REVIEW
OF
LITERATURE
Overweight and obesity are two terms that are often used together and interchangeably although they differ in their connotations. Overweight is excess body weight whereas obesity reflects excess body fat. Both are chronic disorders generally caused by an energy imbalance (excess energy intake and/or reduced energy expenditure) and are also defined as an accumulation of fat in adipose tissue (Goran, 2000). In the past, obesity was more prevalent in affluent countries. It is now steadily affecting low and middle income countries, particularly in urban settings. It is estimated that the number of overweight people is more than the number of undernourished ones. This changing scene all over the world is due to globalization, rising incomes, dietary and lifestyle changes (WHO, 2002).

Obesity begins and increases the risk of several disorders all which are related to obesity. In adults, obesity is linked to non-communicable disorders. According to the World Health Organization Report (2002) it is related to the risk of cardiovascular diseases, hypertension and diabetes. Obesity in children is also associated with several health problems. It is an early risk factor for adult obesity, cardiovascular disorders, diabetes and cancers in adulthood and even death later in life (Shetty, 1997; Giridharan, 2002; Reilly and Kelly, 2011). Therefore, childhood obesity is one of the most serious public health challenges of the 21st century (WHO, 2009).

Definition of Obesity and Norms for Classification:

The World Health Organization (1998) has defined overweight in adults as a Body Mass Index (BMI) of 25kg/m² and obesity as a BMI of 30 kg/m². Today, BMI is used as a
standard measurement to identify obesity in adults. However the same cannot be used for children as their BMI is lower. Hence, percentiles have been introduced. The Centers for Disease Control and Prevention (CDC), USA defined overweight and obesity for children as ≥ 85th percentile and ≥ 95th percentile of BMI for age respectively (CDC, 2009). Those children whose BMI is ≥ 85th percentile are said to be ‘at-risk’ of obesity. However, BMI has some limitations. It does not reflect body composition and whether a high BMI is due to greater muscle mass or body fat. In spite of this, it has been accepted because of the good specificity for identifying obese children (Styne, 2001).

The CDC percentiles of BMI were accepted for identifying obesity in children by most countries. However, due to inter country variations, there have been doubts about their universal acceptability. The relationship between percent body fat and BMI varies in different ethnic groups. Also, there were concerns about the use of BMI as an indicator of body fat in children of various age groups, as the age of onset of puberty differed. These differences may be due to differences in body build or in energy balance (Deurenberg et al., 1998; James, 2001).

The World Health Organization recommended that for children less than 10 years old, the weight for height Z-scores (WHZ) should be used. The WHZ value of 2 and more is classified as overweight. A Z-score of 2 corresponds to the 97th percentile and a Z-score of 1.65 to the 95th percentile (WHO, 2002).
Some countries started using the 90th, 95th, or 97th percentiles of the CDC BMI cut offs as the basis for distinguishing obese children from children with normal BMI. A workshop organized by the International Obesity Task Force (IOTF) proposed that the adult cut off points of BMI should be linked to body mass index centiles for children and that child cut off points should be provided to determine overweight and obesity. It was suggested that BMI cut-off points for obesity should be population specific (IOTF, 2004).

Cole et al., (2000) gave a new definition of overweight and obesity in childhood, based on data from six countries. They have proposed the use of body mass index and linked it to the widely used adult obesity cut off point of 30 kg/m2. They have developed smoothened percentile BMI curves on a sex-specific basis that are more accurate. With data from six countries- United States, UK, Netherlands, Hong Kong, Singapore, and Brazil, the centile curves of BMI were established by them and today Cole’s standards are being widely used. The International Obesity Task Force also adopted these BMI cut offs. The sensitivity and specificity of the IOTF BMI cutoff points for overweight and obesity were assessed and were found to be very good for identifying overweight children, but had lower sensitivity for obesity cut off points (Reilly et al., 2000). Some investigators have suggested that the IOTF criteria should be used only for screening overweight and obesity. However, for determination of body fat, an accurate measure should be used (Zimmerman et al., 2004).
Prevalence of childhood obesity: The prevalence of obesity continues to increase. The presence of overweight and obesity among preschool children has been reported in both developed and developing countries (Reilly, 2005). WHO reported the prevalence of obesity in preschool children was 2% in developing countries like Nicaragua, Brazil, Antigua, Zambia, and Venezuela and Peru, whereas Barbados, Honduras, Bolivia, Trinidad, Iran and Mauritius had 4% prevalence. Jamaica and Chile topped the list with 10% prevalence in preschool children. As early as 1999, Shetty reported that there was an increase in obesity among children from Thailand and Saudi Arabia. In 2000, the incidence of obesity in US children was more than 15%. In 2004, USA had approximately nine million obese children over 6 years of age (COPI, 2004). In Japan, the prevalence of obesity had doubled in 20 years between 1974 and 1993 (Deckelbaum and Williams, 2001). In the United Kingdom, 21.8% boys and 27.5% girls between the ages of 2 and 15 years were found to be overweight or obese (ICFAI, 2005).

The IOTF reported that obesity and overweight had increased dramatically in English school children. In a survey of 7 to 11 year old children, it was observed that one in four children was overweight and 6-7% were obese (IOTF, 2004). They also reported that between 1974 and 1988 the number of overweight children had increased from 7 to 27%. Similarly, the number of obese children in this age group had increased from 1% in 1974 to 7% in 2002. IOTF also reported that one in 10 children in the world that is about 155 million were overweight and 30-45 million were obese. In Europe, the highest prevalence
was in southern European countries. In northern Europe the prevalence of overweight in children was 10-20% compared to 20-35% in southern Europe. Surveys in Italy and Sicily reported 36% children were obese. In Greece the reported figures in the 6–17 years age group were 26% in boys and 19% in girls. Spain and Crete reported, 27% of children and adolescents and 39% children aged 12 years, respectively to be obese. Table 2.1 shows the rate of increase in childhood obesity in different countries. The prevalence of obesity has been said to increase with age (Reilly, 2005). In adolescents, obesity had increased from 6.1% to 15% and it had tripled from 4% to 15.3% in children aged 6 to 11 years between the 1970's to 1990's (Shetty, 1999).

**TABLE 2.1: RATE OF INCREASE IN CHILDHOOD OBESITY IN DIFFERENT COUNTRIES**

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Period</th>
<th>Percent change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1985 – 1995</td>
<td>10 years</td>
<td>12 to 20</td>
</tr>
<tr>
<td>Brazil</td>
<td>1971 – 1997</td>
<td>26 years</td>
<td>4.1 to 13.9</td>
</tr>
<tr>
<td>Canada</td>
<td>1981 – 1996</td>
<td>15 years</td>
<td>12 to 30</td>
</tr>
<tr>
<td>China</td>
<td>1991 – 97</td>
<td>6 years</td>
<td>7.7 to 12.4</td>
</tr>
<tr>
<td>USA</td>
<td>1971 – 2000</td>
<td>29 years</td>
<td>15.4 to 25.6</td>
</tr>
<tr>
<td>Chile</td>
<td>1987 – 2000</td>
<td>13 years</td>
<td>13 to 20</td>
</tr>
<tr>
<td>Czechoslovakia</td>
<td>1991 – 1999</td>
<td>8 years</td>
<td>10 to 12.5</td>
</tr>
<tr>
<td>Japan</td>
<td>1974-1995</td>
<td>21 years</td>
<td>5.5 to 10.8</td>
</tr>
</tbody>
</table>

Source: (Lobstein, 2004)
Prevalence of obesity has increased in all countries including Singapore, South Korea and Thailand. In Hongkong the rise in obesity was not as much as seen in China. In contrast, two countries- Russia and Poland showed a decline in obesity prevalence. In Russia, the prevalence reduced from 15.6% to 9% and Poland from 10% to 8% (Lobstein, 2004).

The International Obesity Task Force (2010) estimated that 200 million school children all over the world are overweight or obese. Today obesity is recognized as a global public health problem. The World Health Organization estimated that in 2010, 43 million children below the age of 5 years would be obese. They also suggested that rate of obesity has been increasing in developed countries as well as in developing countries. WHO has stated that probably out of the 43 million obese children, only 8 million were in developed countries and the rest were in developing countries (WHO, 2009). A summary of studies showing the prevalence of obesity is given in Table 2.2.
<table>
<thead>
<tr>
<th>Continents/ Country</th>
<th>Author</th>
<th>Year</th>
<th>Age group (years)</th>
<th>Sample size</th>
<th>Overweight (%)</th>
<th>Obesity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>America</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>Hanley et al.,</td>
<td>2000</td>
<td>2-19</td>
<td>445</td>
<td>30.7</td>
<td>*</td>
</tr>
<tr>
<td>Canada</td>
<td>Veugelers and Fitzgerald</td>
<td>2005</td>
<td>10</td>
<td>4298</td>
<td>32.9</td>
<td>9.9</td>
</tr>
<tr>
<td>United States of America</td>
<td>Molaisson et al.,</td>
<td>2006</td>
<td>6-14</td>
<td>729</td>
<td>24.0</td>
<td>*</td>
</tr>
<tr>
<td>Brazil</td>
<td>Souza et al.,</td>
<td>2010</td>
<td>10-14</td>
<td>*</td>
<td>11.8</td>
<td>*</td>
</tr>
<tr>
<td>Europe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>Danielzik et al.,</td>
<td>2004</td>
<td>5-7</td>
<td>2631</td>
<td>31.3</td>
<td>*</td>
</tr>
<tr>
<td>Germany</td>
<td>Will et al.,</td>
<td>2005</td>
<td>6-7</td>
<td>525</td>
<td>11.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Poland</td>
<td>Jodkowska et al.,</td>
<td>2010</td>
<td>13-15</td>
<td>8065</td>
<td>12.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Greece</td>
<td>Manios et al.,</td>
<td>2010</td>
<td>1-5</td>
<td>2,374</td>
<td>16.2</td>
<td>17.5</td>
</tr>
<tr>
<td>London</td>
<td>Samani-Radia and McCarthy</td>
<td>2011</td>
<td>5-14</td>
<td>2298</td>
<td>*</td>
<td>5.9</td>
</tr>
<tr>
<td>Sweden</td>
<td>Moraeus et al.,</td>
<td>2012</td>
<td>7-9</td>
<td>3636</td>
<td>13</td>
<td>2.6</td>
</tr>
<tr>
<td>Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kenya</td>
<td>Adamo et al.,</td>
<td>2009</td>
<td>9-13</td>
<td>179</td>
<td>11.7</td>
<td>*</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Mosha and Fungo</td>
<td>2010</td>
<td>6-12</td>
<td>428</td>
<td>6</td>
<td>17.5</td>
</tr>
</tbody>
</table>

*Data not reported
As seen in Table 2.2 the prevalence of obesity varies greatly. The difference in prevalence rates could be due to socio-cultural factors, differences in food consumption and physical activity patterns. Also, globalization and development changes have changed lifestyles. Studies done in America show that a large percentage of children are overweight. Such children are likely to be obese adults. Hence the prevalence of obesity in the population per se is likely to be high. The consumption of processed food and junk food along with sedentary lifestyles have been identified as a cause. Similar observations are made for the developed nations in Europe.

**Asia:** In 2010, the prevalence of obesity in Asia was 4.9% and the countries which had more obese children were Bangladesh, India, and Pakistan compared to the other Asian countries. However, individual prevalence rates in the Asian countries may be different. India and China have been reported to lead the increasing trend of obesity in Asia (Onis et al., 2010). Table 2.3 presents data on prevalence of obesity in selected Asian countries.
<table>
<thead>
<tr>
<th>Country</th>
<th>Author</th>
<th>Year</th>
<th>Age group (years)</th>
<th>Sample size</th>
<th>Overweight (%)</th>
<th>Obesity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sri Lanka</td>
<td>Wickramsinghe et al.,</td>
<td>2004</td>
<td>8-12</td>
<td>1224 ##</td>
<td>3.7</td>
<td>*</td>
</tr>
<tr>
<td>Malaysia</td>
<td>Moy et al.,</td>
<td>2004</td>
<td>12-24</td>
<td>3620 @</td>
<td>14.8</td>
<td>17.3</td>
</tr>
<tr>
<td>South Korea</td>
<td>Eunkyung et al.,</td>
<td>2005</td>
<td>8-18</td>
<td>1229 @</td>
<td>12.5</td>
<td>9.8</td>
</tr>
<tr>
<td>Qatar</td>
<td>Bener</td>
<td>2006</td>
<td>12-17</td>
<td>3923 @</td>
<td>23.75</td>
<td>6.34</td>
</tr>
<tr>
<td>Taiwan</td>
<td>Chen et al.,</td>
<td>2006</td>
<td>6-18</td>
<td>13935 #, @</td>
<td>21.6</td>
<td>*</td>
</tr>
<tr>
<td>Pakistan</td>
<td>Warraich et al.,</td>
<td>2009</td>
<td>11 – 13</td>
<td>284 #, @</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>China</td>
<td>Shang et al.,</td>
<td>2010</td>
<td>6-12</td>
<td>6929 @</td>
<td>14.9</td>
<td>7.8</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Mohsin et al.,</td>
<td>2010</td>
<td>3-18</td>
<td>468 #, @</td>
<td>17.6</td>
<td>*</td>
</tr>
<tr>
<td>Iran</td>
<td>Gaeini et al.,</td>
<td>2011</td>
<td>3-6</td>
<td>756 #</td>
<td>9.9</td>
<td>4.6</td>
</tr>
</tbody>
</table>

*Data not reported # rural @urban

The percentage of children who are overweight is high in almost all counties except Sri Lanka and Pakistan. Differences between countries may also be attributed to the type of population studied i.e. rural/urban. The rates of overweight and obesity in the developing Asian countries have been reported to be higher than in Africa. The countries which have
still not overcome undernutrition, now have to tackle overnutrition among children who may face health problems in later life (Hawkes et al., 2004).

The increased body weights have increased the incidence of diabetes, hypertension and cardiovascular disorders. It has also been emphasized that Asians are prone to abdominal obesity and have higher waist circumferences (Giridharan, 2002). Along with obesity there is a rising prevalence of non communicable diseases which were earlier thought to be prevalent in developed countries. The nutrition transition in developing countries is the result of urbanization and globalization. Therefore the developing countries today face the problems of over nutrition and under nutrition together (Shetty, 1999; Hawkes et al., 2004).

Due to changes of urbanization in many countries, the number of women gainfully employed outside the home has led to double income families. As more women are working, food habits have shifted from consumption of homemade wholesome foods to increasing reliance on processed and convenience foods, junk foods etc. Less fruits, vegetables and pulses are consumed whereas there is a rise in consumption of attractively packaged high fat, high sugar and high salt foods. People in urban areas and those belonging to the middle and the high income groups, consume more fatty foods compared to those in rural areas (Gopalan, 1998). Globalization is also bringing cultures close
together. Food habits are moving towards establishment of fast food chains and super markets that make processed foods easily available.

Urbanization has also led to a fast-paced life with little time for physical activity. The change in physical activity pattern is due to environmental factors including transport facilities, infrastructure and energy saving equipment/gadgets due to modernization has increased resulting in less energy expenditure on physical activities. Thus, both dietary changes and physical activity changes have contributed to the rise in overweight and obesity (Onis et al., 2010). It is therefore said that urbanization has brought non communicable diseases closer to a large number of people (Shetty, 1999).

**Prevalence of obesity in India:** The prevalence of undernutrition has reduced in India and health status has improved (Gopalan, 1998). Obesity is reported in young Indian adults and even in children (Yajnik, 2004). The change in nutritional status has been so rapid that obesity in children is visibly seen and thus it can be said that prevalence of overweight and obesity is rising in India. Several studies have been conducted in various parts of India on children of different age groups and belonging to different socio economic backgrounds. A large difference in the prevalence of overweight and obesity is clearly seen in these studies. Table 2.4 lists some of the studies conducted in India.
TABLE 2.4: PREVALENCE OF OBESITY IN DIFFERENT PARTS OF INDIA FROM 2000 TO 2012.

<table>
<thead>
<tr>
<th>Author</th>
<th>Place and Year</th>
<th>Age group (years)</th>
<th>Sample Size</th>
<th>Overweight (%)</th>
<th>Obesity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South India</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ramachandran et al.,</td>
<td>Chennai, 2002</td>
<td>13-18</td>
<td>4700 #</td>
<td>16.8</td>
<td>*</td>
</tr>
<tr>
<td>Raj et al.,</td>
<td>Kerala, 2007</td>
<td>5-16</td>
<td>24842 ##</td>
<td>*</td>
<td>6.5</td>
</tr>
<tr>
<td>Kotian et al.,</td>
<td>Mangalore, 2010</td>
<td>12-15</td>
<td>900 #</td>
<td>9.9</td>
<td>4.8</td>
</tr>
<tr>
<td>Keerthan et al.,</td>
<td>Karnataka, 2011</td>
<td>12-15</td>
<td>500 ##</td>
<td>3</td>
<td>2.6</td>
</tr>
<tr>
<td>Aravindalochanan et al.,</td>
<td>Chennai, 2012</td>
<td>9-13</td>
<td>260 #</td>
<td>14.9</td>
<td>17.2</td>
</tr>
<tr>
<td>North India</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marwah et al.,</td>
<td>Delhi, 2006</td>
<td>5-18</td>
<td>21485 #</td>
<td>10.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Bhardwaj et al.,</td>
<td>Delhi, 2008</td>
<td>14-17</td>
<td>3493 #</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Western India</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rao et al.,</td>
<td>Pune, 2009</td>
<td>9-16</td>
<td>2223 ##</td>
<td>24.2</td>
<td>*</td>
</tr>
<tr>
<td>Goyal et al.,</td>
<td>Ahmedabad, 2010</td>
<td>12-18</td>
<td>5664 #</td>
<td>11.7</td>
<td>2.2</td>
</tr>
</tbody>
</table>

# urban, ## rural *Data not reported
Prevalence figures vary from one region to another. This may be attributed to socioeconomic and environmental differences in the regions and the study samples. The age groups and number of children included in the studies also differ. Rural and urban differences in food consumption and physical activity may also affect the prevalence of overweight and obesity in children.

Children at risk of overweight and obesity can be identified at three stages of the life cycle (Styne, 2001; NFI, 2009). The three stages are:

1. Gestational period and birth weight
2. Adiposity rebound period between 5-7 years.
3. Adolescence

1) The gestational period and birth weight- There is an association between a high maternal gestational weight gain and higher weight in childhood. Higher gestational weight gain has been associated with increased risk of early onset of childhood obesity (Makides, 2008). Also, higher birth weight has been associated with higher BMI’s and obesity in later life (Lobstein, 2004; Reilly, 2005). Babies with higher birth weights have been reported to be more likely to be obese at five years of age (Brophy et al., 2009). Hence they may be expected to be overweight or obese in childhood and adult life. However, birth weight is not an indicator of body fat.
Low birth weight was also noted to be a risk factor for development of obesity and other disorders. It has been suggested that low birth weight may predict abdominal obesity (Lobstein, 2004; Yajnik, 2004). "The thrifty phenotype hypothesis" was proposed by Barker in 1989. Barker hypothesized that poor nutrition in fetal life alters metabolism to become thrifty. Low birth weight babies tend to preserve their body fat and have been seen to have increased abdominal deposition of fat (Dietz, 1998; Yajnik, 2000; Reilly, 2005). This leads to the development of risk factors for non communicable diseases in later life, particularly if the child is exposed to overnutrition postnatally (Schmidhuber and Shetty, 2004; Rolland-Cachera et al., 2006). Indian babies of low birth weight had higher adipose tissue. Thus the 'thin-fat' child is likely to be at risk of obesity in childhood and even adulthood has been reported by Yajnik (2004). Steijn et al., (2009) tested the 'thin-fat' phenomenon in Surinami South Asian babies who were born to at least fourth generation migrant parents from India. They were compared with babies in Pune. The BMI in both the groups were comparable. Though the Pune babies were smaller, the sub scapular skin fold was same in both groups. The thin-fat phenomenon was seen in babies even after several generations of migrants.

2) The adiposity rebound period between 5 – 7 years: School age is a period of steady growth and there is a growth spurt in prepubertal years but the rate of
growth is slower between 5-9 years. During childhood, there is a decrease in BMI and body fat followed by a rise during the ages of 5-7 years. This phenomenon is known as adiposity rebound. Adiposity rebound occurs at different ages, which is related to genetic and environmental factors such as diet (Lobstein, 2004). An early adiposity rebound indicates the possibility of obesity in adulthood (Rolland-Cachera et al., 2006). In girls, puberty occurs early in case of excess adiposity whereas in boys it delays puberty (Solarazo and McCartney, 2010). Early adiposity rebound occurs in children who have lower fat mass in the early years of their life. These children tend to have higher BMI in later life which predisposes them to non-communicable diseases at an early age (Rolland-Cachera et al., 2006; WHO, 2009). This will increase expenditure on health in adult life.

3) Adolescence – There is rapid growth during 10-15 years of age. The adolescent growth spurt in girls begins at about 10 years and continues till 12 years. In boys, the growth spurt begins at 12 or 13 years until 16-17 years. During, puberty there are changes in body composition. Girls accumulate more fat than boys at this time. Also abdominal obesity may be seen (Lobstein, 2004). Adolescent weight status is a strong predictor of adult obesity. Several researchers have reported that when the child is obese in the late adolescent stage, the chances of obesity in adulthood increase (Gutin and Barbeau, 2000; Bhave et al., 2004, Lobstein, 2004). The period of adolescence is vulnerable for the development of obesity.
Environmental conditions like rich food are conducive for higher body weights. Therefore, this stage is very crucial in terms of development of overweight and obesity (Lobstein, 2004).

Causes of Childhood Obesity: Obesity is not a simple condition. It has several causes - genetics, environmental factors including diet and activity behavior. All these causes contribute to the development of obesity in children and adults and no single factor is solely responsible.
1) Genetic - Obesity is known to be hereditary and that it runs in families. If one parent is obese, the odds ratio is 3 for obesity in adulthood. If both are obese, the odds are 10 (Ronzio, 1997). Parental obesity as well as maternal diabetes contributes to high birth weights and obesity in childhood. In Poland, a positive correlation was observed between children's BMI and the BMI of fathers as well as mothers (Zywienia, 2006). Thus, having overweight or obese parents is a strong predictor of childhood overweight and obesity (Michaelsen, 2008).

2) Socio Economic Status - In developed countries high income is linked with higher BMI. Children in families with more spending money, have better living conditions and more access to different facilities (WHO, 2009). Thus, fatness has been linked with prosperity. In low income families low birth weights, frequent infections and related health problems have been seen but overweight, obesity, asthma are new additions to the list of health problems in children (SCN, 2004). Some studies in low socio economic groups have indicated a rise in overweight and obesity in children (Will et al., 2005; Veugelers and Fitzgerald, 2005; Brophy et al., 2009 and Kleiser, 2009). In Canada, it was observed that 35% of children living in low socio economic conditions were overweight (Sen-Gupta, 2007). Children raised in poor surroundings, are at a higher risk of being overweight than those compared to children living in better conditions (Byrne and Puma, 2007).
villages too, obesity is rapidly increasing observed in children as in the urban areas, which is attributed to urbanization (Yajnik, 2004). In Spain, the prevalence of obesity was 1.45 times higher in children of lower socio economic status compared to high socio economic status (Navalpotro, 2012). Several factors may contribute to the rising prevalence of overweight and obesity in this population. In low socio economic conditions, recreational facilities for physical activity are lacking. Facilities like play grounds, parks, and commercial facilities like clubs are available to the better off urban families (Powell et al., 2006; Navalpotro, 2012). In rural areas, public transport is limited due to which people may have to walk. Also, they may be working in fields which increase their activity.

3) **Gender**- Rate of obesity in women tends to be higher in developing countries whereas, in developed countries more men are overweight. Among children the prevalence of overweight and obesity in girls is higher and this has been associated with low physical activity (Danielzik, 2004). The prevalence of obesity in girls and boys is also dependent on the environmental factors.

4) **Diet-related causes of obesity**- Eating habits are central to good health. It is well established that food habits inculcated in childhood can last a lifetime and nutritional status in childhood plays an important role in determining adult health and disease (Corbin et al., 2000). Dietary patterns have changed so that the
consumption of vital nutrients has reduced and that of fats, sugar and salt has increased. Thus nutrition-related disorders are a result of nutritionally poor diets and reduced physical activity levels (Schmidhuber and Shetty, 2004; Lukito and Wahlqvist, 2006).

The dietary causes of childhood obesity are as follows:

a) *Maternal Feeding Practices* – Mothers prefer plump children as it is a sign of being healthy and therefore feed generously. Parents also believe that fatness is temporary and will soon vanish as the child grows (Bhave et al., 2004).

**Breast feeding versus bottle feeding:** Breast feeding is said to be protective against the development of obesity. The longer the duration of breast feeding, lower is the incidence of overweight (Michaelsen, 2008). Leise et al., (2001) conducted a study in Germany on more than 2000 children. They reported a significantly lower prevalence of obesity in breast fed children compared to bottle fed children. Also a decreasing prevalence of overweight was associated with longer duration of breast feeding. However, this has not been consistently reported by all investigators. Some authors have reported no association with breast feeding alone, as a cause of obesity (Herring and Oken, 2010). Bottle-feeding may cause overfeeding as a child may consume more milk compared to a breast-fed infant (Mohanty, 2008). Many a times, babies are forced to finish the
bottle feed. This causes an increased intake of calories and results in “early-onset obesity” (Wabitsch, 2008).

Parenting practices: Childhood is a period of developing food preferences, dietary patterns and even activity patterns (Birch and Davison, 2001). Children’s eating behaviors are influenced by parent’s food choices and parenting practices. Several mothers force-feed large quantities of food, which causes higher energy intakes. Thus, some children have more fat cells. If such children are overfed, hypertrophy of fat cells can occur (Ronzio, 1997). Some mothers restrict foods, which become attractive and may tempt children to consume such foods in more than desirable amounts. When parents restrict the child’s dietary intake, it may result in the child covertly consuming high energy foods (Braun et al., 2003). Food is also used as a reward for children and the reward is usually a sweet food. Blisset et al., (2010) conducted a study on three to five year old children and found that children whose mothers used food to regulate emotions ate more cookies and chocolates even when they were not hungry. Also restricting certain foods makes a child eat large quantities when permitted or even sneak the foods and eat them.

Nutrition knowledge of mothers: Nutrition knowledge of mothers also influences child feeding practices. Lack of knowledge can lead to exclusion of foods rich in essential nutrients especially micronutrients and inclusion of foods that are
convenient to cook and may be more energy dense. Low and medium education of mothers was associated with obesity among rural children in Sweden (Moraeus, 2005). Zywienia (2006) observed a significant correlation between mother’s education and children’s obesity in 236 children in Poland.

**Feeding habits:** Improper feeding habits are associated with overweight. Children usually dislike fruits and vegetables. Parents should therefore, promote consumption of fruits and vegetables and should also keep a supply of these foods (Nicklas et al., 2001). Fruits and vegetables being perishable foods, if not regularly supplied lose their place as snack items and are likely to be replaced by snacks that are usually highly flavored and attractively packed. Parents can be good role models of eating behaviors. When parents ate fruits and vegetables, children also reported a high intake of these foods and low intake of fats and sugars (Gray et al., 2003).

b)  

**High Energy Intake** –The energy density of foods depends on their contents of sugar, fat and/or water. Consumption of large amounts of fats and sugars increases the energy supplied by the diet whereas inclusion of fruits and vegetables reduces the energy content (Drewnowski, Almiron-Roig et al., 2004). A report by the World Health Organization (2002) indicated that the consumption of high energy density foods is associated with the rising rate of obesity.
Carbohydrates and refined foods: A high carbohydrate diet, particularly when it contains refined foods and a high fat intake leads to excess energy intake. Intake of sugar should be in moderation. Processed foods contain sugar and therefore increase sugar intakes unknowingly. Frozen, canned and preserved foods all contain some sugar. Breads, breakfast cereals, soft drinks, cakes, pastries and chocolates are major contributors of sugar in the diet. On the other hand dietary fiber is one carbohydrate that can reduce dietary energy.

In recent years, consumption of whole grains has reduced and refined foods have increased in the daily diet. Gopalan stated as far back as 1998 that in the traditional Indian diet, refined cereals have taken the place of whole grains and millets leading to a reduction of fiber, B complex vitamins and other micronutrients in the diet. With a decrease in cereal intake, the intake of sugar and fats has increased, especially because fast foods and convenience foods have found easy acceptance. Traditional foods are being replaced with junk food rich in fat, sugar, sodium and preservatives (Parizkova et al., 2007). Also, fibre intake has reduced. Consumption of diets high in fat is one of the causes of obesity (Duyff, 2006). Over a period of ten years, there has been an increase in the percentage of energy from fat and simple sugars in Chinese diets, particularly saturated fat. This change has been observed in urban and rural areas and it is said to be due to an easy availability of a wide variety of foods (Parizkova et al.,
2007). In a study of 8 to 11 year old children in Washington, it was observed that boys consumed a larger amount of food and had higher energy intakes than girls in the pubertal period. In boys the greater energy intake was during late puberty whereas in girls a greater energy intake was seen in the mid puberty period (Shoemaker et al., 2010).

Fat intake: Fat intake is also responsible for the increase in pediatric obesity. Children with a higher percentage of body fat or BMI were observed to report a greater preference for fat (Ronzio, 1997). Addleman (1992) reported a positive relationship between fat intake and adiposity in children in USA. Results from the Bogalusa Heart study showed that children who consumed more than 30% energy from fat had a lower consumption of calcium, iron and vitamin E and vitamin B complex (Nicklas et al., 2001). On the other hand a high intake of dark green leafy vegetables and deep yellow vegetables was associated with a lower fat mass in children. High intake of fried food and processed meat was associated with high body fat in 3 to 8 year old children (Wosje et al., 2010). Higher energy intakes particularly with high fat intakes can be a cause of obesity in children (Kapur and Sethi, 2003). Children generally purchase more of candy, snack foods, soft drinks and fast foods (Katz, 2011).
Consumption of Junk Foods – Consumers have easy accessibility to fast foods today compared to a few years before. Fast foods are often low in essential nutrients and high in fat and refined carbohydrates. Such foods therefore play an important role in childhood obesity (NFI, 2009). Food tastes are changing and taste influences food choices in all age groups. Fast foods, which match the fast pace of life, are preferred. Foods like pizzas, burgers, noodles, desserts and many such foods are replacing home cooked meals in the diet of children. Fast foods or junk foods are usually deep fried with less other nutrients value. They are high in energy, carbohydrate and saturated fat, lacking in fibre and trace elements (Kapur and Sethi, 2003). Increased consumption of sugar, salt, chocolates, mithais and a reduced consumption of cereals, vegetables and fruits was observed in a survey conducted on households in Mumbai (Udipi, 2011). The same survey also reported that children generally demanded junk food like pizza, burger and Frankie as well as chocolates.

Children's food habits have gradually changed from eating traditional foods to convenience foods. A study on Nepalese school children showed an increased intake of ready-to-eat foods like biscuits, potato chips, doughnuts and other local fried snacks (Sharma, 1998). Earlier this change was only in snacks but now-a-days convenience foods have begun to replace wholesome meals. Nicklas et al., (2001) observed in their study of 10 year old children that consumption of snacks
was significantly associated with overweight. Fast food outlets are extremely popular with children and adolescents. These outlets are also perceived as meeting places for friends.

Colas, sweetened fruit juices, squashes are empty calorie drinks and have replaced milk in a child’s diet and have been linked to obesity and type 2 diabetes in children (Addleman, 1992). Colas contain no other nutrients and have only calories and so is said to be ‘empty calories’. The consumption of cola drinks has been observed to be usually accompanied by fried snacks or fast foods in American children (Katz, 2011). A study of 1562, 10 year old children showed that consumption of foods like soft drinks, flavored drinks had a positive association with overweight (Nicklas et al., 2001). In a survey conducted on households in Mumbai, Udipi (2011) observed an increased consumption of soft drinks.

d) Accessibility to Food - A changing environment has increased food options. A wide choice of foods has changed eating habits leading to a high energy intake over the requirements. Convenience food stores located near the house has affected selection of food. These stores stock their shelves with a greater selection of pre-packaged foods, fast foods and soft drinks. This has affected the choice of people in the low socio economic group who may not be able to afford fresh fruits
and vegetables and therefore choose processed foods that are affordable but, may actually be high in fat, sugar, and calories (Duyff, 2006).

**e) Skipping Breakfast** - Children who eat breakfast are more likely to meet their nutritional needs of micronutrients. A steady decline in breakfast consumption along with a rising incidence of obesity has been seen in recent years (ADA, 2008). Skipping breakfast increases the risk of obesity (Tsakalu et al., 2004; Tin et al., 2011). Skipping breakfast makes a person eat more food later and often the wrong foods during the rest of the day (Siega-Riz et al., 1998; Story and Sztainer, 2002). A high waist circumference and waist to hip ratio were found to be correlated with irregular breakfast habits in a study on 9-11 year old children from Finland (Lehto et al., 2011). Children who skipped breakfast consumed higher amounts of fat and those who had a regular breakfast consumed less fat. This was reported in a study of more than 700 children in the USA. Omitting breakfast has been associated with significantly higher fasting total and LDL cholesterol (Hamid et al., 2005). It was seen that girls skipped breakfast more than boys. In Fiji, McCormick et al., (2010) reported 68% girls to be skipping breakfast and also 25% overweight and 15% obese. In UAE, 37% girls and 28% boys between 6-7 years skipped breakfast. Musaiger (2011) has suggested that eating breakfast can be a factor to prevent overweight and obesity. Besides this, skipping breakfast affects learning and school performance of children (ADA, 2008).
Consumption of Dairy Foods- There is increasing evidence that increasing dairy
intake by about two servings per day could reduce the risk of overweight by up to
70%. In addition, higher calcium intake was associated with 21% reduced risk of
development of insulin resistance that could reduce the risk of diabetes among
overweight young adults. Higher calcium intake and more servings of dairy foods
per day were associated with reduced adiposity in children studied longitudinally.
Children who consumed least servings of dairy foods per day had statistically
greater gains in BMI and body fat than those who consumed more servings. In the
Framingham Children's study, Moore et al., (2003) evaluated dairy intake in
relation to changes in body fat in 99 children over a period of 12 years. Children
who consumed the fewest servings of dairy products per day had statistically
greater gains in BMI and body fat than those who consumed more servings. The
researchers concluded that low intakes of dairy foods might be associated with
higher body fat in childhood. Albertson et al., (2003) have also reported that low
intakes of dairy foods may be associated with higher body fat in childhood. Barba
et al., (2005) evaluated the relationship between milk consumption and body mass
in 900 Italian children of ages between 5 – 11 years. The researchers found an
association between higher milk consumption and lower BMI scores. There was a
significant association between obesity and low intake of dairy foods in a study
conducted by Olivares et al., (2004). Thus, dairy foods have been considered
protective against obesity. In contrast, high dairy food consumption was

In a study on children between 2 – 8 years of age, those who had a higher dietary calcium intake from dairy foods had a lower percentage of body fat by Skinner et al., (2003). A study conducted by Novotny et al., (2004) in Asian and Caucasian girls, between 9 – 14 years of age indicated that dairy calcium intake was associated with low body fat. Lappe et al., in 2004 reported similar findings in girls. The girls on a high calcium diet consumed 150 kcal more per day but did not have greater increase in BMI or fat mass as compared to the control group. Hungarian researchers Levolovics et al., (2004) found that the heaviest children (ages 4 – 14 years) had lowest calcium intake from dairy foods.

Marshall et al., (2003) conducted a study on 249 children. Boys who had high fat mass reported low milk, low fruit intake and a high sugared beverage intake as well as less of physical activity. Moore et al., (2004) reported that children who ate more dairy foods and had a moderate intake of dietary fat gained loss weight and fat than children who ate fewer dairy foods and had low or high intakes of dietary fat. A study of 1701 children in Chile from 3rd to 7th grade found a
significant association between obesity and low intake of dairy foods. In the same study, intake of energy dense foods as well as TV watching associated with obesity (Olivares et al., 2004).

Television Viewing and Food Advertising – In the present day, children are surrounded by several forms of media that includes television, FM radio, print media, videos, and numerous internet and web sites. All these contribute to more sedentary lifestyles. Persons of all ages particularly children and adolescents rely on television for entertainment. The duration of viewing TV has been associated with obesity and poor fitness levels. This simply is due to reduced physical activity and a high possibility of a high energy intake due to snacking while watching TV. The authors suggested that it is difficult or almost impossible to prevent TV watching. The same has happened with video games, however eating snacks is not associated with video games. They are linked to low physical activity (Swinburn and Shelly, 2008).

Advertisements also promote a high calorie intake (Story, 2002). A lot of food advertisements are targeted at young vulnerable age groups. Their influence is obvious from the demands of children who desire high caloric, junk food frequently. Today advertisements of packaged and processed foods attract consumers whereas healthy foods like fruits and vegetables are never advertised.
The consumption of energy rich foods and soft drinks has increased because of the intense advertisements on TV (Swinburn and Shelly, 2008). Food selection is influenced by advertising, convenience and taste. Some foods are marketed as healthy, low fat, or fat-free, but may contain more calories than the fat containing food they are designed to replace (Duyff, 2006). There is evidence of a strong association between TV advertisements of food and children’s food selection (Patrei et al., 2003). A study conducted by Fitzgibbon, (2006) showed that advertisements influenced the food preferences in children. Not only children, even adults are influenced by the advertisements and choose fast foods or even elect eating out. Due to the advertisements on TV, the demand for high calorie, low nutrient foods is more especially in overweight children (Matheson, 2004). Longer the hours of TV viewing higher were the intakes of total fat, saturated fat, energy and protein (Abbot et al., 2003). Day et al., (2009) examined the association of fat intake and TV watching time in 556 children of 8, 11 and 14 years in Texas, USA. They reported that both boys and girls who had a high fat intake watched TV for a longer time compared to children who had a low fat intake. A restriction on TV watching television by the elders in the family or parents may help prevent obesity has been suggested by Oliver et al., (2010).

Children and adults responded to aggressive food marketing and the convenience of eating out. More than a decade ago, in America food companies spent 75
percent and fast-food restaurants spend 95 percent of their advertising allocation on TV advertisements (Gallo, 1999). Television is the favorite advertising medium used by the food industry. In USA, for example, fast-food restaurants spent more than 95% of their advertising budgets on television advertisements. Exposure to food advertising—especially commercials for fast food, convenient foods, and soft drinks—may influence viewer's food choices towards higher-fat or higher energy foods. If the average adolescent views about 2.5 hours of television per day, or 17.5 hours per week, at 6 minutes of commercials per hour, potentially 105 minutes of commercial advertising could reach the average adolescent during a typical week. It is said that obesity can be prevented by restricting television viewing. It has been suggested that reducing the number of food related advertisements can be one strategy to reduce incidence of obesity (ADA, 2002). Abbot et al., (2003) studied 2000 children to investigate the relationship between TV viewing and diet quality. The group that viewed TV for four hours or more per day had higher intakes of total fat, saturated fat, energy and protein above the recommended dietary intakes (RDI). The effects of TV advertisements on nutrition knowledge and attitudes are a cause for concern particularly due to the association between TV viewing and adiposity. While dairy foods have been considered protective against obesity, sugared beverage intakes have been associated with obesity.
The World Health Organization (2003) stated that TV advertising influences the food purchases of children. Massive advertising of high calorie, low nutrient, and fast foods was reported to increase the risk of childhood obesity. Harrison and Marske (2005) conducted a study on food commercials in USA. These authors reported that more than 80% of the advertisements were targeted at children and the foods advertised included snacks, fast foods or sweets. They also observed that these foods exceeded the recommended amounts of fat and sodium. The influence of marketing and brand names was demonstrated in a study by Robinson et al., (2007). They offered the same food as McDonald’s to two groups of preschoolers; one with a Mc Donald wrap whereas the other was simply wrapped. About 70 % children preferred the food with the Mc Donald wrap, as they thought that it was from Mc Donald’s.

h) Nutrition Knowledge of Children — Hellems et al., (2003) assessed nutrition knowledge and habits of 1144, 3rd to 8th grade students. Children scored poorly on nutrition knowledge questions. Children who identified low fat foods were likely to choose low fat foods for a week. Most children failed to meet the nutritional guidelines. Those who answered nutrition questions correctly were more likely to report healthier eating habits. Singhal et al., (2010) reported a significant improvement in the nutrition knowledge of children in their intervention study conducted in Delhi. They also reported the intervention group to have a lower
consumption of aerated drinks and energy dense foods along with a proper packed lunch and an increased fruit intake.

i) **Meal Pattern and Portion sizes** - Recent research has shown that the eating two or three large meals per day is more likely to be fattening than five or six smaller meals (ADA, 2002). Fewer numbers of meals may result in consumption of larger portion sizes, thus increasing the energy consumption. Also, larger portion sizes of the fast foods have led to people eating larger quantities during a meal or snack (ADA, 2002). Young and Nestle (2007) examined portion sizes in fast food chains between 2002 and 2006. They studied serving sizes of sodas, French fries, and hamburgers at McDonald's, Burger King and Wendy's. They observed that McDonald's had reduced their largest portion size whereas Burger King and Wendy's had increased portion sizes. They also observed that portion sizes in America were larger than those in Europe. Children are attracted by large portions. A large meal or snack supplies more energy than actually needed. This has been listed as one of the cause of obesity in children (Duyff, 2006).

j) **Income** – Income level is linked to physical activity as well as food consumption pattern. Higher income groups have better facilities for physical activity. Low income group families may face a lack of places and facilities/infrastructure for physical activity and access to healthy food like fruits and vegetables. Therefore
low income group children may spend more time in watching TV (SCN, 2004). Children and adolescents of lower socioeconomic status have been reported to be less likely to eat fruits and vegetables and to have a higher intake of total and saturated fat (Fitzgibbon and Stolley, 2006).

In view of these various diet-related factors linked to obesity, a joint effort needs to be made by parents, family and schools to reduce 'obesogenic' environments and to protect the future generations from obesity and related health problems.

The role of schools, family and neighbourhood/community in developing good food habits are briefly delineated herein:

Role of schools-
Schools are important as many food habits are formed here. The school environment also affects food quality. Children spend considerable amount of time in school. Hence, a large part of their daily intake happens in this setting. Not only the food choices but also eating patterns, physical activity behavior and nutrition knowledge are influenced by the school environment. Therefore it is important that schools should promote healthy behaviors. Instead, schools provide easy access to fast foods. Chips, soft drinks, chocolates and candy are sold in every school. In the US, vending machines in school are common and are sponsored by fast food establishments. Schools are also a prey to advertisement...
funds and so frequently, advertisements of food companies are seen in school. School buses also carry these advertisements (Story, 2002). Therefore health and nutrition education in school has to be included in curriculum. A teacher has an important role in influencing consumption of healthy foods by children (WHO, 2002). To prevent the increase in prevalence of obesity in children schools can -

- Have a policy of nutrition education.
- Supply and serve healthy food.
- Train the staff for preparation of nutritious food.
- Avoid advertising or promoting junk foods in school.

Lobstein, 2004).

Role of Family-

Children learn eating behaviors as well as physical activity behaviors from parents. Dietary habits depend on foods eaten at home. The tradition of eating together at dining tables daily is now reduced to holidays. Due to the fast pace of life, busy routines and women working, more and more families are eating out. The diets of children who eat at home with family are of better quality, with a higher consumption of fruits and vegetables (ADA, 2008). Sen (2006) reported that those children who ate at least three meals per week with their family had decreased odds of becoming overweight and those who were overweight initially
and ate seven meals per week with their family had increased odds of losing weight.

Role of neighborhood and community-

The neighborhood environment is also responsible for shaping physical activity behaviors. The availability of parks, clubs and recreation facilities determine opportunities for physical activities. Children in the low-income group may not have such places for play. However, there may be fast food outlets and convenience stores may be accessible nearby so that children may have opportunities to purchase unhealthy foods (SCN, 2004).

Cultural differences are seen in eating patterns of families. Food is an important part of religious functions and weddings. At such functions, a large variety of food is usually served. Therefore it is important to provide environments which encourage healthy food choices.

5) Lack of adequate physical activity – Energy balance can be achieved by regular physical activity as well as good eating habits. However, energy expenditure has decreased as the preference for more sedentary activities has increased (Bleich et al., 2011). Sedentarism is defined as a deliberate and extensive engagement in behaviours which are mainly regarded as minimal movement with a low energy
expenditure and rest (Tremblay, 2010). Sedentarism or physical inactivity is closely linked to skeletal health, cardiovascular disease risk, fitness and psychological factors (Hills, 2009).

There has been a major change in India particularly in the urban areas, with sedentary behaviours increasing in the population. Earlier people walked to work whereas now more people use public transport for travel resulting in decreased physical activity. Physical activity has also reduced due to increased use of labor saving devices in daily living. Some examples of this are-

(1) Increased use of buses taxis and trains instead of walking.
(2) Using washing machines, dish washers and other devices for household work.
(3) Increased use of computers.
(4) Watching TV for leisure.
(5) Use of elevators or escalators instead of stairs.

(Gopalan, 2006).

Shetty (1999); Bharadwaj et al., (2008) and Nutrition Foundation of India (2009) have given the following reasons for reduced physical activity in children:

a. Active play and participation in sports by children has reduced that can be attributed to the burden of school studies and additional classes out of school.
There is a changing trend of preference for more sedentary activities like TV watching. Norris et al., (2003) in their study of one hundred and one 4th grade students reported that physical activity was low in and out of school. Leisure time was spent in playing video games or watching TV.

b. It is difficult for children to be active as there are limited open spaces, parks etc in cities for play.

c. Technological development has introduced video games and computer games which has reduced physical activity of children.

With increasing prevalence of obesity and lifestyle disorders in children and adults the benefits of physical activity are to be remembered.

*Benefits of physical activity* - Physical activity is responsible for maintaining good health. It also helps the individual to gain stamina and endurance (Parfitt et al., 2009). The benefits of physical activity have been summarized by Naidu and Sakalkale (2011).

- Increased lean muscle, bone strength and decreases body fat.
- Helps maintain weight.
- Helps to reduce depression, anxiety and improves mood.
- Lowers the risk of lifestyle disorders.
- Relieves tension and stress.
- Decreases mortality and improves quality of life.
Regular physical activity is associated with reduced risk of obesity, metabolic syndrome, diabetes mellitus, heart disease and improved physical fitness. Aerobic activity burns calories, reduces weight, decreases the risk of heart disease and high blood pressure.

**Physical activity and overweight/obesity:** There is evidence which shows a negative correlation between physical activity and obesity. Low levels of physical activity are a common cause of obesity for any age group (Hills et al., 2009). Shetty (1999) has stated that children are less active than before. Brambilla et al., (2011) have estimated that children may be spending lesser calories per day compared to children 50 years ago. The regularity and intensity of physical activity both determine risk of obesity and poor physical fitness.

Jafar et al., (2008) have studied the 2074 Pakistani children of age 5-14 years. They observed a significant inverse correlation between physical activity and overweight/obesity. Children who were active for more than half an hour per day were less likely to be overweight or obese. Zarrouk et al., (2009), studied the physical activity patterns of normal 8-11 year-old children and compared them with overweight children. There was no significant difference between normal weight and overweight children in the time allocated to vigorous and high intensity activities. However overweight children performed more sedentary activities, and less moderate intensity of physical activity. In contrast, normal weight children spent more time in moderate activity and less time in
sedentary activities. Rittenhouse et al., (2011) observed among 8 to 12 year old boys that overweight boys spent a greater amount of time in sedentary activities and scored fewer accelerometer counts than normal weight boys.

Kotian et al., (2010) conducted a study on 900 adolescents. The risk of overweight and obesity was reported to be double in the high SES group compared to the low SES group. The chances of being overweight were 7.3 times higher in adolescents who watched TV or played computer games for more than four hours a day. There was an inverse correlation between overweight/obesity and physical activity in adolescents who had less than one hour of activity per day were compared to active adolescents. Souza et al., (2010), conducted a cross sectional study on 10 to 14 year old adolescents in Brazil. They observed that 11.8% adolescents were overweight and there was a significant positive association between physical inactivity and overweight and obesity although the association was positive only for boys. Michalopoulou et al., (2011) examined the daily step counts using a pedometer and examined the association between BMI and body weight in 9 to 14 year old children. Also, step count per day was significantly more in boys compared to girls. Children with normal weight walked significantly more steps per day compared to the overweight and obese children.

Results of some studies indicate that physical activity of children has significantly reduced (Lopez and Hynes, 2006; Bouchard et al., 2010; Adams and Prince, 2010). In a
study in Delhi, 67.3 % of obese children in the age group of 7-12 years reported no regular exercise. Obese children reported a preference for indoor games (Kapur and Sethi, 2003). Gray and Smith (2003) in their study on 9 to 18 year old American youth found that 59% of them were sedentary. Leisure time has increased but it is used in television viewing, internet, cyber games and has even led to reducing sleeping time. This trend is associated with a higher prevalence of obesity (Lopez and Hynes, 2006).

Physical activity in boys and girls: The pattern of physical activity differs in girls and boys. Boys are generally more active than girls. Hussey et al., (2007) measured physical activity with an accelerometer in 224 girls and boys aged 7 to 10 years from primary schools in Dublin. A significant difference between the daily physical activity of girls and boys was observed. They also found in another study in 2007, that boys spent more time in moderate and vigorous activity than girls. Mota et al., (2007) examined the relationship between leisure time physical activity, sedentary behaviors in girls and boys. Girls who reported no leisure time physical activity significantly spent more time in TV viewing. Boys did not show any change in leisure time physical activity but girls seemed to be influenced by watching television. Similarly, a study by Hardman et al., (2009) observed that boys had accumulated more steps at leisure time compared to girls at weekends as well as on school days. Prista et al., (2009) examined physical activity particularly household tasks in children and adolescents in Mozambique and Portugal using an accelerometer. They reported that Mozambican boys were more active than girls.
Mozambican children had significantly higher total physical activity; showed less decline of physical activity with age and engaged in fewer minutes at higher intensity physical activity compared to Portuguese children and adolescents.

Role of TV and sedentary activities: Sedentary activities such as video games were independently associated with obesity in the study conducted by Ortega and Ruiz et al., (2010), in 1075 children aged 9 to 15 years in Sweden. Maddison et al., (2011) tested the hypothesis that active video games may help increase physical activity and improve body composition in children. They concluded that an active video game intervention had a positive effect on BMI and body composition in overweight and obese children.

In rural and urban regions of Iran, low income group children were found to spend more time watching TV (Kelishadi et al., 2007). TV viewing and video gaming were inversely associated with socio economic status. The greatest proportion of children participating in sport was from the high socio economic status. Fairclough (2009), examined physical activity pattern in children (n = 6,337) between 9 and 10 years of age. They found that a significantly greater number of boys than girls spent their time in watching television and playing video games.

Children are reported to be having more of sitting time with the most common sedentary behavior being TV viewing and other screen-based games (Hills et al., 2009). Studies
report that odds of becoming obese increases with numbers of hours of TV viewed every day. Hanley et al., (2000) studied television viewing in 445 children between 2-19 years. There was an increase in the risk of overweight in the highest category of daily television viewing compared to the lowest category of TV viewing. The risk of overweight was not significant in subjects who watched moderate amounts of television daily. There was a 2.5-fold risk of overweight in children who watched TV for more than 5 hours/day. Children who watched more TV had lower BMR’s and also consumed more food that were high in calories and highly preserved food most of which was advertised on TV (Patrei, 2003).

Separate TV in children’s rooms has encouraged TV viewing. A study by Wiecha et al., (2006) showed that the presence of a television in a child’s bedroom increased the time spent in watching television by an average of 38 minutes per day. Their study also reported that a child rarely has family dinners if TV viewing is for 33 minutes. In children where there is no parental control on television viewing time, it was 29 minutes of more viewing. Parental limits on television viewing time were associated with 13 minutes of more reading per day. Children who watched TV or played computer games for more than four hours per day had a 7.3 times higher possibility of being obese (Kottian et al., 2010). TV viewing, a TV in the child’s room and less total physical activity was associated with high waist to hip ratio in 1146 Swedish children aged 9 to 11 years (Lehto et al., 2011).
Physical activity, BMI and risk of disease: Physical activity pattern of 2300 black and white girls was studied by Kimm et al., (2002). They observed a decline in physical activity as girls grew older. At 16-17 years, 56% black and 31% white girls reported having no leisure time activity. Low level of parental education was also reported to be the cause for decline of physical activity. The decline in physical activity was significantly associated with higher BMI. Wolf et al., (1993) studied the activity pattern of 552 American girls of grades 5 to 12. They found a significant inverse relation between BMI and physical activity level; but there was no association between prevalence of obesity and level of physical activity. Also, between no association was found between TV viewing and prevalence of obesity. In the same study, researchers reported racial differences in physical activity levels. They observed that Hispanics and Asians reported lower levels of activity compared to other ethnic groups.

Physical activity was inversely related to BMI and body fat in 2379, 9 to 10 year old African American girls in the study of Obarzanek et al., (1994). Effects of childhood activity persist through later years as it affects body fat. Higher amounts of physical activity protects against accumulation of excess adipose tissue (Janz et al., 2009). The duration of vigorous physical activity was linked to abdominal adiposity in children and adolescents (Rowlands et al., 2006). Ruiz et al., (2006) observed that children who engaged in a longer duration of vigorous physical activity (40 minutes/day) had a significantly lower body fat than compared to children who engaged in a lower duration
of vigorous physical activity (10 to 18 minutes/day). In UK, girls who had a lower total activity had a significantly higher body fat than boys. Boys showed high total activity compared to girls (Rowlands et al., 2006; Hesket et al., 2008). Ortega and Ruiz et al., (2010) examined the associations between physical activity and abdominal adiposity in 1075 children aged 9 to 15 years. They reported no association between the physical activity and waist circumference; however duration of vigorous physical activity was inversely associated with waist circumference and abdominal adiposity.

Physical activity improves insulin resistance and other cardiovascular disease risk factors in obese youth. There is a growing incidence of impaired glucose tolerance and type 2 diabetes in children and adolescents. The risk factors of insulin resistance in childhood are increased body fat, abdominal fat, insulin resistance and onset of puberty (Goran et al., 2001). Physical activity was significantly correlated with fasting insulin and insulin sensitivity in 357 10 to 16 year old non diabetic children in the study of Schmitz et al., (2002). The researchers suggested that increasing physical activity among youth may reduce the incidence of type 2 diabetes in children. Brage et al., (2004) suggested the importance of physical activity to prevent diabetes in children. They reported the results of their study on 589, 9 year old children in Denmark on physical activity and insulin resistance. Fasting glucose was not significantly associated with physical activity. However, insulin resistance was significantly related to physical activity only in girls but not in boys. Similar results were reported by Imperatore et al., (2006) in their study of 12
to 19 year old adolescents. A positive association was found between high levels of physical activity and insulin sensitivity only in boys and not in girls. They concluded that greater physical activity will improve insulin sensitivity among boys, whereas in girls it will help maintain weight. Rizzo et al., (2008) also reported the results that there was a significant inverse relation between physical activity and insulin resistance in adolescents. The results also indicated that higher levels of intense physical activity and longer times spent at moderate and vigorous physical activity may have a positive effect on insulin resistance.

Schools, families and community have a role in modifying food behavior of children and these segments of society also can play a very important role in determining the lifestyle behavior and thereby reduce risk of non-communicable diseases among children.

Role of family in physical activity:
An active lifestyle is learnt from the family in early life. Parents play a big role in helping kids to remain active. Active behaviours of parents are aped by children. An association between sedentary behaviors, TV watching, encouragements and discouragements for activity was investigated by Jago et al., (2005). Sedentary behavior was prominently observed in the children. They suggested that reducing the time children spent in sedentary behaviour would help to increase physical activity. Parents can and should encourage children to participate in active sports in school and active play in leisure time.
They should also limit a child’s daily TV and computer time (Yeung et al., 2007). Involving children in activities gives them a positive role model and they can also remain motivated to be active in later life too. The habit of daily physical activity can be a good alternative to sports. Edwardson and Gorely (2010) examined the relationship between parenting practices and activity patterns in 117 children 8 years of age. No differences between the sexes in the mean level of activity were seen. However it was found that mothers and fathers had different activity related parenting practices. Mothers had more sedentary behavior for both boys and girls compared with fathers. Father’s parenting attitude for boys was significantly associated with moderate vigorous physical activity and vigorous physical activity.

Role of schools in physical activity:
Schools have an important role in maintaining physical activity levels. The changing trends school related physical activity among children as identified by Joint WHO/FAO expert consultation (2003) indicated the following- there is a fall in the proportion of children walking to school. They have reported that the percentage of children walking to school has fallen from 62% in 1989 to 56% in 1991. Also, earlier 5% school children cycled to school which had reduced to just 2%. Today most schools have school buses or children are sent to school in a car pool or auto rickshaws. Promotion of active commuting to school can be an important way to increase levels of physical activity in school children was suggested by Panter et al., (2011) after studying the associations
between active commuting, levels of physical activity and distance to school in 9 to 10 year old children. For both boys and girls, significant positive associations were observed between walking to school and physical activity as well as in moderate to vigorous physical activity during weekday travel to school. The association was also better when the distance of the school was longer.

Educational programs in school can help children to exercise which will be good for their health in later life too. There is lack of adequate space which has restricted physical education as well as activity in school (Stanton 2003, Melville et al., 2003). Due to lack of space, the physical activity programmes in school have changed. A reduced risk of obesity in children was observed by Veugelers and Fitzgerald (2005) when schools had physical education classes more than two times a week. Legarde and LeBlanc (2010) reviewed the school environment for physical activity. They suggested that schools are an ideal surrounding as they can provide a variety of activities to improve physical activity levels in children. They also suggested interventions like safe physical education and physical activity, extracurricular physical activity and active transport to school. Singhal et al., (2010) also reported that a higher proportion of children participated in physical activity when there was an intervention programme in school compared to children where there was no intervention.
A decrease in the number of children participating in sports in school has been reported. A survey conducted in England showed that the proportion of children participating in sports in school has reduced from 46% in 1994 to 33% in 1999 (WHO/FAO, 2003). Higher socio economic populations are more physically active due to a greater participation in sports (Kelishadi et al., 2007). In their study, Fairclough et al., (2009) reported that the greatest proportion of children participating in sports was from the high socio economic status.

Brambilla, Pozzobon and Pietrobelli (2011) have recommended that children and adolescents should be motivated to be active at least for an hour daily. The pattern of activity in children is short duration mild activity which should be changed to moderate activity at least for 20 minutes daily. This will help reduce body fat. Counsel children not to be sedentary for too long and to interrupt sedentary behavior with some physical activity.

**Environmental factors affecting physical activity**

In China it was observed that urban people had become sedentary between the 1989 and 1991 (Shetty, 1997). The reasons for this are many. In India, China and other Asian cities, incomes have risen and hence bicycles have been replaced with motorbikes and cars (Gopalan, 1998). People of low economic levels and even a low education level are more likely to be obese than the higher income group simply because of lack of adequate
facilities (Kelishadi et al., 2007). It has been reported that neighbourhood safety and availability of recreational facilities influence physical activity in children. The availability of grounds, gyms, parks, stadiums affects physical activity (Dietz, 1998; Shetty, 1999; Wen et al., 2003). The safety of public places is also a deterring factor as public places sometimes are dark and unsafe. Gray and Smith (2003) therefore have suggested that exercise should be incorporated in the education programme for children. An area which does not have proper paths to walk on is linked to reduced physical activity and increased risk of obesity (Lopez and Hynes 2006). A study in Canada also reported that low income areas lacked adequate play grounds and parks and the rate of obesity there in children between 5 to 17 years of age was high. From the low income areas 35% children were obese compared to 24% children in higher income areas (Sen Gupta et al., 2007). In Taiwan, urban children had higher physical activity than rural children mainly because of the facilities available there. There were more play areas and accessibility to sports and exercise in urban areas than rural areas (Chen, 2008).

Recommendations for physical activity-
O’Dea (2003) has suggested the following to make children more active-

- Plan outdoor activities with friends.
- Introduce new activities and unconventional ones like rock climbing, water sports, archery, hiking etc.
• Teach children time management so that they can make time for regular physical activity.

• Try to restructure the existing environment so that children become more active.

American Dietetic Association (2008) recommended that children should perform at least 60 minutes of physical activity every day. The activity should be in the form of free play, outdoor activities, athletics or even physical education classes to ensure the daily recommendation. Bennet and Sothem (2009) have suggested remedies for improved physical activities for different age groups. They are as follows-

° Preschool children- should have general activities like running, jumping etc.
° Children aged 6-9 years- should participate in recreational sports.
° Puberty age group children- should involve in different skills and organized sports.
° Adolescents- should focus on skill and fitness based activities.

World Health Organization (2010) has recommended the following-

a) 1 hour of weekly physical education classes.

b) Identify barriers and solutions to physical activity with the help of students.

c) Involve teachers who have the knowledge and skills for improving physical activity in children.

d) Conduct regular classes of physical education in the school.
e) Plan and conduct physical education classes in public places like beaches and parks.

f) Plan treks and excursions to national parks, forests and gardens.

g) Prioritize funding of physical education and sports activities in the school budget.

h) Make an allocation for training physical education teachers.

i) Participate in making a national policy of physical education and make it compulsory in schools.

j) Increase awareness of staff for the policy of increasing physical activity of children in the school.

k) Provide students with safe and appropriate spaces to spend time actively.

l) Initiate partnerships with parents and community to use recreation facilities effectively.

m) Encourage participation in inter-school sport activities

n) Provide free extracurricular sport training activities.

o) Encourage walking to school by ensuring safe walking areas.

The most important benefit of physical activity is that it will prevent overweight and obesity. Also, physical activity improves insulin sensitivity in children. Physical activity, its type, frequency and duration, all affect the metabolism of carbohydrates and lipids and
therefore it is an ideal method of preventing metabolic disease risk (Brambilla, Pozzobon and Pietrobelli, 2011).

Consequences of Childhood Obesity-

Overweight and obese children are likely to stay obese into adulthood and are also likely to be more vulnerable towards developing non communicable diseases at a younger age. Good dietary habits and physical activity patterns can help to prevent over weight and obesity in children and adults as well as maintain fitness (Boreham et al., 2004).

Childhood obesity affects- Childhood obesity has adverse influences on physical and mental health including physical fitness.

- The cardiovascular system- Hypercholesterolemia, dyslipidemia, hypertension have been observed in obese children.
- The endocrine system- The incidence of hyper-insulinism, insulin resistance, impaired glucose tolerance, Type 2 diabetes and menstrual irregularity is rising in obese children.
- Mental health- Depression and low self-esteem are associated with obesity. They are equally damaging like other medical disorders and are known to hamper growth in children.
- Respiratory system: Asthma and sleep apnea syndrome in children is associated with obesity.

- Other systems: Gastrointestinal, hepatic and skeletal systems are also affected in obesity.

(Lobstein, 2004)

1) The cardiovascular system: Cardiovascular diseases in adulthood are known to be a consequence of obesity in childhood as well as later years. Hypercholesterolemias, dyslipidemia, hypertension that are linked to cardiovascular diseases are caused by obesity and are commonly seen in children (Lobstein, 2004).

Childhood obesity is associated with an unfavorable lipid profile. Serum cholesterol and triglyceride levels were significantly higher in obese children (Freidland et al., 2003). Obese children were studied for risks of hyperlipidemia, hypertension and high blood glucose levels. It was reported that severely obese boys had higher serum triglyceride and LDL cholesterol levels compared to normal weight children. However, girls had only significantly higher serum triglyceride. Blood pressure was also significantly higher in the severely obese group of children (Eunkyung et al., 2003). Blood cholesterol, LDL and serum TG levels were positively correlated with body fat in obese children (Young et al., 2003). There is a growing incidence of obesity, metabolic syndrome, PCOD and cardiovascular risk factors in Indian children too (Bharadwaj, Misra et al., 2008).
Hypertension in childhood has been linked to central obesity and an abnormal lipid profile. The prevalence of hypertension in children is reported not only in high socioeconomic status but also in children of low socioeconomic backgrounds. Blood pressure also has been associated with cardiovascular risk in children. The incidence of high blood pressure in children is the result of lifestyle changes which include improper diets and inadequate physical activity. Improper diet includes excessive intakes of fat and salt (WHO, 2003).

2) The endocrine system- Hyper-insulinism, insulin resistance, impaired glucose tolerance, Type 2 diabetes and menstrual irregularity is known to occur in children who are obese (Decklebaum et al., 2001). Obese girls may suffer from menstrual irregularity, poly cystic ovary syndrome, hirutism or acne.

Syndrome X in children is associated with improper lifestyles- high fat, high cholesterol and high sodium diets and lack of physical activity and exercise (WHO, 2003). ‘Syndrome X’ is characterized by insulin resistance, impaired glucose tolerance, hypertension, elevated plasma triglyceride and low HDL cholesterol. The glucose tolerance test was administered to 439 children and adolescents where the results showed that prevalence of metabolic syndrome increased with obesity. Metabolic syndrome was also reported to increase significantly with increased insulin resistance. Also C-reactive protein levels had increased with increasing obesity (Weiss et al., 2004). A study of Indian adolescents
reported high CRP levels in 13% of the study sample. Out of the overweight sample, twenty two percent and twenty five percent of the obese who had a high body fat level reported high CRP levels. There was also an association between CRP levels and body fat, waist-hip ratio, waist circumference and triceps skin fold thickness. A high fat intake correlated with high CRP levels (Bharadwaj et al., 2008).

In the early nineties type 2 diabetes was not so common in children. However since the mid nineties, it has been seen to increase in children of various ethnicities. In the past ten years there has been a noticeable increase in the incidence of type 2 diabetes in children. Scott et al., (1997) in their study found ninety percent adolescents with type 2 diabetes who were overweight.

Simmons-Morton et al., (1997) have suggested that though there are various causes of these, obesity in children is the most significant cause of type 2 diabetes in children. Tresaco et al., (2003) studied ninety five obese children and adolescents to assess the prevalence of type 2 diabetes, impaired glucose tolerance and insulin resistance. They found the prevalence of impaired glucose tolerance in obese children and adolescents to be 7.4 percent. Fasting glucose and insulin concentrations did not significantly differ between obese children with or without impaired glucose tolerance although 35.8 % of the obese children were insulin resistant. In five hundred and eighty nine Danish children, Brage et al., (2004) reported that physical activity correlated with insulin resistance.
Fasting insulin levels varied in the children and were significantly associated with the variance in physical activity.

Perichart and Balas (2007) screened more than five hundred children for risk factors of metabolic syndrome. They reported significantly higher insulin resistance indexes among the obese when compared with normal weight children. Rizzo et al., (2008) studied skin fold thicknesses and fasting insulin as well as fasting glucose in six hundred and thirteen adolescents from Sweden and Estonia. All markers of insulin resistance were significantly correlated to each other. Waist circumference and BMI were significantly correlated to insulin and glucose. Casazza, Gower and others (2009) assessed fitness and insulin activity in two hundred and nineteen children. They reported a strong association between fitness and insulin sensitivity index. Lower levels of childhood cardio respiratory fitness was associated with increased odds of adult obesity as well as insulin resistance by Dwyer et al., (2009).

A decline in fitness level from childhood to adulthood was associated with obesity and insulin resistance. This decline in fitness was attributed to reduced physical activity and was associated with obesity and insulin resistance in adulthood. Jago et al., (2010) examined cardio metabolic risk factors in about five thousand adolescents. Fasting blood glucose and insulin concentrations were analyzed. Insulin was inversely associated with fitness.
India is facing a rapid rise in children with type 2 diabetes mellitus. This is due to obesity in children. In a study of one hundred and sixty seven obese children and adolescents one fourth of the children showed impaired glucose tolerance (Sinha et al., 2002). A high body fat, skin fold thickness and abdominal adiposity are the reason for the increased prevalence of insulin resistance in children in India. A study in India reported that about one third of urban children who were overweight or obese had insulin resistance (Bharadwaj, Misra et al., 2008).

It is suggested that excess adiposity in childhood influences pubertal development in children. Obesity and particularly a high body fat bring puberty early to girls and delay it in boys. Early menarche is associated with menstrual abnormalities (Lobstein, 2004). The increased levels of abrogenic hormones, a hirsutism and poly cystic ovary together is called a polycystic ovary syndrome. It is significantly associated with abdominal fat and also causes infertility (Hills et al., 2007). Obese girls are at a risk of hyperandrogenemia and polycystic ovary syndrome (Solorzano and McCartney, 2010).

3) **Respiratory system** - Sleep disordered breathing is linked to loud snoring and day time sleepiness. This is due to an obstruction of the upper airway during sleep. Children who were obese were more disposed to having irregular breathing in their sleep compared to normal weight children. Redline et al., (1999) studied sleep disordered breathing and obesity in 399, 2-18 year old children. There was a significant association between
moderate level of sleep disordered breathing and obesity. They reported that African American children were three and a half times more likely to have disordered breathing than other children.

Asthma and sleep apnea syndrome in children are associated with obesity. Obesity related hypoventilation syndrome is called a 'Pickwickian Syndrome' and is a serious disorder which may even lead to death (Lobstein et al., 2004 and Gale et al., 2004). Occurrence of asthma has been reported in children with higher BMI (Tauman et al., 2006). Gale et al., (2004) reported that one third of obese children showed symptoms of sleep apnea and 5% even had severe obstructive sleep apnea in their study. Obesity has been said to increase the risk of asthma in children. This is probably because of inflammation of the airways and due to changes in airway hyper-responsiveness. It is suggested that asthma decreases the quality of life in children (Heyward, 2006).

4) **Other systems** – Gastro intestinal, hepatic and skeletal systems are also affected in obesity (Gale et al., 2004). Cholelithiasis, fatty liver and gastro esophageal reflux disease are seen to be present in obese children. It is estimated that 23 to 53% of obese children all over the world suffer from fatty liver disease. It is a silent disease and such children may be frequently fatigued (Lobstein, 2004). Gall stones are reported in almost 33% obese children and it is said to be caused because of obesity. The high amount of
subcutaneous and visceral fat is said to be the cause of gastro esophageal reflux disease in obese children (Hills et al., 2007).

Obese children are also more prone to fractures. Overweight and obesity in younger ages predisposes to fractures. Such children also have a low bone mass and higher body weights put a pressure on the bones. Other bone related problems such as knock knees, ankle sprains are also reported in overweight and obese children. Flat feet in obese children may be the reason of knock knees and ankle sprains (Hills et al., 2007). All of these along with social isolation and low self esteem could well result in lower participation in various physical activities especially group activities by children. This in turn could make the children more sedentary and increase the risk of overweight and obesity as well as adversely affecting physical fitness.

5) Mental health – Obese children are often discriminated against. They show dissatisfaction about their bodies and are depressed or have a low self esteem. Obese children are likely to be less socially competent, have more behavior problems, poor self perception and more negative interactions with others. Depression and low self esteem are associated with obesity and the social stigma is associated with poor growth in children.
Song et al., (2005) reported that obese children and adolescents had impaired self reported psycho social health. For the same group, a higher percentage of children were reported by parents to have impaired psycho social health. The number of children and adolescents with impaired school function was four times larger in obese children compared to normal. One hundred and fifty five obese children 5 to 17 years of age were studied to examine the relation between psychiatric disorders and obesity. More than half of the children reported an anxiety disorder. Children were also reported to have poorer social skills (Byrne and Hills, 2007). Parfitt et al., (2009) in their study on four hundred children in 7-12 grades found a significant injurious impact of overweight and obesity on depression, self-esteem, school and social functioning.

In a study of 2813, 11 year old girls and boys, it was reported that obese girls had low perception of physical appearance, self worth and athletic competence compared to boys. Both girls and boys who were obese, reported to be lower in their self perception compared to the normal children. Boys had a low social acceptance perception whereas girls had a low appearance perception (Franklin et al., 2006). Overweight and obese children are frequently teased by their peers as ugly, stupid and lazy resulting in low self esteem and social isolation (Hills et al., 2007). Wang et al., (2006) reported their study of two thousand eight hundred children where obese children had twice the odds of reporting low self esteem compared to normal weight children.
Physical fitness- Good physical fitness contributes to good health and well being by preventing chronic diseases. Astrand (1992) has stated that regular exercise is necessary for optimal function of body physical training and can produce improved physical fitness. Physical fitness is an important health marker in children and adolescents (Ruiz et al., 2006). Obesity and lack of flexibility can impair mobility. This leads to inactivity and can further increase weight. Reduced physical activity in overweight/obese children can reduce physical fitness on one hand and increase the risk of weight gain on the other, ultimately resulting in a vicious cycle that leads to obesity. Parizkova and Chin (2003) stated that increasing obesity in all age groups from many countries has been related with reduced levels of skill-related and health related fitness.

Healthy eating habits and physical activity can be established in childhood and has been shown to be important for fitness. Poor physical fitness in adolescence tends to trail into adulthood. Hence, low physical fitness in younger age is a warning for long-term poor health in adulthood. Unhealthy dietary and activity behaviors in children will eventually influence nutritional status and risk of obesity in later life (Lohman et al., 2008).

Physical fitness is interpreted in different ways by people. It is said to be the capacity for sustained physical activity without excessive fatigue or as the capacity to perform everyday activities with reserve energy for emergency situations. By these definitions many persons incorrectly classify themselves as physically fit. However it is incorrect to
say so when the relations between inactivity and health are considered. Some individuals consider physical fitness synonymous with cardio respiratory fitness, whereas others focus their perception on muscular strength and endurance (Heyward, 2006).

Both can be achieved with regular exercise, proper nutrition and rest. Health-related physical fitness includes cardio respiratory fitness, muscular strength, muscular endurance, flexibility and body composition mainly leanness versus fatness (Caspersen et al., 1985). Health-related physical fitness implies that organic systems of the body are healthy and function efficiently. Thus a healthy individual is able to engage in vigorous tasks and leisure activities. It exerts a positive influence on several risk factors associated with cardiovascular diseases, and it is effective in reducing the risk of back pain, diabetes, osteoporosis and obesity. It also is effective in managing emotional stress. It can be said that components of health-related fitness are responsible for making a person look better, feel better and enjoy a healthy, happy life (Corbin et al., 2000).

Skill-related physical fitness includes agility, balance, coordination, power, reaction time and speed and provides the same benefits as health-related physical fitness, but it also is important for motor skills required in sports and specific types of jobs in occupations and daily activities (Corbin et al., 2000). Participation in sports is not essential for a healthy lifestyle. But many individuals enjoy taking part in sports, and the enjoyment is greater for those possessing skill-related physical fitness.
Being physically fit benefits all – young, old, even the diseased. The contribution and benefits of the various components of fitness in a healthy life are as follows:

**Cardio Respiratory Fitness:** Cardio respiratory fitness is also called aerobic fitness and is considered to be an important component of health-related physical fitness. It is the overall ability of the cardiovascular and respiratory systems to carry out prolonged strenuous exercise without fatigue. It is a strong and independent predictor of cardiovascular disease (Lee et al., 2010). In simple terms, cardio respiratory endurance is the ability to carry out simple exercises like distance running, cycling, swimming, etc. Cardio respiratory fitness is usually expressed in metabolic equivalents (METs) or maximal oxygen uptake (VO$_2$ max) measured by exercise tests such as treadmill or cycle ergometer. The more intense the work or activity, greater the uptake of oxygen by the body. The greatest rate at which oxygen can be taken in and used during exercise is called maximum oxygen consumption (VO$_2$ max). Maximum VO$_2$ is also termed as maximum oxygen intake or aerobic capacity. VO$_2$ max is usually reported as the volume of oxygen consumed per kilogram of body weight per minute of work (ml/kg/min). The more the oxygen is taken in and utilized, the longer the person is able to work and not be exhausted. The higher the VO$_2$ max attained the more effective the circulatory and respiratory systems (BFY, 1999).
Cardio respiratory fitness has many advantages. Children with high levels of cardio respiratory fitness have been reported to have a lower risk of heart disease, a reduced risk of type 2 diabetes mellitus, hypertension years and increased bone density. Cardio respiratory fitness improves energy for work and play. Developing cardio respiratory fitness by exercising regularly has been shown to improve self-esteem. Habitual exercise also improves muscle tone and helps control weight (Kansal, 1996). Various factors affect cardio-respiratory fitness (Corbin, 2002; Heyward, 2006):

- **Age** - As age increases cardio respiratory fitness reduces.
- **Heredity** - The cardio vascular system inherited at birth is an important indicator of fitness status. This may be one reason for individual differences in cardio-respiratory fitness even if they are undergoing a similar exercise program.
- **Physical activity** - A younger person is generally more active than an older person. Children are very active and have higher VO₂ max levels (Bouchard, 2000).
- **Body fat level** - Obesity and high body fat are directly related to cardiovascular disease. Both are associated with reduced cardio respiratory fitness (Malina et al., 1995)
- **Exercise** - Exercise is essential for cardio respiratory fitness. Like other muscles, the heart becomes stronger if exercised regularly. An active person therefore has better cardio respiratory fitness than a sedentary person.
Aerobic Fitness and Body Composition – Body composition is an important indicator of good health and fitness of an individual. Body composition refers to the absolute and relative amounts of muscle, bone and fat tissues and water of the body. A certain amount of fat is necessary for normal physiological functions. However, too much of body fat at any age group leads to health problems, obesity, diabetes and hypertension (Hills et al., 2007). Body fatness is associated with several health problems in all age groups. Childhood and adolescence are periods of growth which show significant changes in body weight as well as body composition. Children are also reported to be having a higher percentage of body fat now days as compared to the past (Corbin et al., 2000). There are many methods of assessing body composition. The field methods are anthropometry- height, weights, skin folds, circumferences and portable bioelectrical impedance analysis (BIA). The laboratory methods include densitometry, dual energy X ray absorptiometry, MRI, CT scan etc. Skin fold measurements are preferred because it is an easy, inexpensive way of assessing body fat compared to other techniques. Only calipers are required. The calipers are portable in the field. Though it is simple, skill and practice of the researcher is necessary. Total body fat can be calculated by measuring skin fold thickness from various sites on the body. The accuracy of total body fat estimates depends upon the number of sites measured for their skin fold (Hills et al., 2007). Aerobic fitness helps to maintain normal body fat levels and prevent obesity.
Factors affecting body composition are –

- Genetics- It is has been reported that people are born with a predisposition towards fatness carried from their parents (Bray et al., 1998)
- Hormonal disorders- Hypothyroidism reduces basal metabolic rate resulting in fat and weight gain (James, 2006)
- Fat cells- Hypertrophy and hyperplasia of fat cells in childhood may result in obesity in childhood and adulthood (Barker et al., 1997).
- Physical activity- Reduced physical activity and exercise is the cause of higher amount of accumulated body fat. It also reduces basal metabolic rate due to which energy expenditure reduces (Bouchard and Katzmarzyk, 2007).
- Excess caloric intake- Consumption of high energy and high fat foods can result in weight gain, accumulation body fat and obesity (Gopalan, 1998).

Fatness and physical fitness of 6700 of 7-17 year old girls were studied by Malina et al., (1995). They reported that the fattest girls had poorer levels of health-related and motor fitness. Tsimeas et al., (2005) studied fitness in relation to fatness in 360 urban and rural Greek children and observed a significant relation between cardio respiratory fitness and body composition. A study of cardio respiratory fitness and fatness was conducted on 4072 children, 9- 15 years old, from Denmark, Portugal, Estonia and Norway. The ergometer cycle test was selected to assess cardio respiratory fitness. A strong relation
was observed between cardio respiratory fitness and skin fold measurements and waist circumference (Heggebo et al., 2006). Thomas et al., (2007) examined aerobic fitness and CHD risk factors in 208 teenagers. A significant inverse relationship was reported between aerobic fitness and body fat. Fatness was significantly related to a risk for cardiovascular disease. They concluded that in young people, body fat rather than fitness is a predictor of cardiovascular disease risk factors. Youth who have relatively high physical activity tend to have lower skin folds, percent body fat and body mass index. Children with higher triceps and biceps skin fold thickness were fitter than the ones with higher sub scapular and supra iliac skin fold thicknesses. In childhood a high body fat accompanied by cardiovascular disease risk factors such as total cholesterol, HDL-cholesterol, LDL-cholesterol, triglycerides, insulin resistance and hypertension have been shown to ‘tag along’ into later life, (Strong et al., 2005).

A relation between cardio respiratory fitness and body composition has been observed. Tsimeas et al., (2005) studied fitness in relation to fatness in 360 urban and rural Greek children. Children were assessed for BMI, percent body fat, sit and reach test, basket ball throw, vertical jump, grip strength as well as a run. Fitness parameters were significantly correlated with body fat.

Ara et al., (2007) studied adiposity, physical activity and physical fitness were in 1068 Spanish children, among whom 31% children were overweight and 6% obese. Physically
active girls had significantly lower BMI than did sedentary girls. The sum of skin folds was significantly lower in the physically active group compared to the sedentary group. Physical activity was significant related to BMI and skin fold in boys but not in girls. Aerobic capacity was also significantly related to adiposity. Low body fat was seen in children with better aerobic capacity. Similar observations were reported by Lohman et al., (2008). Fat-free mass was significantly associated with cardio respiratory fitness in 1440 adolescent girls. Cardio respiratory fitness was assessed using a cycle ergometer. Body composition estimated using triceps skinfold measurement showed a significant linear relationship with cardiorespiratory fitness.

Aerobic Fitness and Obesity – Weight status and physical fitness was studied in 6929 children aged 6 – 12 years in China by Shang et al., (2010). The overall prevalence of underweight was 3.1%, overweight was 14.9% and obesity was 7.8%. The prevalence of overweight and obesity was more in boys but prevalence of underweight and obesity was more in girls. The distance of standing broad jump was significantly longer for boys than girls. Boys ran significantly faster than girls in the sprint and shuttle test. Martins et al., (2010) conducted a 5 year long study where they examined BMI and its association with BMI changes in 285 children from Azores Islands. Changes in aerobic fitness were not significantly associated with BMI changes in 5 years. However, children who had better motor coordination had lower values of BMI during the 5 year period. The authors concluded that there was considerable individual variation in baseline BMI and changes
over time. Fitness was not associated with BMI changes but motor function was negatively associated with.

**Aerobic Fitness and Cardio Vascular Disease** – Cardio vascular disease risk factors can be altered by good cardio vascular endurance. Hager et al., (1995) studied aerobic fitness in 262 children. The estimated VO$_2$ maximum and the time taken for the 1 mile run was significantly associated with triglycerides and other lipids. They suggested that the level of aerobic fitness is a significant predictor of lipid levels and cardio vascular disease risk factors in children. Hansen et al., (2005) investigated the association between low physical fitness and cardiovascular disease risk in 696 children. They reported that children in the lowest quartile of fitness had an odds ratio of 2:1 for having three or more risk factors as compared to fit children.

**Cardio Respiratory Fitness and Type 2 Diabetes**- In the past ten years there has been a noticeable increase in the incidence of type 2 diabetes in children. Scott et al., (1997) in their study of 376 children in America found 90% adolescents with type 2 diabetes were overweight. Sinha et al., (2002) observed that among 167 obese children and adolescents, one-fourth of the children showed impaired glucose tolerance. Tresaco et al., (2003) studied 95 obese children and adolescents to assess the prevalence of type 2 diabetes, impaired glucose tolerance and insulin resistance was 7.4% and 35.8% of the obese children were insulin resistant. Fasting glucose and insulin concentrations did not
significantly differ between obese children with or without impaired glucose tolerance. This increase in frequency is attributed to the rising prevalence of obesity in children and adolescents (Steinberger and Daniels, 2003). This impact of obesity in children is scaring as the health status of future generations has an impact on a country’s development (Lobstein, Baur and Uauy, 2004).

Perichart and Balas (2007) screened 561 children for risk factors of metabolic syndrome. They reported significantly higher insulin resistance indexes among the obese when compared with normal-weight children. Rizzo et al., (2008) studied physical activity, skin fold thicknesses and fasting insulin as well as fasting glucose in 613 adolescents from Sweden and Estonia. All markers of insulin resistance were significantly correlated to each other. Waist circumference and BMI were significantly correlated to insulin and glucose. Casazza, Gower and others (2009) conducted a study on 219 children to assess their fitness and insulin activity. They reported a strong association between fitness and insulin sensitivity index. Dwyer et al., (2009) observed that lower level of cardiorespiratory fitness in children was associated with increased odds of adult obesity as well as insulin resistance by. Jago et al., (2010) examined cardio metabolic risk factors in 4955 adolescents. Fasting blood glucose and insulin concentrations were analyzed. Insulin was inversely associated with fitness.
Cardio Respiratory Fitness and Hypertension- Cardiorespiratory fitness can help maintain normal blood pressure at rest and after exercise. Improved cardiorespiratory fitness also helps to reduce blood pressure if it is elevated. Systolic and diastolic blood pressures were reported by Fraser et al., (1983) to be lower in children who had above average fitness than in children who had below average fitness and the relationship between fitness and systolic blood pressure was statistically significant in girls and boys. Gutin et al., (1990) studied the relationship between blood pressure and aerobic fitness in 216 children. Diastolic blood pressure was inversely related to fitness in boys and girls. They concluded that children exhibit same risk factors for cardiovascular disease seen in adults. Kikuchi et al., (1995) conducted a cross sectional study on cardiorespiratory fitness and blood pressure of 299 boys and 282 girls in England. Systolic blood pressure was significantly related to the performance of the test in girls and boys.

Cardio Respiratory Fitness and Skeletal Health- High bone mineral content and lower levels of fatness have been observed in children who regularly participate in sport activities. Regular physical activity has a favorable effect on bone mineral content and bone mineral density. This was noticed when athletes and non-athletes were compared. A study on children and adolescents who participate in regular sports activities showed a correlation to adult bone mineral content (Strong et al., 2005). Skeletal health problems were found to be associated with significant pain in joints, osteoporosis and osteoarthritis (Sharkey et al., 2007).
Cardio Respiratory Fitness and Mental Health: Exercise has much more benefits than the physical benefits. It is important to know that there are many psychological benefits of regular exercise. Exercise can reduce anxiety both in the short term and long term. Aerobic exercise decreases anxiety and depression. Exercise helps to keep positive mood states. Even low intensity activities can have a marked impact on mood. There is evidence to suggest that physical activity and exercise lessen symptoms of mild to moderate depression (Taylor et al., 1985). Physical activity significantly reduces depression in all age groups (North, McCullagh and Tran., 1990). Moderate exercise is more effective in lessening anxiety than high intensity exercise (Weinberg and Gould, 2003). A simple activity like walking can reduce anxiety. Like adults, children and adolescents may also suffer from disorders such as depression, anxiety or low self-esteem. Childhood obesity and low self-esteem have been linked (Sharkey et al., 2007).

Muscular Strength: is the capacity to carry out work against resistance. Everyday household tasks such as lifting grocery bags, moving furniture etc require muscular strength. The role of muscular fitness in the performance of exercise and activities of daily living, in preventing disease and sports performance is being increasingly recognized (Kansal, 1996).

Benefits of Muscular Strength: Regular strength training has several health benefits. Stronger the muscles, lesser the chances of joint pain or muscle strain during physical
activity. Strength training also affects self-esteem. There are many benefits in regular daily activities, for example ease in carrying heavy things or even doing simple housework (Howley et al., 2003).

Corbin, (2000) has listed factors affecting strength:

- Genetics- Each person is born with a certain amount of muscles. People who have a higher amount of large twitch muscles have more muscle size and also strength.
- Gender- Women have lesser muscle mass than men and therefore lesser strength. This difference is due to smaller amounts of testosterone which is an anabolic hormone.
- Age- Strength declines with age. It is maximum in the twenties.
- Training- It is possible to improve strength by proper training. At any age irrespective of genetic factors, muscular strength and endurance is better in people who train or exercise than those who do not.

Grip strength is important as an indicator of strength and good health. The handgrip test is one of the frequently used tests for assessing muscular fitness (Newman et al., 1984). Muscular strength can be improved in children by weight training programmes (Howley et al., 2003). Kenjle et al., (2005) studied grip strength as an index of nutritional status in 787, 6 - 10 year old girls and boys. The results showed a significant and high correlation between grip strength and age. Boys of all ages had higher grip strength than girls. Grip
strength was significantly correlated with height, weight, mid upper arm circumference, triceps and was found to be a specific measure of lean body mass. The authors suggested the use of grip strength for assessing nutritional status of children. The influence of anthropometric measurements on grip strength in 6 – 10 years children was also studied by Semproli et al., (2007). These authors reported that boy’s heights and BMI were the strongest predictors of grip strength particularly in older children. With increasing age and BMI, grip strength was stronger in boys than girls.

Hand grip strength was evaluated using a digital dynamometer in 2125 girls and boys between 6 – 18 years. Grip strength increased with age. Grip strength was also significantly related to lower percent body fat but it was not significantly associated with BMI (Serrano et al., 2009). Nine thousand five hundred and seventy four subjects were assessed for their lean and fat mass, and grip strength by Sherriff et al., (2009). Lean index and grip strength was associated in girls and boys. BMI had weaker association and the fat index was unrelated to grip strength. It was concluded that lean indices relate to muscle function and fitness while fat does not. Jurimae et al., (2009) examined the relationship of hand grip strength with anthropometric variables in 64 children between 8 – 11 years. Body height was the most important predictor for grip strength in boys and girls. Skin fold thickness were not related to grip strength in any group. Wind et al., (2010) conducted a cross sectional study on 384 healthy Dutch children, adolescents and young adults of 8 – 20 years. Muscle strength was measured using a hand dynamometer.
Grip strength was strongly correlated with total muscle strength. They suggested that grip strength can be a tool to provide an indication of muscle strength. Cohen et al., (2010) evaluated grip strength, in relation to gender and age in 7147 English school children. A significant increase in grip strength was found between every age group, although boys were stronger than girls. The age related rise in strength of boys was significantly greater than girls. Similar results were obtained by Butterfield et al., (2009) in 5 – 19 years old children.

**Flexibility:**

Flexibility is the capacity of a joint to move through its full range of motions. Flexible persons can bend and twist at their joints easily. Without regular stretching, muscles become stiff, which can impair flexibility. Every person needs some flexibility in order to perform activities of daily living (Heyward, 2006).

**Benefits of Flexibility:** Flexibility is important in performing exercise efficiently. Lack of flexibility might stress muscles and cause discomfort (Greenberg et al., 2004). There are various benefits of increased flexibility, such as ease of joint mobility, prevention of low-back problems, efficient body movements and good posture.
According to Kansal (1996) the factors affecting flexibility are-

- **Age**: Flexibility changes with age. As the children grow from age 6 to 12 they improve their flexibility progressively till adolescence. Young children are more flexible than adults. Adults generally lose flexibility with age, the reason being an increase in their inactivity with age.

- **Sex**: Males are less flexible than females. Females maintain this advantage throughout life.

- **Life-style**: An active lifestyle maintains one's flexibility, whereas an inactive or sedentary lifestyle gradually reduces one's flexibility.

- **Injuries**: Injured joints have reduced flexibility.

- **Physique and Body Composition**: Persons with more percentage of body fat have less flexibility than those having more amount of lean body mass.

- **Exercise Training**: Flexibility can be improved and retained longer compared to other components of fitness. With regular exercise, the flexibility can be increased permanently.

In a study by Deforche et al., (2003) on 3214 Flemish school children, obese children did not show a hindered performance in flexibility tests. A longitudinal study of two thousand nine school children in Lithuania was done for ten years to assess differences in health-related fitness. Boys and girls in the age groups 12, 14, 16 years performed significantly better in the sit and reach test but performed poorly in sit ups in 1992.
compared to 2002. This decline in fitness and flexibility was attributed to the decrease in physical activity and the socioeconomic changes during those years (Volbekiene and Griciute, 2007). Three hundred and thirty one children aged 7 – 8 years participated in a study in Taiwan to assess their physical fitness and activity. The study reflected on the effect of socio economic status factors and physical activity on fitness. Older children had significantly better flexibility than younger children. Boys in urban school had poor flexibility compared to rural boys. Urban girls also had better flexibility as well as higher end scores than did rural girls (Chen et al., 2008). Greek school children were assessed for flexibility by Nevill et al., (2009). They reported that height was negatively associated with flexibility.

Testing health-related physical fitness can facilitate individuals to maintain good health. Testing skill-related physical fitness can assist and motivate individuals to perform activities at higher levels and even participate in sports (Miller, 2002). Fitness testing is important as it is a reflection of current status as well as the future health potential. The purposes of testing physical fitness are:

1. Diagnosis and classification: Parents and teachers are curious to know about a child’s physical fitness level. With the testing of physical fitness level of the child, he or she can be put into appropriate categories of physical fitness. This
enables proper programmes to be drawn up for each participant to improve his/her physical fitness.

2. Motivation: Knowledge of the level of physical fitness can motivate people to improve their level of fitness.

3. Selection: The testing of physical fitness eases the selection of potential sportsmen at a young age so as to give them the necessary professional training to them.

4. Training Evaluation: The repeated testing of physical fitness (eg. Before, mid and after training) helps to find out the effects of training programmes. This training evaluation also helps to compare the mean physical fitness for same age, different regions, ethnic groups and sports categories etc.

5. Development of Norms: The collection of physical fitness data on large number of individuals helps set up norms for different populations.

(Kansal, 1996).

Several fitness tests have been developed and tested since the early sixties. Adults and children undergo almost the same tests with age related differences in the tests. The tests also differ depending on the fitness component to be studied (Corbin, 2000). There is no single test that measures all components of health-related or skill-related physical fitness. As there is no one item that measures total body muscular strength, muscular endurance, flexibility or body composition, a variety of tests are used depending on the component to
be measured. This approach is most appropriate if tests are age and gender related (Miller, 2002).

The most important purpose of developing physical fitness tests is to provide an economical and efficient way of evaluating physical fitness of large number of individuals. Instead of using expensive methods (laboratory) of testing physical fitness, the majority of physical fitness tests are based on indirect methods of testing muscular strength, muscular endurance, cardio-respiratory endurance, flexibility through test items like chin-ups, pull-ups, push-ups, standing-broad jump, reach and high jump, 12 minute run, sit and reach, front to rear / side splits etc. (Kansal, 1996).

**Fitness Testing:**

Measurement of Muscular Strength: Muscular strength, muscular endurance, and bone strength determines musculoskeletal fitness. This refers to the ability of the skeletal and muscular systems to perform work. Muscular strength is the maximal force or tension level that can be produced by a muscle group. Muscular endurance is the ability of a muscle to maintain sub maximal force levels for extended periods. Bone strength is directly related to the risk of fracture and is a function of the mineral content and density of the bone tissue. Resistance training is one of the most effective ways to improve the strength of muscles and bones and to develop muscular endurance (Heyward, 2006). A large number of tests have been developed for measuring muscular strength since the 19th
century. Many tests have been tried and high multiple correlations have been found among the tests proving validity of muscular strength test (Howley and Franks, 2003).

**Measurement of Flexibility:** Flexibility is the ability to move a joint or series of joints smoothly through the complete range of motion. Flexibility is limited by factors such as bony structure of the joint and the size and strength of muscles, ligaments and other connective tissues. Daily stretching can greatly improve flexibility. Flexibility may be measured by many tests which are divided into the following two types: tests of absolute flexibility and relative flexibility. The movement in relation to an absolute performance goal is measured irrespective to the size of concerned body part when absolute flexibility is being measured. For relative flexibility, the movement is measured relative to the length or width of the concerned body part. Bridge-up test, Shoulder and Wrist elevation test, Trunk and Neck extension test are examples of relative flexibility tests. Flexibility is the component of physical fitness which affects the performance of sports activities. For example, performance in butterfly swimming is highly correlated with flexibility. A loss in flexibility is considered as the first sign of getting out of shape, or becoming physically unfit.

**Measurement of Cardio respiratory fitness:** Cardio respiratory fitness is the ability to perform whole body physical activity of moderate to high intensity for relatively long periods of time. It is the ability of the circulatory and respiratory systems to adjust to
vigorous exercise and to recover from the effect of such exercise. It involves the functioning of the heart and lungs, the blood and its capacity to carry oxygen. Aerobic fitness, cardiovascular endurance and cardio respiratory endurance all essentially mean cardio respiratory fitness. Cardio respiratory fitness increases physical working capacity at all ages, (Miller, 2002). Measurement of cardio respiratory fitness helps identify individuals who have poor cardio respiratory fitness and then to recommend the appropriate activities for them. Cardio respiratory fitness testing is often performed to measure changes in fitness. Tests like treadmill or ergometer are expensive as against distance runs which are practical, inexpensive and less time consuming. Activities such as walking, running, swimming, bicycling and bench stepping are used to assess cardio respiratory fitness. For children, a treadmill is preferred as they may not be able to maintain constant pedalling of the ergometer. Also for children less than 8 years, the height of the cycle may be high. The 1 mile run test is also used for children. Step test is also used for children. The advantage of the step test is that it can be done on large samples in the field. The equipment is simple and not expensive (Heyward, 2006).

Fitness can be developed and all can take efforts to improve fitness parameters. Miller (2002) has specified some strategies to improve physical fitness components, they are:
Development of Cardio Respiratory Fitness-
• Can be developed by regular aerobic activities like running, walking, swimming, and cycling.
- Any activity which is selected should be for a long distance and duration. Each individual can choose the activity which they enjoy.

- Aerobic activities should be performed for at least three to four times a week.

- A program selected for improving cardiorespiratory fitness should be low in intensity initially and then can be gradually increased.

Development of Flexibility:

- Static and Ballistic stretching techniques to improve flexibility. Static stretching involves slowly moving to a position to stretch the designated muscles and holding the position for a specified length of time. Ballistic stretching makes use of repetitive, bouncing motions.

- There are several Proprioceptive neuromuscular facilitation techniques used for stretching but all involve a combination of alternating contractions and relaxations of both agonist and antagonist muscles.

- Both static and Proprioceptive neuromuscular facilitation stretching will improve flexibility.

- Flexibility is highly specific to each joint and activity, therefore flexibility exercises should be performed for each joint in which increased flexibility is desired.
Development of Muscular Strength:

- Muscular Strength will improve within weeks if the correct exercises are done on a regular basis.
- Muscular strength can be improved without the use of expensive equipment or a special room. It is essential to perform stretching and warm up exercises before attempting muscular effort.
- Perform the ones that provide mild overload and gradually progress to the more difficult ones. Begin with 10 repetitions and add 2 or 3 repetitions each week until the desired number is reached.
- If unable to perform 10 repetitions, begin with a lower number. Perform the exercises 3 to 5 days per week.

Children’s fitness levels can steadily improve with practice and good nutrition. Today children are coached to participate in various sports and this will also keep them fit. It is important to look at both health related and skill related fitness. To know the overall fitness of children and to observe any change, fitness should be assessed frequently with different fitness test. There should also be a regular note of sedentary lifestyles and dietary intake in children. Children’s fitness levels can steadily improve with practice and good nutrition. Today children are coached to participate in various sports and this will also keep them fit. Children imitate parents and so if parents take up fitness activities they can be a motivation to their children.