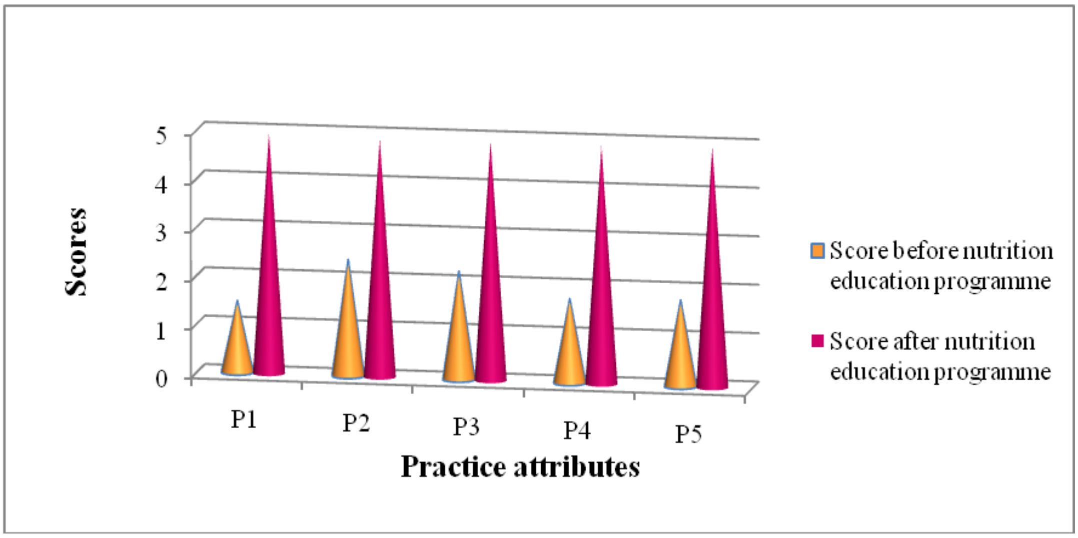


Figure 10 - Attributes of practice before and after nutrition education programme

Knowledge of nutrition, along with good eating habits is very important to create a healthy generation. To assess the nutrition-related practices of adolescent girls a set of questions regarding their preferences in selection of food items, their contribution in meal planning within the family, preferences in buying food items, cooking practices etc. were included.

From the above table it is seen that practical application of nutritional knowledge was way below average before nutrition education programme. The awareness through the nutrition education programme brought out dramatic changes in the score. This indicates that the nutrition education programme was very effective. The scores obtained for P1 was only 1.48, which includes practices like consumption of fast foods and junk foods. This change in practice towards consumption of fast foods and junk foods could be seen through a difference of -3.48 which was found to be most effective among all the various practice attributes and statistically significant at one per cent level ($P<0.01$). The scores obtained before education programme for P2 and P3 were 2.4 and 2.2 respectively. Both increased to 4.93 and 4.91 respectively, with a difference of -2.52 and -2.70. These differences were statistically significant at one per cent level ($P<0.01$) with *p*-value of 0.000.

Practices regarding meal pattern and consumption of dietary supplements were poor among adolescent girls before nutrition education programme. This was probably due to the lack of awareness of the importance of good nutrition and health. The scores recorded in P4 and P5 before education programme were only 1.74 and 1.78 respectively. But after the effective education programme, the value increased to 4.91 and 4.97 which are remarkable. The scores reached high with a difference of -3.17 and -3.18 respectively. Self-reported attributes of practice related to nutrition were evaluated before and after one week of nutrition education programme and paired t test shown a highly significant impact i.e. one per cent level significance with a *p*-value of 0.000.

4.6 Biochemical parameters

Haemoglobin levels were assessed in a sub-sample of 202 adolescent girls using Cyanmethimoglobin method. The results indicated that 57 per cent of the respondents were anaemic. They were further analysed for serum iron and serum folic acid levels.

4.6.1 Categorization of subjects based on haemoglobin levels

Haemoglobin is a protein contained in red blood cells that conveys oxygen to and carbon dioxide far from, the body's cells. The haemoglobin test is primarily used to detect various types of anaemia. Following table shows the categorization of subjects based on haemoglobin levels.

Table 21

Categorization of subjects based on haemoglobin levels

(N=202)

Anaemia classification*	Number	Per cent
Normal (≥12 g/dl)	87	43.06
Mild anaemia (10-11.9 g/dl)	111	55
Moderate anaemia (7-9.9g/dl)	4	1.9
Severe anaemia (<7g/dl)	0	0
Total	115	57
Mean haemoglobin level	11.7g/dl	

*WHO (1989)

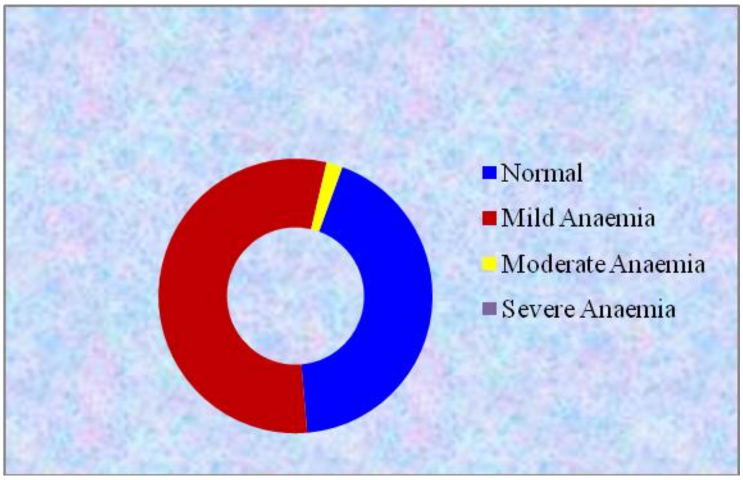


Figure 11 - Categorization of subjects based on haemoglobin levels

Anaemia was grouped into three categories as per WHO: mild, moderate and severe. Haemoglobin cut-off values of anaemia were 10.0-11.9 g/dl (mild), 7-9.9 g/dl (moderate) and < 7.0 g/dl (severe).

From the above table it is evident that the total percentage of anaemia of adolescent girls under study was 57 and it is significantly higher percentage with a mean haemoglobin level of 11.7g/dl. Only 43.06 per cent of the subjects had normal haemoglobin levels. Mild anaemia was seen among 55 per cent of the subjects, whereas, only 1.9 per cent of the subjects had moderate anaemia. Severe anaemia was not observed among the study respondents.

These results support the UNICEF (2011[b]) data in which it is given as, "In India - home to nearly 113 million adolescent girls-the prevalence of anaemia in adolescent girls is estimated at 56 per cent". Anaemia during adolescence affects the growth and development of girls, reduces their focus in everyday tasks, restricts their learning ability, increases their vulnerability to dropping out of school, reasons loss of appetite, bringing about reduced food intake and irregular menstrual cycles, and lessens physical fitness and future work efficiency.

Additionally, anaemia during adolescence impacts women's entire life cycle, since anaemic girls will have lower pre-pregnancy iron stores. As pregnancy is too short a period to construct the iron stores needed to address the needs of the growing foetus, women who enter pregnancy anaemic are at an expanded danger of giving birth to children with a low birth weight (below 2,500 grams), delivering pre-term newborns, and/or dying while giving birth. Furthermore, children born to anaemic women are more prone to die before the age of one year and be sick, undernourished and anaemic, thus perpetuating the intergenerational cycle of maternal and child undernutrition (UNICEF, 2011[b]).

4.6.2 Symptoms of anaemia

The common symptoms of anaemia experienced by the respondent adolescent girls are briefed in the following table.

Table 22

Symptoms of anaemia experienced by the adolescent girls

(N=500)

Symptoms	Number	Per cent*
Headache	378	75.6
Fatigue	188	37.6
Dyspnoea	50	10
Blurring vision	43	8.6
Paraesthesia	19	3.8
Syncopal attacks	26	5.2

*Multiple response

In the present study, intermittent headache was experienced by 75.6 per cent of the subjects. Fatigue was another symptom found among 37.6 per cent of the subjects. Dyspnoea or shortness of breath was experienced by 50 (10%) subjects. Paraesthesia is a sensation of tickling, tingling, burning, pricking, and/or numbness of a person's skin with no apparent long-term physical effect. It is known as the feeling of "pins and needles". The manifestation of paraesthesia was reported by 3.8 per cent adolescent girls under study. Syncopal attack was common among 5.2 per cent of the adolescent girls under the study.

Goel and Gupta (2007) also reported that signs and symptoms like headache, fatigue, dyspnoea, paraesthesia and syncopal attacks were significantly more among the anaemic senior secondary school students (10-19 years) of Shimla.

4.6.3 Haemoglobin, serum iron, serum folic acid and vitamin B_{12} levels of adolescent girls

Haemoglobin, serum iron, serum folic acid and vitamin B_{12} levels were analysed in a sub-sample of 115 anaemic adolescent girls and is presented in the following table.

Table 23

Haemoglobin, serum iron, serum folic acid and vitamin B_{12} levels of adolescent girls

Parameters (N=115)	**PS**	**Normal range**
Haemoglobin (g/dl)	11.7± 0.88	≥12g/dl**
Serum iron (µg/dl)	25.69 ± 4.82	35-150µg/dl♦
Serum folic acid levels (ng/ml)	2.54 ± 0.45	3-17ng/ml*
Vitamin B_{12} (pg/ml)	359.2±106.6	200-960 pg/ml•

PS –Present study
*Ashraf *et al.*, (2008)
♦Monson *et al..*, (2002)
• WHO (1968)
**WHO (2001[b])

According to WHO (2001[b]), the population is anaemic if haemoglobin concentration is less than 12 g/dl for the 12-14 years age group. The test results of this study shown in the above table indicate that the respondents under this present study had an average Hb level of 11.7 g/dl, a little below the normal range. Serum iron level was found to be well below (25.69 µg/dl) the normal range (35-150 µg/dl) indicated by Monson *et al*., (2002). Also the serum folic acid level was found to be well below (2.5 ng/ml) the normal range (3-17 ng/ml) prescribed by Ashraf *et al*., (2008), whereas vitamin B_{12} status of the subjects found satisfactory with a mean of 359.2 pg/ml. Hence, it has been concluded that haemoglobin, serum iron and serum folic acid levels measured for the anaemic girls in the study were below the respective average levels indicated.

4.7 Dietary pattern of adolescent girls

Meal pattern, dieting and meal skipping practices, individual and environmental factors influencing diet pattern, frequency of consumption of nutritious foods, actual nutrient consumption assessed using 24-hour recall and food frequency questionnaire and snacking pattern of a sub-sample of 150 adolescent girls are discussed under this section.

4.7.1 Meal pattern

Type of diet and its frequency among adolescent girls were ascertained and the results are presented in the following table:

Table 24

Meal pattern of adolescent girls

Subjects	**Type of meal**			**Number of meals per day**				
	Non-vegetarian (%)	Veg-etarian (%)	Non-vegetarian often takes vegetarian foods (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)
Adolescent girls (N=500)	64.2	4.8	31	2.4	6.4	87	4	0.2

Majority of the adolescent girls were non vegetarians (64.2%) and had almost 3-4 meals per day. The four meals pattern found by the 24-hour recall method and it was composed of four main meals (Breakfast, lunch, a light evening meal and dinner) and a healthy mid-time snacks were missing in majority of the respondents' diet pattern.

Choudhary *et al*., (2010) observed dietary nature of the adolescent girls of Chiraigaon block of Varanasi and reported that "28.89 per cent, 41.85 per cent and 14.80 per cent subjects were vegetarian, non-vegetarian and eggetarian, respectively. Frequency of meals 2-3 times/day and 3-4 times/day were practiced by 207 (76.67%) and 62 (22.96%) respondents, respectively. About half (50.37%) of the adolescent girls used to take their meals in fixed times".

4.7.2 Dieting and meal-skipping pattern of adolescent girls

Dieting is the act of eating food in a regulated manner to accomplish or keep up a controlled weight. Lack of scientific knowledge on dieting, psychological problems, peer group pressure, lack of confidence on physical stature or appearance were probably the most common reasons for unscientific dieting and meal-skipping. The table shows dieting and meal-skipping practices of adolescent girls under study.

Table 25

Dieting and meal skipping practices of adolescent girls

Dieting and meals skipping practices	Number of subjects	Per cent
Dieting practices (N=500)	52	10.4
Meal skipping (N=500)	204	40.8
Breakfast (N=204)	127	62.2*
Lunch (N=204)	10	4.9*
Tea time snack (N=204)	8	3.9*
Dinner (N=204)	79	38.7*

*Multiple response

Dieting was followed by 10 per cent of the subjects under the study. For dieting adolescent girls reduced the amount of food or skipped their meals without considering that they are normal in weight. Dissatisfaction about their body and image and a desire to be thinner was found to be the motivating factor behind the majority of adolescent girls who followed dieting. Findlay (2004) pointed out that teenagers with lower self-esteem are more likely to diet, often in an attempt to feel better about themselves if weight loss is successful. The process of dieting, it has been proved, may make the situation worse and results further negative impact on the young person’s self-esteem

From the above table it is observed that 40.8 per cent adolescent girls skipped at least one meal of a day. Majority i.e. 62.2 per cent skipped their breakfast which is the most important meal of the day. Breakfast is suggested as a major aspect of a healthy diet as it is associated with healthier macro and micronutrient intakes, BMI and lifestyle. Breakfast is also promoted to enhance cognitive functions and scholastic performance (Hoyland *et al.*, 2009). Therefore skipping of breakfast among adolescent girls under study will have a negative impact on their scholastic performance. Reasons for skipping breakfast could be lack of time, hurry, lack of appetite, too early to take a meal, dislike for certain foods and working mothers.

Among the study respondents, only 5 per cent adolescent girls were in the habit of skipping lunch. The practice of bringing and eating rice-based packed lunches was common among adolescent girls under study because lunch was considered as a main meal that contributed to a whole day’s food intake. There is a strong belief that eating rice-based lunch provides adequate energy and feeling of satiety. The skipping of tea and tea time snack was observed among 3.9 per cent of the respondents. The practice of having a light snack on returning from school or college was observed among majority of the subjects. The preferred items for this light snack were chips, mixtures, fried foods and crackers.

4.7.3 Individual and environmental factors influencing diet pattern

Influence of individual and environmental factors like friends, peers, media, advertisements and psychological statuses on the diet pattern of adolescent girls is explained below:

Table 26

Individual and environmental factors influencing diet pattern

(N=500)

Influencing factors	Number	Per cent*
Family	451	90
Friends/peers	443	89
Media/advertisements	436	87
Psychological status	276	55

*Multiple response

From the above table it is clear that majority of the adolescent girls were influenced by family, friends/peers and media/advertisements. Among these, family was found to be the major (90%) influencing factor. Friends/peers influenced 88.6 per cent of the adolescent girls under study, followed by media/advertisement (87.2%). Whereas diet pattern of 55.2 per cent of the subjects were influenced by psychological status like happiness, anger, frustration and exam tensions.

Parents and friends provide two of the most important social influences on youths' eating behaviour (Salvy *et al.*, 2011). Families could influence adolescents' eating behaviour in two ways: (i) food preferences, willingness to try new foods and food availability are influenced by parental attitudes and (ii) family meal patterns, such as eating meals together can positively influence fruits and vegetables consumption and negatively impact soft drink consumption (Gillman *et al.*, 2000; Benton, 2004; Eliassen, 2011).

4.7.4 Frequency of consumption of foods

The consumption pattern of certain common nutritious foods by the adolescent girls as assessed by food frequency questionnaire is presented in the table below:

Table 27

Frequency of consumption of foods

Food groups	Frequency of consumption, days per week (% of subjects)				
	Never	1-3 days	4-5 days	6-7 days	Mean
Cereals	0	0	0	100	7
Pulses	0	3.3	50	46.6	5.4
Green leafy vegetables	24.6	75.3	0	0	1.4
Roots and tubers	0	50.6	42.6	6.6	3.5
Other vegetables	0	0	34	66	6.0
Fruits	0	76.6	23.3	0	2.8
Fish and meat	0	0	32	68	5.97
Milk and milk products	2	0	0	98	6.86
Sugars	0	0	0	100	7
Fats and oils	0	0	0	100	7

It was observed that nutritious foods like green leafy vegetables and fruits were consumed less frequently by the adolescent girls with mean days of 1.4 and 2.8 per week. Only occasional consumption of green leafy vegetables was observed among 24.6 per cent of the subjects. Average frequency of intake of green leafy vegetables was between one to three days. Intake of cereals, milk and milk products, sugars and fats were satisfactory with an average of 7, 6.8, 7 and 7 days per week respectively. Consumption frequencies of fruits were also around 1-3 days per week with mean day of only 2.8. Average frequency of consumption of pulses was 4-5 days with an average of 5.4 days. Green gram, Bengal gram, black gram were the most commonly used pulses. Thus the intake of nutritious foods by the respondent adolescent girls was far from being satisfactory.

These findings were parallel to the results of a study conducted by Choudhary *et al*., (2010) which states that daily consumption of body building (viz. pulses and milk) and protective (viz. fruits, green vegetables and other vegetables) foods by an adolescent was practically non-existent in the study area . Consumption of green vegetables once or twice per week was to the degree of 69.26 per cent. Root vegetables, fruits and Sharbat were consumed maximally either occasionally or demonstrated an occasional pattern. As a matter of fact, pulses, vegetables and milk products were dodged by 4.07 per cent, 13.70 per cent and 7.41 per cent of study subjects, separately.

4.7.5 Nutrient consumption of adolescent girls

The actual intake of nutrients was ascertained using 24-hour recall technique. Energy, protein, fat, calcium, iron, vitamin C and folic acid intakes per day were computed. Comparison of these with RDA values (ICMR, 2004) prevailing during the study period is presented in the following table and illustrated in figure no 12 and 13.

Table 28

Nutrient consumption of adolescent girls

(N=150)

Age	Nutrients	Actual intake	RDA	% of RDA met	% of surplus or deficit	t value	*p*-value
17-18 years (N=116)	Energy (Kcal)	1567.10 (±257.07)	2060	76.07	-23.92	20.65	0.000**
	Protein (gm)	64.57 (±12.24)	63	102.49	+2.49	1.38	0.844NS
	Fat (gm)	50.08 (±11.33)	22	227.63	+127.63	26.69	0.000**
	Calcium(mg)	607.29 (±308.41)	500	121.45	+21.45	3.75	0.0001**
	Iron (mg)	19.01 (±5.83)	30	63.36	-36.64	20.30	0.0001**
	Vitamin C (mg)	22.24 (±9.65)	40	55.6	-44.4	19.80	0.0001**
	Folic acid (µg)	73.22 (± 9.50)	100	73.22	-26.78	30.37	0.0001**
Age 19 years (N=34)	Energy (Kcal)	1566.25 (±251.40)	1875	83.54	-16.46	7.16	0.0001**
	Protein (gm)	67.00 (±11.46)	50	134	+34	8.65	0.0001**
	Fat (gm)	49.25 (± 10.85)	20	246.25	+146.25	15.72	0.0001**
	Calcium (mg)	677.57 (±287.08)	400	169.39	+69.39	5.64	0.0001**
	Iron (mg)	15.13 (±2.30)	30	50.43	-49.57	37.73	0.0001**
	Vitamin C (mg)	16.51 (±7.12)	40	41.2	-58.8	19.22	0.0001**
	Folic acid (µg)	63.91 (±10.59)	100	63.91	-36.09	19.87	0.0001**

**Significant at one per cent level
NS-Not significant

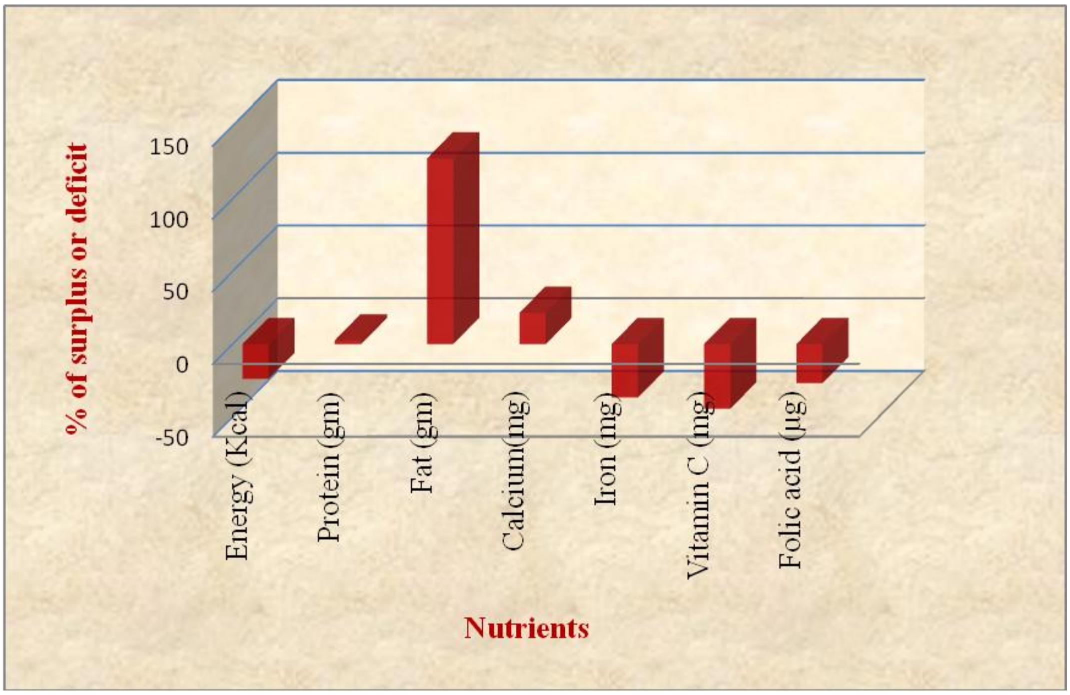


Figure 12 - Nutrient consumption of adolescent girls (17-18 years)

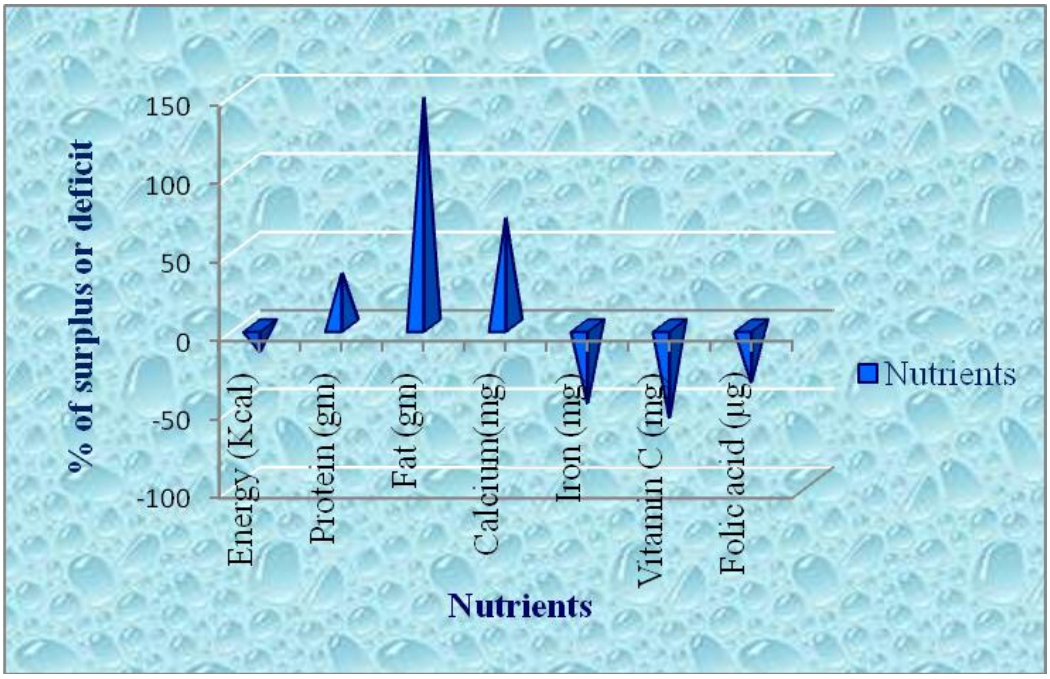


Figure13 - Nutrient consumption of adolescent girls (19 years)

The results indicated that intake of all the nutrients except protein, fat and calcium was significantly lower ($P<0.01$) than RDA among the adolescent girls. It was found that the consumption of energy, iron, vitamin C and folic acid did not meet the Recommended Dietary Allowance (RDA). However, protein, fat and calcium intakes exceeded the RDA levels. The intake of protein and calcium were at par with RDA and that of fat was significantly higher ($P<0.01$) than RDA for the ages 17, 18 and 19, that may be because of the frequent intake of fried foods and excessive use of coconut. Iron intake of adolescent girls between the age group of 17 to 19 was remarkably low with percentage around 55. This may be related to the intake of particular food groups as green leafy vegetable intake was very poor. Vitamin C intake reported the least percentages, i.e. 55.6 per cent for age 17 and 18 and 41.2 per cent for age 19. This can be a result of low intake of fruits and vegetable consumption reflected in food frequency questionnaire.

These findings were coinciding with the study conducted by Parimalavalli and Sangeetha (2011). Mean nutrient intake of the selected Government school girls was remarkably lower than compared to Recommended Dietary Allowance of Indians. The mean energy intake of the government (1905 kcal) and the matriculation (2034 kcal) school girls were significantly lower than RDA. Intake of nutrients such as proteins (48.9 g), fat (19.3 g), calcium (400.7 mg), iron (17.8 mg) and vitamin C (29.1 mg) were found to be significantly far below the RDA.

Varsha *et al.*, (2008) stated that the rural adolescent girls of Marathwada region were consuming all nutrients below the recommended, revealed gross deficiency of nutrients. Compared to other nutrients, fat intake was found to be slightly satisfactory as the intake was almost one-third of the requirement.

4.7.6 Snacking pattern of adolescent girls

Snack is a food or drink eaten between main meals. Snacking patterns might also reflect unhealthy eating habits. Weekly pattern of consumption of various snacks by the adolescent girls were depicted in the following table.

Table 29

Snacking pattern of adolescent girls

(N=150)

Category of snacks	Frequency per week (% of subjects)				
	Never	Once	Twice	Thrice	More than thrice
Fast foods	-	25.4	38.6	36	-
Fried snacks	-	-	-	20.7	79.3
Sweet snacks	2.6	31.3	36	26.6	3.3
Other sweets	-	26	28	25.4	20.6
Soft drinks	22.6	37.3	21.3	8.6	10.6

The frequency of consuming different categories of snacks, was basically once to thrice a week. It is surprising to note that 79.3 per cent of the adolescent girls consumed fried snacks more than thrice in a week. Banana fritters, *vada*, cutlets, *samosa*, *bajis,* etc. were the fried snacks consumed more frequently by the adolescent girls. Other sweets like ice cream, chocolates, cookies, toffees and soft drinks were also consumed very frequently. Almost all the subjects had strong liking for fried foods (79.3%), sweets (26.6%) and soft drinks (10.6%). Maggi noodles, vada, samosa, cutlets, ice-cream, chocolate and soft drinks formed the mainstream nibble things among adolescent girls.

Shrivastav and Thomas (2010) conducted school-based cross-sectional study to evaluate the snack ingestion pattern of 702 adolescent girls of Delhi. The outcomes showed a higher inclination for snacks. Different categories of snacks were consumed mostly once to thrice a week. Fast foods, fried foods and sweet snacks were most preferred by the children. Chowmein, maggi, samosa, ice-cream (mainly ice candies), chocolate and toffee were additionally the prevalent nibble things.

4.8 Multiple correlates of family income

Correlation of family income with age at menarche, BMI, nutritional knowledge and incidence of anaemia was studied and discussed under this section.

4.8.1 Correlation between family income and age at menarche

Correlation between family income and age at menarche was worked out and the result is presented in table 30 and figure 14.

Table 30

Correlation between family income and age at menarche

Age at menarche	Income category				Total	Result
	EWS	LIG	MIG	HIG		
Up to 12 years	34 37.4%	80 43.5%	42 36.5%	34 44.2%	190 40.7%	r = .041 p = .378
Above 12 years	57 62.6%	104 56.5%	73 63.5%	43 55.8%	277 59.3%	
Total	98 100.0%	91 100.0%	184 100.0%	115 100.0%	467 100.0%	

EWS-Economically weaker section
LIG-Low income group
MIG-Middle income group
HIG-High income group

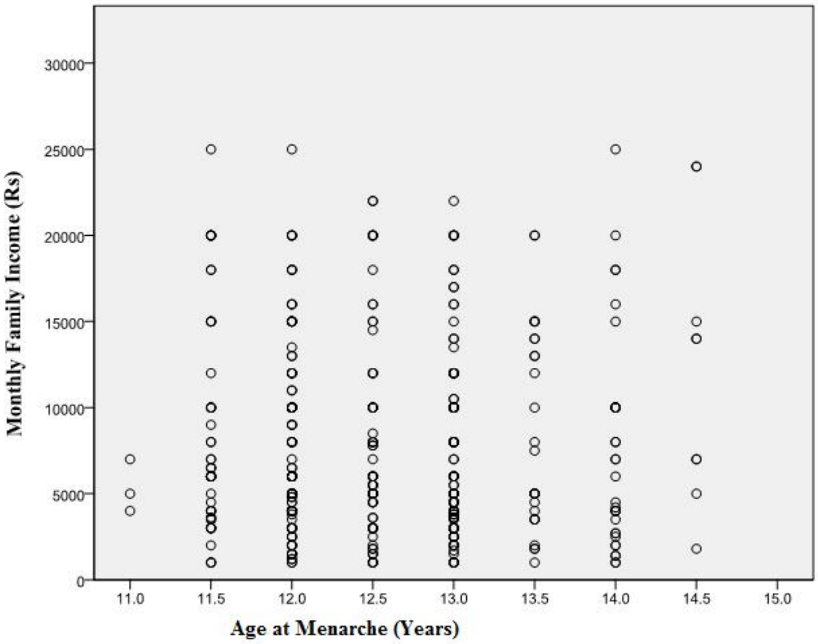


Figure 14 - Correlation between income and age at menarche

The above table presents the income category and age at menarche. The respondents were grouped into two categories by their age at menarche i.e. those who attained menarche at the age of 12 years and earlier and those whose age of menarche was above 12 years. From the data presented, it can be inferred that, 80 (43.5%) adolescents of the low income group respondents attained their menarche at the age of 12 or earlier, followed by 42 (36.5%) of the middle income group. A majority (104, 56.5%) of low income group respondents attained their menarche after 12 years of age. To sum up, a majority (277, 59.3%) of the respondent adolescents' age of menarche were above 12 years.

To examine the relationship between family income level and age of menarche Pearson's r-correlation test was applied. From the correlation table, it can be seen that the correlation coefficient (r) equals .041, indicating a very positive relationship with an associated p = .378, which is greater than the critical value .05, indicates that the coefficient does not significantly differ from 0. The square of the coefficient (r^2) is .0017, which means that only 0.17 per cent of the variation is related, which is very insignificant. Hence, it has been concluded that there was no statistically significant relationship between family income and age at menarche of the respondents.

Study by Rokade and Mane (2008) supported the association between age of menarche and socio-economic status, but not associated with type of diet and day-to-day physical activity. Whereas Todd *et al*., (2010) suggests that lower socio-economic status at 7 years and reductions in socio-economic status in early childhood are both associated with an earlier age at menarche.

4.8.2 BMI in relation to family income

Family income was found to be a significant factor of BMI in many of the studies. The relationship of family income of the adolescent girls and BMI is discussed in the following table.

Table 31

BMI in relation to family income

Income category*	BMI category				Total	Result
	Under-weight	Normal	Over weight	Obesity		
EWS	25 16.9%	73 22.0%	0 .0%	0 .0%	98 19.6%	*r* =.015 *p* = .742
LIG	58 39.2%	129 38.9%	8 50.0%	2 50.0%	197 39.4%	
MIG	37 25.0%	80 24.1%	4 25.0%	2 50.0%	123 24.6%	
HIG	28 18.9%	50 15.1%	4 25.0%	0 .0%	82 16.4%	
Total	148 100.0%	332 100.0%	16 100.0%	4 100.0%	500 100.0%	

*HUDCO (2007)
EWS-Economically weaker section
LIG-Low income group
MIG-Middle income group
HIG-High income group

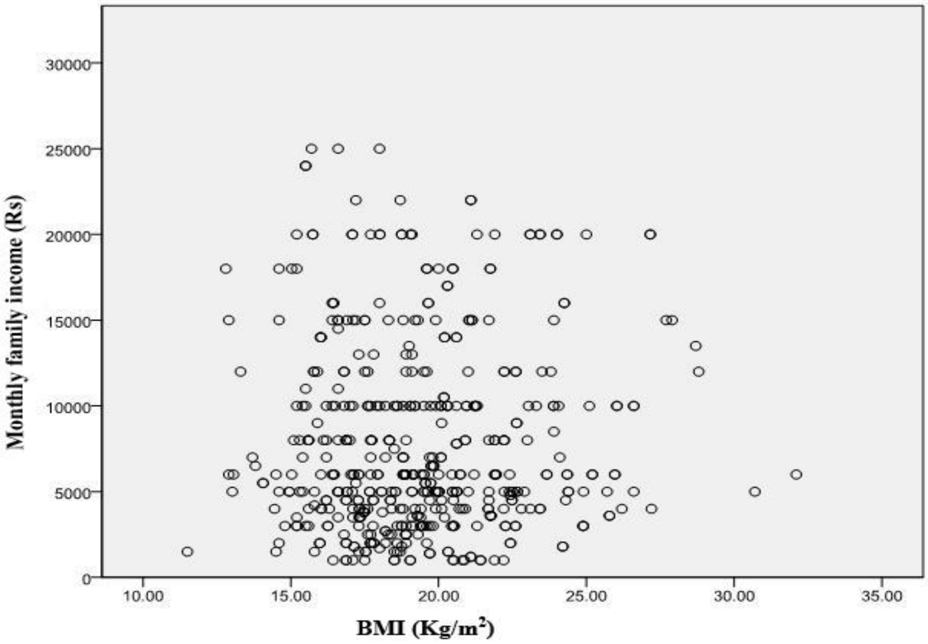


Figure 15 - BMI in relation to family income

The cross table above shows the income and BMI. BMI was grouped into four categories viz. *Underweight*, *Normal*, *Overweight*, and *Obesity*. The respondents' monthly income was grouped into four levels based on the HUDCO (2007) scale, viz. *Economically Weaker Section* (< Rs. 3,300), *Low Income Group* (Rs.3, 301-7,300), *Middle Income Group* (Rs.7, 300-14,500) and *High Income Group* (> Rs.14, 500). Cross table data shows that out of the total respondents, the low income group (LIG) had the largest share of "underweight" (58, 39.2%), "normal" (129, 38.9%) and "overweight" adolescents (8, 50.0%). The economically weaker section (EWS) had the lowest share (25, 16.9%) of underweight adolescents. To sum up, majority of the respondents (332, 66.4%) had normal BMI and only 0.8 per cent respondents were found to be obese.

Correlation between income and BMI was examined by using Pearson's r-correlation test. From the correlation statistic table, it can be seen that the correlation coefficient (r = .015) indicates a very weak positive relationship and the associated probability (p = .742) is greater than the critical value .05, indicates that the coefficient is not significantly different from 0. The square of the coefficient (r^2 = .0002) shows that only .02 per cent of the variation is related, which is very negligible. Hence, it has been concluded that household income was not an indicator to predict the adolescent's BMI.

Sinha and Pankaj (2009) studied 1,530 adolescent girls from backward districts of 12 different Indian states selected under Rashtriya SamvikasYojana and quoted that out of the total samples, 44.3 per cent are underweight excluding 41 overweight cases. District wise picture showed that the problem of underweight among adolescent girls is very serious and omnipresent, irrespective of income status of the family.

4.8.3 Correlation between family income and nutritional knowledge

Relationship between family income and nutritional knowledge is discussed under the following table.

Table 32

Correlation between family income and nutritional knowledge

Variables	Number	Mean	Results
Monthly family income (Rs)	500	8343.40 ± 7703.895	r = 0.072 p =0.108
Knowledge score	500	6.06 ± 1.902	

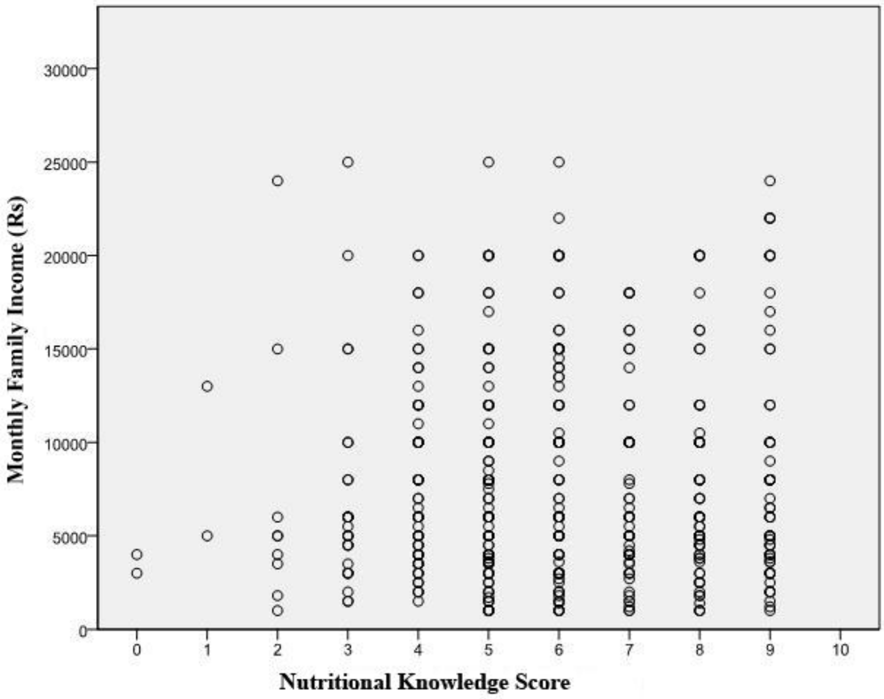


Figure 16 - Correlation between family income and nutritional knowledge

To examine the relationship between family income level and the respondent's knowledge about nutrition, Pearson's r-correlation test was applied. From the correlation table, it can be seen that the coefficient (r = .072) indicates a very weak positive relationship with an associated $p = .108$, which is greater than the critical value .05, indicates that the coefficient does not significantly differ from 0. The square of the coefficient (r^2= .0052) shows that only 0.52 per cent of the variation is related, which is very insignificant. Hence, it has been concluded that the respondents' knowledge on nutrition was not associated with the household income.

Alam *et al*., (2010) studied 4,993 unmarried adolescent girls, aged 13–18 years in rural Bangladesh and reported a positive association of nutritional knowledge with their age, education, access to mass media, and the household assets.

4.8.4 Correlation between family income and incidence of anaemia

Correlation between family income and incidence of anaemia is discussed under the following table.

Table 33

Correlation between family income and incidence of anaemia

Income category	Hb Level				Total	Result
	Severe anaemia (<7g/dl)	Moderate anaemia (7-9.9g/dl)	Mild anaemia (10-11.9 g/dl)	Normal (≥12g/dl)		
EWS	0 0%	0 .0%	16 14.4%	9 10.3%	25 12.4%	r = -0.059 p =0 .408
LIG	0 0%	1 25.0%	44 39.6%	34 39.1%	79 39.1%	
MIG	0 .%	0 .0%	33 29.7%	22 25.3%	55 27.2%	
HIG	0 0%	3 75.0%	18 16.2%	22 25.3%	43 21.3%	
Total	0 0%	4 100.0%	111 100.0%	87 100.0%	202 100.0%	

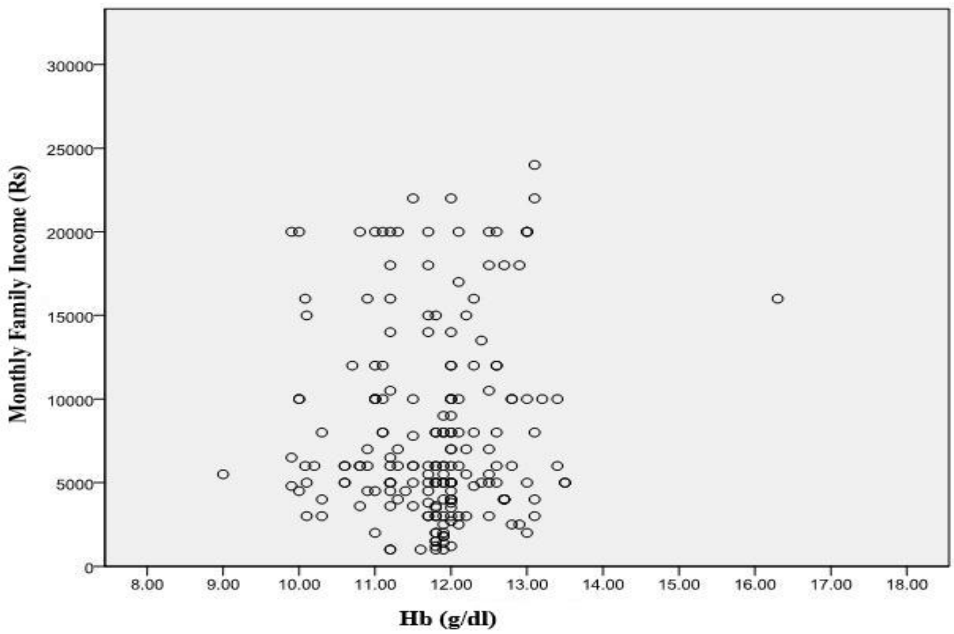


Figure 17 - Correlation between family income and incidence of anaemia

The above table presents the income category and haemoglobin levels. The haemoglobin level was grouped under four categories viz. *Normal* (≥ 12g/dl), *Mild Anaemia* (10-11.9 g/dl), *Moderate Anaemia* (7-9.9 g/dl) and *Severe Anaemia* (<7g/dl). From the data presented, it can be inferred that, a majority (75.0%) of the moderate anaemic girls were from the high income group. Largest number (39.6%) of mild anaemic children was from the low income group followed by middle income group (29.7%). Severe anaemic condition was not found among the respondents. Out of the total 202 haemoglobin measured samples, nearly half (111, 54.95%) of the respondents was found to be 'mild anaemic'.

Correlation between income and Hb level was examined by applying Pearson's r-correlation test. From the correlation table, it can be seen that the correlation coefficient (r) equals -.059, indicating a very weak and negative relationship with an associated $p = .408$, which is greater than the critical value .05, indicates that the coefficient is not significantly different from 0. The negative sign associated with the calculated 'r' denotes that higher the income, lower the Hb level and vice-versa. The square of the coefficient (r^2) is .0035, which means that only 0.35 per cent of the variation is related, which is very insignificant. Hence, it has been concluded that household income did not have any significant influence on the respondents' haemoglobin level.

But Karaoglu *et al*., (2010) identified income level as a predictor of anaemia among the family members, especially children.

4.9 Selected variables vs. Body Mass Index

Relationship of variables like age, age at menarche, nutritional knowledge and incidence of anaemia of adolescent girls with their BMI is presented below.

4.9.1 Body Mass Index vs. age

Relationship of age with BMI was studied and represented below.

Table 34

Age classification vs. BMI

(N=500)

Age category	Number	Under-weight (%)	Normal (%)	Over-weight (%)	Obese (%)	Df	*p*-value
Early adolescence (≤16 years)	300	11.3	82.3	5.3	1	3	0.798 [NS]
Late adolescence (17-19 years)	200	13.5	81.5	4.5	0.5		

NS-Not significant

Out of the 500 adolescent girl respondents, majority, i.e. 82.3 per cent and 81.5 per cent from both early and late adolescent phases were normal, whereas underweight subjects were more in late adolescent stage i.e. 13.5 per cent when compared to early adolescent stage (11.3%). Overweight subjects were more in early adolescent phase, i.e. 5.3 per cent than late adolescent age i.e. 4.5 per cent. Obese subjects were found in both early and late adolescent phases with 1 per cent and 0.5 per cent. From the above table it is clear that there is no significant relation between age and BMI (P >0.05 i.e. 0.79).

4.9.2 Correlation between Body Mass Index and age at menarche

"World Health Organization recommended BMI-for-age as the best indicator for use in adolescence as it incorporates the required information on age; it has been validated as an indicator of total body fat at the upper percentiles and it provides continuity with recommended adults' indicator" (Rao, 2001). The test was conducted to examine the correlation between age of the respondents and the BMI measured.

Table 35

Correlation between Body Mass Index and age at menarche

Age of menarche	Number	BMI				
		Under weight	Normal	Over weight	Obesity	*Result*
Up to 12 years	190 40.7%	139 8.4%	139 29.8%	11 2.4%	1 0.2%	r = -0.255 p = 0.000
Above 12 years	277 59.3%	85 18.2%	184 39.4%	5 1.1%	3 0.6%	
Total	467 100.0%	124 26.6%	323 69.2%	16 3.4%	4 0.9%	

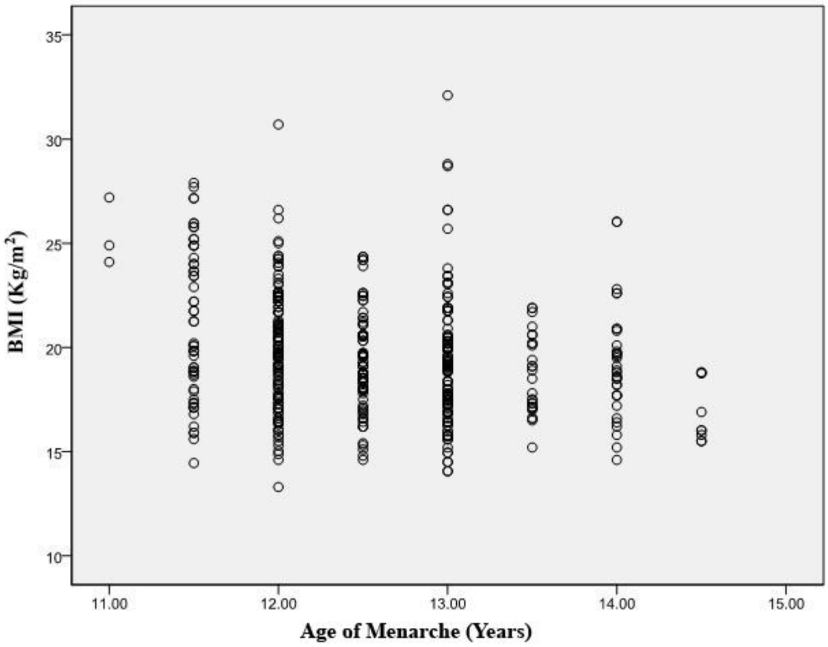


Figure 18 - Correlation between age at menarche and BMI

The respondents were grouped under two categories of age groups viz. those whose age at menarche 12 years and below and those whose age at menarche was above 12 years, as shown in the above table. Out of the 467 respondents, a majority, i.e. 277 (59.3%) had age at menarche above 12 years and the remaining 190 (40.7%) had 12 years and below. The test results show that the Pearson's correlation coefficient, r = -0.255 (< .5), which means a negative correlation and at the same time weak correlation. This shows that girls with higher age at menarche had lower BMI levels and those with lower age at menarche had higher BMI values. Even though weak, the significance value p = 0.000, is less than the significance α level 0.05. This indicates that the correlation is statistically highly significant and not by chance.

A number of studies have also shown an inverse relationship between age at menarche and BMI. Age at menarche was conversely and essentially associated with likelihood of overweight and obesity (p = 0.001) (Al-Awadhi *et al*., 2013). Adesina and Peterside (2013) found significantly higher BMI at 10, 12 and 13 years respectively among subjects who had attained menarche during their early adolescence period.

Based on the above results of Pearson's correlation test, it has been concluded that there is a statistically significant negative correlation between the age at menarche and the level of BMI.

4.9.3 Correlation between Body Mass Index and nutritional knowledge of adolescent girls

Correlation between nutritional knowledge of adolescent girls with their BMI is presented under the following table with figure.

Table 36

Correlation between nutritional knowledge and Body Mass Index

(N=500)

Variables	Mean	*p*-value
BMI (Kg/m^2)	19.36 ± 3.054	0.019*
Nutritional knowledge score	6.06 ± 1.902	

*Correlation is significant at the 0.05 level

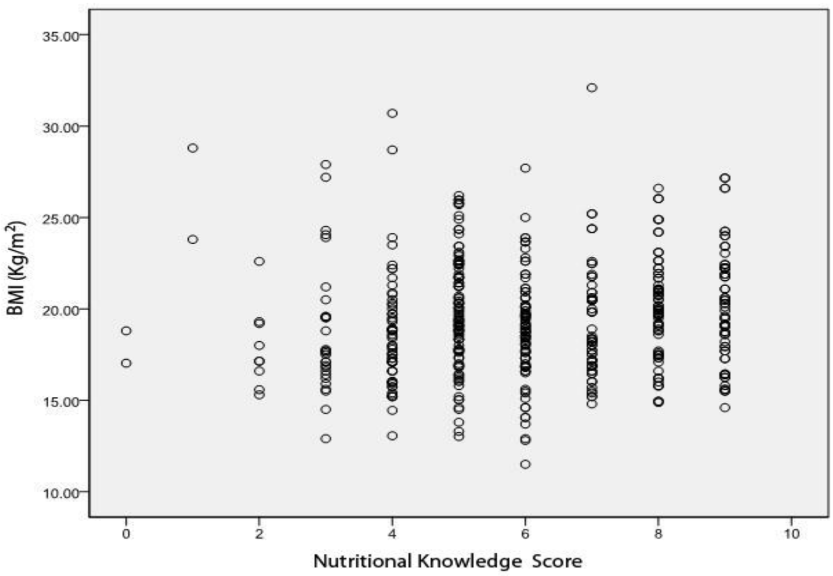


Figure 19 - Correlation between BMI and nutritional knowledge

The cross tabulation above shows the nutritional knowledge score and the corresponding BMI studied grouped into four categories, viz. (i) under-weight; (ii) normal; (iii) overweight; and (iv) obesity. It was found that out of the 500 respondents, larger number (332, 66.4%) were having normal BMI; 148 respondents (29.6%) were underweight and only 16 (3.2%) and 4 (0.8%) respondent adolescents were found to be overweight and obese respectively.

Pearson's correlation test results between nutritional knowledge score and the corresponding BMI value shows $r = 0.105$, which means a positive correlation between nutritional knowledge score and BMI. The corresponding probability score $p = 0.019$, which is less than α level 0.05, indicates a statistically significant correlation between nutritional knowledge score and BMI.

Based on the Pearson's r-correlation coefficient test results discussed above, it has been concluded that there is a statistically significant correlation between nutritional knowledge and BMI – the two scores are quite independent.

4.9.4 Correlation between Body Mass Index and incidence of anaemia

Haemoglobin concentration, body weight, structure and Body Mass Index (BMI) are some of the most popularly used parameters for the evaluation of human health. The association between incidence of anaemia and BMI was analysed for this study.

Table 37

Correlation between Body Mass Index and incidence of anaemia

BMI category	Number	Percentage of incidence				
		Normal (≥12 g/dl)	Mild anaemia (10-11.9 g/dl)	Moderate anaemia (7-9.9 g/dl)	Severe anaemia (<7g/dl)	*Result*
Underweight	43 21.3%	20 9.9%	22 10.9%	1 0.5%	0 0%	
Normal	149 73.8%	61 30.2%	86 42.6%	2 1.0%	0 0%	
Overweight	9 4.5%	5 2.5%	3 1.5%	1 0.5%	0 0%	r = -.031 p = .658
Obesity	1 0.5%	1 0.5%	0 0.0%	0 0.0%	0 0%	
Total	202 100%	87 43.1%	111 55.0%	4 2.0%	0 0%	

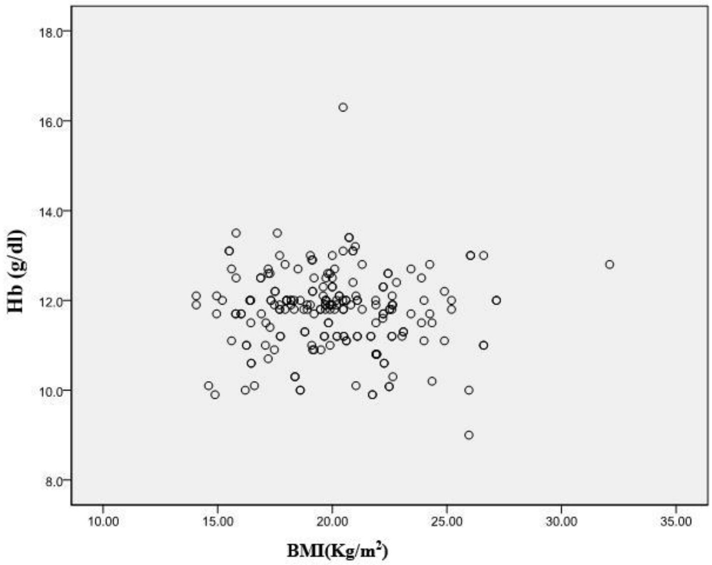


Figure 20 - Correlation between Body Mass Index and incidence of anaemia

Out of the 202 respondents, majority (149, 73.8%) were found to have normal BMI, followed by 43 (21.3%) respondents, who were found to be underweight and 9 (4.5%) and only one (0.5%) respondents were found to be overweight and obese respectively. Mild anaemia was found to be more among normal BMI group respondents (86, 42.6% of 149) and again in overall, more than half (111, 55%) were found to have mild anaemia and none had severe anaemia.

The correlation value was found as r = -.031 from the Pearson's r-Correlation. This means, a negative or inverse relationship between BMI and level of haemoglobin but the relationship was weak. This implies that higher the BMI, lower the haemoglobin level and vice-versa. The probability score 0.658 is higher than the critical value 0.05. This indicates the marginal inverse correlation is not statistically significant.

Saxena *et al*., (2011) found a negative association of haemoglobin with nutritional status (BMI) (r = -0.59; p = 0.24). Singh and Mangang (2012) found a negative association (r = -0.060) and the value was found insignificant (t = 0.566).

Based on the Pearson's r-correlation test, it has been concluded that a negative correlation was found between the BMI and level of haemoglobin but it was not statistically significant.

4.10 Health and family related parameters vs. anaemia

Relationships of anaemia with health and family related parameters are discussed below.

4.10.1 Incidence of anaemia among different religious groups

Incidence of anaemia among the different religious groups is presented in the following table.

Table 38

Difference in the level of anaemia incidence between the three religious groups

Religion	**Number**	**Percentage of incidence**				
		Normal ($\geq$12g/dl)	**Mild anaemia (10-11.9 g/dl)**	**Moderate anaemia (7-9.9 g/dl)**	**Severe anaemia (<7g /dl)**	***Result***
Hindu	112 55.4%	46 22.8%	64 31.7%	2 1.0%	0 0%	χ^2 = 0.464 *p* = 0.793 df = 2
Christian	68.0 33.7%	32 15.8%	34 16.8%	2 1.0%	0 0%	
Muslim	22.0 10.9%	9 4.5%	13 6.4%	0 0%	0 0%	
Total	202 100%	87 43.1%	111 55.0%	4 2.0%	0 0%	

The percentage of incidence of anaemia was studied under four groups, viz. Normal ($\geq$12g/dl); Mild anaemia (10-11.9 g/dl); Moderate anaemia (7-9.9g/dl) and Severe anaemia (<7g/dl). The distribution of respondents shows that 112 (55.4%) respondents were Hindus; 68 (33.7%) belonged to Christian religion and 22 (10.9%) respondents were of Muslims. Out of this, adolescents of Hindu religion constituted the highest number (64, 31.7%) with mild anaemia, followed by adolescents of Christian religion (34, 16.8%) and Muslim adolescents registered the lowest of all (13, 6.4%). Incidence of severe anaemia was not at all found.

The output of Kruskal-Wallis test shows that the calculated chi-squared value as $\chi^2 = 0.464$, which is lower than the table value (5.991) at df = 1 and the associated *p*-value 0.793, is higher than the critical α value (0.05) to prove any significance. This indicates that the difference between the means compared is not statistically significant.

The same result has been found in other studies too. A higher prevalence of anaemia (91.2%) was found among Hindu adolescent girls, as compared to Muslims and other faiths (Ahmad *et al*., 2010). But no significant difference in anaemia prevalence was found by Dutt *et al*., (2009) between Hindu and Muslim faith adolescent girls in rural area of Raigad district, Maharashtra.

Based on the results output of Kruskal-Wallis test, it has been concluded that there has been no statistically significant difference in the level of incidence of anaemia between respondents belonged to Hindu, Christian or Muslim religious groups.

4.10.2 Anaemia incidence and mother's educational level

Children and adolescents depend on their parents for right nutrition and mothers play a crucial role in ensuring appropriate nutrition to their children. Hence mother's education and knowledge about nutrition plays a crucial role in children's health. The following table shows the association between mother's educational status and incidents of anaemia.

Table 39

Association between mother's educational attainment and the adolescent's anaemia

Educational level of mothers	Number	Percentage of incidence: Normal (≥12 g/dl)	Mild anaemia (10-11.9 g/dl)	Moderate anaemia (7-9.9 g/dl)	Severe anaemia (<7 g/dl)	*p*-value
Up to 10th Std	17 8.4%	8 4.0%	9 4.5%	0 0%	0 0%	χ^2 = 0.334 P = .953 df = 3
10th Passed	79 39.1%	32 15.8%	46 22.8%	1 0.5%	0 0%	
12th Passed	70 34.7%	31 15.3%	37 18.3%	2 1.0%	0 0%	
Graduation and above	36 17.8%	16 7.9%	19 9.4%	1 0.5%	0 0%	
Total	202 100%	87 43.1%	111 55.0%	4 2.0%	0 0%	

Mother's educational level and her adolescent's anaemia incidents are shown above. The incidence of anaemia was studied under four categories viz. Normal (≥12 g/dl); Mild anaemia (10-11.9 g/dl); Moderate anaemia (7-9.9 g/dl) and Severe anaemia (<7 g/dl) and the mother's educational level was studied under four groups as shown above. Out of the 202 respondents, the majority (79, 39.1%) of mothers has passed class 10, followed by 70 (34.7%) respondent mothers have studied up to 12th. Thirty six respondent mothers (17.8%) were graduates or above and the remaining 17 respondent mothers (8.4%) have studied up to 10th standard only.

The calculated χ^2 value, according to the result of Kruskal-Wallis test was found to be 0.334, which is less than the table value (7.8147) at df = 7. The associated probability value $p = 0.953$, is higher than the critical α value 0.05, which indicates no statistical association between the compared means, i.e. the educational groups.

According to Abuya *et al*., (2012), maternal education has been connected with nutrition outcomes among children in studies in different settings. Economists agree that there is a positive association between parents' education and child health (Rosenzweig and Schultz, 1982; Behrman and Deolalikar, 1988). However, the empirical studies provide a different picture. Some (Appoh and Krekling, 2005) have established significance of effect of maternal education on child health status, while others (Martorell *et al*., 1984) argue that there is little or no evidence.

According to the results of Kruskal-Wallis test results, it has been concluded that there has been no significant association between the different educational level of the mothers and the incidence of anaemia among their adolescent female children.

4.10.3 Incidence of anaemia and type of family

Relationship of type of family and incidence of anaemia is presented under the following table.

Table 40

Incidence of anaemia and type of family

Type of family	Number	Percentage of incidence				
		Normal (≥12g/dl)	Mild anaemia (10-11.9 g/dl)	Moderate anaemia (7-9.9 g/dl)	Severe anaemia (<7 g/dl)	*Result*
Joint family	28 13.9%	13 6.4%	14 6.9%	1 0.5%	0 0%	U =2368.5 Z = -.271 *p* = 0.787
Nuclear family	174 86.1%	74 36.6%	97 48.0%	3 1.5%	0 0%	
Total	202 100%	87 43.1%	111 55.0%	4 2.0%	0 100%	

The above cross-tabulation enables comparison of family type with incidence of anaemia. Among the 202 respondents, the majority (174, 86.1%) were from nuclear families. A high incidence (97, 48.0%) of mild anaemia was found to be present among adolescent respondents from nuclear families. Overall, more than half (111, 55.0%) of the adolescent female respondents had mild anaemia. Incidence of severe anaemia was not at all found.

The results of Mann-Whitney U-test shows the calculated U value as 2368.5 and Z value as -.271. The associated probability score was found to be (p = 0.787) greater than the critical α level (0.05). This shows that the difference between the two means compared are by chance only and have no statistical significance.

More studies have proved that family structure is a substitute for the process variables that specifically impact children's well-being and health (Emery *et al.*, 1985; Block *et al.*, 1988; Kurdek, 1981).

Based on the results of the Mann-Whitney U-test, it has been concluded that there is no statistically significant difference in the incidence of anaemia between the joint and nuclear family adolescent girls.

4.10.4 Correlation between age of menarche and incidence of anaemia

Correlation between age of menarche and incidence of anaemia is presented and discussed below.

Table 41

Relationship between age at menarche and incidence of anaemia

Age of menarche	**Number**	**Percentage of incidence**				
		Normal ($\geq$12 g/dl)	**Mild anaemia (10-11.9 g/dl)**	**Moderate anaemia (7-9.9 g/dl)**	**Severe anaemia (<7 g/dl)**	***Result***
Up to 12 years	57 28.2%	25 12.4%	28 13.9%	4 2.0%	0 0%	r = 0.138 p = 0.050
Above 12 years	145 71.8%	62 30.7%	83 41.1%	0 0.0%	0 0%	
Total	202 100%	87 43%	111 55.0%	4 2.0%	0 0%	

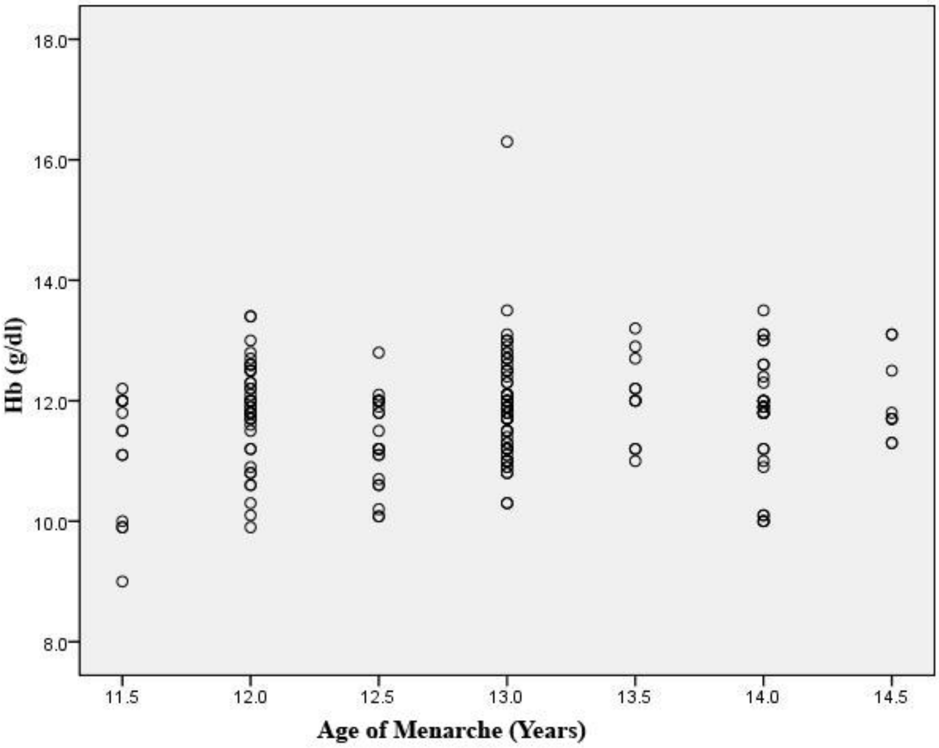


Figure 21 - Correlation between age of menarche and incidence of anaemia

From the above table, it can be inferred that respondents who attained menarche after 12 years constituted the most part of mild-anaemia segment. Overall, out of the 202 respondents, nearly more than half (111, 55.0%) of the adolescents had mild anaemia. Severe anaemia was not found among the respondents.

To examine the correlation between age at menarche and incidence of anaemia, Pearson's r-correlation test was used and found a very weak correlation (r = 0.138) with an associated probability level of 0.050, which is exactly equal to the critical value α = 0.05. This indicates that there exists a moderately significant relationship.

Bano (2012) in her study found that age at menarche was significantly correlated with anaemia. Another study by Shekhar (2005) showed prevalence of anaemia as high as 54.6 per cent and also showed higher mean menarcheal age. Vasanthi *et al*., (1994) also found that prevalence of anaemia, among urban girls, increased with the increase in age. But on the contrary, Kulkarni *et al*., (2012) did not find any association between menstrual factors and anaemia.

Based on the findings of Pearson's r-correlation test, it has been concluded that there is a moderately significant, but very weak positive correlation between the age at menarche and the incidence of anaemia.

4.10.5 Incidence of anaemia and dietary habit

Relationship between incidence of anaemia and dietary habit of adolescent girls were studied and presented here.

Table 42

Difference in incidence of anaemia between the three different dietary groups

Dietary habit	Number	Percentage of incidence				
		Normal (≥12 g/dl)	Mild anaemia (10-11.9 g/dl)	Moderate anaemia (7-9.9 g/dl)	Severe anaemia (<7g/ dl)	*Result*
Vegetarian	11 5.4%	6 3.0%	5 2.5%	0 0%	0 0%	χ^2 = 0.706 *p* = 0.703 df = 2
Non-vegetarian	65 32.2%	29 14.4%	32 15.8%	4 2.0%	0 0%	
Non-vegetarian but often take vegetarian food	126 62.4%	52 25.7%	74 36.6%	0 0%	0 0%	
Total	202 100%	87 43.0%	111 55.0%	4 2.0%	0 100%	

The respondents' dietary habits was studied by grouping into three categories, viz. vegetarian, non-vegetarian and non-vegetarian, but most often take vegetarian food. Out of the 202 respondents, the majority (126, 62.4%) belonged to third category i.e. non-vegetarian but often take vegetarian food. Followed by 65 (32.2%) non-vegetarians and 11 (5.4%) were vegetarians. Overall, a high level of mild anaemia was found among 74 (36.6%) respondents belonged to third category. No respondents were found to have severe anaemia.

The non-parametric test Kruskal-Wallis results shows χ^2 value as 0.706, which is lower the corresponding expected value (5.9915, df = 2). The probability score $p = 0.703$ is quite higher than the significant critical value 0.05. This proves that the difference between the three compared means is not statistically significant.

In a study by Basu *et al*., (2005) prevalence of anaemia in adolescent girls was found to be related to nutritional status and food habits. Sharma *et al*., (2003) in their study concluded the high prevalence of anaemia probably due to very low frequency of meat eating in India, but different types of dietary habits were found to have no effect on the prevalence of anaemia.

Based on the Kruskal-Wallis test results, it has been concluded that there is no statistically significant difference in the incidence of anaemia between the three dietary groups compared.

4.10.6 Incidence of anaemia among worm infested and non-infested adolescents

Worm infestation is probably a more significant reason of anaemia than specific vitamin and mineral deficiencies in developing countries like India. It is more common in India due to bad hygiene, poor awareness and poverty (Kumar *et al*., 2003). The relation of worm infestation and haemoglobin levels was examined and presented below.

Table 43

Difference in level of anaemia between worm infested and non-infested groups

History of worm infestation	**Number**	**Percentage of incidence**				
		Normal (≥12 g/dl)	**Mild anaemia (10-11.9 g/dl)**	**Moderate anaemia (7-9.9 g/dl)**	**Severe anaemia (<7 g/dl)**	***Result***
Infested	150 74.3%	61 30.2%	86 42.6%	3 1.5%	0 0%	U = 3541.5 Z = -1.136 *p* = 0.256
Non-infested	52 25.7%	26 12.9%	25 12.4%	1 .5%	0 0%	
Total	202 100%	87 43.1%	111 55.0%	4 2.0%	0 0%	

The above table shows the level of anaemia incidence among worm infested and non-infested groups of respondents. It was found that the highest (86, 42.6%) number of respondents who were infested had mild anaemia. Severe anaemia was not found among the respondents. Overall, out of the 202 respondents, more than half (111, 55.0%) had mild anaemia.

As per the test results of Mann-Whitney U-test, U = 3541.5 and Z = 1.136, and the associated probability value p = .256, which is greater than the critical α value 0.05. This indicates that there is no significance. From the Ranks statistics result, mean rank of worm infested group (99.11) was found to be greater than the mean rank of not infested (108.39).

Kumar *et al*., (2003) in their study among school going children found that out of 435 anaemic girls, 76.8 per cent demonstrated evidence of worms in their stool. Chakma *et al*., (2000) and Curtale *et al*., (1998) also demonstrated the association between infestation and anaemic condition.

Based on the Mann-Whitney U-test, it has been concluded that there is no statistically significant difference in the level of incidence of anaemia between worm infested and non-infested group of adolescent girl respondents.

4.10.7 Correlation between incidence of anaemia and iron intake

"The major cause of anaemia is low dietary iron intake. Strategies for reducing anaemia include supplementation, fortification and improving the diet" (Creed-Kanashiro *et al*., 2000). In this study, the effect of iron intake on the haemoglobin level was examined.

Table 44

Relationship between iron intake and haemoglobin level

Category	Mean	Std. Deviation	N	Result
Iron Intake (mg)	18.011	5.3585	150	r = .413 p = .000
Haemoglobin level (g/dl)	11.669	.8752	150	

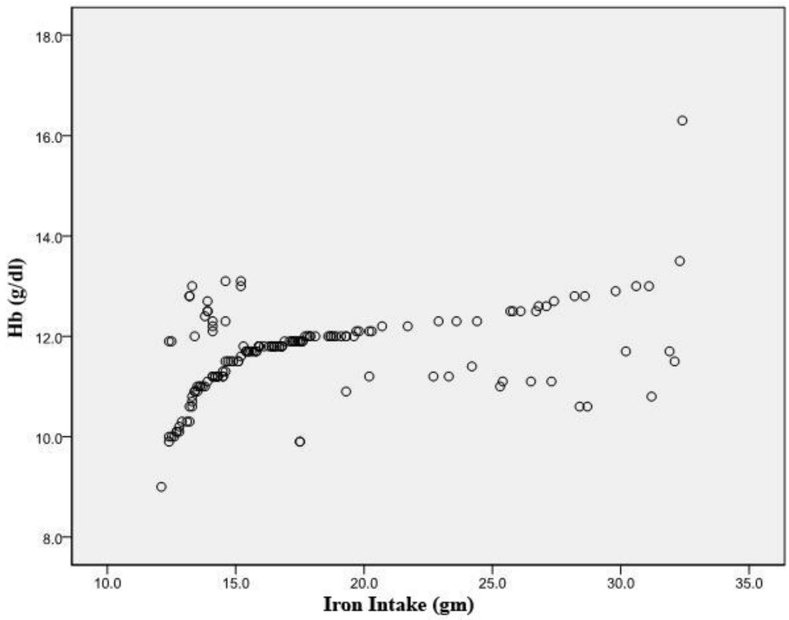


Figure 22 - Correlation between incidence of anaemia and iron intake

The descriptive statistics results are shown in the above table. The correlation coefficient (r = .413) indicated a strong positive correlation between iron intake and level of haemoglobin. The probability value (p = .000) is less than the critical value α (0.005). This shows that the positive correlation was highly significant.

Based on the Pearson's r-correlation test results, it has been concluded that there is a strong, positive and statistically significant correlation between iron intake and haemoglobin level, i.e. iron intake improves haemoglobin level.

The same result has been established by a number of studies. Ahmed *et al*., (2006); Siddharam *et al*., (2011); Ramzi *et al*., (2011) in their study found that after weekly supplementation with iron-folic acid tablets, the prevalence was diminished by 20.5 per cent.

4.10.8 Correlation between folic acid intake and incidence of anaemia

Correlation between folic acid intake and incidence of anaemia was analysed and depicted below.

Table 45

Relationship between folic acid intake and haemoglobin level

Category	Mean	Std. Deviation	Number	Result
Folic acid intake (µg)	70.977	10.4004	150	*r* = .754 *p* = .000
Haemoglobin level (g/dl)	11.669	.8752	150	

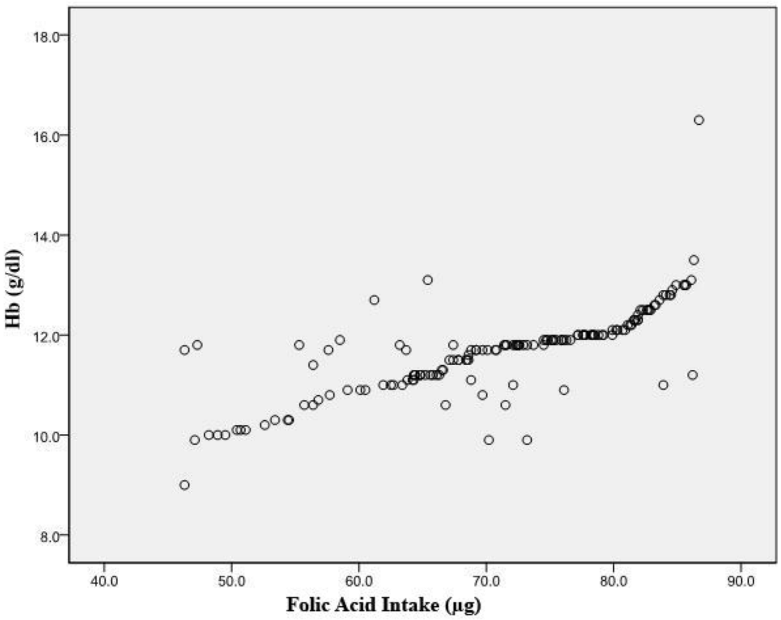


Figure 23 - Correlation between folic acid intake and incidence of anaemia

The descriptive statistics results are shown in the above table. The correlation coefficient (*r* = .754) indicated a very strong positive correlation between folic acid intake and level of haemoglobin. The probability value (*p* = .000) is less than the critical value α (0.005). This shows that the positive correlation was highly significant.

The findings of Sen and Kanmani (2012) Chaudhary and Dhage (2008) also confirmed that IFA supplementation significantly improved haemoglobin.

Based on the Pearson's r-correlation test results, it has been concluded that there is a very strong, positive and statistically significant correlation between folic acid intake and haemoglobin level, i.e. folic acid intake improves haemoglobin level.

4.11 Impact of different intervention methods on haematological parameters

The haemoglobin analysis revealed that 57 per cent of subjects were anaemic. The selected 202 respondents were further divided into four groups of 25 subjects each, the first group received the synthetic supplement (Livogen, a micronutrient fortified tablet) and they consumed one tablet per day for a period of three months. One dose of Albendazole (anti-worm drug) was also provided to the selected subjects of supplementation group. Anaemic adolescent girls in the second group received 100g iron-folic acid rich food supplement per day in the form of biscuits, weighing 20gm each for a period of three months. These biscuits formed a part of their daily diet and were advised to take in mid-morning and in mid-evening. The members of the third group received individual diet counselling. The last group was the control group and they did not receive any kind of intervention. Haemoglobin, serum iron and folic acid levels of all the subjects, were recorded before and after the intervention.

4.11.1 Impact of supplementation of micronutrient tablet on haematological parameters

Composition of the micronutrient tablet, effect of supplementation on haemoglobin, serum iron and serum folic acid levels were analysed and presented below.

4.11.1.1 Composition of the micronutrient tablet

The nutrient composition of the micronutrient tablet used in the supplementation study is presented in table 46 below.

Table 46

Composition of the micronutrient tablet

Name of the tablet	Contents
Livogen-Cap-tab (Ferrous fumerate and folic acid tablet)	Ferrous fumerate- 152 mg Folic acid-1500 mcg

Synthetic supplement selected for the study was Livogen, a micronutrient fortified tablet, which contained 152 mg of ferrous fumerate and 1500 mcg of folic acid, a product of Merck Ltd. Aurangabad. The cost of the tablet supplement worked out to be Rs.1.8 per subject per day. An anti-worm drug (Albendazole) was also given to the subjects before the supplementation study to note the accurate changes in the parameters.

Since it is hard to influence dietary behaviour because of social reasons and poverty, it is proposed mutually by UNICEF/UNU/WHO/MI (1998) that in nations where anaemia prevalence surpasses 40 per cent in pregnant women, procurement of widespread iron supplements for adolescent girls (at a minimum for those aged 12 to

16 years) and women of childbearing age is important. Iron-folic acid supplements are cost-effective and positive results are apparent in a brief time of a couple of months. Since menarche often sets in by 12 years of age, it is basic to guarantee that adolescents consistently consume iron-folic acid tablets to avert iron deficiency anaemia (WHO, 2011[c]).

4.11.1.2 Effect of supplementation on haemoglobin levels

The effect of supplementation on the respondents' haemoglobin level compared with the control group is presented below. The haemoglobin levels, before and after supplementation, was examined by applying paired *t*-test and differences in the haemoglobin levels between control and supplementation groups, was studied by one-way ANOVA test.

Table 47

Effect of supplementation on haemoglobin levels

Groups	Mean Hb levels (g/dl)		Difference	*t*-test	ANOVA
	Before	After			
Supplementation group (N=25)	11.08 ± 0.779	12.19± 0.47	1.11	$t = -11.742$ $p = .000$ df = 24	$p = .000$
Control group (N=25)	11.2 ± 0.63	11.38± 0.59	0.18	$t = -2.687$ $p = .013$ df = 24	

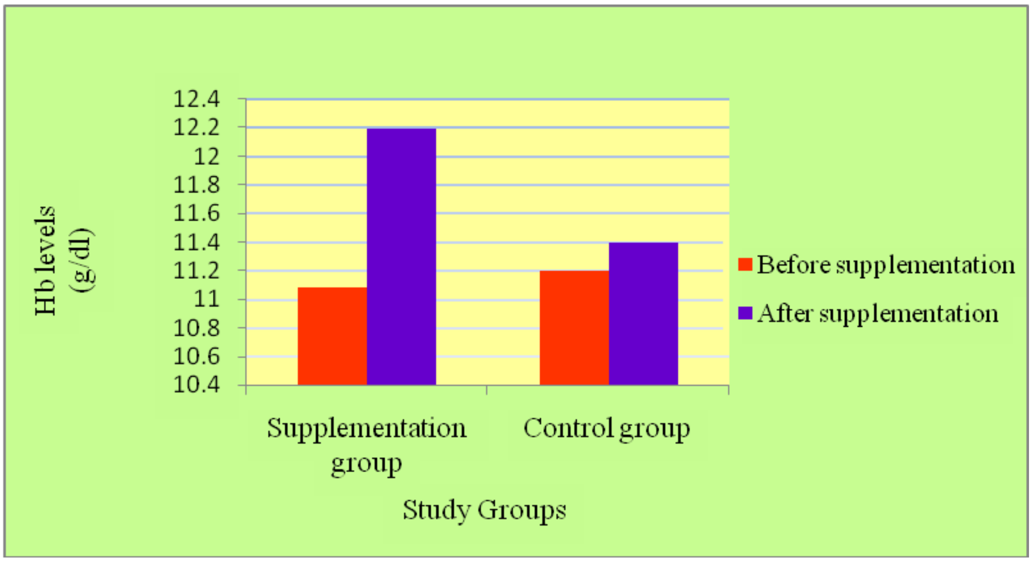


Figure 24 - Effect of supplementation on haemoglobin levels

Paired *t*-test result for the supplementation group shows that *t* (24) = 11.742 and *p* = .000, indicates significance (as P < .05) and for the control group *t* (24) = 2.687 and the associated *p* = .013, indicates significance (as P < .05). One-way ANOVA test result shows *p* = .000, that is less than the critical value (α = .05), shows a statistically significant difference between the compared means of experimental and control groups.

Based on the above test results, it has been concluded that a significant increase in the Hb level was found due to supplementation among the experimental group respondents. Interestingly the Hb level of the control group too showed a significant increase. But a higher level of increase in the Hb level was found (*t* = 11.742) in the supplementation group than in the control group (*t* = 2.687). Also the increase in the post-haemoglobin level of supplementation group significantly differed from the control group.

As per the supplementation study conducted by Trivedi and Palta (2007) in Raipur City, 360 anaemic adolescent girls of high school were categorized into experimental and control group. The first group was given supplementation with iron and folic acid tablets, while the second group which was the control group was provided only with nutrition education. The study revealed that role of iron and folic acid supplementation is important in improving the haemoglobin level of anaemic adolescent girls. Twice a week supplementation has turned out to be more successful and economical.

4.11.1.3 Effect of supplementation on serum iron levels

Paired t-test was run on supplementation group and control group respondents to study the effect of supplementation on the serum iron level and the difference in the level of increase in the serum iron levels between control and experimental groups was assessed by one-way ANOVA test. The test results are tabulated below.

Table 48

Effect of supplementation on serum iron levels

Groups	Serum iron levels (μg/dl)		Difference	*t*-test	ANOVA
	Before	After			
Supplementation group (N=25)	26.43 ± 4.476	35.11 ± 6.304	8.68	*t = -5.961* *p* = .000 df = 24	*p* = .000
Control group (N=25)	25.6 ± 4.94	25.36 ± 4.85	0.16	*t = -1.038* *p* = .310 df = 24	

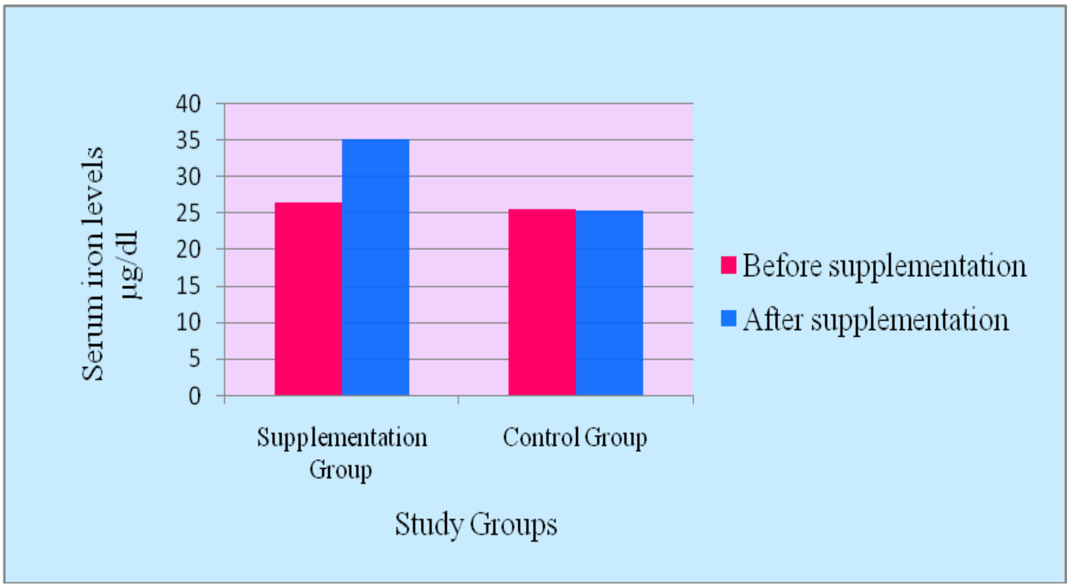


Figure 25 - Effect of supplementation on serum iron levels

Paired *t*-test result (before and after) for the supplementation group shows that t (24) = 5.961 and p = .000, indicates significance (as $P < .05$) and for the control group t (24) = 1.038 and the associated p = .310, indicates no significance (as $P > .05$). One-way ANOVA test result shows p = .000, that is less than the critical value (α = .05), shows a statistically significant difference in the compared means of serum iron levels between experimental and control groups.

Based on the above test results, it has been concluded that a significant increase in the serum iron level was found due to supplementation in the experimental group. There was no significant increase in the serum iron level among the control group, before and after the supplementation. Also the increase in the post-serum iron level of supplementation group significantly differed from the control group.

4.11.1.4 Effect of supplementation on serum folic acid levels

The effect of supplementation on the respondents' serum folic acid level compared with the control group is presented below. The serum folic acid level, before and after supplementation was examined by paired *t*-test and the difference in the increase in the serum folic acid levels between control and experimental groups was studied by one-way ANOVA test.

Table 49

Effect of supplementation on serum folic acid levels

Groups	Serum folic acid levels (ng/ml)		Difference	*t*-test	ANOVA
	Before	After			
Supplementation group (N=25)	2.40± 0.547	4.15± 0.995	1.75	*t = -13.431* p = .000 df = 24	p = .000
Control group (N=25)	2.32± 0.379	2.33± 0.4019	0.02	*t = -0.464* p = .647 df = 24	

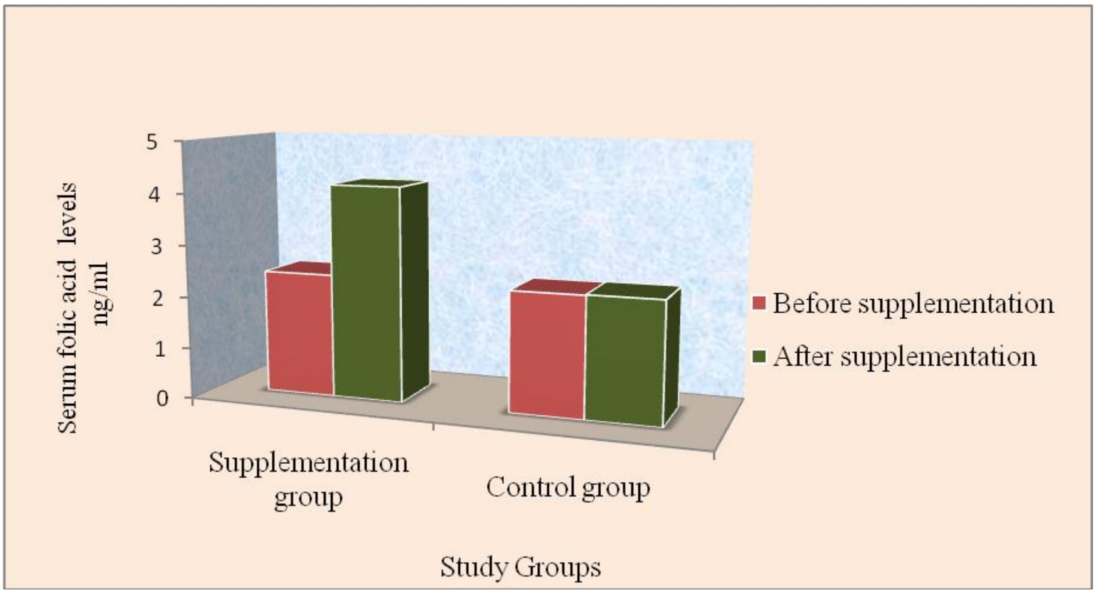


Figure 26 - Effect of supplementation on serum folic acid levels

Paired *t*-test result (before and after) for the supplementation group shows that t (24) = 13.431 and p = .000, indicates significance (as $P < .05$) and for the control group t (24) = 0.464 and the associated p = .647, indicates no significance (as $P > .05$). One-way ANOVA test result between the two groups shows p = .000, that is less than the critical value (α = .05), shows a statistically significant difference in the compared means of serum folic acid levels between experimental and control groups.

Based on the above test results, it has been concluded that a significant increase in the serum folic acid level was found due to supplementation in the experimental group respondents. There was no significant improvement in the serum folic acid level among the control group. Also the increase in the post-serum folic acid level of supplementation group significantly differed from the control group.

A study was conducted in urban areas of Vadodara among adolescent girls in 10–18 years showed that there was an increase of 17.3 g/L haemoglobin in the group of girls getting IFA supplements. A remarkable weight gain of 0.83 kg was seen in the intervention group, while girls in the control group demonstrated little weight gain. IFA supplementation is prescribed for growth promotion among teenage girls who are underweight (Kanani and Poojara, 2000).

4.11.2 Effect of supplementation of micronutrient fortified biscuits

Food And Agriculture Organization and World Health Organization define food fortification as the addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups (FAO/WHO 1994).

Dietary diversity has been associated with better growth and micronutrient status. Food-based approaches to meet micronutrient intakes have been successfully proven in many studies. In the present study an iron and folic acid rich biscuits were developed and which were supplemented among anaemic adolescent girls. The composition and method of preparation of the biscuit are outlined in Appendix XVI. Plate 2 shows the ingredients and the iron and folic acid rich foods used in the preparation of the supplement. And the effectiveness was studied in terms of haemoglobin, serum iron and serum folic acid levels.

4.11.2.1 Information regarding the recipe of iron - folic acid rich biscuits

Snacks play an important role in supplying energy between meals and to meet nutrient requirements. Baked snacks are increasingly popular because of their convenience and taste. Biscuits top the list of favourite snacks by the adolescent girls under study. Details regarding biscuit like form, source of recipe, equipments used, time of preparation etc. has been tabulated under the following table.

Table 50

Information regarding the recipe

Information	Details
Form	Biscuit
Source of recipe	Cookery book with self made modifications.
Weight/serving	20g
Equipments used	Squeezer, Oven
Time of preparation	30 (minute)

Recipe of the biscuit was collected from cookery book (Varughese, 1996) and final recipe was derived with self made modifications. Each biscuits weigh about 20 gm. The biscuit was prepared by using labour saving equipments like squeezer and oven. And the preparation time was 30 min.

"Biscuit can be used as a vehicle for fortification because it is seen as a snack rather than a meal and therefore, unlikely to replace meals given to the child at home. Additional advantages of using biscuits are that it needs no preparation, is easy to distribute and has long shelf life. It is also easy to monitor and therefore, less open to misuse and corruption" (Goyle, 2012).

4.11.2.2 Evaluation of organoleptic qualities of the standardized recipe

Organoleptic quality includes the typical sensory properties of a food like taste, appearance, colour, flavour and mouth feel. Sensory evaluation is an invaluable tool in product development. Results of the sensory evaluation of the iron-folic acid rich biscuit is given in the following table.

Table 51

Sensory attributes of the standardized recipe

Sensory attributes	**Panel members' score**							**Mean score**
	1	**2**	**3**	**4**	**5**	**6**	**7**	
Appearance	5	5	4	5	5	5	5	4.86
Flavour	5	5	4	4	4	4	5	4.43
Taste	5	5	5	3	5	5	5	4.71
Colour	5	4	5	5	4	4	4	4.43
Consistency/Crispness	5	5	5	4	4	4	5	4.57
Total	**25**	**24**	**23**	**21**	**22**	**22**	**24**	**23.00**

Customers see item quality with their senses, and therefore, organoleptic assessments are a vital part of any food products. All of the technical, chemical and microbiological parameters of a product may well be inside the satisfactory level, but if the product fails to meet sensory expectations, the utilization rate will be poor particularly in the case of children and teenagers.

The acceptability on the basis of organoleptic parameters such as appearance, flavour, taste, colour, consistency was rated by selected panel members using the scoring procedure. The iron- folic acid rich biscuit was highly acceptable with a total mean score of 23 out of the maximum score of 25. Appearance was one of the sensory attribute of the biscuit, scored a high mean score of 4.86 followed by taste (4.1). Consistency/Crispness of the biscuit got a good score of 4.57. Colour and flavour rated the same mean score of 4.43.

4.11.2.3 Sensory attributes over a period of 12 weeks

Table 52 shows the mean acceptability score of the iron-folic acid rich biscuit over a period of 4, 8 and 12 weeks of storage.

Table 52

Mean acceptability score of the iron- folic acid rich biscuit over a period of 12 weeks

Sensory attributes	Mean score		
	4 Weeks	8 Weeks	12 Weeks
Appearance	4.86	4.57	4.28
Flavour	4.29	4.14	3.85
Taste	4.71	4.57	4.42
Colour	4.42	4.42	4.42
Consistency/Crispness	4.42	4.2	4.14
Total	**22.7**	**21.9**	**21.14**

Results of sensory evaluation of products provide important information for several functions like quality control, process variation assessment, cost reduction, improvement of product, shelf life, and new product development.

The total acceptability scores of the iron-folic acid rich biscuit over twelve weeks of storage at 37^{o}C shows that the mean score for different sensory attributes were decreasing with increasing the number of weeks. It can be noted from the above table that there were no colour changes up to 12th week. And at the end of the 12th week flavour and the crispness came down to 3.85 and 4.12 respectively. The mean value of the total acceptability score was more than 21 even after the 12th week.

It is obvious that the iron-folic acid rich biscuit developed had acceptable keeping quality in terms of shelf life for at least three months. So the formulated iron-folic acid rich biscuits can be considered as an ideal product for the adolescent girls under study.

2.11.2.4 Evaluation of shelf life of iron-folic acid rich biscuits

Shelf life determines the period of time for which an item can be stored, within specified conditions, and stay in ideal condition and appropriate for consumption. A product's shelf life is influenced by various variables, including key parameters, which incorporate as pH and moisture content, and extraneous parameters, such as environmental factors.

In the present study, the shelf life of the product was evaluated by six parameters. They are: Moisture, total microbial count, reducing sugar, peroxide value, total ash and acid insoluble ash. The results are presented in the following table.

Table 53

Evaluation of shelf life of iron- folic acid rich biscuits

Parameters	Fresh sample	After 12 week sample	Difference
• Moisture content (%)	3.1	4.9	1.8
* Total microbial count (cell/g) at 37^0 C	$16x10^3$	$23x10^3$	$7x10^3$
Reducing sugar (%)	0.02	0.1	0.08
Peroxide value (m.Eq/Kg)	12	13.7	1.7
Total ash (%)	2.9	2.9	0
**Acid insoluble ash (%)	0.1	0.1	0

• Acceptable upto 5 per cent, as per Bureau of Indian Standards (BIS, 2009)
* Acceptable upto $50x10^3$, as per The Prevention of Food Adulteration Act (PFA, 1954)
** Acceptable upto 0.1 per cent, as per Food Safety and Standard Authority of India (FSSAI, 2012)

"The principal mechanisms involved in the worsening of processed foods are microbiological spoilage, chemical changes and moisture migration. Microbiological spoilage sometimes accompanied by pathogen development, whereas chemical and enzymatic activity results in lipid breakdown, colour, odour, flavour, and texture changes. Moisture and/or other vapour migration induce changes in texture, water activity and flavour" (Sewald and DeVries, 2003).

Moisture lowers shelf-life and crispness and lead to microbial spoilage. Moisture content of the fresh and 12 weeks old biscuits (3.1% and 4.9%) were within the BIS specification limit i.e. 5 per cent.

The difference of total microbial count of the freshly prepared biscuit and 12 weeks old biscuits was $7x10^3$ cell/g. Total microbial count of both fresh and 12 weeks old biscuits were lower than the acceptable limit of $50x10^3$ cell/g.

Detection of Peroxide gives the beginning confirmation of rancidity in unsaturated fats and oils. Despite the fact that different strategies are accessible, peroxide value is basically utilized as this technique gives a measure of the degree to which an oil sample has undergone primary oxidation. Peroxide value of the fresh and 12 weeks old iron-folic acid rich biscuits showed a difference of 1.7mEq/kg. Arogba (2002) also reported an increase in peroxide value during 90 days of storage of cookies made from mango (Mangiferaindica) kernel flour.

Level of reducing sugar also gets increased by 0.08 mg. Since standards for the biscuits were not available, comparison of the latter parameters is made with the values obtained for the fresh sample.

Total ash is the inorganic residual remaining on incineration in a muffle furnace. This reflects the quantity of mineral matter present in the flour. Total ash present in the biscuit was 2.9 per cent. And there was no difference in the ash content after 12 weeks storage.

"Acid insoluble ash reflects added mineral matter in milled products such as dirt, sand, etc." (Sivasankaran *et al.,* 2014). Acid insoluble ash percentage was 0.1 per cent for both fresh and 12 weeks old sample. As per FSSAI (2012) maximum acceptable limit of acid insoluble ash is 0.1 per cent.

4.11.2.5 Nutrient content of the iron-folic acid rich biscuits

The existing nutrient deficits in the diets of the adolescent girls were arrived through 24-hour recall method coupled with 'Food Frequency' approach. An iron-folic acid rich biscuit was formulated with the following items to supplement their daily intake and to meet their nutrient requirements.

Table 54

Nutrient content of the iron-folic acid rich biscuits

Ingredients	Amount (gm)	Energy (Kcal)	Protein (gm)	Fat (gm)	Calcium (mg)	Iron (mg)	Folic acid (µg)
Fortified wheat flour	40	136.4	4.84	0.68	19.2	2	60
Rice Bran Flour	13	51.09	1.75	2.10	8.71	4.55	-
Soy bean flour	10	43.2	4.32	1.9	24	1.04	0.8
Gingelly seeds	20	112.6	3.66	8.6	290	1.86	10.2
Peanut butter	7	33.33	1.33	2.66	-	2.85	2.85
Egg	30	52	4	4	18	0.63	21.09
Sugar	18	71.04	0.02	0	2.14	0.02	-
Total		499.6	19.9	20.0	362.05	12.95	94.94
Total amount of folic acid in biscuit after baking							50
% of baking loss of folic acid							47

The mean deficit of iron and folic acid in the diets of adolescent girls were found to be 13mg and 32µg respectively. To bridge these existing deficits, a biscuit rich in iron and folic acid was formulated with fortified wheat flour 40gm, a rich source of folic acid and iron. Gingelly seeds, peanut butter and egg are good sources of iron and folic acid. An ideal composition was arrived through standardization. Forty seven per cent of baking loss was occurred in the actual folic acid content of the biscuit. The formulated biscuit provided 50 µg of folic acid and 12.95 mg of iron per 100 gms.

Johansson *et al.*, (2002) reported 20-25 per cent loss of fortified folic acid in the wheat breakfast rolls used for intervention. Gujska *et al.*, (2005) also reported 12-21 per cent baking loss during bread making of wheat and rye.

4.11.2.6 Cost of the iron-folic acid rich biscuits

The cost of the iron-folic acid rich biscuits was calculated as per the market prices of 2011 is tabulated under the following table.

Table 55

Cost of the 100 gm iron-folic acid rich biscuits

Ingredients	Amount (gm)	Cost (Rs.)
Fortified wheat flour	40	0.88
Soy bean flour	10	0.31
Rice bran flour	13	0.007
Gingelly seeds	20	0.79
Peanut butter	7	1.70
Egg	30	1.50
Sugar	18	0.32
Baking powder	1	0.01
Total cost	**Rs 5.52/-**	

The ingredients for the preparation of the iron-folic acid biscuits were fortified wheat flour, soy bean flour, gingelly seeds, peanut butter, egg, sugar and baking soda. The total cost of 100 gms of biscuits was Rs.5.52. Among them rice bran and gingelly seeds were the low cost iron rich items. And gingelly seeds and eggs were the low cost folic acid rich items. This richness of nutrients is an advantage to correct iron and folic acid deficiency among adolescent girls.

Hundred grams constitutes five biscuits of 20 gms each. The standardized recipe was highly acceptable with a total mean score of 23 out of the maximum score of 25. Apart from being nutritionally superior the biscuits were highly acceptable for the adolescents. The cost of the biscuits was affordable and the preparation required very little effort, but facilitated easier administration for the adolescent girls under study.

4.11.2.7 Effect of fortification on haemoglobin levels

The effect of fortification on the respondents' haemoglobin level compared with the control group is presented below. The haemoglobin level, before and after fortification was examined by paired *t*-test and difference in the haemoglobin levels between control and fortification groups was studied by one-way ANOVA test.

Table 56

Effect of fortification on haemoglobin levels

Groups	Mean haemoglobin levels (g/dl)		Difference	*t*-test	ANOVA
	Before fortification	After fortification			
Fortification group (N=25)	11.28 ±0.510	11.91±0.512	0.63	*t* = -22.085 p = .000 df = 24	p = .007
Control group (N=25)	11.21±0.63	11.38±0.599	0.17	*t* = -2.687 p = .013 df = 24	

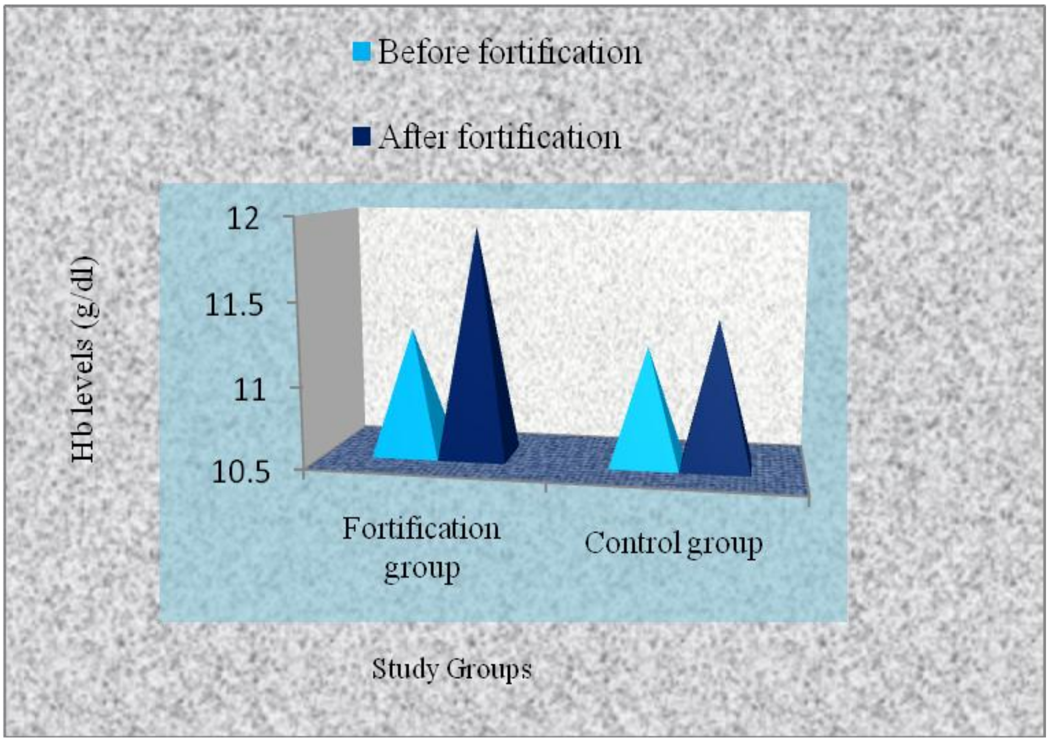


Figure 27 - Effect of fortification on haemoglobin levels

Paired *t*-test result (before and after) for the experimental group shows that t (24) = 22.085 and p = .000, indicates significance (as $P < .05$) and for the control group t (24) = 2.687 and the associated p = .013, indicates significance (as $P < .05$). One-way ANOVA test result between the two groups shows p = .007, that is less than the critical value (α = .05), shows a statistically significant difference in the compared means of haemoglobin levels between experimental and control groups.

Based on the above test results, it has been concluded that a significant increase in the haemoglobin level was found due to fortification in the experimental group respondents. There was also significant improvement in the post-haemoglobin level among the control group respondents. Further, the increase in the haemoglobin level of fortification group significantly differed from the control group.

4.11.2.8 Effect of fortification on serum iron levels

The effect of fortification on the respondents' serum iron level compared with the control group is presented below. The serum iron level, before and after fortification was examined by paired *t*-test and difference in the serum iron levels between control and fortification groups was studied by one-way ANOVA test.

Table 57

Effect of fortification on serum iron levels

Groups	Serum iron levels (µg/dl)		Difference	*t*-test	ANOVA
	Before fortification	After fortification			
Fortification group (N=25)	25.56± 4.507	28.94± 3.8100	3.38	*t* = -9.332 *p* = .000 df = 24	*p* = .065
Control group (N=25)	25.2± 4.94	25.36± 4.85	0.16	*t* = -1.038 *p* = .310 df = 24	

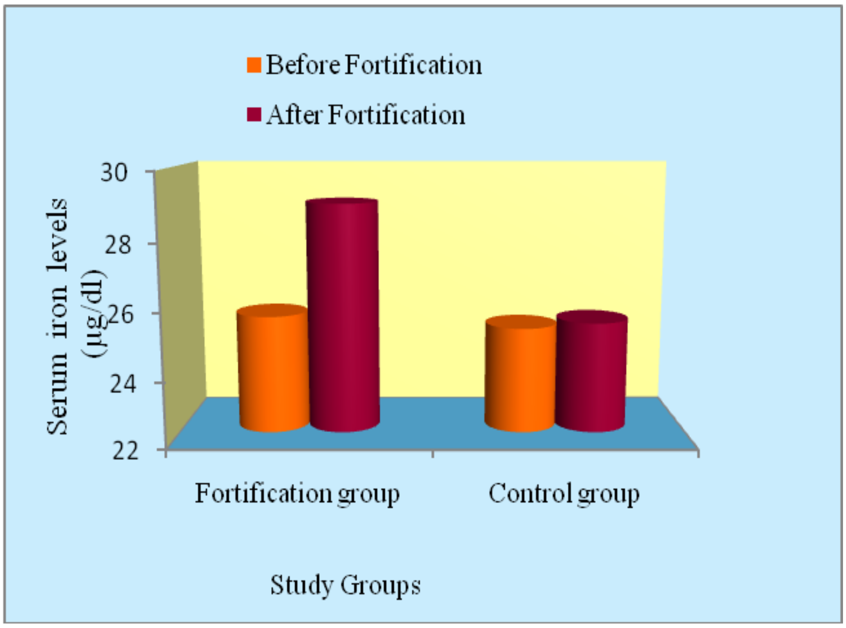


Figure 28 - Effect of fortification on serum iron levels

Paired *t*-test results (before and after) for the fortification group show *t* (24) = 9.332 and *p* = .000, which indicates significance (as P< .05) and for the control group *t* (24) = 1.038 and its associated *p* = .310, indicates no significance (as P> .05). One-way ANOVA test result between the two groups shows *p* = .065, which is greater than the critical value (α = .05), proves that there was no statistically significant difference in the compared means of serum iron levels between the experimental and control groups.

Based on the above test results, it has been concluded that a significant increase in the serum iron level was found due to fortification in the experimental group respondents. No significant increase in the serum iron level was found in the control group respondents. Also the increase in the post serum iron level of fortification group significantly differed from the control group.

4.11.2.9 Effect of fortification on serum folic acid levels

The effect of fortification on the respondents' serum folic acid level compared with the control group is presented below. The serum folic acid level, before and after fortification was examined by paired *t*-test and difference in the increase of serum folic acid levels between control and fortification groups was studied by one-way ANOVA test.

Table 58

Effect of fortification on serum folic acid levels

Groups	Mean serum folic acid levels (ng/ml)		Difference	*t*-test	ANOVA
	Before fortification	After fortification			
Fortification group (N=25)	2.74±0.349	3.42±0.358	0.68	*t = - 17.850* *p* = .000 df = 24	*p* = .000
Control group (N=25)	2.32±0.379	2.33±0.4019	0.01	*t = - 0.464* *p* = .647 df = 24	

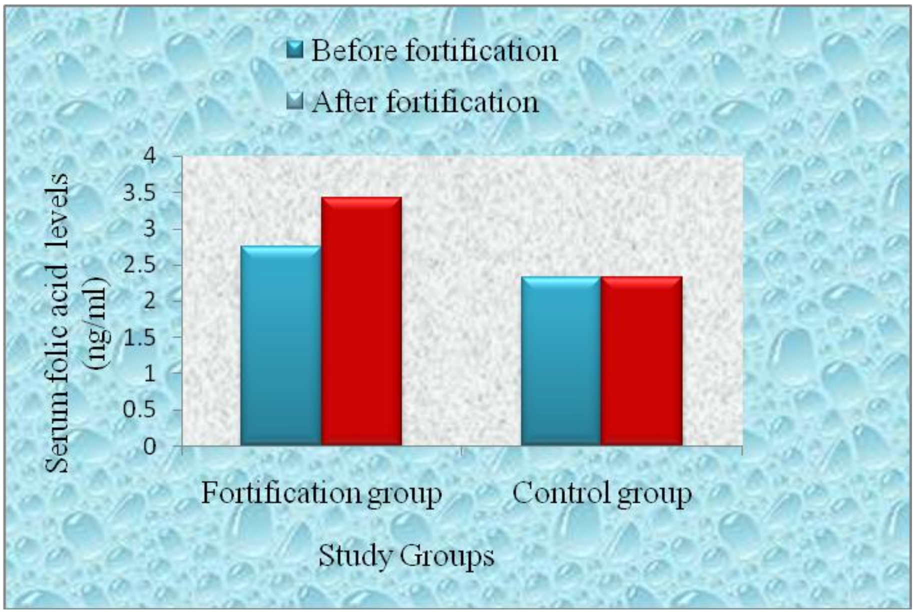


Figure 29 - Effect of fortification on serum folic acid levels

Paired *t*-test results (before and after) for the fortification group show *t* (24) = 17.850 and *p* = .000, which indicates significance (as P< .05) and for the control group *t* (24) = 0.464 and its associated *p* = .647, indicates no significance (as P> .05). One-way ANOVA test result between the two groups shows *p* = .000, which is less than the critical value (α = .05), proves that there was statistically significant difference between the compared means of serum folic acid levels of experimental and control groups.

Based on the above test results, it has been concluded that a significant increase in the serum folic acid level was found due to fortification in the experimental group respondents. Again a significant increase in the serum folic acid level was found in the control group respondents. Also the increase in the post-serum folic acid level of fortification group significantly differed from the control group.

Adolescence is a critical time in the life course to target for folic acid intake because adolescents' nutritional needs tend to increase and overwhelmingly their pregnancies are unplanned and may not occur in the most optimal of circumstances. Additionally, habits that are formed during the adolescent period may continue throughout their reproductive years (California Nutrition and Physical Activity Guidelines for Adolescents, 2012).

4.11.3 Impact of diet counselling on haematological parameters of adolescent girls

Nutrition counselling is a persistent process. Health professional, works with an individual to evaluate his or her typical dietary intake and recognize regions where change is required. Nutrition counsellor provides information, instruction materials, support, and follow-up to help the person to make and keep up the required dietary changes.

Individual diet counselling is an effective strategy to combat anaemia among adolescent age groups and that have been proven in previously conducted studies all over India. Individual dietary counselling was tailored to meet the unique needs of each adolescent girl. A diet chart was prepared as a dietary counselling tool for anaemic adolescent girls. By considering the likes, dislikes, and food allergies, individual diet chart were prepared and distributed during the counselling. Follow up was carried out regularly at an interval of one month.

4.11.3.1 Effect of diet counselling on haemoglobin levels

The effect of diet counselling on the respondents' haemoglobin levels compared with the control group is presented below. The haemoglobin level, before and after diet counselling was examined by paired *t*-test and the difference in the increase of haemoglobin levels between control and counselling groups was examined by one-way ANOVA test.

Table 59

Effect of diet counselling on haemoglobin levels

Groups	Mean haemoglobin levels (g/dl)		Difference	*t*-test	ANOVA
	Before diet counselling	After diet counselling			
Counselling group (N=25)	11.34±0.676	11.92± 0.661	0.58	t = -18.655 p= .000 df = 24	*p* = .006
Control group (N=25)	11.2±0.63	11.38± 0.59	0.18	*t = -2.687* *p* = .013 df = 24	

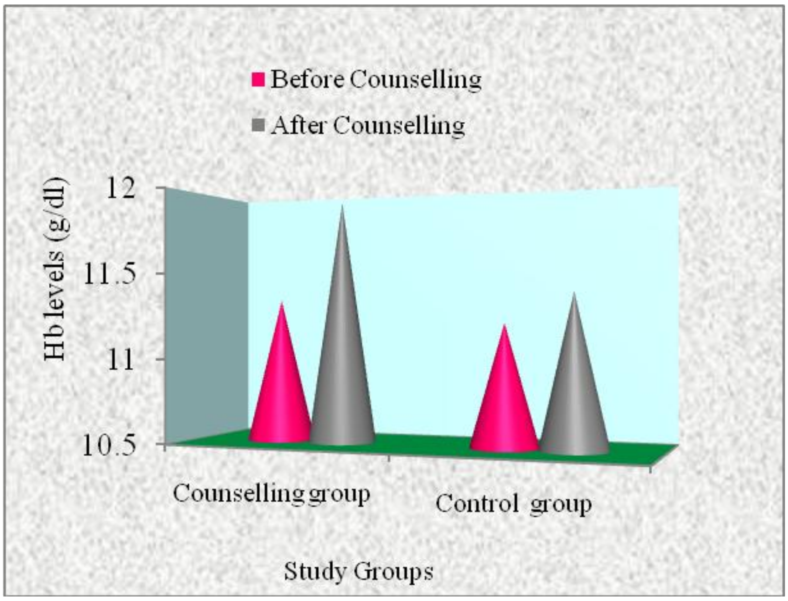


Figure 30 - Effect of diet counselling on haemoglobin levels

Paired *t*-test results (before and after) for the counselling group show t (24) = 18.655 and p = .000, which indicates significance (as P< .05) and for the control group t (24) = 2.687 and its associated p = .013, indicates significance (as P< .05). One-way ANOVA test result between the two groups shows p = .006, which is less than the critical value (α = .05), proves that there was statistically significant difference between the compared means of haemoglobin levels in the experimental and control groups.

Based on the above test results, it has been concluded that a significant increase in the haemoglobin level was found due to counselling in the experimental group respondents. Also a significant increase in the haemoglobin level was found in the control group respondents. The increase in the post- haemoglobin level of counselling group significantly differed from the control group.

4.11.3.2 Effect of diet counselling on serum iron levels

The effect of diet counselling on the respondents' serum iron level, compared with the control group is presented below. The serum iron level, before and after counselling was examined by paired *t*-test and difference in the increase in serum iron levels between control and counselling groups was studied by one-way ANOVA test.

Table 60

Effect of diet counselling on serum iron levels

Groups	Serum iron levels (µg/dl)		Difference	*t*-test	ANOVA
	Before diet counselling	After diet counselling			
Counselling group (N=25)	25.75± 5.176	26.15± 5.182	0.4	*t = 0.111* *p* = .913 df = 24	*p* = .999
Control group (N=25)	25.2± 4.94	25.36± 4.85	0.16	*t = -1.038* *p* = .310 df = 24	

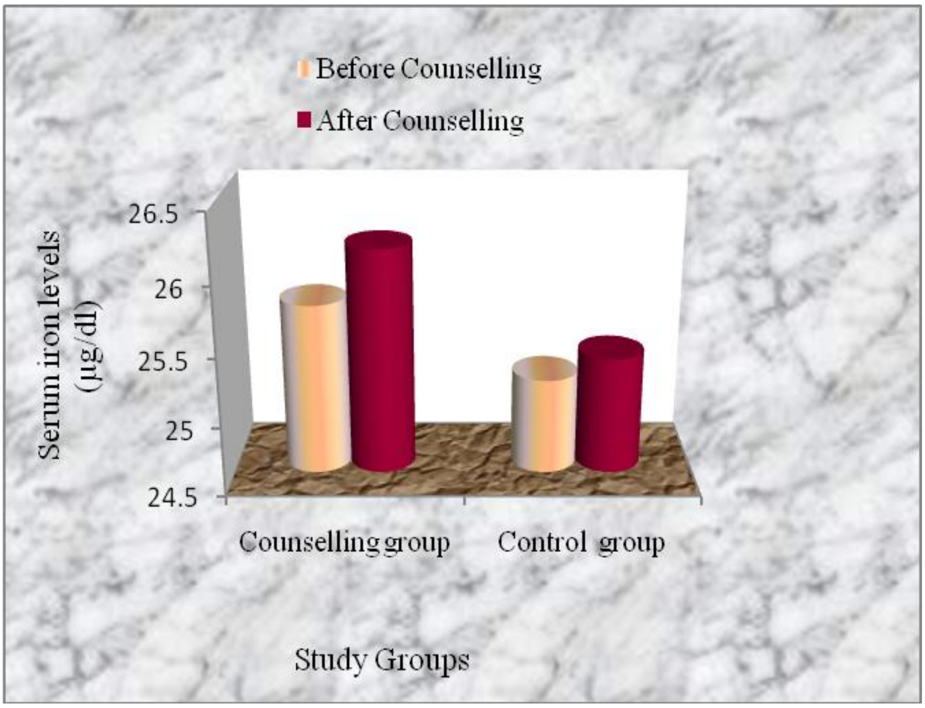


Figure 31 - Effect of diet counselling on serum iron levels

Paired *t*-test results (before and after) for the counselling group show *t* (24) = 0.111 and *p* = .913, which indicates no significance (as P> .05) and for the control group, *t* (24) = 1.038 and its associated *p* = .310, indicates also no significance (as P> .05). One-way ANOVA test result between the two groups shows *p* = .999, which is greater than the critical value (α = .05), proves that there was no statistically significant difference in the compared means of serum iron levels between the experimental and control groups.

Based on the above test results, it has been concluded that no significant increase in the serum iron level was found due to counselling in the experimental group respondents, as well as no significant increase in the serum iron level was found in the control group respondents. Also the increase in the post serum iron level of counselling group did not significantly differ from the control group.

4.11.3.3 Effect of diet counselling on serum folic acid levels

The effect of diet counselling on the respondents' serum folic acid level compared with the control group is presented below. The serum folic acid level, before and after, was examined by paired *t*-test and difference of increase in the serum folic acid levels between control and diet counselling groups was studied by one-way ANOVA test.

Table 61

Effect of diet counselling on serum folic acid levels

Groups	Serum folic acid levels (ng/ml)		Difference	*t*-test	ANOVA
	Before diet counselling	After diet counselling			
Counselling group (N=25)	2.81±0.284	3.1±0.248	0.29	*t = -7.530* *p* = .000 df = 24	*p* = .000
Control group (N=25)	2.32±0.379	2.33±0.401 9	0.01	*t = -0.464* *p* = .647 df = 24	

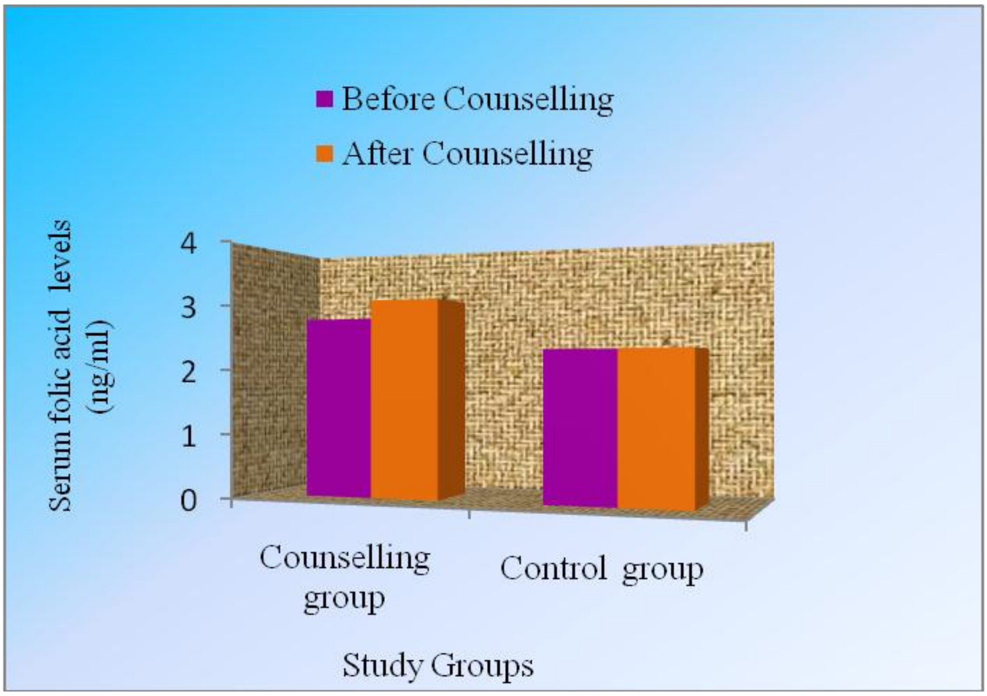


Figure 32 - Effect of diet counselling on serum folic acid levels

Paired *t*-test results (before and after) for the diet counselling group show *t* (24) = 7.530 and *p* = .000, which indicates significance (as P < .05) and for the control group *t* (24) = 0.464 and its associated *p* = .647, indicates no significance (as P > .05). One-way ANOVA test result between the two groups shows *p* = .000, which is less than the critical value (α = .05), proves that there was statistically significant difference between the compared means of serum folic acid levels of the experimental and control groups.

Based on the above test results, it has been concluded that a significant increase in the serum folic acid level was found due to counselling in the experimental group respondents. No significant increase in the serum folic acid level was found in the control group respondents. Also the increase in the post-serum folic acid level of fortification group significantly differed from the control group.

4.12 Comparison of impact of different interventions on haematological parameters

Comparison of impact of different interventions on haematological parameters of the subjects were analysed and presented below.

4.12.1Comparison of impact of different interventions on haemoglobin levels

Impact of different interventions on the haemoglobin levels of adolescent girls were depicted below.

Table 62

Comparison of impact of different interventions on haemoglobin levels

Dependent variable	Groups	Mean difference	*p*-value
Haemoglobin	Control vs. Supplementation	-0.8032*	0.000
	Control vs. Fortification	-0.5272*	0.007
	Control vs. Counselling	-0.5392*	0.006
	Supplementation vs. Fortification	0.2760	0.317
	Supplementation vs. Counselling	0.2640	0.356
	Fortification vs. Counselling	-0.0120	1.000

*Significant at five per cent level

As the One-way ANOVA test indicated that a significant difference in the haemoglobin level existed between groups, Post Hoc test of multiple comparisons was performed and it indicated that the mean difference observed among three groups i.e. Control vs. Supplementation, Control vs. Fortification, and Control vs. Counselling. On the basis of the results, it has been concluded that in all the intervention groups haemoglobin levels significantly improved when compared to the control group. The mean difference observed between control group and supplementation group was -0.8032 and it was significant at five per cent level with a *p*-value of 0.000. While considering the fortification and counselling group control vs. fortification reported mean difference -0.5272 with an associated *p*-value of 0.007. Mean difference of the pair Control vs. Counselling was -0.5392 and, the *p*-value was 0.006 – also significant.

4.12.2 Comparison of impact of different interventions on serum iron levels

Impact of different interventions on serum iron levels of adolescent girls were depicted below.

Table 63

Comparison of impact of different interventions on serum iron levels

Dependent variable	Groups	Mean difference	*p*-value
Serum iron	Control vs. Supplementation	-9.7520*	0.000
	Control vs. Fortification	-3.5800	0.065
	Control vs. Counselling	-0.1760	0.999
	Supplementation vs. Fortification	6.1720*	0.000
	Supplementation vs. Counselling	9.5760*	0.000
	Fortification vs. Counselling	3.4040	0.087

*Significant at five per cent level

Statistically significant difference in serum iron levels between groups was found in One-way ANOVA test and a Post Hoc Test, which indicated that when compared with control group supplementation group showed a significant improvement in the serum iron levels i.e. -9.7520 with a *p*-value 0.000. When examining the pair Supplementation vs. Fortification, mean difference was 6.1720 and *p*-value of the same was 0.000. Supplementation vs. Counselling also showed a significant mean difference of 9.5760 with a significant value of 0.000. Hence it has been concluded that there was a significant difference in the level of serum iron levels between the groups.

4.12.3 Comparison of impact of different interventions on serum folic acid levels

Impact of different interventions on serum folic acid levels of adolescent girls were depicted below.

Table 64

Comparison of impact of different interventions on serum folic acid levels

Dependent variable	Groups	Mean difference	*p*-value
Serum folic acid	Control vs. Supplementation	-1.8200*	0.000
	Control vs. Fortification	-1.0840*	0.000
	Control vs. Counselling	-0.7640*	0.000
	Supplementation vs. Fortification	0.7360*	0.000
	Supplementation vs. Counselling	1.0560*	0.000
	Fortification vs. Counselling	0.3200	0.214

*Significant at five per cent level

Post Hoc test indicated that mean difference in serum folic acid levels of the five pairs, i.e. Control vs. Supplementation, Control vs. Fortification, Control vs. Counselling, Supplementation vs. Fortification and Supplementation vs. Counselling were significant with a *p*-value 0.000 (P<.05). Mean differences in serum folic acid levels of Control vs. Supplementation and Control vs. Fortification were -1.8200 and -1.0840 respectively. Similarly, mean difference indicated between Control vs. Counselling and Supplementation vs. fortification was -0.7640 and 0.7360 respectively. Supplementation vs. Counselling pair reflected a mean difference of 1.0560, whereas Fortification vs. Counselling pair did not show any significant difference in serum folic acid levels.

V. SUMMARY AND CONCLUSION

During adolescence good nutrition and dietary behaviours are essential to achieve full growth potential and appropriate body composition, to endorse health and well being, and to decrease the risk of chronic diseases in adulthood. Anaemia during adolescence is a serious health problem in India, which affects the mental and physical development, as well as health maintenance and work performance. Iron deficiency is by far the most common cause of anaemia worldwide.

The present study entitled **"NUTRITIONAL STATUS OF ADOLESCENT GIRLS (12-19 years) AND IMPACT OF INTERVENTION PROGRAMMES"** is an experimental study involving three types of interventions. The primary objectives of the study are to assess adolescent girls' nutritional status, including their haemoglobin, iron, folic acid and vitamin B_{12} status; to examine their dietary pattern and to identify significant factors that affect nutrient consumption among the respondent adolescent girls and to evaluate their knowledge on nutrition related aspects; to evaluate the effectiveness of computer-aided tool and three different nutrition intervention methods. The results of this study are summarized in this chapter.

The study was conducted in Kottayam Taluk with a total sample size of 500 adolescent girls in the age group of 12-19 years were selected through multistage random sampling from two schools and two colleges and a sub-sample of 202 subjects in the age group of 17-19 years were selected for the detailed intervention study. Data were collected through a semi-structured interview schedule which included socio-economic background, anthropometric details, details regarding menstruation, general health details, intake of nutritional supplements, dietary pattern, intrinsic and extrinsic factors influencing nutrient intake and awareness about nutrition in adolescence.

Three types of interventions were applied in this study, viz. (i) supplementation, (ii) fortification and (iii) diet counselling for the experimental groups and no intervention for the control group. Consumption of nutritional supplements, anticonvulsant drugs and other medicines and gynaecological problems were the exclusion criteria considered for selecting subjects for interventions. Three biochemical parameters were measured before and after the intervention: (1) haemoglobin level (2) serum iron and (3) serum folic acid.

Major findings of the study can be summarised as follows

The demographic status of the respondents showed that the majority (78.4%) of the respondents were from nuclear family and only 19.6 per cent belonged to the economically weaker section having less than Rs.3,300 as their average monthly income. Income groups were classified based on HUDCO (2007) economic status and scale.

All the respondents' mothers were educated and about half (51.8%) belonged to Hindu religion. More respondents (34.6%) were of Christian origin than from Muslim religion (13.6%).

Nuclear family system was predominant among the respondents (86.1%). More than half (56.2%) of the adolescent girls under this study were first born female child followed by 36.0 per cent and 7.8 per cent were second and later-born.

The health problems of the respondents were examined with reference to three problems, i.e. intestinal problems, ENT problems, heart problems and other problems.

A large number (236, 47.2%) of the respondents were found to have a history of worm infection. Other ailments reported were acidity and peptic ulcer (5.8%), allergic to certain eatables (1.4%), appendicitis (1%) and piles (0.4%).

Under ENT category asthma (5.2%), migraine and sinusitis (3.8%) Tonsillitis/fever/infection (1.2%) and hypothyroidism and goitre (0.4%) were reported. Other problems reported were polycystic ovarian disease (0.4%), urinary calculi (0.2%), skin diseases (0.2%) and muscle pain (0.2%).

Academic or exam related stress was reported by a majority (82.2%) and social stress and parental expectations were just 1 per cent of the adolescent girls.

The respondent adolescent girls were of the habit of taking dietary supplements and medicines. Consumption of iron tablets and multivitamin tablets was very common among the study respondents compared to other supplements.

The popular health drink among the study respondents was Bournvita (1.2%); followed by Boost, Horlicks, Annatone and Winsmart. Only 2.2 per cent of the respondents were of the habit of consuming iron tablets and 1.4 per cent took multivitamin tablets. Apart from this Vitamin A, B-Complex, Iron folic acid tablet and Riboflavin tablets were also consumed by very negligible percentage of the respondents. Interestingly 2.0 per cent were used to take an Ayurvedic supplement

“Chavanaprasha”. Consumption of Eptoin was reported by only 0.2 per cent of the study samples.

Majority (59.3%) of the adolescent girls attained menarche after 12 years of age. The mean age of menarche of this study group was 12.5 years. An absolute majority (93%) of the respondent girls were in postmenarcheal stage.

Of these postmenarcheal stage respondents, menstruation-related problems were reported, such as gynaecological problems; dysmenorrhea complex, gastrointestinal symptoms; psychological symptoms and some other physical symptoms.

Symptoms of gynaecological problems included irregular cycle (31.4%) and amenorrhea (41.7%). Dysmenorrhea complex included abdominal pain (63.8%) and back ache (28.0%). Gastrointestinal symptoms included abdominal blotting (9.2%), loss of appetite (33.8%) and vomiting/nausea/constipation (2.1%).

Psychological symptoms included irritability (50.5%), aggressiveness (36.6%) and depression (24.4%). Other physical symptoms included, fatigue (41.3%), breast heaviness (3.4%), increased weight (1.2%), headache (20.3%) and skin disorders (7.2%).

These menstrual-related problems were found to have impact on their daily activities. Missed social activities (52.8%) and prolonged rest (44.9%) were commonly reported. Academic and exam-related stress such as pressure on home-works, teachers’ attitude etc. was commonly experienced by most of the adolescent girls (82.2%).

Height and weight of the respondent adolescent girls were measured based on standard indexes. The mean height of the study group between 12 and 19 years of age ranged from 145.7 cm to 157.8 cm and their mean weight ranged from 35.6 kg to 53.5 Kg. Similarly Body Mass Index also ranged from16.8 to 21.3 Kg/m$^{2.}$

Till the age of 16 years the mean weight, mean height and the mean BMI recorded a gradual increase and skewed downward after 16 years of age and again improved at 18 and 19 years of age. The mean heights of adolescent girls of all age groups under study were not achieved NCHS standards with a *p*-value <0.01 and *p*-value <0.05 for age 16. The mean weight of adolescent girls of all age groups under study except 16 years were not achieved NCHS standards with a *p*-value <0.01.

Mean heights and weights of the respondents were also compared with ICMR standards, which revealed that the mean height of adolescent girls of all age groups under study were significantly higher than ICMR standards with a *p*-value<0.01 and *p*-value <0.05 for age 17. Similarly the mean weight of adolescent girls of all age group under study except 17 years achieved ICMR standards with a *p*-value <0.01.

Majority of the study population (75 to 87.5%) between age group of 12-19 were having normal Body Mass Index ($\geq 5^{th}$-$<85^{th}$ percentile). Only 3.1 per cent obesity (BMI for age $\geq 95^{th}$percentile) observed in age group of 14, whereas in the age group of 17, 18.8 per cent were underweight.

Waist-to-hip ratio of the respondent adolescent girls ranged from 0.73 to 0.75. Waist hip ratio was observed to be lowest (0.73) for girls aged 19 years.

The overall nutrition knowledge of adolescent girls was found to be low. Majority of the respondents could not name the main food sources of nutrients and were not aware of the importance of taking extra nutrients during adolescence for growth spurt. It is concluded that early adolescent (≤16years) scored a mean score of 4.97 while girls in the late adolescent stage scored much higher mean score of 7.68.

Majority of the respondents (72.2%) believed that dieting is good for all; 85.4 per cent were of the opinion that men need more nutrients than women in all stages of life; 95 per cent were not aware about folic acid and neural tube defects; 83.8 per cent were of the opinion that early pregnancy does not cause birth defects; 81.4 per cent reported girl-child discrimination at home; 54.8 per cent reported that they were discouraged eating pickles, tamarind and other citrus foods.

An absolute majority (98.8%) believed washing vegetables before and after cutting, cooking in open pan were good but 98.8 per cent were aware of the benefits of sprouting and 95 per cent of the respondents were of the opinion that nutrition science should be included in their curriculum.

All the 500 adolescent girls attended the computer aided educational programme on nutrition. The topics of this educational programme were definition, classification and importance of adolescence, importance of nutrition in adolescence, balanced diet, nutrient rich sources, common deficiency diseases among adolescents, its causes, consequences and prevention and health tips for adolescents.

It was found that the nutrition education programme was highly significant at one percentage level with *p*-value of 0.000 ($P<0.01$). Mean knowledge score obtained before education programme was 6.0580 and it was significantly increased to 10.0 after the nutrition education programme.

The nutritional knowledge was examined before and after the education, under five attributes. They were: K1 included questions regarding nutrients and sources; K2 dealt with balanced diet and general health; K3 included anaemia and other deficiencies; K4 comprised of importance of nutrition during adolescence and K5 was about government aids and interventions.

Almost all (95%) of the respondents expressed their interest in including nutritional science in their regular curriculum. A significant (p=0.000) increase in the level of knowledge was observed after attending the nutritional education. Also a significant improvement, after the nutrition education was found in all the five (K1, K2, K3, K4, and K5) knowledge attributes. The practice of practical application of nutritional knowledge was observed using five attributes: P1, P2, P3, P4 and P5. A significant difference (p=0.000) was found in practice attributes between before and after the nutrition education. Each of the five practice attributes showed significance (p=0.000).

Out of the 202 sub-samples, nearly half (57.7%) were found to be anaemic with a mean haemoglobin level of 11.7 g/dl. More number (111, 55.0%) of the study respondents were found to have mild anaemia (10-11.9 g/dl), followed by 43.1 per cent were normal subjects ($\geq$ 12 g/dl) and severe anaemia condition was not observed among the study respondents.

While examining the type of symptoms of anaemia (headache, fatigue, dyspnoea, blurring vision, paraesthesia and syncopal attack), the results indicated that a majority (75.6%) had headache. Paraesthesia was found to be the symptom with very few (3.8%) of the respondents. Haemoglobin level of the sub-sample varied from 9-11.9 g/dl and serum iron between 17-34 μg/dl and the serum folic acid levels from 1.7 ng/ml to 3.5 ng/ml, whereas vitamin B_{12} status of the subjects found satisfactory with a mean of 359.2 pg/ml.

Majority (64.2%) of the respondents girls were non- vegetarians and used to take 3-4 meals per day. Meal-skipping was observed among 40.8 per cent of the respondents and mostly (62.2%) skipped breakfast.

The dietary pattern was influenced by predominantly (90%) by family followed by friends (89%), media and adds (87%) and psychological status (55%).

The frequency of intake of leafy vegetables and fruits was very less (1.4-2.8 mean days/week). Cereals were the most frequently consumed (7 mean days/week), followed by milk/milk products (6.86 mean days/week) and fish and meat (5.97 mean days/week). Most of the adolescent girls (79.3%) were in the habit of consuming fried snacks once to thrice a week.

Intake of protein, fat and calcium were at par with Recommended Dietary Allowance (RDA) and particularly, intake of fat was significantly higher ($P<0.01$) for the ages 17, 18 and 19, whereas, consumption of energy, iron, vitamin C and folic acid was significantly ($P<0.01$) lower than the RDA.

For studying the relationship between family income and study attributes monthly family income was grouped into four categories based on the HUDCO

(2007) scale viz. economically weaker section (<Rs.3,300); low income (Rs.3,301-7,300); middle income (Rs.7,300-14,500) and high income group (> Rs.14,500).

Nearly half (59.3%) of the respondent adolescent girls' age at menarche was 12 years and above. However, more than half (56.5%) of the low income group respondents attained their menarche after 12 years of age. Family income and age of menarche did not have significant (p=.378) relationship. No significant correlation (p=.108) between family income and nutritional knowledge was found.

Relationship of BMI with study factors revealed that the majority of respondents (332, 66.4%) were found to have normal BMI. Highest share (39.2%) of the underweight adolescents belonged to low income group, but interestingly, economically weaker section had the lowest (25, 16.9%) share of underweight adolescent girls.

BMI was not significantly correlated (p=.742) with the income status. Underweight adolescents were found to be more (13.5%) in the late adolescent (17-19 years) groups and obesity was observed among both late and early adolescent groups (1% and 0.5%).

Age of menarche was significantly (p=.000) negatively associated with BMI, i.e. girls who attained menarche early had higher BMI and vice versa. Adolescent girls with lower level of nutritional knowledge had a higher BMI and vice versa (p=.019). Haemoglobin level was not found to be an indicator of BMI, but a marginal and inverse correlation was observed among the respondents.

Relationship between haemoglobin levels and study factors were also studied. No respondent was found to be severe anaemic (<7g/dl). Among the respondents, the majority (75.0%) of mild anaemic girls were from high income group and the largest number (39.6%) of mild anaemic adolescents was from low income group. Income was not correlated (p=.408) with the anaemic condition.

Religion was not associated with the respondents' anaemic condition (p=.793). Out of the 111 mild anaemic cases, within the three religious groups (Hindu, Christian and Muslim); more (31.7%) mild anaemic (10-11.9 g/dl) girls belonged to Hindu religious group. Moderate anaemic condition was observed equally (1.0%) among the Hindu and Christian groups.

Mother's education was not an influencing factor of the girl child's anaemic condition (p=.953). Majority of the respondents' mothers have passed 10thStd and a greater number (37, 18.3%) of the mild anaemic symptoms were found among this group than in other educational level groups.

More number of mild anaemic (48.0%) and moderate anaemic (1.5%) conditions were observed among the respondents from nuclear family system.

Haemoglobin level was related to age of menarche (p=.050) among the study respondent, i.e. more (41.1%) of the respondents who have late age of menarche were mild anaemic. Among the girls who achieved menarche at age 12 and earlier, 2.0 per cent were found to be moderately anaemic.

No significant (p=.703) relationship was found between food habits and anaemic condition. Within the three categories of dietary habit groups (vegetarian, non-vegetarian, non-vegetarian but often take vegetarian food), a higher ratio (36.6%) of the mild anaemic condition was prevalent among the “non-vegetarian, but often take vegetarian food” category and moderate anaemia was observed only among the “non-vegetarian” group.

Within the 111 mild anaemic girls, a greater number (86, 42.6%) were worm infested. But no significant association (p=.256) was observed between infestation status and anaemic condition. The results proved that intake of iron and folic acid improves haemoglobin level (p=.000) independently.

Supplementation, fortification and diet counselling are the three intervention methods applied in the present study.

Livogen-cap-tab (ferrous fumerate 152 mg and folic acid-1500 mcg) tablet, one per day for a period of three months and one Albendazole were consumed by the 25 anaemic adolescent girls of supplementation group. All the three parameters viz. haemoglobin, serum iron and serum folic acid levels significantly (p=.000) improved among the intervention group compared to the control group.

Iron-folic acid rich food supplement was given to the 25 anaemic adolescent girls of fortification group in the form of biscuits, each weighing about 20 gms, comprised of fortified wheat flour, rice bran flour, soy bean flour, gingelly seeds, peanut butter, egg and sugar.

The fresh and after-12 weeks (storage at 37^{o}C) mean score of the five sensory attributes of the fortified biscuits were (i) appearance (4.86, 4.28), (ii) flavour (4.43, 3.85), (iii) taste (4.71, 4.42), (iv) colour (4.3, 4.42) and consistency/crispness (4.57, 4.14) respectively.

The total microbial count (cells/g at $37^{o}C$) registered a difference of $7x10^3$ cells/g (fresh = 16 x 10^3 cells /g and after 12 weeks = 23 x 10^3 cells/g), well within the acceptable level of 50 x 10^3 (PFA, 1954).

Moisture content of the fresh and 12 weeks old biscuits (3.1% and 4.9%) were within the BIS specification limit i.e. 5 per cent.

About 0.08 mg per cent of difference (increase) in reducing sugar percentage was found between fresh (0.02 mg%) and after 12-week sample (0.1 mg%).

Peroxide value measured a difference of 1.7 m.eqO_2/kg between fresh sample (12 meqO_2/kg) and after 12-week sample (13.7 meqO_2/kg).

Total ash present in the biscuit was 2.9 per cent. Acid insoluble ash percentage was 0.1 per cent for both fresh and 12 weeks old sample.

The ANOVA test revealed that haemoglobin and serum folic acid levels improved significantly (p=.007, p=.000 respectively) among the intervention groups viz. after fortification i.e. consumption of iron-folic acid rich biscuits by the 25 fortification experiment group respondents. But serum iron level has not significantly improved (p=.065) even after consuming the fortified biscuits.

For the adolescent girls of counselling group, individual diet charts were prepared by considering the likes, dislikes, and food allergies and distributed during the counselling section. Follow up was carried out regularly at an interval of one month.

After three months, diet counselling showed a significant increase on haemoglobin level and serum folic acid levels (p=.006 and p=.000 respectively). But counselling did not result in a significant increase in serum iron levels (p=.999).

The inter-relationship of improvement in the three test parameters, i.e. haemoglobin level vs. serum iron level vs. serum folic acid level showed significance predominantly.

No significant increase in the haemoglobin level was found (i) between supplementation and fortification (p=0.317); supplementation and counselling (p=0.356) and fortification and counselling (p=1.000) groups.

A highly significant increase in the serum iron level was found between supplementation and fortification (p=0.000) and supplementation and counselling (p=0.000) groups. But the difference in the level of increase in serum iron level was not significant (p=0.087) between fortification and counselling groups.

High level of significance (p=0.000) in the improvement of serum folic acid level was resulted between supplementation and fortification and supplementation and counselling groups. But the difference between fortification and counselling groups in the level of increase was not statistically significant (p=0.214).

Prevalence of anaemia in India is among the highest in the world. This study has shown that anaemia is prevalent even among higher income and educated segments of the population. The study substantiates the results of previous studies that irrespective of socio-economic and educational background, diet and nutrition play a crucial role in maintaining good health for adolescent girls. The study will be a contribution to the existing literature on adolescent nutrition related health problems in Kerala, particularly in Kottayam district. Further, longitudinal studies are needed to identify the reasons for poor growth throughout the period of adolescence. As the three intervention methods studied in this present investigation were found to be effective among the adolescent population, those in modified forms may have scope for the development of appropriate policies and programmes to address anaemia and thereby bridging the gap of undernutrition.

Recommendations for future research

1. Studies contributing information on the health statistics like nutritional status, anaemia and obesity of adolescents in Kerala.

2. Awareness about the importance of nutrition in adolescence and health of girl child need to be popularised among the parents and the children.

3. Inclusion of mothers in nutrition education programmes will be beneficial as the mothers are involved in making food for the family members.

4. Relationship of nutritional status to cognitive and academic performance of adolescents in Kerala.

5. Effectiveness of participation of Government agencies and Non-Governmental organisations in improving health of adolescent girls.

BIBLIOGRAPHY

AAP. (American Academy of Paediatrics). (2006). Menstruation in girls and adolescents: Using the menstrual cycle as a vital sign. *Paediatrics*, Vol.118 (5), pp.2245-2250.

Abuya, B.A., Ciera, J. and Kimani-Murage, E. (2012). Effect of mother's education on child's nutritional status in the slums of Nairobi. *BMC Pediatrics*, Vol.12 (80), pp.1-10.

ADA. (American Dietetic Association). (2011). *International dietetics and nutritional terminology – Reference manual: Standard language for the nutrition care process* (3rd ed.). Chicago, IL: American Dietetic Association.

Adesinal, A.F. and Peterside, O. (2013). Age at menarche and body mass index (BMI) among adolescent secondary school girls in Port Harcourt, Nigeria. *IOSR Journal of Dental and Medical Sciences (JDMS)*. Vol.3 (5), pp.41-46.

Agarwal, A.K. and Agarwal, A. (2010). A study of dysmenorrhea during menstruation in adolescent girls. *Indian Journal of Community Medicine*, Vol.35 (1), pp.159-164.

Agarwal, D.K. and Agarwal, K.N. (1992). Physical and sexual growth pattern of affluent Indian children from 5-18 years of age. *Indian Pediatricts*, Vol.29 (10), pp.940-949.

Agarwal, M. (2010). A study on impact of iron folic acid along with vitamin C on the haemoglobin status of adolescent girls in an ICDS block. Locknow; NIPCCD Regional center.p14.

Agarwal, K.N., Gomber, S., Bisht, H. and Som, M. (2010). Anaemia prophylaxis in adolescent school girls by weekly or daily iron-folate supplementation. *Indian Paediatrics,* Vol.40, pp.296-301.

Agarwal, V. and Tejwani, S. (1999). Prevalence of Iron Deficiency Anaemia in Indian Antenatal Women Especially in Rural Areas. *Indian Medical Gazzette*, pp.300-303.

Ahmad, N., Kalakoti, P., Bano, R. and Aarif, S.M.M. (2010). The prevalence of anaemia and associated factors in pregnant women in a rural Indian community. *Australasian Medical Journal*, Vol.3 (5), pp.276-280.

Ahmed, F., Khan, M.R., Akhtaruzzaman, M., Karim,R., Williams, G., Torlesse, H., Darnton-Hill, I., Dalmiya, N., Cadi P., Banu and Nahar,B. (2010). Long-term intermittent multiple micronutrient supplementation enhances hemoglobin and micronutrient status more than iron + folic acid supplementation in Bangladeshi rural adolescent girls with nutritional anemia. *Journal of Nutrition*, Vol. 140 (10), pp.1879-1886.

Ahmed, F., Khan, M.R., Akhtaruzzaman,M., Karim,R., Marks,G.C., Banu,C.P., Nahar,B. and Williams,G. (2005). Efficacy of twice-weekly multiple micronutrient supplementation for improving the hemoglobin and micronutrient status of anemic adolescent schoolgirls in Bangladesh. *American Journal of Clinical Nutrition*, Vol. 82 (4), pp.829-835.

Akhter, N. and Sondhya, F.Y. (2013). Nutritional Status of Adolescents in Bangladesh: Compaison of Severe Thinness Status of a Low-income Family's Adolescents Between Urban and Rural Bangladesh. *Journal of Education and Health Promotion*, Vol.2 (1), p.27.

Alam, N., Roy, S.K. and Ahmed, A.M.S. (2010). Nutritional status, dietary intake and relevant knowledge of adolescent girls in rural Bangladesh. *Journal of Health, Population and Nutrition*, Vol.28 (1), pp.86-94.

Al-Awadhi, N., Al-Kandari, N., Al-Hasan, T., Almurjan, D., Ali, S. and Al-Taiar, A. (2013). Age at menarche and its relationship to body mass index among adolescent girls in Kuwait. *BMC Public Health*, Vol.13 (1), pp.13-29.

Ali, A.A. and Adam, I. (2011). Anaemia and Stillbirth in Kassala Hospital, Eastern Sudan. *Journal of Tropical Pediatric*, Vol.57(1), pp.62-64.

Allen, L.H, Ahluwalia, N. (1997). *Improving Iron Status through Diet. The Application of Knowledge Concerning Dietary Iron Bioavailability in Human Populations.* Arlington VA: Management of Social Transformation Programme. John Snow Incorporated/OMNI Project, p.13.

Amoke-P'Olak, K., Burger, H., Ormel, J., Huisman, M., Verhulst, F.C and Oldehinker, A.J. (2009). Socioeconomic Position and Mental Health Problems in Pre- and Early-adolescents – The TRAILS study. *Social Psychiatry and Psychiatric Epidemiology*, Vol.44 (3), pp.231-238.

Amone, K.P., Ormel, J., Huisman, M., Verhulst, F.C., Oldehinkel, A.J and Burger, H. (2009). Life stressors as Mediators of the Relation between Socioeconomic Position and Mental Health Problems in Early Adolescence: The TRAILS Study. *Journal of the American Academy of Child and Adolescent Psychiatry*, Vol.48 (10), pp.1031-1038.

Anderson, A.S., Porteous, I.E., Foster, E., Higgins, C., Stead, M., Hetherington, M., Ha MA. and Adamson, A.J. (2005). The Impact of a School-Based Nutrition Education Intervention on Dietary Intake and Cognitive and Attitudinal Variables Relating to Fruits and Vegetables. *Public Health and Nutrition*, Vol.8 (6), P.650.

Ang, R.P. and Huan, V.S. (2006). Relationship between academic stress and suicidal ideation: Testing for depression as a mediator using multiple regression. *Child Psychiatry and Human Development*, Vol.37 (2), pp.133-143.

Anumudu, C., Afolami, M., Igwe, C., Nwagwu, M. and Keshinro. O. (2008). Nutritional Anaemia and Malaria in Pre-school and School Age Children. *Anals of African Medicine*, Vol.7 (1), pp.11-17.

APA. (American Psychological Association). (2002). *Developing Adolescents*. APA, Washington DC, p.3.

Appoh, L.Y. and Krekling, S. (2005). Maternal nutritional knowledge and child nutritional status in the Volta region of Chana. *Maternal and Child Nutrition*, Vol.1(2), pp.100-110.

Aradhya, G.H. (2013). Psychosocial morbidities in school going adolescent girls: A study from a South Indian City. *Journal of Clinical and Diagnostic Research*, Vol.7 (4), pp.684-686.

Armistead, L., McCombs, A., Forehand, R., Wierson, M., Long, N and Fauger, R. (1990). Coping with Divorce: A Study of Young Adolescents. *Journal of Clinical Child Psychology*, Vol.19 (1), pp.79-84.

Arogba, S.S. (2002). Quality characteristics of a model biscuit containing processed mango (Mangifera indica) kernel flour. *International Journal for Food Properties*, Vol.5 (2), pp.249-260.

Ashraf, J., James, R.C., Michael, B. and Rothberg. (2008). Clinical utility of folic acid testing for patients with anaemia or dementia. *Journal of Genetics and International Medicines*, Vol.23 (6), pp.824-826.

Assunção, M.C. and Santos, I.S. (2007). Effect of Food Fortification with Iron on Childhood Anaemia: A Review Study. *Cad Saude Publica*, Vol.23 (2), pp.269-281.

Ata., R.N., Ludden, . A., Lally, . M. (2007). The effects of gender and family, friend, and media influences on eating behaviors and body image during adolescence. *Journal of Youth and Adolescence*, Vol.36 (8), pp.1024-1037.

Attie, I. and Brooks-Gunn, J. (1989). Development of eating problems in adolescent girls: A longitudinal study. *Developmental Psychology*, Vol.25 (1), pp.70-19.

Aubery, F. (2012). The detrimental effect of malnutrition on school achievement – evidence from two districts of Madagascar. Centre d'Etude et de Recherche sur le Development International (CERDI). Available at http://graduateinstitute.ch/ webdav/site/cfd/shared/docs/Journees%20doctorales%202012%20papers/Aubery%20F%20-%20Nutrition%20Education.pdf. Last accessed on 10 June 2013.

Augustine, L.F. and Poojara. (2003). Prevalence of obesity, weight perceptions and weight control practices among college girls. *Indian Journal Community Medicine*, Vol.25 (4), pp.189-190.

Austin, S.B., Kim, J., Wiecha, J., Troped, P.J., Feldman, H.A., Peterson, K.E. (2007). School-based overweight preventive intervention lowers incidence of disordered weight-control behaviors in early adolescent girls. *Archives of Paediatric and Adolescent Medicines*, Vol.161 (9), pp.865-869.

Azagba, S.I. and Asbridge, M. (2013). School connectedness and susceptibility to smoking among adolescents in Canada. *Nicotine and Tobacco Research*, Vol.15(8), pp.1458-1463.

Babey, S.H., Hastert, T.A. and Wolstein, J. (2013). Adolescent sedentary behaviours: Correlates differ for television viewing and computer use. *Journal of Adolescent Health*, Vol.52 (1), pp.70-76.

Balasubramanian, P. (2005). Health Needs of Poor Unmarried Adolescent Girls – A Community-Based Study in Rural Tamil Nadu. *Indian Journal of Population Education*, pp.18-33.

Balci, Y.I., Karabulut, A., Gürses, D. and Çövüt, I.E. (2012). Prevalence and risk factors of anemia among adolescents in Denizli. Turkey. *Iranian Journal of Pediatrics*, Vol.22 (1), pp.77-81.

Bamji, M.S., Krishnaswamy, K. and Brahmam, G.N.V. (2010). *Text book of human nutrition*. New Delhi: Oxford & IBH Publishing Company Pvt. Ltd, p.113.

Banerjee, S., Dias, A., Shinkre, R. and Patel, V. (2011). Under-nutrition among adolescents: A survey in five secondary schools in rural Goa. *The National Medical Journal of India*, Vol.24 (1), pp.8-11.

Bano, R. (2012). Anaemia and its impact on dysmenorrhea and age at menarche. *IOSR Journal of Pharmacy and Biological Sciences*, Vol.4 (2), pp.21-24.

Baral, K.P. and Onta, S.R. (2009). Prevalence of anaemia amongst adolescents in nepal: A community-based study in rural and urban areas of Morang district. *Nepal Medical College Journal*, Vol. 11(3), pp.179-182.

Basu, S., Basu, S., Hazarika, R. and Parmar, V. (2005). Prevalence of anaemia among school going adolescents of Chandigarh. *Indian Paediatrics*, Vol.42 (6), pp.593-597.

Beaton, G.H., Corey, P.N. and Steel, C. (1989). Conceptual and Methodological Issues Regarding the Epidemiology of Iron Deficiency. *American Journal of Clinical Nutrition*, Vol.50 (3 suppl), p.575-585.

Beaver,K.M. (2011). Environmental Moderators of Genetic Influences on Adolescent Delinquent Involvement and Victimization, *Journal of Adolescent Research*, Vol.26 (1), pp.84-144.

Beegum, M.R. (2001). *"Prevalence of malnutrition among adolescent girls: A Case Study in Kalliyoor Panchayat, Thiruvananthapuram".* Discussion Paper No.35, Kerala Research Programme on Local Level Development Centre for Development Studies, Thiruvananthapuram, p.7.

Behrman, J. and Deolalikar, A. (1988). Health and nutrition, *Handbook of development economics*. Vol. 1, pp.631-711.

Bener, A., Al-Maadid, M.G., Al-Bast, D.A. and Al-Mari, S. (2006). Maternal knowledge, attitude and practice on folic acid intake among Arabian Qatari women. *Reproductive Toxicology*, Vol.21(1), pp.21-25.

Benton, D. (2004). Role of parents in the determination of the food preferences of children and the development of obesity. *International Journal of Obesity and Related Metabolic Disorders*, Vol.28 (7), pp.858-869.

Berg, B.L. (1998). *Qualitative research methods for the social sciences* (3rd Ed.). Needham Heights, MA: Allyn and Bacon, p.229.

Best, J.W. and Khan, J.V. (1999). *Research in education*. India, New Delhi: Prentice Hall, p.23.

Bhanushali, M.M., A.R.Shirode, Y.M.Joshi and V.J.Kadam (2011). An Intervention on Iron Deficiency Anaemia and Change in Dietary Behaviour among Adolescent Girls. *International Journal of Pharmacy and Pharmaceutical Sciences*, Vol. 3(1), pp.40-42.

Bigal, M.E., Lipton, R.B., Winner, P., Reed, M.L., Diamond, S. and Steward, W.F. (2007). Migraine in adolescents: Association with socioeconomic status and family history. *Neurology*, Vol.69 (1), pp.16-25.

Bilimale, A., Anjum, J., Sangoli, H.N. and Mallapur, M. (2010). Improving adherence to oral iron supplementation during pregnancy. *Australasian Medical Journal*, Vol.3 (5), pp.281-290.

Biradar, S.S., S.P. Biradar, A.C.Alatagi, A.S.Wantamutte and P.R.Malur (2012). Prevalence of Anaemia among Adolescent Girls: A One Year Cross-Sectional Study. *Journal of Clinical and Diagnostic Research*, Vol. 6 (3), pp.372-377.

BIS (Bureau of Indian Standards). (2009). *Indian standard Biscuit-specification* (Fourth Revision) ICS 67.060 IS1011:2002, p.6.

Black, R.E., Allen, L.H., Bhutta, Z.A.,Caulfield, L.E., Onis, M.D., Majid Ezzati, Mathers, C. and Rivera, J. (2008). Maternal and child under-nutrition: Global and regional exposures and health consequences. *Lancet*, Vol.371 (9608), pp.243-260.

Bleichrodt, N. and Born, P.M. (1994). A meta-analysis of research on iodine and its relationship to cognitive development. In *The Damaged Brain of Iodine Deficiency: Neuromotor, Cognitive, Behavioural and Educative Aspects,* ed. Stanbury JB. Port Washington, NY: Cognizant Communication Corp, pp.195-200.

Block, J.H., Block, J. and Gjerde, P.F. (1988). Parental functioning and the home environment in families of divorce: Prospective and concurrent analysis. *Journal of The American Academi of Child and Adolescent Psychiatry,* Vol.27, pp.207-213.

Bose, K., Bhunia, D. and Paul, G. (2006). Age and Sex Variations in Under-nutrition of Rural Bengalee Primary School Children of East Kidnapur District, West Bengal, India. *Ecology, Culture, Nutrition, Health and Disease, Human Ecology,* Special issue no:14, p. 71-75.

Bosley, B. (2011). *Nutrition Education*. Available at http://whqlibdoc.who.int/monograph/WHO_MONO_62_(chp20).pdf. Last accessed on 03 January 2015.

Bovell-Benjamin, A.C., Viteri, F.E., Allen, .LH. (2000). Iron absorption from ferrous bisglycinate and ferric trisglycinate in whole maize is regulated by iron status. *American Journal of Clinical Nutrition*, Vol.71 (6), pp.1563-1569.

Burner, A.B., Joffe, A., Duggan, A.K., Casella, J.F. and Brandt, J. (1996). Randomized Study of Cognitive Effects of Iron Supplementation in Non-anaemic iron-deficient Adolescent Girls. *The Lancet*, Vol.348 (9033), pp.992-996.

Calaguas, G.M. (2013). Parents/teachers and self-expectations as sources of academic stress. *International Journal of Research Studies in Psychology*, Vol.2 (1), pp.43-52.

California Nutrition and Physical Activity Guidelines for Adolescents . (2012). *Folic Acid and Folate* ,CDPH 2012, Funded by Federal Title V Block Grant through the Maternal, Child and Adolescent Health Division, Center for Family Health, pp FA.1-FA.5.

Cauffman, E. and Steinberg, L. (1996). Interactive Effects of Menarcheal Status and Dating on Dieting and Disordered Eating among Adolescent Girls. *Development Psychology*, Vol.32 (4), pp.631-635.

Celik, M. (2014). Age at menarche :international perspectives, *Handbook of Diet and Nutrition in the Menstrual Cycle, Periconception and Fertility*, ed. Caroline, J., Martin, H., Akker,O.B.A., Martin,C.R ., Preedy,V.R. Wageningen Academic Publishers, p.67.

Cetin, F.C., Tüzün, Z., Pehlivantürk, B., Ünal, F. and Gökle, B. (2010). Attachment styles and self-image in Turkish Adolescents. *Journal of Research on Adolescence*, Vol.20 (4), pp.840-848.

Chakma, T., Rao, P.V. and Tiwary, R.S. (2000). Prevalence of anaemia and worm infestation in tribal areas of Madhya Pradesh.*Journal of Indian Medical Association*, Vol.98 (9), pp.567-570.

Chakma, T., Rao, V.P. and Meshram, P.K. (2013). Factors associated with high compliance/ feasibility during iron and folic acid supplementation in a tribal area of Madhya Pradesh, India. *Public Health and Nutrition*, Vol.16 (2), pp.377-380.

Chang, M.C., Poh, B.K., June, J., Jefrydin, N. and Das, S. (2009). A study of prevalence of anaemia in adolescent girls and reproductive-age women in Kula Lumpur. *Archives of Medical Science*, Vol.5 (1), pp.63-68.

Chaudhary, S.M. and Dhage, V.R. (2008). A study of anaemia among adolescent females in the urban area of Nagpur. *Indian Journal of Community Medicine*, Vol.33 (4), pp.243-245.

Chiplonkar, S.A. and Tupe, R. (2010). Development of diet quality index with special reference to micronutrient adequacy for adolescent girls consuming a lacto-vegetarian diet. *Journal of American Dietary Association*, Vol.110 (6), pp.926-931.

Choudhary, S., Mishra, C.P. and Shukla, K.P. (2010). Dietary pattern and nutrition related knowledge of rural adolescent girls. *Indian Journal of Preventive Social Medicine*, Vol.41 (3 & 4), p.207-215.

Christenbury, L., Bomer, R. and Smagorinsky, P. (2009). *Handbook of Adolescent Literacy Research*. New York: Guilford Press, p.4.

CINI (Child In Need Institute). (2005). *Distribution of fortified candy in ICDS*: A pilot project in Howrah, West Bengal. West Bengal, Daulatpur, p.44.

Coleman, J.C. and Hendry, L.B. (2011). *The Nature of Adolescence* (3rd ed.). New York: Routledge, p.1.

Contento, I.R. (2008). Nutrition Education: Linking Research, Theory and Practice. *Asia Pacific Journal of Clinical Nutrition*, Vol. 17 (1), pp.176-179.

Contento, I.R., Randell, J.S. and Basch, C.E. (2002). Review and analysis of evaluation measures used in nutrition education intervention research. *Journal for Nutrition Education Behaviour*, Vol. 34 (1), pp.02-25.

Cortazar, R. Z. (2006). *Adolescent criminal behavior partly a matter of choice.* Retrieved from http://www.news.harvard.edu/gazette/2006/11.09/13-sharkey.html. Last accessed on 13 November 2012.

Costello, E.J., Mustillo, S., Erkanli, A., Keeler, G. and Angold, A. (2003). Prevalence and Development of Psychiatric Disorders in Childhood and Adolescence. *Archives of General Psychiatry*, Vol.60 (8), pp.837-844.

Creed-Kanashiro, H.M., Uribe, T.B., Bartolini, R.M., Fukumoto, M.N., Lopez, T.T., Zavaleta, N.M. and Bentley, M.E. (2000). Improving dietary intake to prevent anaemia in adolescent girls through community kitchens in a Periurban population of Lima, Peru. *Journal of Nutrition*, Vol.130 (2), pp.459S-461S.

Crider, A.B., Goethal, G.R., Kavanaugh, R.D. and Solomon, P.R. (1983), *Psychology* USA:Foresman Company, p.482.

Curtale, F., Nabil, M., el Wakeel, A., Shamy, M.Y. (1998). Anaemia and intestinal parasitic infections among school age children in Behera Governorate, Egypt, Behera Survey Team. *Journal of Tropical Pediatrics*, Vol.44 (6), pp.323-328.

Dahiya, M. and Rathi, V.K. (2010). Relationship between age at menarche and early-life nutritional status in India. *British Journal of Sports and Medicines*, Vol.44 (suppl.1), p.143.

Daniels, S.R., Arnett, D.K. and Eckel, R.H. (2005). Overweight in Children and Adolescents: Pathophysiology, Consequences, Prevention and Treatment. *Circulation*, Vol.111(15), pp.1999-2002.

Dapi, L.N., Hörnell, A., Janlert, U., Stenlund, H. and Larsson, C. (2011). Energy and nutrient intakes in relation to sex and socio-economic status among school adolescents in urban Cameroon, Africa. *Public Health Nutrition*, Vol.14 (5), pp.904-913.

Das, D.K. and Biswas, R. (2005). Nutritional status of adolescent girls in a rural area of North 24 Parganas District, West Bengal. *Indian Journal of Public Health*, Vol.49 (1), pp.18-21.

Das, S., Bhansali, A., Dutta, P., Aggarwal, A., Bansal, M.P., Garg, D., Ravikiran, M., Walia, R., Upreti, V., Ramakrishnan, S., Sachdeva, N. and Bhadada, S.K. (2011). Persistence of goitre in the post-iodization phase: Micronutrient deficiency or thyroid autommunity. *The Indian Journal of Medical Research*, Vol.133 (1), pp.103-109.

Dasgupta, A., Butt, A., Saha, T.K., Basu, G., Chattopadhyay, A. and Mukherjee, A. (2010). Assessment of malnutrition among adolescents: can BMI be replaced by MUAC. *Indian Journal of Medicine*, Vol.35 (2), pp.276-279.

Datta, B.N.D. (1979). Psycho-social Behavioural Problems of Children during Adolescence. *Indian Journal of Paediatrics*, Vol.46 (375), pp.121-125.

Davidson, S. (1990). *Blood biochemistry.In:Clinical Biochemistry*, Capeto Publication, pp.4-8.

Deb, S. (2001). A Study on the Negative Effects of Academic Stress. Paper presented at the *International Seminar on Learning and Motivation*, Kedah Darul Aman, Malaysia.

Delange, F. (2001). Iodine deficiency as a cause of brain damange. *Postgraduate Medical Journal*, Vol.77 (906), pp.217-220.

Deshmukh, P.R., Garg, B.S. and Bharambe, M.S. (2008). Effectiveness of weekly supplementation of iron to control anaemia among adolescent gils of Nasik, Maharashtra. *India Journal of Health and Population Nutrition*, Vol.26 (1), pp.74-78.

Dey, I., Biswas, R., Ray, K., Bhattacherjee, S., Chakraborty, M. and Pal, P.P. (2011). Nutritional Status of School Going Adolescents in a Rural Block of Darjeeling, West Bengal, India. *The Health*, Vol.2 (3), pp.75-77.

Dias, M.D.K.L., de Sival, A., Lanerolle, P., Arambepola, C. and Atukorala, S. (2012). Micronutrient status of female adolescent school dropouts. *Ceylon Medical Journal*, Vol.57 (2), pp.74-78.

Dodge, K.A and Pettit, G.S. (2003). A Biopsychosocial Model of the Development of Chronic Conduct Problems in Adolescence. *Developmental Psychology*, Vol.39 (2), pp.349-371.

Donohoue, P.A. (2004). *Obesity*. In: Behrman, R.E., Kleigman, R.M. and Jenson, H.B. (ed.). *Nelson textbook of paediatrics* (17^{th} ed.), Philadelphia: WB Saunders, p.173.

Duncan, J.S., Duncan, E.K. and Schofield, G. (2011). Associations between weight perceptions, weight control and body fatness in a multiethnic sample of adolescent girls. *Public Health Nutrition*, Vol.14 (1), pp.93-100.

Dutt, R., Patil, S., Joshi, S., Mhatre, R. and Ramdev. (2009). Prevalence of anaemia among adolescent girls in rural area of Raigad district, Maharashtra. *Indian Journal of Preventive Social Medicines*, Vol.40 (3), p.143.

Eat Well. (2011). *Review of policy actions, data available for their analysis and existing evaluations throughout Europe. Deliverable 1.1. of Eat Well for the European Commission*. Retrieved from: eatwellproject.eu/en/Eatwell-research/Project-Reports/.

Eisenberg, M.E and Sztainer, N.D. (2010). Friends' Dieting and Disordered Eating Behaviours among Adolescents Five Years Later: Findings from Project EAT. *Journal of Adolescent Health*, Vol.47 (1), pp.67-73.

Elgar, F.J., Roberts, C., Moore, L and Tudor-Smith, C. (2005). Sedentary Behaviour, Physical Activity and Weight Problems in Adolescents in Wales. *Public Health*, Vol.119 (6), pp.518-524.

Eliassen, E.K. (2011). Impact of teachers and families on young children's eating behaviours. *Young Children*, p.84.

Ellwood, D.T. and Jencks, C. (2004). *The spread of single-parent families in the United States since 1960*. Working Paper, Cambridge, Mass: Harvard University, John F. Kennedy School of Government, p.3.

Emery, R.E., Hethrington, E.M. and DiLalla, L.F. (1985). Divorce, children and social policy. In: Stevenson, H.W. and Siegel (eds.).*Child development research and social policy*. Chicago: Chicago University Press, p.1.

Emily, E. and Smith, T. (2012). Pubertal development and adolescent girls' substance use: Race, ethnicity and neighbourhood contexts of vulnerability. *The Journal of Early Adolescence*, Vol.32 (5), pp.621-664.

Ernst, I.Z., McKenna, A.A., Badenhop, N.E. (1998). Iron Status, Menarche and Calcium Supplementation in Adolescent Girls. *American Journal of Nutrition*, Vol.68 (4), pp.880-887.

Essau, C.A., Conradt, J. and Petermann, F. (2000). Frequency, comorbidity and psychosocial impairment of anxiety disorders in German adolescents. *Journal of Anxiety Disorders*, Vol.14 (3), pp.163-279.

FAO/WHO (Food And Agriculture Organization / World Health Organization). (1994). *Methods of analysis and sampling*. Joint FAO/WHO Food Standards Programme Codex Alimentarius Commission, Vol. 13, 2nd edition.

Findlay, S. (2004). Dieting in adolescence. *Paediatrics and Child Health*, Vol.9 (7), pp.487-491.

FSSAI (Food Safety and Standard Authority of India, Ministry of health and family welfare). (2012). F.No.06/QAS/2012/import issues/FSSAI,3rd floor FDA Bhawan, Kotla road, New Delhi, p.26.

Forbes, G.R. (1992). Nutrition and Growth. In: McAnarney, E.R., Kreipe, R.E., Orr, D.P., Comerci, G.D. (eds.). *Textbook of Adolescent Medicine*. Philadelphia: WB Saunders, pp.68-74.

Fox, M.K., Hanson, C. and Briefel, R. (2007). *Nutrition Education Research Brief: Message Framing, Use of Interactive Technology to Tailor Messages, and Intervention Intensity*, Submitted to U.S. Department of Agriculture, pp.1-7.

Friel, S, Kelleher, C., Campbell, P. and Nolan, G. (1999). Evaluation of the nutrition education at primary school (NEAPS) programme. *Public Health Nutrition*, Vol.2 (4), pp.549-555.

Fu, B. and Labuza, T.P. (1997). *Quality in Frozen Food. Shelf-Life Testing: Procedures and Prediction Methods*, Published by Springer, US, p.377.

Galloway, R. (2003). Anaemia Prevention and Control: What Works. Part I: Programme Guidance. *Population, Health and Nutrition Information Project* (PHNI). Jorge Scientific Corporation, Washington D.C. p.11.

Garrow, J.S. (2000). *Checklist for the months of selection of dietary investigations – Human nutrition and dietetics* (10th ed.). Aharcount Publisher (P) Ltd., pp.327-331.

Gautam, V.P., Bansal, Y., Taneja, D.K. and Saha, R. (2002). Prevalence of Anaemia Amongst Pregnant Women and its Socio-Demographic Associates in a Rural Area of Delhi. *Indian Journal of Community Medicine*, Vol.XXVII (4), pp.157-160.

Ghandour, R.M., Overpeck, M.D., Huang, Z.J., Kogan, M.D. and Scheidt, P.C. (2004). Headache, stomachache, backache and morning fatigue among adolescent girls in the United States: Associations with behavioural, sociodemographic and environmental factors. *Archives of Paediatric Adolescent Medicines*, Vol.158 (8), pp.797-803.

Gibson, R.(2005). ed. *Principles of nutritional assessment*. Oxford, Oxford University Press, p.601.

Giedd, J.N., Blumenthal, J., Jeffries, N.O., Castellanos, F.X., Liju, H., Zijdenbos, A., Paus, T., Evans, A.C. and Rapoport, J.L. (1999). Brain Development During Childhood and Adolescence: A Longitudinal MRI Study. *Nature Neuroscience*, Vol.2 (10), pp.861-863.

Gil, A. (2010). Tratado de Nutrición: Tomo III - Nutrición Humana en el Estado de Salud (2nd ed., 3rd Volume). Madrid: Editorial Médica Panamericana, S.A.

Gillman, M.W., Rifas-Shiman, S.L. and Frazier, A.L. (2000). Family dinner and diet quality among older children and adolescents. *Archives of Family Medicine*, Vol.9 (3), pp.235-240.

Giuseppina D. (2000). Nutrition in adolescence. *Paediatrics in Review*, Vol.21 (1), pp.32-33.

Glewwe, P. and Miguel, E. (2008). The Impact of Child Health and Nutrition on Education in Developing Countries. In: *Handbook of Development Economics*, Vol.4. Ed: Schultz, T.P. and Strauss, J. Amsterdam: North Holland Press, p.6.

Goel, S. and Gupta, B.P. (2007). Low anaemia prevalence among adolescents of an urban hilly community. *Indian Journal of Community Medicine*, Vol.32 (1), pp.67-68.

Gomez, J.I., Miranda, R. and Palanco, L. (2011). Acculturative stress, perceived discrimination and vulnerability to suicide attempts among emerging adults. *Journal of Youth Adolescence*, Vol.40 (11), pp.1465-1476.

Goodman, E., Ewen, B.S., Dolan, L.M., Schafer-Kalkhoff, T and Adler, N.A. (2005). Social Disadvantage and Adolescent Stress. *Journal of Adolescent Health*, Vol.37 (6), pp.494-492.

Gortmaker, S.L., Walker, D.K., Weitzman, M. and Sobol, A.M. (1990). Chronic Conditions, Socioeconomic Risks, and Behavioural Problems in Children and Adolescents. *Pediatrics*, Vol.85 (3), pp.267-276.

Government of India. (1995). Health Information of India,. DGHS, Nirmal Bhawan, Government of India, New Delhi.

Goyle, A. (2012). Effect of micronutrient fortified biscuit supplementation on the weight, height and BMI of adolescent girls. *Collegium Antropologicum*, Vol.36 (2), pp.573-579.

Goyle, A. and Prakash, S. (2010). Effect of supplementation of micronutrient fortified biscuits on haemoglobin and serum iron levels of adolescent girls from Jaipur city, India. *Nutrition and Food Science*, Vol.49 (5), pp.477-484.

Graber, J.A., Brooks-Gunn, J., Jeanne., Paikoff, R.L., Warren, M.P. (1994). Prediction of eating problems: An 8-year study of adolescent girls. *Developmental Psychology*, Vol.30 (6), pp.823-834.

Grigg, M., Bowman, J. and Redman, S. (1996). Disordered Eating and Unhealthy Weight Reduction Practices among Adolescent Females. *Preventive Medicine*, Vol.25 (6), pp.748-756.

Gujska, E., Majewska, K. (2005). Effect of baking process on added folic acid and endogenous folates stability in wheat and rye breads. *Plant Foods for Human Nutrtion*, Vol.60 (2), pp.37-42.

Guest, J., Bilgin, A., Pearce, R., Baines, S. Zeuschner, C., Rossignol-Grant, C.L., Morris, M.J. and Grant, R. (2010). Evidence for under-nutrition in adolescent females using routine dieting practices. *Asia Pacific Journal of Clinical Nutrition*, Vol.19 (4), pp.526-533.

Gupta, A., Parashar, A., Thakur, A. and Sharma, D. (2012). Anaemia among adolescent girls in Shimla Hills of North India: Does BMI and onset of menarche have a role? *Indian Journal of Medical Sciences*, Vol.66 (5), pp.126-130.

Gupta, N. and Kochar, G. (2009). Role of nutrition education in improving the nutritional awareness among adolescent girls. *The Internet Journal of Nutrition and Wellness*, Vol7 (1), pp.42-81.

Gupta, N. and Kochar, G.K. (2010). Supplementation effect of iron and folic acid capsule with and without Thandai on anaemic adolescent girls. *Ethno Medicine*, Vol.4 (2), pp.95-98.

Gupta, S.P. (2003). *Statistical Methods*. Sultan Chand and sons.New Delhi, p.310.

Haboubi, J and Rizwana, B. (2009). A comparison of the nutritional status of adolescents from the selected schools of South India and UAE: A cross-sectional study. *Indian Journal of Com Med*, Vol.34 (2), pp.108-111.

Haldar, A., Munsi Kumar, A., Chatterjee, T. Saha Kumar, A. and Basu, S.S. (2004). A cross sectional study on iodine deficiency disorder among school Children in West Bengal. *The Indian Journal of Nutrition and Dietetics,* Vol.41 (4), pp.160-164.

Haldar, D., Chatterjee, T., Sarkar, A.P., Bisoi, S., Kr.Biswas, A and Sardar, J.C. (2012). A study on impact of school-based health and nutrition education in control of nutritional anaemia among primary school children in rural West Bengal, *Indian Journal of Community Medicine*, Vol.37 (4), pp.259-162.

Hallal, P.C., Clark, V.L., Assunção, M.C., Araújo, C.L.P., Gonçalves, H., Menezes, A.M.B. and Barrosa, F.C. (2012). Socio-economic trajectories from birth to adolescence and risk factor for non-communicable disease: Prospective analysis. *Journal of Adolescent Health*, Vol.51 (6), pp.S32-S37.

Hallberg, L., Björn-Rasmussen, E., Garby, L., Pleehachinda, R. and Suwanik, R. (1978). Iron absorption from South-East Asian diets and the effect of iron fortification. *American Journal of Clinical Nutrition*, Vol.31 (8), pp.1403-1408.

Hickey, M. and Balen, A. (2003). Menstrual disorders in adolescence: Investigation and management. *Human Reproduction Update*, Vol.9 (5), pp.493-504.

Hindin, T.J., Contento, I.R. and Gussow, J.D. (2004). A Media Literacy Nutrition Education Curriculum for Head Start Parents about the effects of Television Advertising on their Children’s Food Requests. *Journal of American Dieticians Association*, Vol.104 (2), pp.192-198.

Hoyland, A., Dye, L. and Laston, C.L. (2009). A systematic review of the effect of breakfast on the cognitive performance of children and adolescents. *Nutrition Research Review*, Vol.22 (2), pp.220-243.

Huberman, A.M. and Miles, M.B. (1994). Data management and analysis methods. In: Denzin, N.K. and Lincoln, Y. (Eds.). *Handbook of qualitative research*. Thousand Oaks, CA: Sage, pp.428-443.

HUDCO (Housing and Urban Development Corporation Ltd). (2007) .*Board meeting ,vide item no.4*, held on 4 July 2007.

Hudson, J.L., Rapee, R.M., Deveney, C., Schniering, C.A., Lyneham, H.J and Bovopoulos, N. (2009). Cognitive-Behavioural Treatment Versus an Active Control for Children and Adolescents with Anxiety Disorders: A Randomized Trial. *Journal of the American Academy of Child and Adolescent Psychiatry*, Vol.48 (5), pp.533-544.

Hurrell, R.F., Furniss, D.E., Burri, J., Whittaker, P., Lynch, S.R. and Cook, J.D. (1989). Iron fortification of infant cereals: a proposal for the use of ferrous fumarate or ferrous succinate. *American Journal of Clinical Nutrition*, Vol.49 (6), pp.1274-1282.

Hussain, A., Kumar, A. and Hussain, A. (2008). Academic stress and adjustment among high school students. *Journal of the Indian Academy of Applied Psychology*, Vol.34, pp.70-73.

Hyder, S.M., Haseen, F, Khan, M, Schaetzel, T., Jalar, C.S., Rahman, M., Lonnerdal, B, Mannar, V. and Mehansho.H. (2007). A Multiple-Micronutrient-Fortified Beverage affects Haemoglobin, Iron, and Vitamin A Status and Growth in Adolescent Girls in Rural Bangladesh. *Journal of Nutrition*, Vol.137 (9), pp.2147-2153.

ICMR (Indian Council of Medical Research). (2000). Iron absorption and its implications on strategies to control iron deficiency anaemia. *ICMR Bulletin*, Vol.30, No.2, p.1.

ICMR (Indian Council of Medical Research). (1989). *Growth and physical development of Indian infants and children*. Technical Rep. Series No.18, Indian Council of Medical Research.

ICMR (Indian Council of Medical Research). (2004). *Recommended dietary allowance for Indians – Nutritive value of Indian foods*. Hyderabad: National Institute of Nutrition, ICMR, p.98.

IHMP. (2011). *Reducing anaemia and changing dietary behaviours among adolescent girls in Maharashtra, India*. Pachod: Institute for Health Management. p.1.

Imuetinyan, B.A.I., Okoeguale, M.I. and Egberue, G.O. (2011). Microalbuminuria in Children with Sickle Cell Anaemia. *Saudi Journal of Kidney Diseases and Transplantation*, Vol.22 (4), pp.733-738.

INACG (International Nutritional Anemia Consultative Group). (1985). Measurement of iron status. A report of the INACG. Washington. p.1-78.

Indian Institute of Health and Family Welfare. (2002). Prevention and control of anaemia among rural adolescent girls through school system in Andhra Pradesh (Hathnura, Kondapur, Jinnaram and Pulkal). Hyderabad: Indian Institute of Health Family Welfare, p.7.

Indian Institute of Health and Family Welfare. (2003). Prevention and control of anaemia among rural adolescent girls through school system in Andhra Pradesh (Hathnura, Kondapur, Jinnaram and Pulkal). Hyderabad: IIHFW. *Research Abstracts on Nutrition 1998 – 2008*, Documentation Centre for Women and Children National Institute of Public Cooperation and Child Development, New Delhi, pp.5-6.

Ingersoll R. (1999). The problem of underqualified teachers in american secondary schools. *Educational Researcher*. Vol.28 (2), pp.26–37.

International Centre for Research on Women. (2006). *Reducing anemia and changing dietary behaviors among adolescent girls in maharashtra, institute of health management, pachod (ihmp), pune.*Improving the reproductive health of married and unmarried youth in India, Final report of the adolescent reproductive health programme in India, Published by ICRW, Washington.p.14.

Jackson, R.T. and Al-Mousa, Z. (2000). iron deficiency is a more important cause of anaemia than haemoglobinopathies in Kuwaiti adolescent girls. *The Journal of Nutrition*, Vol. 130 (5), pp.1212-1216.

Jain, M. and Sharma, S. (2012). “Iron deficiency and anaemia”. *Indian Journal of Fundamental and Applied Life Insurances*, Vol.2(2), pp.101-107.

Jain, S., Pant, B., Chopra, H. and Tiwari, R. (2010). Obesity among adolescents of affluent public schools in Meerut. *Indian Journal of Public Health*, Vol.54 (3), pp.158-160.

Jelliffe, D.B. and Jelliffe, D.E.F. (1991). *Community nutrition assessment*. Oxford Medical Publication, pp.13-93.

Johansson, M. Witthöft, C.M., Bruce, A. and Jägerstad, M. (2002). Study of wheat breakfast rolls fortified with folic acid – The effect on folate status in women during a 3-month intervention. *European Journal of Nutrition*, Vol.41 (6), pp.279-286.

Johnson, J.G., Cohen, P., Kasen, S., Brook, J.S. (2002). Eating Disorders during Adolescence and the Risk for Physical and Mental Disorders during Early Adulthood. *Archives of General Psychiatry*, Vol.59 (6), pp.545-552.

Joshi, M. and Gumashta, R. (2013). Weekly iron folate supplementation in adolescent girls – an effective nutritional measure for the management of iron deficiency anaemia. *Global Journal of Health Science*, Vol.29:5 (3), pp.188-194.

Junior, E.V., Cesar, C.L., Fisberg ,R.M. and Marchioni, D.M. (2011). Socio-economic variables influence the prevalence of inadequate nutrient intake in Brazilian adolescents: Results from a population-based survey. *Public Health Nutrition*, Vol.14 (9), pp.1533-1538.

Kamath, R., Kumar, M., Pattanshetty, S. and Kamath, A. (2012). Nutritional Status Assessment of School Children in Mangalore City Using the Multicenter

Growth Reference Study WHO 2007 Z-scores. *International Journal of Nutrition, Pharmacology, Neurological Diseases*, Vol.2 (3), pp.233-236.

Kannani, S.J. and Poojara, R.H. (2000). Supplementation with iron and folic acid enhances growth in adolescent Indian girls. *Journal of Nutrition*, Vol.130 (2), pp.452S-455S.

Kapantais, E., Chala, E., Kaklamanou, D., Lanaras, L., Kaklamanou, M. and Tzotzas, T. (2011). Breakfast skipping and its relation to BMI and health-compromising behaviours among Greek adolescents. *Public Health Nutrition*, Vol.14 (1), pp.101-108.

Kapil, U., Singh, P., Pathak, P., Dwivedi, S.N. and Bhasin, S. (2002). Prevalence of Obesity amongst Affluent School Children in Delhi. *Indian Pediatrics*, Vol.39 (5), pp.449-452.

Kapil, U. (2007). Health Consequences of Iodine Deficiency, *Sultan Qaboos University Medical Journal*,Vol. 7 (3), pp.267–272.

Kapur, D., Agarwal, K.N. and Agarwal, D.K. (2002). Nutritional anemia and its control. *The Indian Journal of Pediatrics*, Vol. 69 (7), pp. 607-616.

Karaoglu, L., Pehlivan, E., Egri, M., Deprem, C., Gunes, G., Genc, M.F. and Temel, I. (2010). The prevalence of nutritional anaemia in pregnancy in an east Anatolian Province, Turkey. *BMC Public Health*, Vol.10 (329), p.1.

Kaur, M., Bassi, R. and Sharma, S. (2011). Impact of Nutrition Education in Reducing Iron Deficiency Anaemia in Adolescent Girls. *Indian journal of Fundamental and Applied Life Sciences*, Vol.1 (4), pp.222-228.

Khader, V., Kumar, R.N., Jayalakshmi, K., Dhanapal, H.M., Kasim, R., Sathiadhas, N.S. and Sudhakara. (2006). *Nutritional status and socio-economic empowerment of fisher women in the coastal ecosystem of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu, India*. Paper submitted at the Global Symposium on Gender and Fisheries, on 1-2 December 2004, at Malaysia, p.69-80.

Khadilkar, V.V. (2006). Secular trends in puberty. *Indian Paediatrics*, Vol.43, pp.475-478.

Khosravi, M.H., Noori-Shadkam, M., Fatehi, F. and Naghiaee, Y. (2010). Once weekly low-dose iron supplementation effectively improved iron status in adolescent girls. *Biological Trace Element Research*, Vol.135 (1-3), pp.22-30.

Koff, E. and Rierdan, J. (1995). Preparing girls for menstruation: recommendations from adolescent girls. *Adolescence*, Vol.30 (120), pp.795-811.

Kotecha, P.V., Patel, R.Z., Karkar, P.D., and Nirupam, S. (2004). *Adolescent Girls Anaemia Reduction Programme – Impact Evaluation (mid-term) of Vadodara District*. New Delhi: Micronutrient Profile of Indian Population, ICMR, pp.33-34.

Kotecha, P.V., S. Nirupam and P.D. Karkar (2009). Adolescent Girls' anaemia control programme, Gujarat, India. *Indian Journal of Medicine Research*, Vol.130 (5), pp.584-589.

Kotecha, P.V., Sangita, V., Patel, R.K., Baxi, V.S., Shobha, M.M., Mehta, K.G., Mansi, D. and Ekta, M. (2013). Dietary pattern of school-going adolescents in urban Baroda, India. *Journal Health and Population Nutrition*, Vol.31 (4), pp.490-496.

Kothari, C.R. (2001). *Research Methodology – Methods and techniques*. Viswaprakasham (p) Ltd, 2nd edition, New Delhi, pp.174-187.

Kothari, C.R. (2003). *Research Methodology*.Wishwaprakasham(P) Ltd.New Delhi.pp.74-187.

Kotian, M.S., Kumar, G.S., and Kotian, S.S. (2010). Prevalence and determinants of overweight and obesity among adolescent school children of south Karnataka, India. *Indian Journal of Community Medicine*, Vol.35 (1), pp.176-178.

Kreider, R.B., Wilborn, C.D., Taylor, L., Campbell, B., Almada, A.L., Collins, R., Cooke, M., Earnest, C.P., Greenwood, M., Kalman, D.S. Kerksick, C.M., Kleiner, S.M., Leutholtz, B., Lopez, H., Lowery, L.M., Mendel. R., Smith, A., Spano, M., Wildman, R., Willoughby, D.S., Ziegenfuss, T.N. and Antonio, J. (2010). ISSN exercise & sport nutrition review: research & recommendations. *Journal of the International Society of Sports Nutrition*, Vol.7 (7), p.1.

Krishnaswamy, K and Nair K.M. (2001). Importance of Folate in Human Nutrition. *British Journal of Nutrition*, Vol.85 (2), pp.S115-S124.

Kulkarni, M.V., Durge, P. M. and Kasturwar, N. B. (2012) . Prevalence of anemia among adolescent girls in an urban slum.*National Journal of Community Medicine* ,Vol.3 (1),p.108.

Kumar, V., Kumar, A., Sunita, V. and Kapur, I. (2003). Prevalence of anaemia and worm infestation in school going girls at Gulbarga, Karnataka.*Indian Pediatrics*, Vol.40, pp.70-72.

Kumar, V.M., Erhardt, J.G. and Rajagopalan, S. (2009). Impact of a multiple-micronutrient fortified salt on the nutritional status and memory of schoolchildren. *International Journal of Vitamin and Nutrition Research*, Vol.79 (5-6), pp.348-361.

Kurdek, L.A. (1981). An integrative perspective of children's divorce adjustment. *American Psychologist*, Vol.36 (8), pp.856-866.

Lacey, K. and Pritchett, E. (2003). Nutrition care process and model: ADA adopts road map to quality care and outcomes management: *Journal of the American Dietetic Association*,Vol.103 (8), pp.1061-1072.

Layrisse, M., Garcia-Casal, M.N., Solano, L., Barón, M.A., Arguello, F., Llovera, D., Ramírez, J., Leets, I. and Tropper, E. (2000). Iron bioavailability in humans from breakfasts enriched with iron bis-glycine chelate, phytates and polyphenols. *Journal of Nutrition*, Vol.130 (9), pp.2195-2199.

Le, L.C. and Blum, R.W. (2011). International injury in young people in Vietnam: Prevalence and social correlates. *MEDICC Review*, Vol.13 (3), pp.23-28.

Lerner, R.M. and Steinberg, L. (2004). *Handbook of Adolescent Psychology*. New Jersey: John Wiley & Sons, p.1.

Lewis, J. (2013). *The psysiological and psychological development of the adolescent*. Yale: New Haven Teachers Institute. Available at http://www.yale.edu/ynhti/ curriculum/units/1991/5/91.05.07.x.html. Last accessed on 04 July 2013.

Linville, D.D., O’Neill, M. and Huebner, A. (2011). Positive adult support and depression symptoms in adolescent females: The partially mediating role of eating disturbances. *Journal of Research on Adolescence*, Vol.21 (2), pp.335-341.

Lokare, P.O., Karanjekar, V.D. Gattani, P.L. and Kulkarni, A.P. (2012). A Study of Prevalence of Anaemia and Sociodemographic Factors Associated with Anaemia in Aurangabad City, India. *Annals of Nigerian Medicine*, Vol.6 (1), pp.30-34.

Lopez, M.A. and Matros F.C. (2004). Iron Availability: An Updated Review. *International Journal of Clinical Nutrition*, Vol.55 (8), pp.597-606.

Loud, K.J., Gordon, C.M., Micheli,L.J.and Field, A.E. (2005) . Correlates of stress fractures among preadolescent and adolescent girls, *Pediatrics* ,Vol. 115 (4), pp.e399-406.

Lumley, J., Watsson, L., Watson, M. and Bower, C. (2001). Periconceptional supplementation with folate and/or multivitamins for preventing neural tube defects. *Cochrane Database of Systematic Reviews,* Vol.3. (DOI: 10.102/14651858.CD001056).

Luwang, N.C., Gupta, V.M. and Khanna, S (1980). Anaemia in Pregnancy in a rural Community of Varanasi. *Indian Journal of Preventive Social Medicine*, Vol.11, pp.83-88.

Madukwe, E. and Eme, P.E. (2012). Chemical evaluation and sensory attributes of soymilk fortified with carrot powder. *African Journal of Food Science*, Vol.6 (2), pp.483-486, p.484.

Malagi, U., M.Reddy and R.K.Naik (2006). “Evaluation of national nutritional anaemia control programme in Dharwad (Karnataka). *Journal of Human Ecology,* Vol.20 (4), pp.279-281.

Malhotra, M., Sharma, J.B., Batra, S., Sharma, S., Murthy, N.S and Arora, R. (2002). Maternal and perinatal outcome in varying degrees of anaemia. *International Journal of Gynaecology and Obstetrics*, Vol.79 (2), pp.93-100.

Maliye, C.H., Deshmukh, P., Gupta, S., Kaur, S., Mehendale, A. and Garg, B. (2010). Nutrient intake amongst rural adolescent girls of Wardha. *Indian Journal of Community Medicine*, Vol.35 (3), pp.400-402.

Maluccio, J., Hoddinott, J., Behrman, J.R., Martorell, R., Agnes, R., Quisumbing and Stein, A.D. (2009). The impact of improving nutrition during early childhood on education among Guatemalan adults. *Economic Journal*, Vol.119 (537), pp.734-763.

Mannar, V. (2001). *Regional approaches for fortification of staples and complementary foods*. Paper prepared for the Asian Development Bank IFPRI Report Technical Assistance Project (RETA) 5824. Nutrition Trends, Policies and Strategies in Asia and the Pacific. Washington DC: International Food Policy Research Institute.

Martin, S.B., Rhea, D.J., Greenleaf, C.A., Judd, D.E. and Chambliss, H.O. (2011). Weight control beliefs, body shape attitudes, and physical activity among adolescents. *The Journal of School Health*, Vol.81(5), pp.244-250.

Martorell, R., Leslie, J. and Moock, P. (1984). Characteristics and determinants of child nutritional status in Nepal. *American Journal of Clinical Nutrition*, Vol.39 (1), pp.74-86.

Marwaha, R.K., Tandon, N., Singh, Y., Aggrawal, R., Grewal, K. and Mani, K. (2006). A study of growth parameters and prevalence of overweight and obesity in school children from Delhi. *Indian Paediatrics*, Vol.43 (11), pp.943-952.

Mathur, B., Ramani, S.V. and Bertin, E. (2005). *A Comparative Study of Impact of Leaf Concntrate and Iron and Folic Acid Supplementation on Blood Profile of Anbaemic Adolescent Girls*. Department of Home Science, University of Rajasthan, Jaipur, Rajasthan (India), pp.1-7.

McLoyd, V.C. (1998). Socioeconomic Disadvantage and Child Development. *American Psychologist*, Vol.53 (2), pp.185-204.

Menendez, C., Todd, J., Alonso, P.L., Francis, N., Lula,t S., Ceesay, S., M'Boge B.and Greenwood B.M. (1994). The effects of iron supplementation during pregnancy, given by traditional birth attendants, on the prevalence of anaemia and malaria. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, Vol.88 (5), pp.590-593.

Mishra, A. and Sharma, A.K. (2001). A Clinico-Social Study of Psychiatric Morbidity in 12 to 18 years School Going Girls in Urban Delhi. *Indian Journal of Communicative Medicines*, Vol.26 (2), pp.71-75.

Mishra, S.K. and Mukhopadhyay, S. (2011). Eating and weight concerns among Sikkimese adolescent girls and their bio-cultural correlates: An exploratory study. *Public Health and Nutrition*, Vol.14 (5), pp.853-859.

Monson, T., Steven A. Schichman, S.A. and Zent,C.S. (2002). Linezolid-Induced Pure Red Blood Cell Aplasia, *Clinical Infectious Diseases*, Vol. 35 (3), pp.e29-e31. doi: 10.1086/340982

Morris, S.S., Ruel, M.T., Cohen, R.J., Dewey, K.G., dela Briere, B. and Hassan, M.N. (1999). Precision, accuracy and reliability of haemoglobin assessment with use of capillary blood. *American Journal of Clinical Nutrition*, Vol.69 (6), pp.1243-1248.

Morrison, D.N., McGee, R. and Stanton, W.R. (1992). Sleep Problems in Adolescence. *Journal of the American Academy of Child and Adolescent Psychiatry*, Vol.31 (1), pp.94-99.

Mulugeta, A., Hagon, F., Stoecker, B., Kruseman, G., Linderhof, V., Abraha, Z., Yohannes, M. and Samuel, G.G. (2009). Nutritional status of adolescent girls from rural communities of Tigray, Northern Ethiopia. *Ethiopia Journal of Health Development*, Vol.23 (1), pp.5-11.

Mungreiphy, N.K., Dhall, M., Tyagi, R., Saluka, K., Kumar, A., Tungdim, M.G., Sinha, R., Rongmei, K.S., Tandon, K., Bhardwar, J., Kapoor, A.K. and Kapoor, S. (2012). Ethnicity, obesity and health pattern among Indian population. *Journal of Natural Science, Biology and Medicine*, Vol.3 (1), pp.52-59.

Nair, M.K.C., Paul, M.K. and John, R. (2004). Prevalence of depression among adolescents. *Indian Journal of Paediatrics*, Vol.71 (6), pp.523-524.

National Crime Records Bureau. (2000). *Accidental Deaths and Suicides in India: 2000*. Delhi, India: Ministry of Home Affairs, Government of India.

National Research Council. (1995). *Adolescents in high-risk settings*. Commission of Behavioural and Social Sciences and Educating Losing Generations. Washington, D.C: National Academy Press, p.16.

Naughton, G., Farpour-Lambert, N.J., Carlson, J., Bradney, M. and Praagh, E.V. (2000). Physiological Issues Surrounding the Performance of Adolescent Athletes. *Sports Medicine*, Vol.39 (5), pp.309-325.

NCBDN. (North Carolina Board of Dietetics/Nutrition) .(2010). *Guideline.A.* North Carolina, 1000 Centre Green Way, North Carolina, p.1.

Neuman, W.L. (2000). *Social research methods: Qualitative and quantitative approaches* (4thed.). Needham Heights, MA: Allyn and Bacon, p.420.

Nevid, J.S. and Rathus, S.A. (2005). *Psychology and the challenges of life: Adjustment in the new millennium*, (9th ed.). Hoboken, NJ: John Wiley & Sons, pp.1-10.

NICHD. (National Institute of Child Health and Human Development): network on early child development. (2005). *Duration and Developmental timing of poverty and children's cognitive and social development from birth through third grade*. *Child Development*, Vol.76 (94), pp.795-810.

Nidhi, R., Padmalatha, V., Nagarathna, R. and Amritanshu, R. (2011). Prevalence of polycystic ovarian syndrome in Indian adolescents. *Journal of Paediatry, Adolescence and Gynaecology*, Vol.24 (4), pp.223-227.

NIN (National Institute of Nutrition). (2005). *NCHS Standards*, NHANES-1, Resource material, Epidemiological tools in assessment of nutritional status, pp.11-17.

NNMB. (National Nutrition Monitoring Bureau). (1979). Special publication series:5, Nutrition foundation of India, p.45.

NNMB. (National Nutrition Monitoring Bureau). (2000). *Report on diet and nutritional status of adolescents. Hyderabad*: National Nutrition Monitoring Bureau and Indian Council of Medical Research. Report no: 20, pp.1-25.

Oguntibeju, O.O. (2003). Parasitic infection and anaemia: The prevalence in a rural hospital setting. *Journal of Indian Academy of Clinical Medicine*, Vol.4 (3), pp.210-212.

Olukunle, O. (2007). *Adolescents transition: The challenges and the way out (African perspective)*. Presentation at the 5th African Publication Conference, 14 October 2007 at Arusha, Tanzania.

Omotoso, O. (2007). *Adolescents transition: The challenges and the way out (African perspective)*. Dissertation submitted to College of Medicine, University of Ibadan, Nigeria, p.1.

Oster, E. And Thornton, R. (2011). Menstruation, Sanitary Products, and School Attendance: Evidence from a Randomized Evaluation. *American Economic Journal: Applied Economics*,Vol.3 (1), pp.91-100.

Pan, L., Sherry, B., Park, S. and Blanck, H.M. (2013). The association of obesity and school absenteeism attributed to illness or injury among adolescents in the United States. *Journal of Adolescent Health*, Vol.52 (2013), pp.64-69.

Parimalavalli, R. and Sangeetha, M. (2011). Anthropometric measurements and nutrient intake of adolescent girls. *Anthropologist*, Vol.13 (2), pp.111-115.

Park, K. (2005). *Park's Textbook of Preventive and Social Medicine*. Banarsidas Bhanot Publishers, Jabalpur , Madhya Pradesh, pp.316-319.

Pasricha, S., Shet, A., Sachdev, H.P.S. and Shet, A.S. (2009). Risks of routine iron and folic acid supplementation for young children. *Indian Paediatrics*, Vol.46 (10), pp.857-866.

Patel, H. J. and Shah, P.U. (2009). A study about anaemic condition of adolescent girls by hemoglobin estimation and dietary survey. Shodh Samiksha aur Mulyankan, *International Research Journal*, Vol.2 (7), p.87.

Patel, V. (2013). Reducing the burden of depression in youth: What are the implications of neuroscience and genetics on policies and programmes? *The Journal of Adolescent Health*, Vol.52 (2), pp.S36-S38.

Pathak, P., Singh, P., Umesh, K. and Raghawanshi, R.S. (2003). Prevalence of Iron, Vitamin A and Iodine Deficiencies amongst Adolescent Pregnant Mothers. *Indian Journal of Paediatrics*, Vol.70 (4), pp.299-301.

Patil, S.N., Wasnik, V. and Wadke, R. (2009). Health problems amongst adolescent girls in rural areas of ratnagiri district of Maharashtra India. *Journal of Clinical and Diagnostic Research*, Vol.3 (5), pp.1784-1790.

Patterson, P. (2010). Multistage Sampling Chapter 13. Available at http://www. math.montana.edu/~parker/PattersonStats/Twostage.pdf. Last accessed on 03 January 2015.

Patterson, R.E. and Pietinen, P. (2004). Assessment of nutritional status in individual and populations. In: *Public health nutrition*, edited by Gibney, M.J., Margetts, B.M., Kearny, J.M. and Arab. India, Noida: Blackwell Science, Grey Publishing, Gopsons Papers Ltd., pp.66-81.

Patton, G.C., Johnson-Sabine, E., Woods, K., Mann, A.H. and Wakeling, A. (1990). Abnormal eating attitudes in London schoolgirls: Outcome at twelve month follow-up. *Psychology and Medicine*, Vol.20 (2), pp.383-394.

Pearson, N. and Biddle, S.J. (2011). Sedentary Behaviour and Dietary Intake in Children, Adolescents and Adults – A Systematic Review. *American Journal of Preventive Medicine*, Vol.41 (2), pp.168-88.

Peter, R., Kumar, R., Sangwan, L. and Pandey, S. (2012). Prevalence of anaemia and its correlation to body mass index: Study among unmarried girls. *International Journal of Basic and Applied Medical Sciences*, Vol.2 (3), pp.58-62.

PFA (The Prevention of Food Adulteration Act).(1954). Act 37 of 1954.

Poh, B.K., Norimah, A.K., Talib, R.B. and Talib, M.N. (2009). Nutrition education for Malaysian children: Evaluation of a school-based nutrition intervention conducted in Kuala Lumpur and Selangor, Malaysia. Available at http://www.cftri.com/news/proc/proc5. Last accessed on 31 December 2009.

Polit, D.F. and Hungler, B.P. (2001). *Nursing Research: Principles and Methods* (6th ed.). Philadelphia: Lippincott, p.367.

Polivy, J and Herman C.P. (1985). Dieting and binge eating. *American Psychology*, Vol.40 (2), pp.193-201.

Popkin, B. (2001). The Nutrition transition and obesity in the developing world. *Journal of Nutrition*, Vol.131(3), p.871S.

Prakash, R., Singh, A., Pathak, P.K. and Parasuraman, S. (2011). Early marriage, poor reproductive health status of mother and child wellbeing in India. *Indian Journal of Family Planning and Reproduction Healthcare*, Vol.37 (3), p.136-45.

Quint, E.H. (2008). Menstrual issues in adolescents with physical and developmental disabilities. *Annals of the New York Academy of Sciences*, Vol.1135, pp.230-236, http://deepblue.lib.umich.edu/bitstream/handle/2027.42/72241/annals. 1429.020. pdf? sequence

Rampersaud, G.C., Pereira, M.A., Girard, B.L., Adams, J. and Metzl, J.D. (2005). Breakfast habits, nutritional status, body weight and academic performance in children and adolescents. *Journal of American Diet Association*, Vol.105 (5), pp.743-760.

Ramzi, M., Haghpanah, S., Malekmakan, L., Cohan ,N., Baseri, A., Alamdari ,A and Zare, N. (2011). Anaemia and iron deficiency in adolescent school girls in Kavar urban area, Southern Iran. *Iran Red Crescent Medicine*, Vol.13 (2), pp.128-133.

Rao, D.H. and Vijayarakhavan, K. (1996). *Anthropometric assessment of nutritional status: Text book of human nutrition*. Oxford and IBS Publishing Co, New Delhi, p.149.

Rao, D.H. and Vijayarakhavan, K. (2003). *Anthropometric assessment of nutritional status: Text book of human nutrition*. New Delhi: Oxford and IBS Publishing Co, pp.148-151.

Rao, S. (2001). Nutritional status of the Indian population. *Journal of Bioscience*, Vol.26 (4), pp.481-489.

Rao, S., Gokhale, M., Joshi, S., Kanade, A. (2010). Early life undernutrition and adolescent pregnancy outcome in rural India. *Annals of Human* Biology, Vol.37 (4), pp.475-87.

Rao, S., Joshi, S., Bhide, P., Puranik, B. and Kanade, A. (2011). Social dimensions related to anaemia among women of childbearing age from rural India. *Public Health Nutrition*, Vol.14 (2), pp.365-372.

Rawat, C.M., Garg, S.K., Singh, J.V., Bhatnagar, M., Chopra, H. and Bajpai, S.K. (2001). Prevalence of anaemia among adolescent girls in rural area of district Meerut, U.P. *Indian Journal of Public Health*, Vol.45 (1), pp.24-26.

Reddy,R.. (2004). *Prevalence of iron deficiency anaemia and malnutrition in India. Bangalore:* Indian Institute for Social and Economic change.Bangalore, p.61.

Remsberg, K.E., Demerath, E.W., Schubert, C.M., Chumlea, C., Sun, S.S and Siervogel, R.M. (2005). Early menarche and the development of cardiovascular disease risk factors in adolescent girls: The Fels Longitudinal Study. *The Journal of Clinical Endocrinology and Metabolism*, Vol.90 (5), pp.2718-2724.

Repetti, R.L., Taylor, S.E and Seeman, T.E. (2002). Risky Families: Family social environments and the mental and physical health of offspring. *Psychological Bulletin*, Vol.128 (2), pp.330-366.

Rey-Lopez, J.P., Rodriguew, G.V., Repasy, J., Isabel, M., Mesana, Ruiz, J.R., Ortega, F.B., Kafatos, A., Huybrechts, I., Garcia, M.C., Leon, J.F., Gross, M.G., Sjostrom, M., de Bourdeaudhuij, I. and Moreno, L.A. (2011). Food and drink intake during television viewing in adolescents: The healthy lifestyle in Europe by nutrition in adolescence (HELENA) study, *Public Health Nutrition*, Vol.14 (9), pp.1-7.

Richards, M.H and Duckett, E. (1994). The Relationship of Maternal Employment to Early Adolescent Daily Experience with and Without Parents. *Child Development*, Vol.65 (1), pp.225-236.

Rogers, L.M., Boy, E., Miller, J.W., Green, R., Sabel, J.C. and Allen, L.H. (2003). High prevalence of cobalamin deficiency in Guatemalan schoolchildren: Associations with low plasma holotranscobalamin II and elevated serum methylmalonic acid and plasma homocysteine concentrations. *American Journal Clinical Nutrition*, Vol.77 (2), pp.433-440.

Rokade, S. and Mane, A. (2008). A study of age at menarche: The secular trend and factors associated with it. *The Internet Journal of Biological Anthropology*, Vol.3 (2), https://ispub.com/IJBA/3/2/7469.

Rosenzweig, M. and Schultz, T.P. (1982). *Child mortality and fertility in Columbia: Individual and community effects' health policy and education*. Amsterdam: Elsevier Scientific Publishing Co, pp.305-348.

Roy, S. and Chakravorty, P.S. (1992). Maternal and Perinatal Outcome in Severe Anaemia. *Journal of Obstetrics and Gynecology of India*, Vol.42, pp.743-750.

Roy, S., Roy, S. and Rangari, K. (2007). Comprehensive healthcare including sexual and reproductive health of adolescents and youths is of vital importance to the nation. *Health and Population-Perspectives and Issues*, Vol.39 (4), p.243.

Ruzita, A.T., Wan Azdie, M.A., and Ismail, M.N. (2007). The Effectiveness of Nutrition Education Programme for Primary School Children. *Malaysian Journal of Nutrition*, Vol.13 (1), pp.45-54.

Sabbah, H., Vereecken, C., Abdeen, Z., Coats, E. and Maes, L. (2009). Associations of overweight and of weight dissatisfaction among Palestinian adolescents: Findings from the national study of Palestinian school children. *Journal of Human Nutrition and Dietetics*, Vol.22 (1), pp.40-49.

Sachan, B., Idris, M.Z. and Singh, A. (2012[a]). Effect of socio-demographic characteristics on the prevalence of anaemia among school going adolescent girls in Lucknow District, India. *South East Asia Journal of Public Health*, Vol.2 (1), pp.8-12.

Sachan, B., Idris, M.S., Jain, S., Kumari, R. and Singh, A. (2012[b]). A nutritional status of school going adolescent girls in Lucknow district. *Journal of Medical Nutrition and Neutraceuticals*, Vol.1 (2), pp.101-105.

Sacks, D. (2003). Age Limits and Adolescents. *Paediatrics and Child Health*, Vol.8 (9), p.577.

Sadhna, G and Achala, S. (2006). Awareness about reproduction and adolescent changes among school girls of different socioeconomic status. *The Journal of Obstetrics and Gynecology of India,* Vol. 56 (4), p.327.

Saluja, S., Bhandari, S., Aggarwal, S. and Kapoor, S. (2009). Osteopetrosis: A Rare Cause of Anaemia – Review of Literature. *Indian Journal of Pathology and Microbiology*, Vol.52 (3), pp.363-367.

Salvy, S.J., Elmo, A. and Roemmich, J.N. (2011). Influence of parents and friends on children's and adolescents' food intake and food selection. *The American Journal of Clinical Nutrition*, Vol.93 (1), pp.87-92.

Samanta, A., Mukherjee, S., Ghosh, S. and Dasgupta, A. (2012). Mental health, protective factors and violence among male adolescents: A comparison between urban and rural school students in West Bengal. *Indian Journal of Public Health*, Vol.56 (2), pp.155-158.

Saxena, Y. and Saxena, V. (2011). Nutritional status in rural adolescent girls residing at hills of Garhwal in India 2009. *Internet Journal of Medicine.* Vol.6 (2), pp.3-8, http://www.akspublication.com/paper01_jul2011.html.

Saxena, Y., Shrivastava, A. and Saxena, V. (2011). Effect of gender on correlation of anaemia with body mass index in medical students. *Indian Journal of Physiology and Pharmacology*, Vol.55 (4), p.364.

Schneider, F., Gruman, J. and Coutts, L.M. (2012). *Applied social psychology: Understanding and addressing social and practical problem.* Thousand Oaks, California: Sage Publications, Inc, p.251

Seal, A., Kafwembe, E., Kassim, I.A., Hong, M., Wesley, A., Wood. J., Abdella, F. and van den Briel, T. (2008). Maize Meal Fortification is Associated with Improved Vitamin a and Iron Status in Adolescents and Reduced Childhood Anaemia in Food Aid-dependent Refugee Population. *Public Health and Nutrition*, Vol.11 (7), pp.720-728.

Seiter, L.N. and Nelson, L.J. (2011). An examination of emerging adulthood in college students and non-students in India. *Journal of Adolescent Research*, Vol.26 (4), pp.506-536.

Sen, A. and Kanani, S.J. (2006). Deleterious functional impact of anaemia on young adolescent school girls. *Indian Paediatrics*, Vol.43 (3), pp.219-226.

Sen, A. and Kanani, S. (2012). Intermitent iron folate supplementation: Impact on hematinic status and growth of schools girls. *International Scholarly Research Notices*, Vol. 2012 (482153), p.1.

Sewald, M. and De Vries, J. (2003). *Food Product Shelf Life*. Analytical Progress Press, Minneapolis,Vol. 2 (21), pp.1-8.

Shariff, Z.M., Bukhari, S.S., Othman, N., Hashim, N., Maznah, I., Jamil, Z., Kasim, S.M., Paim, L., Samah, B.A. and Hussein, Z.A.M. (2008). Nutrition education intervention improves nutrition knowledge, attitude and practices of primary school children: A pilot study. *International Electronic Journal of Health Education*, Vol.11 (1), pp.119-132.

Sharma, A., Prasad, K. and Rao, V.K. (2011). *Identification of an appropriate strategy to control anaemia in adolescent girls of poor communities* Nutrition Foundation of India, New Delhi.

Sharma, A.K., Shukla, D. and Kannan, A.T. (2005). Calorie and Protein Intake and its Determinants among Adolescent School Girls in Delhi. *Indian Journal of Community Medicine*, Vol.30 (1), pp.8-10.

Sharma, J.B., Soni, D., Murthy, N.S. and Malhotra, M. (2003). Effect of dietary habits on prevalence of anaemia in pregnant women in Delhi. *Journal of Obstetrics and Gynaecology Research*, Vol.29 (2), pp.73-78.

Sharma, K.S., Narain, K., Devi, K.R., Mohapatra, P.K., Phukan, R.K. and Mahanta, J. (2012). Haemoglobinopathies – Major Associating Determinants in Prevalence of Anaemia among Adolescent Gir Students of Assam, India. *WHO South-East Asia Journal of Public Health*, Vol.1 (3), pp.299-308.

Shekhar, A. (2005). Iron status of adolescent girls and its effect on physical fitness. *Indian Journal of Nutrition and Dietetics*, Vol.42 (10), p.451.

Shivaramakrishna, H.R., Deepa, A.V. and Sarithareddy, M. (2011). Nutritional status of adolescent girls in rural area of Kolar District – A cross sectional study. *Al Ameen Journal of Medical Science*, Vol.4 (3), pp.243-246.

Shrivastav, M. and Thomas, S. (2010). Snack consumption among underprivileged adolescent girls. *Indian Paediatrics*, Vol.47 (10), pp.888-890.

Siddharam, S.M., Venketesh, G.M. and Thejeshwari, H.L. (2011). A study of anaemia among adolescent girls in rural area of Hassan District, Karnataka, South India. *International Journal of Biological and Medical Research*, Vol.2 (4), pp.922-924, http://www.researchgate.net/publication/265204029_A_Study_of_Anemia_Among_Adolescent_Girls_in_Rural_Area_of_Hassan_district_Karnataka_South_India.

Singh, A.K., Maheshwari, A., Sharma, N. and Anand, K. (2006). Lifestyle associated risk factors in adolescents. *Indian Journal of Paediatrics*, Vol.73 (10), p.901.

Singh, M.R. and Mangang, K. (2012). Anaemia and body mass index (BMI) of fisherwomen inhabiting in Karang island of Loktak lake, Manipure. *Eurasian Journal for Anthropology*, Vol.3 (2), pp.47-53.

Singh, R. (2008). Socio-Demographic Factors Causing Anaemia in Adolescent Girls in Meerut. *Health and Population Perspectives and Issues*, Vol.31 (3), pp.198-203.

Singh, S., Kansal, S., Kumar, A. (2012). Assessment of nutritional status of adolescent girls in rural area of district, Varanasi. *Annnvikshiki The Indian Journal of Research*, Vol.6 (6), p.31, http://www.anvikshikijournal.com/viewpaper.aspx?pcode=3ad49f8d-fda9-4eee-932d-a30f7c1c0c80.

Sinha, A.K. (2006). *Socio-economic conditions of adolescent girls – A case study of backward district of poverty dominates states*. Final report submitted to Planning Commission, Government of India, New Delhi, p.205.

Sinha, A.K. and Pankaj. P. (2009). *Socio-economic condition of adolescent girls. Study conducted among the backward districts selected under Rashtriya*

Samvikas Yojana. India: Planning Commission, Deep and Deep Publications, p.95.

Sivasankaran, C., Johnson, W., Arockiaswamy, Ramanujam, P., Chellamuthu, S., Muruganantham, K. and Shanmugam, L. (2014). Prevention of bread spoilage and to enhance the quality of bread by using lactic acid bacteria. *International Journal of Chemical Technology Research*, Vol.6 (9), pp.4161-4165.

Smojver-Azic, S. and Bezinović, P. (2011). Sex differences in patterns of relations between family interactions and depressive symptoms in adolescents. *Croat Medical Journal*, Vol.52 (4), pp.469-477, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3160708.

Spear, B.A. (2002). Adolescent growth and development. *Supplement to the Journal of The American Dietetic Association*, Vol.102 (3), p.S23.

Sridevi, K.V. (2012). Awareness towards adolescent reproductive health among teacher trainees of Awassa, South Ethiopia. *Review of Research*, Vol.1 (8), pp.131.

Srilakshmi, B. (2003). *Food science* (3rd ed.). New Age International Publishers, p.280.

Srinivasan, K. and Prabhu, G.R. (2004). A study of the nutritional status of the social welfare hostels in Tirupati, Andhra Pradesh. *The Indian Journal of Nutrition and Dietetics*, Vol.41 (5), pp.210-214.

Stang, J and Story, M. (eds.). (2009). *Guidelines for Adolescent Nutrition Services*. Available at http://www.epi.umn.edu/let/pubs/adol_book.shtm. Last accessed on 23-6-15.

Stattin, H., Kerr, M. and Skoog, T. (2011). Early pubertal timing and girls' problem behavior: Integrating two hypotheses. *Journal of Youth Adolescence,* Vol.49 (10), pp.1271-1287.

Stice, E., Presnell, K., Shaw, H., and Rohde, P. (2005). Psychological and behavioural risk factors for obesity onset in adolescent girls – A prospective study. *Journal of Consulting and Clinical Psychology*, Vol.73 (2), pp.195-202, http:// www.ori.org/files/Static%20Page%20Files/SticePresnelletal05.pdf.

Striegel-Moore, R.H., Silberstein, L.R. and Rodin, J. (1986). Toward an understanding of risk factor for Bulimia. *American Psychologist*, Vol.41 (3), pp.246-263.

Story, M., Neumark-Sztainer, D. and French, S. (2002). Individual and environmental influences on adolescent eating behaviors. *Journal of the American Dietetic Association*, Vol.102 (3 suppl), pp.S40-51.

Suriakanthi, A. (2009). *Child development – An introduction* (4rd ed.). Gandhigram, Tamil Nadu: Kavitha Publications.p.189.

Sztainer, D.N., Eisenberg, M.E. and Fulkerson, J.A. (2008). Family meals and disordered eating in adolescents: Longitudinal findings from Project EAT. *Archives of Pediatric Adolescent Medicine*, Vol.162 (1), pp.17-22.

Sztainer, D.N., Patterson, J., Mellin, A., Ackard, D.M., Utter, J., Story, M. and Sockalosky, J (2002). Weight Control Practices and Disordered Eating Behaviours among Adolescent Females and Males with Type 1 Diabetes. *Diabetes Care*, Vol.25 (8), pp.1289-1296.

Sztainer, N.D., Wall, M., Guo, J., Story, M., Haines, J and Eisenberg, M. (2006). Obesity, Disordered Eating and Eating Disorders in a Longitudinal Study of Adolescents: How do Dieters fare 5 Years Later. *Journal of American Diet Association*, Vol.106 (4), pp.559-568.

Takii, M., Komaki, G., Uchigata, Y., Maedia, M., Omori, Y and Kubo, C. (1999). Differences between Bulimia Nervosa and Binge-eating Disorder in Females with type 1 Diabetes. The Important Role of Insulin Omission. *Journal of Psychosom Research*, Vol.47 (3), pp.221-231, http://www.researchgate.net/publication/12725717_Differences_between_bulimia_nervosa_and_binge-eating_disorder_in_females_with_type_1_diabetes_The_important_role_of_insulin_omission.

Thakkar, H.K., Misra, S.K., Gupta, S.C and Kaushal, S.K. (2010). A Study on Prevalence of Obesity among College Going Girls in Agra District of UP. *Indian Journal of Community Health*, Vol.21 (2 pp.61-64.

Thanulingam, N. (2000). *Research methodology*. Himalayan Publishing House, pp.65-68.

The Hindu. (2004). Adolescent Girls Worst Hit by Malnutrition, *The Hindu*, dated Saturday, September 11, 2004.

Thimmayamma, B.V.S. (1987). *Handbook of schedules and guidelines in socioeconomic and diet surveys*. Hyderabad: National Institute of Nutrition, pp.1-70.

Titaley, C.R. and Dibley, M.J. (2012). Antenatal iron/folic acid supplements, but not postnatal care, prevents neonatal deaths in Indonesia: analysis of Indonesia Demographic and Health Surveys 2002/2003–2007 (a retrospective cohort study), *BMJ Open*; doi:10.1136/bmjopen-2012-001399, Vol.2 (6) pp.1-11.

Tiwari, B.D., Godbole, M.M., Chattopadhyay, N., Mandal, A. and Mithal, A. (1996). Learning disabilities and poor motivation to achieve due to prolonged iodine deficiency. *American Journal of Clinical Nutrition*, Vol.63 (5), pp.782-786.

Todd, T.J., Tehranifar, P. and Terry, M.B. (2010). The impact of socioeconomic status across early life on age at menarche among a racially diverse population of girls. *Annals of Epidemiology*, Vol.20 (11), pp.836-842.

Tolentino, K. and Friedman, J.F. (2007). An update on anaemia in less developed countries. *American Journal of Tropical Medicine & Hygiene*, Vol.77 (1), pp.44-51.

Toteja, G.S., Singh, P., Dhillon, B.S., Saxena, B.N., Ahmed, F.U., Singh, R.P., Prakash, B., Vijayaraghavan, K., Singh, Y., Rauf, A., Sarma, U.C., Gandhi, S., Behl, L., Mukherjee, K., Swami, S.S., Meru, V., Chandra, P., Chandrawari. and Mohan. U. (2006). Prevalence of anaemia among pregnant women and adolescent girls in 16 districts of India. *Food and Nutrition Bulletin*, Vol.27 (4), pp.311-315.

Tripathi, S. (2002). *Study of health status and effectiveness of iron folic acid prophylaxis among adolescent girls of Lucknow*.Thesis for MD, K.G.M.C., Lucknow, p-1.

Trivedi, P. and Palta, A. (2007). Prevalence of anaemia and impact of iron supplementation on academic adolescent school girls. *Health and Population-Perspectives and Issues,* Vol.30 (1), pp.45-55.

Uhlin, D.M. (1962). The relationship of adolescent physical development to art expression. *Studies in Art Education :A Journal of Issues and Research*, Vol.3 (2), pp.64-68.

UNFPA (United Nations Population Fund). (2005). *State of world population 2005: The promise of equality, gender equity, reproductive health and millennium development goals*. United Nations Population Fund, p.4.

UNICEF/UNU/WHO/MI. (The United Nations Children's Fund). (1998). *Technical workshop on preventing iron deficiency in women and children – Technical consensus on key issues*. New York: UNICEF, p.34.

UNICEF. (United Nations International Children's Emergency Fund). (2011[a]). *The state of the world's children 2011: Adolescence – an age of opportunity,* The Emerging Generation, p.2.

UNICEF. (United Nations International Children's Emergency Fund). (2011[b]). *The adolescent girls anaemia control programme breaking the inter-generational cycle of undernutrition in India with a focus on adolescent girls. briefing paper series:innovations, lessons and good practices*. The United Nations Children's Fund, New Delhi,p.1-4.

UNICEF. (United Nations International Children's Emergency Fund). (2012). *Progress for children-A report card on adolescents*, Number 10, UNICEF, New York, pp.20-24.

United Nations. (2008). Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2008 revision, www.esa.un.org/unpd/wpp2008/index.htm, accessed October 2010, and UNICEF global databases, accessed October 2010.

Vaclavik, V. and Christian ,E.W. (2013). Essentials of Food Science, Springer Science & Business Media, p.471.

Varsha, Z., Rohinidevi. and Asha, A. (2008). Effect of supplementation of biofortified biscuits on haematological parameters of selected adolescent girls of Marathwada Region. *Indian Journal of Nutrition and Dietetics*, Vol.45, pp.520-529.

Varughese, B.F. (1996). *Recipes for all occasions- Part I*, (6th ed.). Kottayam: Premise Offset Printers, pp.240-241.

Vasanthi, G., Fawashe, A.B., Susie, H., Sujatha, T. and Raman, L. (1994). Iron nutritional status of adolescent girls from rural area and urban slum. *Indian Paediatrics*, Vol.31 (2), pp.127-32.

Verma, A., Rawal, V.S., Kedia, G., Kumar, D. and Chauhan, J. (2004). Factors influencing anaemia among girls of school going age (6-18 years) from the slums of Ahmedabad City. *Indian journal of Community Medicine*, Vol.29 (1), pp.25 & 26.

Vijayalakshmi, R., Sohba, I. and Reddy, M.S.N. (2003). Social nutrition and elderly. *Social Welfare*, Vol.46, pp.10-18.

Viner, R.M., Coffey, C., Mathers, C., Bloem, P., Costello, A., Santelli, J. and Patton, G.C. (2011). 50-year mortality trends in children and young people: A study of 50 low-income, middle-income and high-income countries. *Lancet*, Vol.2 (377/9772), pp.1162-1174.

Viteri, F.E., Alvarez, E., Batres, R., Torún, B., Pineda, O., Mejía, L.A., Sylvi, J. (1995). Fortification of sugar with iron sodium ethylenediaminotetraacetate (FeNaEDTA) improves iron status in semirural Guatemalan populations. *American Journal of Clinical Nutrition*, Vol. 61 (5), pp.1153-1163.

Walter, T., Dallman, P.R., Pizarro, F., Velozo, L., Pena, G., Bartholmey, S.J., Hertrampf, E., Olivares, M., Leteelier, A. and Arredondo, M. (1993). Effectiveness of iron-fortified infant cereal in prevention of iron deficiency anemia. *Pediatrics*, Vol.91 (5), pp.976-982.

Wang, R., Hsu, H., Lin, S., Cheng, C. and Lee, S. (2010). Risk behaviours among early adolescents: Risk and protective factors. *Journal of Advanced Nursing*, Vol.66 (2), pp.313-323.

Ward, E. and Ashley, D. (2013). The new imperative: Reducing adolescent-related violence by building resilient adolescents. *Journal of Adolescent Health*, Vol.52 (2/2), pp.S43-S45.

Warren, J.M., Henry, C.J., Lightowler, H.J., Bradshaw, S.M. and Perwaiz, S. (2003). Evaluation of a pilot school programme aimed at the prevention of obesity in children. *Health Promotion International*, Vol. 18 (4), pp.187-296.

Weeks, M., Coplan, R.J. and Kingsbury, A. (2009). The correlates and consequences of early appearing social anxiety in young children. *Journal of Anxiety Disorders*, Vol.23 (7), pp.965-72.

Weiss, D.D. and Last, C.G. (Eds.). (2001). *Developmental Variations in the Prevalence and Manifestations of Anxiety Disorders: The Developmental Psychopathology of Anxiety*. Oxford: Oxford University press, pp.27-42.

White, J. and Jago, R. (2012). Prospective associations between physical activity and obesity among adolescent girls: Racial differences and implecations for prevention. *Archives of Paediatric and Adolescent Medicine*, Vol.166 (6), pp.522-7.

WHO. (World Health Organization). (1968). *Nutritional anaemias. Report of a WHO scientific group*, World Health Organization Technical Report Series, vol.405, p.22.

WHO. (World Health Organization). (2001[a]). *The Second Decade, Improving Adolescent Health and Development*, Department of Child and Adolescent Health and Development, Family and Community Health,World Health Organization,Geneva, p.2.

WHO. (World Health Organization). (2001[b]). *Iron deficiency anaemia: Assessment, prevention and control – A guide for programme managers*. Methods of assessing iron status, WHO/NHD, p.33.

WHO. (World Health Organization). (2004). Appropriate body mass index for Asian Populations and its implications for policy and intervention strategies. *Lancet*, Vol.363 (9403), pp.157-163.

WHO. (World Health Organization). (2011[a]). *Adolescent Nutrition – A Neglected Dimension*. Available at https://apps.who.int/nut/ado.htm. Last accessed on 10 June 2013.

WHO. (World Health Organization). (2011[b]). *Nutrition – Challenges*. World Health Organization. Available at http://www.who.int/nutrition/challenges/on. Last accessed on 8 June 2013.

WHO. (World Health Organization). (2011[c]). *Prevention of Iron Deficiency Anaemia in Adolescents, Role of Weekly Iron Folic acid Supplementation*, WHO regional office for south-east Asia, p-10.

WHO. (World Health Organization). (2015[a]). *Adolescent Health. World Health Organization, Health Topics*. World Health Organization. Available at www.who.inttopics/adolescent_health/en/. Last accessed on 10 June 2013.

WHO. (World Health Organization). (2015[b]). *Adolescent Development.* Available at http://www.who.int/maternal_child_adolescent/topics/adolescence/dev/en/.Last accessed on 14 march 2015.

WHO. (World Health Organization). (2014). Adolescent mental health, http://www.who.int/maternal_child_adolescent/topics/adolescence/dev/en/.Last accessed on 14 October 2014.

WHO. (World Health Organization). (1989). DeMaeyer, E.M., Dallman, P., Gurney, J.M., Hallberg, L., Sood, S.K. and Srikantia, S.G. *Assessment, prevalence and consequences of iron deficiency anaemia through primary health care*. World Health Organization, Geneva, p.26.

Willet, W.C., Dietz, W.H. and Colditz, G.A. (1999). Guidelines for healthy weight. *The New England Journal of Medicine*, Vol.341 (6), pp.427-434.

Wong, Y., Chang, Y.J., Tsai, M.R., Liu, T.W. and Lin, W. (2011). The body image, weight satisfaction and eating disorder tendency of school children: The 2-year follow-up study. *Journal of the American College of Nutrition*. Vol.39 (2), pp.126-133.

Yadav, S. and Jain, V. (2001). Precocious puberty in children. *Asian Journal of Paediatric Practice*, Vol.4, pp.31-40.

Yazdani, Mohsen, H.S., Zamsam, P. and Reza, S.G. (2010). Effect of nutrition education on nutritional knowledge and attitude among adolescent girls (Isfahan-Iran). *Health System Research*, Vol.6 (1), pp.73-77.

Yusoff, H., Daud,W.N.W. and Ahmad. Z. (2013). Effectiveness of Nutrition Education vs. Non-Nutrition Education Intervention in Improving Awareness Pertaining Iron Deficiency among Anemic Adolescents. *Iranian Journal of Public Health*, Vol. 42 (5), pp. 467–471.

Zaimin, W., Patterson, C.M. and Andrew, H.A. (2003). The Relationship between BMI and Intake of Energy and Fat in Australian Youth: A Secondary Analysis of the National Nutrition Survey, 1995. In: Preetha, N., Shiny, P. and Hemamalini, A.J. (2013). Assessment PCOS and implementation of nutritional knowledge among adolescent girls (15-18 years). *International Journal of Innovative Research and Development*, Vol.2 (9), pp.197-202.

APPENDIX I

LIST OF SCHOOLS AND COLLEGES IN KOTTAYAM TALUK

Schools (UP, HS and HSS)

1. C.M.S. H.S. Olassa
2. Parippu H.S
3. St. Mary's U.P.S, Kudamaloor
4. P.J.M. U.P.S, Aymanam
5. Govt. H.S, Kudamaloor
6. Govt. H.S. L.P.S, Kudamaloor
7. Blind School, Olassa
8. Govt. U.P.S. Kummanam ,Aymanam
9. Govt. W. U.P.S Karimadom
10. Govt. H.S, Karipputhitta ,Arpookara
11. Medical College H.S, Arpookara
12. St. Mary's G.H.S. Athirampuzha
13. St. Alosious H.S, Athirampuzha
14. St.Ephrem's H.S.
15. Kuriakose Elias E.M.S HS
16. Govt. U.P.S. Kottackapuram
17. St. Paul's G H S
18. St. Sebastian's U.P.S, Peroor
19. Town U.P.S. Ettumanoor
20. Holy Cross H S, Thellakom
21. Sree Vidyadhiraja EMHS
22. Mangalam E M H S
23. M.G.Public School
24. Govt. Girls H.S Ettumanoor
25. Govt. Boys V.H.S. Ettumanoor
26. Govt. U.P.S Punnathura
27. St.George H.S, Kaipuzha.
28. St. Margaret's U.P.S, Kaipuzha
29. S.K.V. Govt. H.S, Neendoor
30. St. John's U.P.S, Kumarakom
31. S.K.M. H.S, Kumarakom
32. Govt. V.H.S. Kumarakom
33. A.B.M. Govt. U.P.S, Kumarakom
34. Govt. U.P.S. Kumarakom
35. N.S.S. H.S. Chingavanam
36. N.S.S U.P.S, Panachickad
37. St. Mary's U.P.S, Kollad
38. Govt. U.P.S Pathammuttam
39. St. Thomas U.P.S, Eravinelloor
40. St. Thomas H.S.
41. V.J.O.M. U.P.S
42. Don Bosco High School
43. St.George E.M.
44. Govt. H.S, Puthuppally
45. St.George Govt.H.S,Puthuppally
46. Govt. U.P.S, Ericud
47. Govt. U.P.S, Pariyaram
48. S.V.G.V.P. H.S, Kiliroor
49. S.N.D.P. H.S, Kiliroor
50. Govt. H.S, Chengalam
51. Govt. U.P.S, Thiruvarppu
52. Girideepam Bethani HS
53. Govt. U.P.S, Nattassery
54. Govt. U.P.S, Vadavathur
55. Infant Jesus H.S. Manarcad
56. St. Mary's H.S, Manarcad
57. Govt. H.S, Areeparamp
58. Govt. U.P.S, Malam
59. Govt. U.P.S, Manarkad
60. L.F. G.H.S, Kanjiramattam
61. St. Alosius H.S. Manalumkal
62. St. Joseph's G.H.S. Moozhoor
63. St.Antony's H.S. Chengalam
64. St. Antony's U.P.S, Paduva
65. Mattakkara H.S
66. S.H. G.H.S. Pangada
67. N.S.S. H.S,
68. M.G.M. N.S.S H.S.S Lakkattor
69. Govt. H.S, Kothala
70. St. Thomas H.S, Anicad
71. N.S.S. H.S, Anicad
72. Govt. U.P.S Elampally
73. Govt. U.P.S, Anicad
74. M.G.M. H.S. Pampady
75. St. Thomas H.S.
76. Govt. H.S, Pampady
77. P.T.M. Govt. H.S, Velloor

78. T.M.U. U.P.S, Meenadom
79. St. Mary's U.P.S, Meenadam
80. Govt. H.S. Meenadom
81. Govt. U.P.S, Cheeramkulam

Colleges

1. Govt. College, Nattakam, Kottayam
2. Sree Sankaracharya University of Sanskrit, Ettumanoor
3. B.K. College for Women, Kottayam
4. Baselius College, Kottayam
5. C.M.S. College, Kottayam
6. College of Applied Science (IHRD), Puthuppally
7. Ettumanoorappan College, Choorakulangara, Ettumanoor
8. K.E. College, Thalayolapramba
9. Kuriakose Gregrios College, Mannarcaud
10. St. Mary's College, Manarcadu
11. Government Dental College, Gandhi Nagar
12. Govt. College of Engineering Rajiv Gandhi Institute of Technology (R.I.T), Nedumkuzhy
13. Mangalam College of Engineering, College Road, Mangalam Hills
14. Mar Gregorious College of Engineering and Technology
15. Government Medical College, Kottayam
16. College of Nursing, Cheliyozhukkam Road
17. Caritas College of Nursing, Kottayam
18. School of medical education , Arpookkara

APPENDIX II

INTERVIEW SCHEDULE USED TO COLLECT THE INFORMATION OF THE SUBJECTS

Name of school/college:

Class/batch : Date:

Code number:

Socio-economic back ground

1) Name :

2) Age and date of birth :

3) Address and phone No :

4) Religion :

5) Type and composition of the family : Joint/nuclear

No.	Members	Sex	Age	Educational Qualifications	Occupation	Monthly income (Rs.)

6) Annual family income (Rs) :

7) Ordinal position (Birth order) :

Anthropometric data

8) Height (cm) :

9) Weight (Kg) :

10) BMI (Kg/m^2) :

11) Waist circumference (cm) :

12) Hip circumference (cm) :

13) Waist to hip ratio :

Details on menstruation

14) Have you attained menarche? : Yes/No

15) If yes, do you experience any menstrual problems? : Yes/No

If yes, specify :

a) Dysmenorrhea	b) Breast heaviness	c) Increased weight
d) Back ache	e) Abdominal bloating	f) Irregular cycle
g) Fatigue	h) Head ache	i) Skin disorders
j) Abnormal duration of menstruation	k) Irritability	l) Aggressiveness
m) Missed cycle	n) GI symptoms	o) Depression
p) Loss of appetite		

16) Dose menstrual problems affect daily routine? : Yes/No

If yes, specify

a) Prolonged rest	b)Missed work	c) Sleep disturbances
		d)Anything else

17) Do you limit or avoid any food or food groups during menstruation? : Yes/No

If yes specify

General health details

18) Are you experiencing the following?

a) Head ache b) Fatigue c)Dyspnoea

d) Missed social activities e) Missed class d)Blurring vision

e) Paresthesia f) Syncopal attacks

19) Do you have a history of worm infestation? : Yes/No

20) Did you suffer from any intestinal problems? : Yes/No

21) Do you take any anticonvulsant drugs like Eptoin, Valproate, Carbazepine, Clonazepam, etc. : Yes/No
If yes specify

22) Did you suffer from any other health problems? : Yes / No
If yes,

i) Name of the illness

a) Allergy b) Asthma c) Migraine

d) Sinusitis e) Tonsillitis f) Fever/infection

g) Hypothyroidism h) Goiter i) Heart problems

j) PCOD k) Urinary calculi l) Skin diseases

m) Muscle pain

ii) Specify frequency of the illness :

23) Do you suffer from stress : Yes/No

If yes, specify the cause of stress

Dietary pattern

24) Basic Dietary Habit :

a) Vegetarian b) Non-Vegetarian c) Non-Vegetarian, but often takes Vegetarian food

25) Common daily meal pattern : 3/4/5/6/>6 meals/day

26) Do you skip any meals? : Yes / No

If yes, specify

27) Are you allergic to any food? : Yes/No

If yes specify

28) Do you take vitamins, minerals, herbal, or other dietary supplements ? : Yes / No

If yes

a. Name of the supplement: : ………………………………

b. Category of the supplement : Ayurveda / Allopathy / Homeopathy / Others (Specify)

c. If you know the type of nutrient present in it specify the nutrient and the amount ……………………………

……………………………

29) How often do you take a multivitamin or folic acid supplement in a week? a) Never b) 1-2 days c) 3-5 days d) 6-7 days

30) Do you follow dieting? : Yes/No

If yes, what are the changes made in your diet and why? :

31) How often do you eat food away from home? :
(Never/ Rarely/ Very often/ Occasionally / Daily)

32) Are you Hosteller or day scholar? :

33) Has the folic acid required in your age group? : Yes/No/Don't know

If yes, why it is needed? :

34) Do you know the sources of folic Acid?

APPENDIX III

NCHS STANDARDS

50th percentile values of heights and weights: Adolescent girls

Age (years)	Height (cm)	Weight (Kg)
12	154.6	43.8
13	159.0	48.3
14	161.2	52.1
15	162.1	55.0
16	162.7	56.4
17	163.4	56.7
18	163.3	59.9
19	163.3	59.9

Ref: NIN (2005)

APPENDIX IV

STANDARD OF BMI

Percentiles of BMI-for–age: Adolescent girls

Age (years)	Percentiles				
	5th	15th	50th	85th	95th
12	14.98	15.98	18.35	22.17	25.95
13	15.36	16.43	18.95	23.08	27.07
14	15.67	16.79	19.32	23.88	27.97
15	16.01	17.16	19.69	24.29	28.51
16	16.37	17.54	20.09	24.74	29.10
17	16.59	17.81	20.36	25.23	29.72
18	16.71	17.99	20.57	25.56	30.22
19	16.87	18.20	20.80	25.85	30.72

BMI Age/Sex centiles	Nutritional grade
$<5^{th}$ centile	Undernutrition
$\geq 5^{th}$ - $<85^{th}$ centile	Normal
$\geq 85^{th}$ - $<95^{th}$ centile	Over weight
$\geq 95^{th}$ centile	Obesity

Ref: NIN (2005)

APPENDIX V

ICMR STANDARD OF HEIGHT AND WEIGHT OF ADOLESCENT GIRLS

Age (years)	Height (cm)	Weight (Kg)
12	139.8	30.5
13	144.5	34.3
14	148	37.7
15	150.2	40.1
16	151.3	41.9
17	151.8	43.0
18	152.2	43.1
19	152.1	43.1

Ref: ICMR (1989)

APPENDIX VI

CYANMETHEMOGLOBIN METHOD

PRINCIPLE

In solution the ferrous ion (Fe^{2+}) of the hemoglobins (Hb) are oxidised to the ferric state (Fe^{3+}) by potassium ferric cyanide to form methemoglobin. In turn, methemoglobin reacts with the cyanide ions (CN^-) provided by potassium cyanide to form cyanmethemoglobin, which has the absorbance at 540nm.

REAGENTS

a. Cyanmethemoglobin solution (Drabkin's solution): Dissolve 0.05 g potassium cyanide, 0.200g potassium ferric cyanide, and 0.140 g dihydrogen potassium phosphate in 1 L of distilled water. Add 1 ml of Triton X-100 and mix. Stable for at least 6 months.

b. Hemoglobin solution : lyophilised human methemoglobin. Each vial is equivalent to hemoglobin concentration of 18 g/dl whole blood when reconstituted in 50 ml of Drapkin's solution stable for 6 months when refrigerated at 2-6 ^{0}C.

PROCEDURE

Transfer 0.02 ml of blood using a calibrated hemoglobin pipette, into a tube containing 5.0 ml of Drapkin's reagent. Rinse the pipette several times with the reagent. Allow diluted haemoglobin solution to stand for at least 5 min to achieve full colour development. Measure the absorbance at 530-550 nm of the unknown sample (Aunk) and that of a standard of known hemoglobin content (Astd) against a reagent blank.

CALCULATION

$$\text{Haemoglobin unknown (g/dl)} = \frac{\text{Aunk} \times \text{con. Of Hb standard (g/dl)}}{\text{Astd}}$$

APPENDIX VII

ESTIMATION OF SERUM IRON CONCENTRATION

Iron is carried in the plasma bound to the protein transferrin (molecular mass 78,000). This molecule binds two atoms of iron as Fe^{3+} and delivers iron to cells by interaction with the membrane transferrin receptor. This method is based on the development of a coloured complex when ferrous iron is treated with a chromogen solution

REAGENTS

Preparation of Glassware.

It is essential to avoid contamination by iron. If Wash glasswares in a detergent solution, soak in 2 mol/l HCl for 12 hours, and finally rinse in iron-free water.

Protein precipitant

100 g/l trichloracetic acid (0.61 M) and 30 ml/l thioglycollic acid in 1 mol/l HCl.

This solution may be stored in the dark for 2 months. Ascorbic acid is an alternative reducing agent, although there may be more interference from copper. However, any benefit from reduced copper interference is usually outweighed by the associated health and safety problems of working with thioglycollic acid. To 45 ml 1 mol/l HCl in a 50 ml screwcap tube add 5 ml 6.1 mol/l trichloracetic acid solution (Sigma 490–10). Add 200 mg ascorbic acid and mix. Make a fresh solution when required and discard after 4 hours.

Chromogen Solution

In 100 ml 1.5 mol/l sodium acetate dissolve 25 mg of ferrozine [monosodium 3-(2-pyridyl)-5, 6-bis (4-phenylsulphonic acid)-1, 2, 4-triazine]. Store the solution in the dark for up to 4 weeks.

Iron standard 80 µmol/l

Add 22.1 ml of deionized water to a universal container (the easiest way is by weight). Add 200 µl of 2 mol/l HCl and mix. Add 100 µl of iron standard solution (1000 µg Fe/ml in 1% HCl, Aldrich No. 30, 595–2) and mix. Store the solution for up to 2 months at room temperature.

Iron-free water

Use deionized water for the preparation of all solutions.

PROCEEDURE

1. Place 0.5 ml of serum (free of haemolysis)
2. 0.5 ml of working iron standard
3. 0.5 ml of iron-free water (as a blank), respectively, in each of three 1.5 ml plastic Eppendorf tubes with lids.
4. Add 0.5 ml of protein precipitant to each and replace the lid
5. Mix the contents vigorously and allow to stand for 5 min
6. Centrifuge the tube containing the serum at 13,000 g for 4 min (in a microfuge) to obtain an optically clear supernatant.
7. To 0.5 ml of this supernatant, and to 0.5 ml of each of the other mixtures, add 0.5 ml of the chromogen solution with thorough mixing.
8. After standing for 10 min, measure the absorbance in a spectrophotometer against water at 562 nm.

CALCULATION

$$\frac{\text{Abs of Test} \quad \times \quad 80}{\text{Abs of STD}}$$

APPENDIX VIII

ESTIMATION OF SERUM FOLIC ACID

REAGENTS

1. 0.2M phosphate buffer, pH7.2
2. 4% ascorbic acid solution
3. 0.2M sodium phosphate buffer, pH6.1
4. folic acid standard (stock): 10mg folic acid in 100ml 0.8% sodium bicarbonate solution to obtain 100µg/ml.
5. Folic Acid working standard : 0.1 ng/ml for assay with L.casei 1 ng/ml for assay with S.faecalis
6. Folic Acid Assay Medium (Difco).

PROCEDURE

Preparation of serum for the assay:

Take 0.5 ml of serum in a 30 ml screw capped tube, add 8.5 ml of 0.05M sodium phosphate buffer (pH6.1) and add 1 ml of 1% ascorbic acid, mix it and autoclaved for 10 min at 15 lbs pressure. Take out, cool it to room temperature and make up to known volume and filter through whatman No. 1 filter paper, collect the filtrate in a bottle or test tube. Store it and use different concentrated sample levels for folic acid assay.
Folic Acid Assay Protocol:

Total volume: 10 ml

FA Working Std		**Distilled Water**	**Basal Medium**	
Blank	Nil	5 ml	5ml	Cover the test tube rack with lint cloth and cotton followed by brown paper with clips both sides. Autoclave it for 12 min. at 12 lbs. take out, cool to room temp. add L.casei
0.05ng	(0.5 ml)	4.5 ml	5ml	
0.1/ng	(1.0 ml)	4.0	5ml	
0.15ng	(1.5 ml)	3.5	5ml	
0.2/ng	(2.0 ml)	3.0	5ml	
0.25ng	(2.5 ml)	2.5	5ml	

<table>
<tr><th colspan="2">FA Working Std</th><th>Distilled Water</th><th>Basal Medium</th><th></th></tr>
<tr><td>0.3/ng</td><td>(3.0 ml)</td><td>2.0</td><td>5ml</td><td rowspan="4">organism suspension. (Already cell washed with 0.9% normal saline) 4 drops in each tube and incubate at 37^oC for 72 hrs. Turbidity measured at 660 nm.</td></tr>
<tr><td>0.35ng</td><td>(3.5 ml)</td><td>1.5</td><td>5 ml</td></tr>
<tr><td>0.4/ng</td><td>(4.0 ml)</td><td>1.0</td><td>5ml</td></tr>
<tr><td>0.5/ng</td><td>(5.0 ml)</td><td>NIL</td><td>5 ml</td></tr>
</table>

L.Casei Cell Washing:

Keep inoculum one day before the assay set up in an inoculum broth inside an incubator at 37^0C for overnight. Thirty ml screw capped tube, 80 ml of 0.9% normal saline in 100ml conical flask with cotton plug, syringe with needle packed with cotton and brown paper, these are autoclaved along with assay rack at 12 lbs for 12 min

Step:

1. The inoculum transferred into 30 ml screw capped tube under asceptic condition using burner/(ultra violet radiation) and centrifuged for 5 min at 3000 RPM.
2. Inoculum supernatant discarded and 10 ml sterilized normal saline added and centrifuged for 5 min at 3000 RPM.
3. Repeat same step 2 once again.
4. Prepare cell suspension in conical flask and use for inoculation of organism in test tubes of folic acid assay.

APPENDIX IX

DETERMINATION OF CYANOCOBALAMIN BY MICROBIOLOGICAL METHOD

PRINCIPLE:

Microbiological methods are based on the observation that certain microorganisms require specific nutrients for growth. Using a basal medium complete in all respects except for the nutrient under test (cyanocobalamin), growth responses of the organism are compared quantitatively in standard and unknown test solutions. Either the acid or the turbidity extends of growth and thereby the amount of nutrient in the test solution measured at 660nm wavelength or 66 filter or red filter in photoelectric colorimeter.

Materials required:
Equipments:

Autoclave	pH meter
Incubator	Laminar hood
Vortex mixer	Bunsen burner
Water bath	Photoelectric colorimeter (Klett Summerson)
Centrifuge	

Glassware and other accessories:
Conical flasks, beakers, test tubes, racks, funnels, filtration stand, pipettes, reagent bottles, aluminum foil, cotton, brown paper, lint or muslin cloth, clips, rubber bands, inoculating needle made of nichrome wire, measuring jars, calculator, graph paper, Whatman no.1 filterpaper, labels, pencil, paper, pens etc.,

REAGENTS

Standard
Cyanocobalamin (Vit-B-12) (Sigma)

Microorganism
Euglena Gracilis

Glass distilled water or deionised water

Samples for analysis

PROCEDURE:

Preparation of standards:

Stock standard: Cyanocobalamin (Sigma)

- 10mg of cyanocobalamin is dissolved in 100 ml of millipore water in a standard volumetric flask.
- The solution gives a stock standard of 100 µg/ml

Working standard

Dilution 1

- 2 ml of stock cyanocobalamin standard is diluted to 10ml in a volumetric flask.
- This dilution gives a standard of 20 µg/ml
- Working standard ranges (0-40 µg/ml)

Basal medium:

Readymade cyanocobalamin basal medium is available with Difco chemicals.

About 5.13 g of the dry basal medium is dissolved in 80 ml of glass distilled water.

Heat to dissolve and make up the volume to 100ml.

Maintenance of stock culture:

Preparation of culture medium

- Add 400 mg of tryptone and 1 ml of vitamin B-12 (containing 10mg vitamin B-12 per ml) to 100 ml double strength basal medium and make up the volume to 200ml.
- About 8–10 ml of the medium is dispensed into test tubes.
- Plug the tubes with cotton.
- Autoclave at 10 lbs for 10 minutes.
- The tubes can be kept for a month.

Culturing the organism

- Three or four drops of a suspension of the organism is added to the tubes under aseptic conditions.
- Incubate the tubes in an illuminated water bath kept at 25-30°C.
- Full growth takes place within 6- 8 days.
- The organism is sub cultured every week.

Preparation of inoculums

It is similar to the preparation of stock culture medium except that tryptone is not added in the preparation of these tubes.

Protocol:

Test tube	Volume of std/sample	Glass distilled water	Double strength basal medium
Un inoculated blank	-	2ml	2ml
Inoculated blank	-	2ml	2ml
Standard 4µg	0.2ml	1.8ml	2ml
Standard 8µg	0.4ml	1.6ml	2ml
Standard 12µg	0.6ml	1.4ml	2ml
Standard 16µg	0.8ml	1.2ml	2ml
Standard 20µg	1.0ml	1.0ml	2ml
Standard 30µg	1.5ml	0.5ml	2ml
Standard 40µg	2.0ml	-	2ml
Sample	0.5ml	1.5ml	2ml
Sample	1.0ml	1.0ml	2ml
Sample	1.5ml	0.5ml	2ml
Sample	2.0ml	-	2ml

Procedure:

- Place tubes in the rack and label them as un inoculated and inoculated blank, standards (ranging from 0-40µg) and samples (0.5-2.0ml)
- Tubes to be taken in duplicates for standards and samples.
- Blank tube will contain glass distilled water and double strength basal medium.
- Add standards 0.2ml to2.0ml (ranging 0-40µg) in duplicates.
- Add samples 0.5-2.0 ml in duplicates.
- Make up the volume to 2ml in each tube (Blank, Standards and samples). Vortex the solution.
- Add 2ml of double strength basal medium in all the tubes and mix well.
- Cover the tubes with aluminum caps
- Autoclave at 10lbs for 10 minutes in an autoclave
- Cool test tubes to room temperature and keep in the laminar hood under aseptic conditions

Cell washings:

- Prepare normal saline in a 100ml conical flask.
- 0.9g NaCl dissolved in 100ml glass distilled water.
- Plug the neck of the centrifuge tube (CF) with cotton and cover it with brown paper and rubber band.
- Then take a syringe and 20-gauge needle. Plug the back of the syringe with cotton cover it with brown paper and rubber band along with the needle.
- Sterilize at 15 lbs for 15 min at 121°C (can be autoclaved along with the standards and samples test tubes rack).
- Cool to room temperature and place in the laminar hood.
- Remove the inoculums with Euglena Gracilis from the incubator and place in a laminar hood.
- Wash the organisms with sterile normal saline under asceptic conditions using a bunsen burner flame.
- Centrifuge the solution.
- Remove the solution leaving the pellet of organisms under asceptic conditions.
- Again add few ml of normal saline and repeat the same.
- Make a suspension of the pellet after the 2nd centrifugation using about 30ml of saline.

Now

- Use the sterilized syringe and needle ^{t}o seed the washed suspension of Euglena Gracilis into the test tube containing Blank, Standards and samples under aseptic conditions except for the un inoculated blank.
- Incubate in an illuminated water bath at 25-30°C for 6 days.
- The tubes are taken out after 6 days, steamed for 3 minutes & diluted with distilled water.
- Turbidity is measured in Klett Summerson or photoelectric colorimeter using 660nm filter (red filter).

Instrument readings: Klett

- The instrument is switched for 10 min for stabilization.
- Red filter is used which gives a wavelength of 660nm.
- The instrument is set to zero using the galvanometer knob.
- Take the uninoculated blanks into the Klett tube and place in the instrument.
- Set to zero.
- Then read the other solutions including inoculated blank, standards and samples.
- Draw the standard graph by plotting the turbidity against concentration of VitaminB_{12} in the standard tubes.
- Note the concentration of the sample using the graph.
- Calculate per ml and note the concentration.
- Calculate cyanocobalamin in the sample mg/100g using the formula.

Amount of vitaminB_{12} = Average vitaminB_{12} content per ml of test solution **x** total dilution

APPENDIX X

24-HOUR RECALL FORM

Respondent No. :
Name of student : Age :
School/College :
Class/Course :
Date : Day :
Please indicate allergic foods :
Do you consume nutritional supplements? Yes/No
If yes list type :
Type of diet : Vegetarian/Non vegetarian/Ovo vegetaria

Meal	Time	Menu	Quantity	Method of preparation	Weight of raw ingredients (gm/ml)
Break fast					
Morning snack					
Lunch					
Afternoon snack					
Dinner					
Bed time milk					

APPENDIX XI

FOOD FREQUENCY QUESTIONNAIRE

1. Respondent No. :
2. Name of student : 3. Age:
4. School/College :
5. Class/Course :
6. Date : 7. Day:

.

Name of food stuff	Frequency of use					
	Daily	4-5 times/week	1-3 times /week	Once in a month	Occasionally	Never
Cereals and millets						
Raw rice						
Rice (Parboiled)						
Wheat						
Wheat flour						
Wheat bread						
Semolina						
Vermicelli						
Ragi						
Pulses, dal and legumes						
Bengal gram						
Black gram dal						
Green gram						
Green gram dal						
Green peas						
Horse gram						
Rajma						
Red gram dal						
Soy beans						
Leafy vegetables						
Amaranth (green variety)						
Amaranth (Red variety)						
Cabbage						

Name of food stuff	Frequency of use					
	Daily	4-5 times/week	1-3 times /week	Once in a month	Occasionally	Never
Cauliflower						
Celery leaves						
Chekkurmanis						
Drum stick leaves						
Lettuce						
Spinach						
Other vegetables						
Ash gourd						
Beans						
Bitter gourd						
Brinjal						
Broad beans						
Cauliflower						
Cluster beans						
Cucumber						
Drum stick						
Ladies finger						
Pumpkin						
Snake gourd						
Tomato						
Roots and tubers						
Beetroot						
Carrot						
Colacasia						
Onion big						
Onion small						
Potato						
Radish						
Sweet potato						
Tapioca						
Yam						
Fruits						
Apple						
Banana						
Custard apple						
Dates						
Gooseberry						
Grapes						
Jack fruit						
Lime						
Mango						

Name of food stuff	Frequency of use					
	Daily	4-5 times/week	1-3 times /week	Once in a month	Occasionally	Never
Musambi						
Orange						
Pappaya						
Pear						
Pine apple						
Plantain						
Pomegranate						
Tomato ripe						
Water melon						
Nuts and oil seeds						
Almond						
Cashew nuts						
Coconut						
Gingelly seeds						
Gingelly seeds						
Ground nut						
Milk and milk products						
Butter						
Butter milk						
Cheese						
Cow’s milk						
Curd						
Ghee						
Paneer						
Animal foods						
Beef						
Chicken						
Egg						
Fish						
Mutton						
Organ meats						
Sugars						
Jaggery						
Palm jaggery						
Refined sugar						
Fats and oils						
Coconut oil						
Sunflower oil						
Vanaspathi						

APPENDIX XII

COMPUTER AIDED TEACHING TOOL

APPENDIX XIII

QUESTIONS TO ASSESS BASIC NUTRITIONAL KNOWLEDGE

1. Citrus fruits contain more amount of ......

   Vitamin C/Vitamin A/Calcium

2. Which one of the following has a vital role in bones and tooth development?

   Iron/Calcium/vitamin E

3. Yellow and orange colour fruits and vegetables are rich in......?

   Vitamin A/Iron/Fat

4. Vitamin D is also known as

   Antisterility vitamin/sunshine vitamin / clotting factor

5. Low haemoglobin indicates......?

   Acidity/ diabetes/anaemia

6. Which one of the following is a fibre rich food?

   Apple/ice cream/chicken

7. Your weight should be maintained by ....

   Dieting/excercise and balanced diet/fasting

8. Which part of the foetus is affected by folic acid deficiency?

   Lungs/stomach/brain and spinal cord

9. Folic acid deficiency causes anaemia

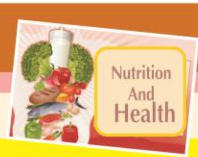
   True/false

10. To ensure a balanced diet

    Increase quantity/include milk/include all food groups

APPENDIX IVX

LEAFLET



Adolescence

- Adolescence represents one of the critical transitions in the life span and is characterized by a tremendous pace in growth and change.
- Good nutrition is critical during the teenage years to ensure healthy growth and development.
- As your body is still growing, it's vital that you eat enough good quality balanced diet to meet the changing nutritional needs.

Balanced diet

- Diet that consists of right amount of essential nutrients such as carbohydrates, proteins, fats, vitamins, minerals, roughage and water required by the body is called balanced diet.

BASIC FIVE FOOD GROUPS

	Food group	Nutrients contributed
1	**Cereal grains and products:** Rice, Wheat, Ragi, Bajra, Maize, Jowar, Barley, Rice flakes, wheat flour.	Energy, Protein, Invisible fat, Vitamin-B1, Vitamin-B2, Folic acid, Iron, Fibre.
2	**Pulses and Legumes:** Bengalgram, Blackgram, Greengram, Redgram, Lentil (whole as well as dhals), Cowpea, Peas, Rajmah, Soyabean, Beans.	Energy, Protein, Invisible fat, Vitamin-B1, Vitamin-B2, Folic acid, Calcium, Iron, Fibre.
3	**Milk and Meat Products:** Milk, Curd, Skimmed Milk, Cheese, Chicken, Liver, Fish, Egg, Meat.	Protein, Fat, Vitamin-B2, Calcium
4	**Fruits and Vegetables:** Fruits: Mango, Guava, Tomato, Papaya, Orange, Sweet lime, Water melon. Vegetables: (green leafy) Amaranth, Spinach, Gogu, Drumstick leaves, Coriander leaves, Fenugreek leaves. Other Vegetables: Carrots, Brinjal, Ladies finger, Beans Capsicum, Onion, Drumstick, Cauliflower.	Carotenoids, Vitamin-C, Fibre, Invisible fat, Vitamin-B2, Folic acid, Iron. Carotenoids, Vitamin-B2, Folic acid, Calcium, Iron, Fibre. Carotenoids, Folic acid, Calcium, Fibre.
5	**Fats and Sugar:** Fats: Butter, Ghee, Hydrogerated fat, Cooking oils like groundnut, Mustard, Coconut. Sugar: Jaggery and sugar	Energy, Fat, Essential fatty acids. Energy

Nutrients and roles

1. Breads, grains and cereals are carbohydrates that provide energy for your brain and muscles and are excellent source of fibre and B vitamins.
2. Meat, chicken, fish, eggs, nuts and legumes are good sources of iron and protein. Iron is needed to make red blood cells, which carry oxygen around your body. Include meat, chicken, fish or eggs in your diet at least twice a day. Fish is important for your brain, eyes and skin. Dairy foods like milk, cheese and yoghurt help to build bones and teeth and keep your heart, muscles and nerves working properly.
3. Fruit and vegetables have lots of vitamins and minerals which help boost your immune system. They're also very important for healthy skin and eyes.
4. Fats and sugars provide energy, fat and essential fatty acids. Eating too much fat and oil can result in you putting n weight.
5. Drink water to keep hydrated, so you won't feel so tired or thirsty. It can also help to prevent constipation.

Importance of iron and folic acid

- Adolescent girls are at high risk of anaemia due to accelerated growth, body mass building, poor dietary intake of iron, high rate of worm infestation and onset of menstruation.
- Satisfactory haemoglobin status at the time of adolescence and conception results into safe pregnancy and healthy child birth.
- Getting enough folic acid before conception and during the early months of pregnancy can prevent birth defects known as Neural Tube Defects.
- Adolescent pregnancy anaemia contribute to the high prevalence of Low Birth Weight and subsequent undernutrition among children.

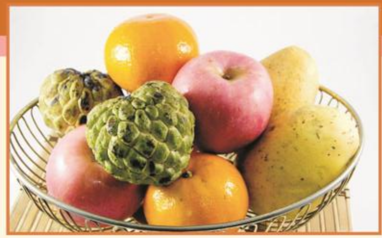
ചില നുറുങ്ങുകൾ TIPS

- വിവിധ നിറത്തിലും തരത്തിലുമുള്ള പച്ചക്കറികളും പഴങ്ങളും ദിവസേന ഭക്ഷണത്തിൽ ഉൾപ്പെടുത്താം.
- ധാരാളം വെള്ളം കുടിക്കണം.
- കുടുംബത്തോടൊപ്പം ഭക്ഷണം കഴിക്കുന്നത് ശരിയായ ആഹാരരീതി വളർത്തി എടുക്കാൻ സഹായിക്കും.
- ഒരു നേരത്തെ ഭക്ഷണം പോലും ഒഴിവാക്കരുത്.
- ചായ, കാപ്പി, കൃത്രിമപാനീയങ്ങൾ എന്നിവ മിതമായി ഉപയോഗിക്കുക.
- പെട്ടെന്നു കഴിക്കാൻ പാകത്തിന് വീട്ടിൽ പഴങ്ങൾ കരുതുക.
- ധാരാളം നാരടങ്ങിയതും മിതമായ അളവിൽ ഉപ്പും പഞ്ചസാരയും എണ്ണയും ചേർന്നതുമായ പ്രാതൽ ഓർമ്മശക്തിയും പഠനശേഷിയും ഊർജ്ജവും പ്രദാനം ചെയ്യുന്നു.
- വിശക്കുമ്പോൾ മാത്രം ഭക്ഷണം കഴിക്കുക.
- ആരോഗ്യമുള്ള ശരീരം സ്വന്തമാക്കുവാനും പഠനത്തിലെ ഏകാഗ്രത വർദ്ധിപ്പിക്കുവാനും വ്യായാമം ശീലമാക്കുക.
- കാൽസ്യം ധാരാളം അടങ്ങിയ പാൽ ഉൽപ്പന്നങ്ങൾ ചെറുമീനുകൾ ഇലക്കറികൾ എന്നിവ കഴിക്കുന്നത് എല്ലിന്റെ ആരോഗ്യം സംരക്ഷിക്കും.

ഓർക്കുക...

Don't FORGET!

- പ്രഭാതഭക്ഷണം ഒഴിവാക്കുന്നത് പഠനത്തിലെ ഏകാഗ്രത കുറയ്ക്കും.
- പരീക്ഷാസമയത്ത് കൊഴുപ്പുകുറഞ്ഞ മിതഭക്ഷണം കഴിക്കാം.
- വിലകൂടിയ ഭക്ഷണത്തിൽ മാത്രമേ പോഷകഗുണമുള്ളൂ എന്നുള്ളത് ഒരു തെറ്റിദ്ധാരണയാണ്.
- ആഹാരം കഴിക്കുമ്പോൾ ടി.വി/കമ്പ്യൂട്ടർ എന്നിവ ഒഴിവാക്കുക.
- ആവർത്തിച്ച് ചൂടാക്കിയ എണ്ണയുടെ ഉപയോഗം, അമിത തോതിലുള്ള ജങ്ക്ഫുഡ്/ഫാസ്റ്റ് ഫുഡ്, ബേക്കറി സാധനങ്ങൾ, മധുരപലഹാരങ്ങൾ, മൈദ എന്നിവ ഗുരുതരമായ ആരോഗ്യപ്രശ്നങ്ങൾ ഉളവാക്കും.



വരാതെ സൂക്ഷിക്കാം...

ഇരുമ്പിന്റെയും ഫോളിക് ആസിഡിന്റെയും അഭാവം

വിളർച്ച, ക്ഷീണം, ശ്രദ്ധക്കുറവ്, കുറഞ്ഞ ശാരീരിക ക്ഷമത, ശിശുക്കളിൽ ഉണ്ടാകുന്ന തൂക്കക്കുറവ്, ജനിതകവൈകല്യങ്ങൾ എന്നിവയ്ക്ക് കാരണമാകുന്നു.

തൂക്കക്കുറവ്

നിരന്തരമായ അസുഖങ്ങളും അണുബാധകളും എല്ലുകൾക്ക് ബലക്കുറവ്, വിളർച്ച, ഹോർമോൺ തകരാറുകൾ, ആർത്തവ പ്രശ്നങ്ങൾ സങ്കീർണ്ണമായ ഗർഭാവസ്ഥ എന്നിവ ഉണ്ടാകാം.

കാത്സ്യത്തിന്റെ കുറവ്

എല്ലുകളുടെ ബലക്കുറവ്, പെട്ടെന്നുള്ള പൊട്ടൽ ദന്തക്ഷയം ഇവയിലേക്ക് നയിക്കുന്നു.

പൊണ്ണത്തടി

രക്താതിസമ്മർദ്ദം, ഉയർന്ന കൊളസ്ട്രോൾ, ഹൃദ്രോഗങ്ങൾ, പ്രമേഹം കാൻസർ എന്നിവയ്ക്കുള്ള സാധ്യത കൂട്ടുന്നു. കൂടാതെ ആത്മവിശ്വാസം കുറയ്ക്കുകയും ശ്വാസതടസവും സന്ധി സംബന്ധമായ പ്രശ്നങ്ങളും ഉണ്ടാകുകയും ചെയ്യുന്നു.

കരുതാം...

നല്ലൊരു നാളേക്കായ്.....!

കൗമാരം

- മനുഷ്യജീവിതത്തിലെ അതിപ്രധാനമായ മാറ്റങ്ങളുടെയും ദ്രുതഗതിയിലുള്ള വളർച്ചയുടെയും കാലഘട്ടമാണ് കൗമാരം.
- കൗമാരത്തിലെ വളർച്ചയെയും വികാസത്തെയും ത്വരിതപ്പെടുത്തുവാൻ ശരിയായ പോഷണം അത്യാവശ്യമാണ്.
- കൗമാരകാലത്തെ മാറുന്ന പോഷക ആവശ്യങ്ങൾ നിറവേറ്റുവാനായി സമീകൃതാഹാരം നിർബന്ധമായും ശീലിക്കേണ്ടതാണ്.

സമീകൃതാഹാരം

എല്ലാ പോഷകങ്ങളും വെള്ളവും നാരും ശരിയായ അളവിലും അനുപാതത്തിലും അടങ്ങിയിരിക്കുന്ന ഭക്ഷണമാണ് സമീകൃതാഹാരം.

പോഷകങ്ങളും പ്രധാന ഉറവിടങ്ങളും.

അന്നജം കൊഴുപ്പുകൾ	ഊർജ്ജത്തിന്	- ധാന്യങ്ങൾ,കിഴങ്ങു വർഗ്ഗങ്ങൾ - എണ്ണയും, നെയ്യ്, മത്സ്യം, മാംസം, നട്ട്സ്
പ്രോട്ടീൻ	ശരീരനിർമ്മിതിക്ക്	- ഇറച്ചി, പയറുവർഗ്ഗങ്ങൾ, മുട്ട, പാൽ, മത്സ്യം, സോയാബീൻ, നട്ട്സ്
വിറ്റാമിനുകൾ	ശരീര സംരക്ഷണത്തിന്	- പച്ചക്കറി, ഇലക്കറികൾ, പഴങ്ങൾ പാൽ, മുട്ട, തവിട്
ധാതുക്കളും ലവണങ്ങളും	ശരീര സംരക്ഷണത്തിന്	മത്സ്യം,പാൽ,പച്ചക്കറികൾ, ഇലക്കറികൾ

പോഷകങ്ങളും അവയുടെ ധർമ്മവും

- ധാന്യങ്ങളിൽ അടങ്ങിയിരിക്കുന്ന അന്നജം മസ്തിഷ്കത്തിനും പേശികൾക്കും ആവശ്യത്തിനു ഊർജ്ജവും കൂടാതെ നാരുകളും ജീവകം ബി- യും നൽകുന്നു.
- ഇറച്ചി, മീൻ , മുട്ട, നട്ട്സ് മുതലായവ ദിവസവും ഒരു നേരമെങ്കിലും ഉൾപ്പെടുത്തിയാൽ ധാരാളം മാംസ്യവും ഇരുമ്പും ലഭിക്കുന്നതാണ്.
- രോഗപ്രതിരോധശേഷിക്കും, ആരോഗ്യമുള്ള ത്വക്കിനും കണ്ണുകൾക്കും ധാരാളം പഴവർഗ്ഗങ്ങളും പച്ചക്കറികളും ഉൾപ്പെടുത്തണം.
- മിതമായ അളവിൽ കഴിക്കുന്ന കൊഴുപ്പുകളും എണ്ണയും നമുക്ക് ഊർജ്ജവും, അത്യാവശ്യമായ ഫാറ്റിആസിഡുകളും പ്രദാനം ചെയ്യുന്നു.
- ശരിയായ ജലാംശം നിലനിർത്തുവാനും ദാഹവും ക്ഷീണവും അകറ്റാനും മാലിന്യങ്ങൾ പുറന്തള്ളാനും ധാരാളം വെള്ളം കുടിക്കേണ്ടത് ആവശ്യമാണ്.

ഇരുമ്പിന്റെയും ഫോളിക് ആസിഡിന്റെയും പ്രാധാന്യം

- ആഹാരത്തിലെ ഇരുമ്പിന്റെ കുറവ്, പെട്ടെന്നുള്ള ശരീരവളർച്ച, ആർത്തവം,വിരശല്യം എന്നിവ പെൺകുട്ടികളിൽ വിളർച്ച ഉണ്ടാകാനുള്ള സാധ്യത കൂട്ടുന്നു.
- കൗമാരത്തിലെ പോഷകാഹാരക്കുറവ് ഗർഭകാലത്തും പ്രസവശേഷവും ആരോഗ്യപ്രശ്നങ്ങൾക്ക് കാരണമാകും.
- കൗമാരകാലം മുതൽ ആവശ്യത്തിനു ഫോളിക് ആസിഡ് ഉൾപ്പെടുത്തുന്നത് നവജാതശിശുക്കളിലെ ജനനവൈകല്യങ്ങൾ തടയും
- കൗമാരത്തിലെ വിളർച്ചയും ഗർഭധാരണവും കുഞ്ഞുങ്ങൾക്ക് തൂക്കക്കുറവും ഭാവിയിൽ ആരോഗ്യക്കുറവും ഉണ്ടാക്കും.

APPENDIX XV

SCHEDULE TO ELICIT NUTRITION KNOWLEDGE AND PRACTICE

Knowledge attributes

K-1:<u>Nutrients and sources</u>

1) Which one of the following is the functions of vitamins and minerals :

a) Increases muscle mass   b) To lose body fat
b) Catalyse biochemical reactions   c) To provide energy

2) Are cereals rich sources of protein ? : Yes/No /Don't know

3) Milk is a rich source of calcium : Yes/No /Don't know

4) Which of the following is a good source of iron? :

a) Rice   b) Dates   c) Orange

5) Which of the following contains more folic acid? :

a) Amaranth   b) Milk   c) Green gram

K-2:<u>General health and balanced diet</u>

1) According to you, what is a balanced diet? :

a) Diet without fat   b) Diet rich in protein   c) A diet containing all nutrients in proper quantities

2) Do you think that adolescence is nutritionally vulnerable period? : Yes/No /Don't know

3) Is nutrient requirement different for different age groups? : Yes/No /Don't know

4) Is iron requirement high in adolescence? : Yes/No /Don't know

5) Which of the following is a rich source of Vitamin B_{12} :

a) Peanut butter
b) Orange
c) Green leafy vegetables
d) Organ meat

K-3: Deficiency diseases

1) Iron deficiency causes Anaemia : Yes/No /Don't know

2) Have you heard of folic acid? : Yes/No

3) Which vitamin deficiency in pregnancy causes left palate and neural tube defects

a) Vitamin A b) Calcium c) Folic acid

4) Is it needed to begin folic acid intake from adolescence to guarantee effective pregnancy outcome in future? : Yes/No /Don't know

5) Which of the following can also cause anaemia other than iron :

a) Vitamin B_{12}
b) Vitamin C
c) All the above
d) Folic acid

K-4: Adolescent nutrition

1) The second, most rapid growth period in human life is.... :

a) Infancy b) Adulthood c) Adolescence

2) Will early marriage and childbearing affects the health of a girl? : Yes/No/Don't know

3) All nutrients needed for an adolescent boy are higher than that of an adolescent girl : Agree/Disagree/Don't know

4) Nutritional status in adolescence is not connected to pregnancy outcome : Agree/Disagree/Don't know

5) Do you agree that adolescents are more prone to bad food habits? : Agree/Disagree/Don't know

K-5: **<u>Nutrition interventions</u>**

1) Do you know the source of supply of folifer tablets? : Yes/No

2) Do you know what fortification is? : Yes/No

3) Did your age group is include in Govt's nutrition intervention programmes? : Yes/No

4) Did you ever try to learn about nutrition? : Yes/No

5) What is your opinion about the inclusion of nutrition in your curriculum? Strongly agree/Agree/Disagree

Practice attributes

P-1: <u>Unhealthy food habits</u>

1) Do you skip your breakfast? : Never/rarely/sometimes/very often

2) How often do you eat from outside in a week? : Never/once/>3times

3) Which one you prefer from the following when you have to eat from outside? :

a) Fast foods b) Fried snacks c) Sweet snacks
d) Fruit e) Vegetable juice

4) Did your friends /advertisements /media ever influence your food selection? : Yes/no

If yes, explain how? :

5) Do you spend more than 2 hours per day watching television and DVDs or playing computer games? : Yes/No

P-2: <u>Common cooking practices</u>

1) Washing vegetables after cutting will not decrease the nutritive value. : Agree/Disagree/Don't know

2) Discarding water after cooking leads to nutrient loss. : Agree/Disagree/Don't know

3) Cooking in open pan is a good practice. : Agree/Disagree/Don't know

4) Sprouting increases nutritive value of pulses : Agree/Disagree/Don't know

5) Using same surface for keeping cooked food and raw foods is a good practice. : Agree/Disagree/Don't know

P-3: Meal pattern

1) Is your food habit is influenced by your family? : Yes/No

2) Do you try to have your food in time? Yes/No/Sometimes

3) Do you purposefully select different variety foods for daily diet : Yes/No

4) Do you bring packed lunches to college : Yes/No

If yes, common food items included for packed lunch :

If yes, the common snack food consumed :

5) Do you help or participate in menu planning of your family? : Yes/Sometimes/No

P-4: Misconceptions

1) According to you, which is the healthiest cooking method :

a) Frying /braising b) Boiling

c) Cooking with fat in a pan d) Steaming

2) Men need more nutrients in all the life stages than women : Agree/Disagree/Don't know

3) Do you discouraged by your family to eat particular foods during menstruation? : Yes/No

If yes, specify the items :

4) Dieting is good for all : Yes/No/Don't know

5) Skipping meals can help to lose weight : Agree/Disagree/Don't know

P-5: Food choices

1) What will you prefer from the following? :

a) Fortified wheat flour b) Ordinary wheat flour

2) Do you consider the nutritional value of the food while selecting? :

3) Do you have a habit of taking sweets or desserts after meals? :

4) List the factors of foods according to your preference? :

a) Taste b) Satiety given by the food

c) Nutritional value d) Cost of food

5) What is your food choice during exams :

a) Very rich food b) Easily eatable foods c) Balanced diet

APPENDIX XVI

RECIPE OF IRON FOLIC ACID RICH BISCUITS

Cooking time- 30 minutes

Yield- 5 nos

INGREDIENTS

Wheat flour (Fortified) -40gm

Rice bran flour-13 gm

Soybean flour -10 gm

Gingelly seeds (Powdered)-20 gm

Peanut butter -7 gm

Egg-30gm

Sugar (powdered) - 18gm

METHOD OF PREPARATION

1) Mix wheat flour, soybean flour, rice bran flour and gingelly seed powder in a bowl.
2) To this mixture add cold peanut butter and beated egg , mash it with hand.
3) Once the flour and butter are mixed thoroughly add powdered sugar and baking powder to it.
4) Roll out on a floured board and cut it into rounds using biscuit cutter.
5) Place on greased tins and bake at 180^0C in an Oven for 10 minutes

APPENDIX XVII

ESTIMATION OF FOLIC ACID IN FOOD SAMPLE

PRINCIPLE

Folic Acid is extracted from food samples using mild alkaline buffer, oxidized with permanganate, and the resulting amine is diazotized. The diazotized compound is coupled with N-(1-naphthyl) ethylenediamine, and the colour developed is determined at 550 nm.

REAGENTS

1. Dibasic potassium phosphate solution: Dissolve 60.61 g K_2HPO_4 in water and make up to 2 litre.
2. Potassium permanganate solution: Take 0.4 g of $KMnO_4$ in a 100-ml volumetric flask, and dilute to volume with water.
3. Sodium nitrite solution: Take 2 g of $NaNO_2$ in a 100-ml volumetric flask, and make up to volume with water.
4. 5 N HCI.
5. Ammonium sulphamate solution: Dissolve 5 g (NH_4) NH_2SO_3 in water, and make up the volume to 100ml.
6. N-(1-naphthyl) ethylenediamine dihydrochloride solution: Place 0.1 g of the substance in a 100-ml volumetric flask, and dilute to volume with water.
7. Sodium chloride
8. iso-Butyl alcohol
9. Stock folic acid standard solution: Dissolve 50 mg of folic acid in water with the help of 2 ml of NH_3, and make up the volume to 100 ml with water (1 ml=500mg).
10. Working folic acid standard solution: Dilute an aliquot of the stock standard solution with K_2HPO_4 solution (Reagent 1) to give a concentration of 10 mg/ml.

PROCEDURE

Place a known amount of the sample containing about 100mg of folic acid in a 100-ml flask. Add about 50 ml of K_2HPO_4 solution, and heat the mixture to a temperature not above 60^0 C with swirling until the sample is properly dispersed.

Cool to room temperature, and make up the volume to 100ml with K_2HPO_4 solution. Filter or centrifuge the solution. Transfer an aliquot of the clear solution containing about 1mg of folic acid to a 100-ml volumetric flask. Dilute to volume with K_2HPO_4 solution. Use this solution for colour development and estimation.

Prepare duplicate assay tubes as follows:

Tube No.	Sample (ml)	Working standard (ml)	Water (ml)	Potassium permanganate solution (ml)
1	5.0	-	-	1.0
2	5.0	2.0	-	1.0
3	5.0	-	1.0	-
4	5.0	2.0	1.0	-

Add 1ml sodium nitrite solution and 1 ml of 5 N HCI to all the tubes. Mix and allow to stand for 2 min. Add 1 ml of ammonium sulphamate solution, and mix with swirling. Now, add 1 ml of N-(1-naphthyl) ethylenediamine dihydrochloride solution, mix, and allow to stand for 10 min. Add 1 g of sodium chloride and 10 ml of iso-butyl alcohol. Shake vigorously for 2-3min. Separate the iso-butyl alcohol layer by centrifugation, and remove about 9 ml of the clear supernatant layer. Read the colour of the iso-butyl alcohol at 550 nm within 25 min using iso-butyl alcohol as the blank.

CALCULATION

Calculate the quantity of folic acid in the sample preparation in mg/ml using the expression:

$$0.4C = \frac{A_1 - A_3}{A_2 + A_3 - (A_1 + A_4)}$$

Where C = concentration of the working standard of folic acid in mg/ml, and A_1, A_2, A_3, and A_4 are the absorbance of tubes 1, 2, 3 and 4 respectively.

APPENDIX XVIII

SENSORY EVALUATION TABLE

Sensory attributes	4th week							Mean	8th week							Mean	12th week							Mean
	1	2	3	4	5	6	7		1	2	3	4	5	6	7		1	2	3	4	5	6	7	
Appearance																								
Flavour																								
Taste																								
Colour																								
Crispiness																								
Total																								

APPENDIX XIX

DETERMINATION OF MOISTURE CONTENT

AIM

To determine the percentage of water in a sample by drying the sample to a constant weight. The water content is expressed as the percentage, by weight, of the dry sample.

APPARATUS

Drying equipment

An oven, hot plate, field stove or the like suitable for drying moisture samples at a uniform temperature not exceeding 239º F (115º C).

Balance

A balance or scale sensitive to 0.1 percent of the minimum weight of the sample to be weighed and with a capacity equal to the maximum wet weight of the samples to be weighed.

PROCEDURE

- Weigh moisture sample immediately and record as "wet weight of sample" .
- Dry the wet sample to a constant weight, at a temperature not exceeding 239º F (115º C) using the suitable drying equipment.
- Allow the sample to cool. 4.4 Weigh the cooled sample again, and record as the "dry weight of sample"

CALCULATION

The moisture content of the sample is calculated using the following equation:

$$\%W = \frac{A - B \times 100}{B}$$

Where: %W = Percentage of moisture in the sample,

A = Weight of wet sample (grams), and

B = Weight of dry sample (grams)

APPENDIX XX

MICROBIOLOGICAL PLATE COUNT

Enumeration (counting) of bacteria by plate count or serial dilution – agar plating technique

The plate count technique is one of the most routinely used procedures because of the enumeration of viable cells by this method. This method is based on the principle that when material containing bacteria is cultured, every viable bacterium develops into a visible colony on a nutrient agar medium. The number of colonies therefore is the same as the number of organisms contained in the sample. In this procedure a small measured volume (or weight) is mixed with a large volume of sterile water or saline called the diluents or dilution blank. Dilutions are usually made in multiples of ten. A single dilution is calculated as follows:

$$\text{Dilution} = \frac{\text{Volume of the sample}}{\text{Total Volume of the sample and the diluents}}$$

Serial dilutions are later prepared by transferring a known volume of the dilution to second dilution blank and so on. Once diluted the specified volume of the dilution sample from various dilutions is added to sterile Petri plates (in triplicate for each dilution) to which molten and cooled (45-50^{0}C) suitable agar medium is added. The colonies are counted on a Quebec colony counter. The number of organism developed on the plates after an incubation period of 24-48 hours per ml in obtained by multiplying the number of colonies obtained per plate by the dilution factor, which is the reciprocal of the dilution. To facilitate calculations, the dilution is written in exponential notation. For example 1:1000 dilutions would be written as 10^{-3}.

$$\text{Number of cells/ml} = \frac{\text{Number of colonies}}{\text{Amount plated x dilution}}$$

Requirements

Sample or Bacterial suspension

9 ml dilution blanks (7)

Sterile Petri dishes (12)

Nutrient agar medium (200 ml)

Colony counter

PROCEDURE

1. Label the dilution blanks as 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5},10^{-6},10^{-7}.
2. Prepare the initial dilution by adding 1ml or 1g of the sample into a 3 ml dilution blank labeled 10^{-1} thus dilution the original sample 10 times (1/1+9=1/10 and is written 1:10 or 10^{-1}).
3. Mix the contents by rolling the tube back and forth between your hands to obtain uniform distribution of organisms (cells).
4. From the first dilution transfer 1 ml of the suspension while in motion, to the dilution blank 10^{-2} with a sterile and fresh 1 ml pipette diluting the original specimen / suspension to 100 times (1/10 x 1/10 = 1/100 or 10^{-2}).
5. From the 10^{-2} suspension, transfer 1 ml of suspension to 10^{-3} dilution blank with a fresh sterile pipette, thus diluting the original sample to 1000 times (1:1000 or 10^{-3}).
6. Repeat this procedure till the original sample has been diluted 10,000,000,(10^{-7}) times (Fig. 4.2) using every time a fresh sterile pipette.
7. From the appropriate dilutions (10^{-4} to 10^{-7}) transfer 1 ml or 0.1 ml of suspension while in motion, with the respective pipettes, to sterile Petri dishes. Three Petri dishes are to be used for each dilution (if 0.1 ml is plated, the dilution is increased 10 times).
8. Add approximately 15 ml of the nutrient medium, melted and cooled to 45^0C, to each Petri dish containing the diluted sample. Mix the contents of each dish by rotating gently to distribute the cells throughout the medium.
9. Allow the medium.
10. Incubate these plates in an inverted position for 24-48 hours at 37^0C.

Observations :

1. Observe all the plates for the appearance of bacterial colonies.
2. Count the number of colonies in the plates, that have colonies in the 30-300 range, by placing the plate on the platform of a Quebec colony counter.

CALCULATION

Calculate the number of bacteria per ml of the original suspension / sample as follows :

$$\text{Organisms per millimeter / gram of the sample} = \frac{\text{Number of colonies (average of 3 replicates)}}{\text{Amount plated x dilution}}$$

For example, if 60 colonies were counted on a 1:10^5 dilution

$$\frac{60 \text{ colonies}}{1\text{ml} \times 10^{-5}} = 6000000$$

$$= 6 \times 10^{6} \text{ bacteria / ml or gram of sample.}$$

APPENDIX XXI

ESTIMATION OF REDUCING SUGAR BY

DINITROSALICYLIC ACID METHOD

For sugar estimation an alternative to Nelson-Somogyi method is the dinitrosalicylic acid method—simple, sensitive and adoptable during handling of a large number of samples at a time.

MATERIALS

Dinitrosalicylic Acid Reagent (DNS Reagent)

Dissolve by stirring 1 g dinitrosalicylic acid, 200 mg crystalline phenol and 50 mg sodium sulphite in 100 mL 1% NaOH. Store at 4°C. Since the reagent deteriorates due to sodium sulphite, if long storage is required, sodium sulphite may be added at the time of use.

40% Rochelle salt solution (Potassium sodium tartrate).

PROCEDURE

1. Weigh 100 mg of the sample and extract the sugars with hot 80% ethanol twice (5 mL each time).
2. Collect the supernatant and evaporate it by keeping it on a water bath at 80°C.
3. Add 10 mL water and dissolve the sugars.
4. Pipette out 0.5 to 3 mL of the extract in test tubes and equalize the volume to 3 mL with water in all the tubes.
5. Add 3 mL of DNS reagent.
6. Heat the contents in a boiling water bath for 5 min.
7. When the contents of the tubes are still warm, add 1 mL of 40% Rochelle salt solution.
8. Cool and read the intensity of dark red colour at 510 nm.
9. Run a series of standards using glucose (0–500 µg) and plot a graph.

APPENDIX XXII

PROCEDURE FOR MEASURING PEROXIDE VALUE

AIM

To determine the peroxide value of the given sample.

PRINCIPLE

Peroxide value is an indicator of the extent of deterioration of lipids during storage. It is determined by iodometric titration method. It is an intermediary product formed during autoxidation of lipids.

REAGENTS

1. Chloroform, acetic acid (AR grade)
2. Saturated potassium iodide solution:-To about 10 ml of water in attest tube, add crystals of potassium iodide .When dissolved, add excess till the solid remains at the bottom.
3 Sodium thiosulphate solution (0.02N):- Dissolve 5 gm of thiosulphate in one litre distilled water and standardize against potassium dichromate solution.
4. Starch solution:- Keep water for boiling (80 ml) .Weigh one gram starch to boiling water, disperse in about 20ml water. Add this to boiling water allow it to boil then cool.

PROCEDURE

Weigh 4-5 g of sample 250ml iodine flask .Add 20ml chloroform followed by 30ml acetic acid. Then add 1 ml **s**aturated potassium iodide solution and keep in dark. After 30 minutes, remove the flask and add 50ml distilled water .Titrate the contents of the flask against sodium thiosulphate solution using starch as an indicator.

CALCULATION

Normality of sodium thiosuphate= volume of dichromate x Normality of dichromate/volume of thiosulphate

Peroxide value of the given sample=Titre value x Normality of thiosulphate x 1000/weight of sample= X meq O_2/Kg

APPENDIX XXIII

DETERMINATION OF TOTAL ASH CONTENT

AIM

The Ash Limit Tests are designed to measure the amount of the residual substances when a sample is ignited under the conditions specified in the individual monograph.

PROCEDURE

Ignite a crucible of platinum, quartz, or porcelain at 500℃ to 550 ℃ for 1 hour, allow to cool in a desiccators, and weigh it accurately Unless otherwise specified, place 2 to 4 g of the sample in the crucible and weigh it accurately. Take off or slide the lid of the crucible if necessary, heat the crucible gently first, then raise the temperature gradually, ignite at 500℃ to 550℃ for not less than 4 hours to incinerate until it is free from charred matter, cool in a desiccator, and weigh accurately. Incinerate the residue to constant weight, cool in a desiccator, and weigh accurately. If charred matter still remains and a constant weight cannot be obtained with the above procedure, add hot water to the matter, filter it through a filter paper for quantitative analysis, and ignite the insoluble residue on the filter paper together with the filter paper at 500℃ to 550℃ until it is free from charred matter. Add the filtrate to the residue, evaporate to dryness, and ignite at 500℃ to 550℃, cool in a desiccator, and weigh accurately. If charred matter still remains, add small amount of ethanol, break up the ash with a glass rod, wash the glass rod with small amount of ethanol, and evaporate carefully the ethanol. Then, proceed as directed previously and weigh accurately.

APPENDIX XXIV

ESTIMATION OF ACID-INSOLUBLE ASH

To the ash in the dish, add 25 ml of dilute hydrochloric acid (10% wt/wt), cover with a watch glass and boil gently over a low flame for 5 min. Filter using an ash less filter paper. Wash the filter paper thoroughly with hot water. Return the paper to the original dish, ignite, cool and weigh the insoluble ash.

APPENDIX XXV

DIET CHART

Menu For A Day

Time	Meal	Menu	Portion
	Dinner		
	Bed Time		

Remarks...

....

....

Signature:..............................

DIET CHART FOR ADOLESCENT GIRL

Name :

School/College :

Class/Batch :

Date :

Type of diet :

Allergic foods :

Likes and Dislikes :

Please bring this diet chart whenever you come for counselling

TAKE RESPONSIBILITY OF YOUR HEALTH

Diet plays a vital role in adolescence. Healthy behaviours, like nutritious eating and regular physical activity, may help you meet the challenges of your life. In fact, healthy eating and regular exercise may help you feel energized, learn better, and stay alert in class. So follow your diet instructions strictly to become healthy women in future.

At first you can measure all foods to be sure of the amounts, later you will be able to visualize each portion without measuring.

It is important to eat well-balanced meals. Eat breakfast, enjoy variety of food items, eat when hungry, exercise well, limit fast foods and junk foods, and ensure healthy weight.Ensure calcium to strengthen bones and teeth. Girls also need iron to support growth and replace blood lost during menstruation.These healthy habits may also lower your risk for diseases such as diabetes, asthma, heart disease, and some forms of cancer.

Menu For A Day

Time	Meal	Menu	Portion
	Breakfast		
	Mid Time		
	Lunch		
	Mid Time		

Cont......